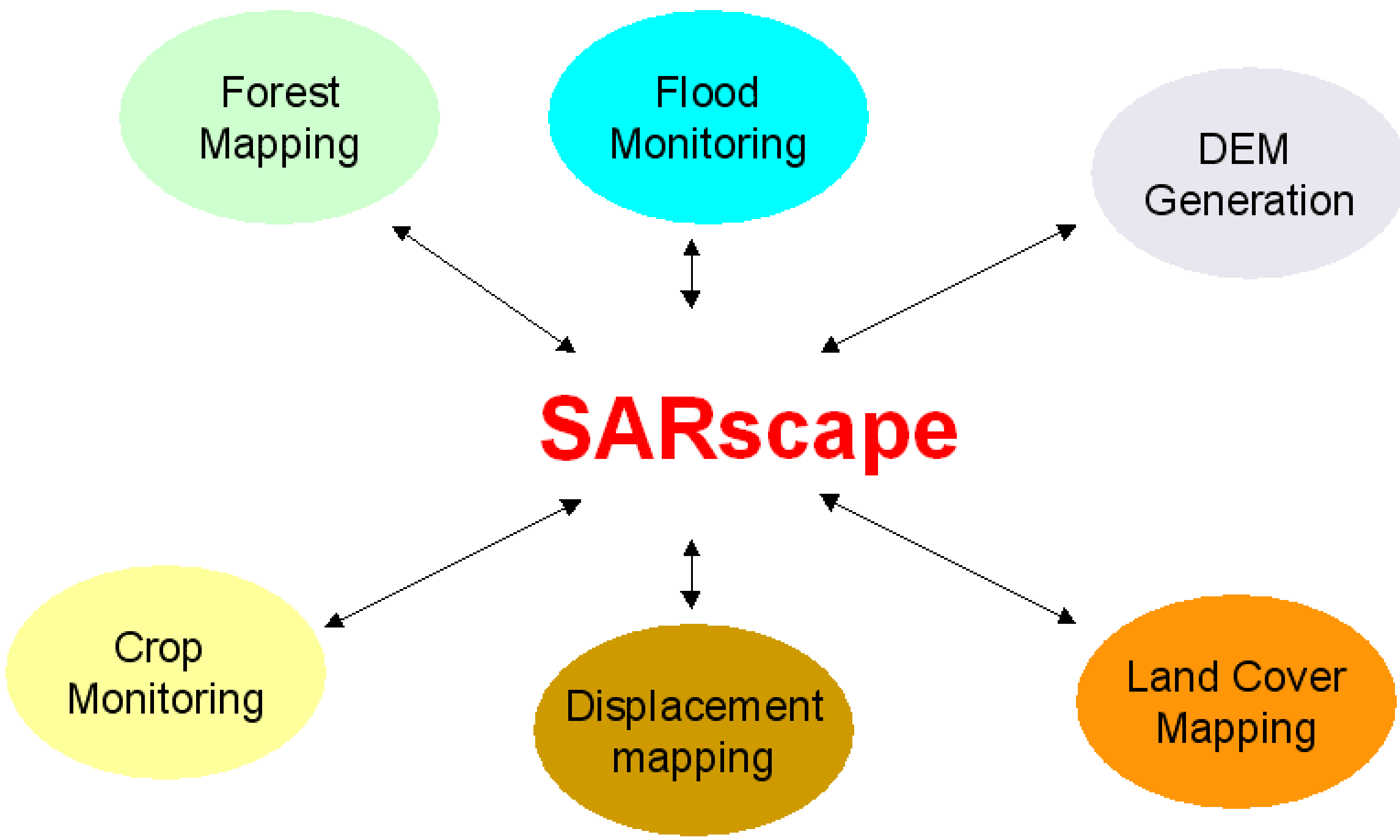
User Guide

This manual is intended to guide SARscape users in generating the best application oriented products from the available input data set.

The exploitation of several application fields, such as



together with a constant and close relationship with the SARscape user community, are key factors to continuously upgrade and optimise the software performance.

1 Help Content

SARscape — The Earth Observation information gateway — Online Help

1.1 General Information

Section Content

1.1.1 Interface common functionalities

The following indications are intended to simplify the procedure of filling the different processing panels with the appropriate information (i.e. files and parameters).

This page must be intended as a general description, which is applicable to all processing panels. Nevertheless some interfaces may require more detailed information about specific files, parameters or settings, which are not considered in the present description; these peculiarities are eventually reported in the relevant section of this guide.

Input Files

This tab allows the definition of all mandatory inputs and, in particular cases (e.g. the SRTM DEM extraction 676), also some optional files. The right mouse button enables the following actions:

- Add - to insert a new input file. The same action can be performed with the "Browse" button.
- Remove - to erase an input file.
- Edit - to modify the name and the path of an input file.

Optional Files

This tab allows the definition of the inputs which are not mandatory to execute the process. The optional files are required only in some special cases. Usually, the process is executed at first without the use of the optional files and, if the results are not satisfactory, the process is re-executed with their inclusion to improve the results. This is for instance the case of the Coregistration file 124, which can be adopted to solve some coregistration related failures; or the GCP file 146, which can be adopted to correct the orbital parameters when they are not sufficiently accurate to achieve an accurate image geo-location.

DEM/Cartographic System

This tab allows either the definition of the output cartographic reference system or entering the reference Digital Elevation Model, which will be considered in processes such as the Geocoding 142, the Interferogram Generation 293, the Interferogram Workflow and others. It is worth to mention that, selecting this tab, one has the possibility to either input an existing DEM or extract a new one by means of the dedicated tool 657.

Output Files

The name and location for the output files is defined. The right mouse button enables the following actions:

- Edit - to modify the name and the path of an output file.
- Remove - to erase an output file. The corresponding input is automatically cancelled.
- Change Output Directories - to modify the name of the destination folder for all output files.
- Change Output File Extensions - to modify the extensions (i.e. file name suffix) for all output files.

Parameters

The interface is structured in order to allow either an easy use (for beginners) or a full interaction with all processing parameters (for advanced users). Two ways are provided to define the processing parameters:

1. Selecting the "Principal Parameters" from the pull down menu, the most important (and easier to understand) values are visualized with the possibility to modify them. Once this has been done the processing step can be executed without changing any of the additional parameters, which are listed in the pull down menu (e.g. "Coregistration", "Filtering", "Flattening", "Others", etc.). Any parameter, which is not specifically set by the user, is automatically retrieved by the program from the currently active Preferences 755. This is the suggested approach for beginners.
2. Beneath the "Principal Parameters" button, in the pull down menu, there are several groups of advanced parameters, which can be loaded and modified by choice (e.g. coregistration, filtering, flattening, others, etc.). The name of each group is based on the parameters which are contained. Experienced users, who already have a good knowledge of SARscape, often prefer to check and possibly tune all available parameters; this is important in order to exploit the characteristics of the software at their best and also to customize the processing depending on the peculiarities of the input data.

It is worth to mention that the original parameters, which are shown within each interface once it is opened, are the same as those written in the currently active Preferences 755. If one or more parameters are modified in any specific processing interface, these new values are adopted for the subsequent processing, while the values written in the currently active Preferences 755 remain unchanged. In other words, the Preferences 755 are not affected by changes applied on the processing interfaces.

In some cases (e.g. General Tools > Geoid Component 655) the processing can be executed only once the required parameter setting has been selected (i.e. "Geoid Operation").

It happens that some portions of the panel appear in light grey (i.e. not editable fields). This is because, in certain processing configurations, those fields must not be considered. This is for instance the case of the "Output Projection", which cannot be specified if a DEM is entered as input; indeed the output cartographic reference system will be the same as the input DEM.

Store Batch

The processing step is stored in the batch list. The Batch Browser 802 button allows to load the processing list.

Exec

The processing step is executed.

Close

The processing panel is closed.

1.1.2 Workflow interface common functionalities

The following indications are intended to simplify the procedure of filling the different workflow processing panels with the appropriate information (i.e. files and parameters).

This page must be intended as a specific description, mainly applicable to the workflow processing panels. Nevertheless some interfaces may require more detailed information about specific files, parameters or settings, which are not considered in the present description; these peculiarities are eventually reported in the relevant section of this guide.

Input

This part of the processing chain is dedicated to the input files and principal parameters required by the workflow. In the different tabs it is possible to enter all mandatory inputs. The following three tabs are available in this section:

- Input File - The name and location of the input files are entered either as single files or as file list.
- DEM/Cartographic System - This tab allows either defining the output cartographic reference system, entering the reference Digital Elevation Model or choose an external one to download through the Digital Elevation Model extraction 657 tool. This information will be considered in processes such as the Geocoding 142, the Interferogram Generation 293, the Interferometric Digital Elevation Model Workflow 268 and others.
- Parameters - The principal parameters of the processing chain to be entered.

Output

This is the part in the processing chain dedicated to the output files and options:

- Output Files - The name and location of the output files are entered either as single files, as file list or output root name. More than one output option might be required
- Delete Temporary Files - to erase all the intermediate temporary files generated during the processing steps.

Parameters

The interface is structured in parts, showing the name of the steps that will be performed in the workflow. By selecting one of the sections (e.g. "Coregistration", "Filtering", "Flattening", etc.), the appropriate parameters will show up in the dialog. In order to allow both an easy use (for beginners) or a full interaction with all processing parameters (for advanced users) of each step of the workflow, two ways are provided to define the processing parameters in each section:

1. Selecting the "Principal Parameters" from the pull down menu, the most important (and easier to understand) values are visualized with the possibility to modify them. Once this has been done the processing step can be executed without changing any of the additional parameters, which are listed in the menu (see the following paragraph). Any parameter, which is not specifically set by the user, is automatically retrieved by the program from the currently active Preferences 755. This is the suggested approach for beginners.
2. Beneath the "Principal Parameters", in the pull down menu, there are several groups of advanced parameters, which can be loaded and modified by choice (e.g. coregistration, filtering, flattening, others, etc.). The name of each group is based on the parameters which are contained. Experienced users, who already have a good knowledge of SARscape, often prefer to check and possibly tune all available parameters; this is important in order to exploit the characteristics of the software at their

best and also to customize the processing depending on the peculiarities of the input data.

It is worth to mention that the original parameters, which are shown within each interface at first opening, are the same as those written in the currently active Preferences 755. If one or more parameters are modified in any specific processing interface, these new values are adopted for the subsequent processing, while the values written in the currently active Preferences 755 remain unchanged. In other words, the Preferences 755 are not affected by changes applied on the processing interfaces.

It happens that some portions of the panel appear in light grey (i.e. not editable fields). This is because, in certain processing configurations, those fields must not be considered. This is for instance the case of the "Output Projection", which cannot be specified if a DEM is entered as input; indeed the output cartographic reference system will be the same as the input DEM.

Preview
By setting this flag, at the end of each processing step the intermediate outputs are made available for visualisation/analysis.

Back
The workflow is brought to the previous step in the chain. This action can also be performed by selecting the desired section in the processing window: if the parameters are changed, all the temporary files generated by the subsequent steps will be erased and the process restarted from the selected section.

Next
The workflow is moved to the following step in the chain.

Cancel
The workflow panel is closed.

1.1.3 Cartographic Reference Systems

Following cartographic and geodetic reference systems, listed in alphabetical order, are supported:

Country	Projection	Ellipsoid	Datum Shift
Albers	Albers	WGS84	
Argentina	Gauss-Krüger	International1924	Campo Inchauspe
Austria	Gauss-Krüger	Bessel1814	Oekie
Bangladesh	UTM	Everest	Indian-M
Belgium	UTM, Lambert72, Lambert2008	Hayford1924, WGS84	BD72
Brazil	UTM	International1967	SAD69, Alegre
Canada	UTM	Clarke1866, WGS84	Alberta, East, Ontario, NorthWest, Yukon
Cartesian-	Cartesian	WGS84	

Global			
Colombia	Gauss-Krüger	International1924	Bogota Observatory
Czech Republic	Gauss-Krüger	Krass	Grimm, Eurotel
Denmark	UTM	International1924	Geodaetisk Institut
Ecuador	UTM	International1924	Provisional South American1956
Egypt	TM	Helmert1906, Clarke1866, Clarke1880	European1950-F
Finland	Gauss-Krüger	International1924	Finnish National System
France	Lambert Conformal Conic	Clarke IGN	WGS84, RGF93
Geo-Global	Geographic	WGS84	WGS84
Germany	Gauss-Krüger, UTM	Bessel1814, International1924, Krassovsky	Laux, DHDN-ETRF, S42-ETRF, Europe50, Graf, LVABW, LVAN
Gnomonic	Gnomonic	WGS 84	
Greece	TM	WGS 84	
Indonesia	UTM	GRS67	MAPINDO3, MAPINDO5
Ireland	TM	Airy modified, WGS84	IG, ITM (IRENET95)
Italy	Gauss-Boaga	International1924	Roma40
Italy	UTM	International1924	Europe50
Japan	UTM	WGS84, Bessel1814	WGS84, Tokyo
Korea	UTM	WGS84	
Lambert Azimuthal Equal Area	Lambert Azimuthal Equal Area	WGS84	WGS84
Lambert Cylindrical Equal Area	Lambert Cylindrical Equal Area	WGS84	WGS84
Lituania	TM	WGS84	
Mercator	Mercator	WGS84	
Miller	Miller	Earth Radius	
Netherlands	Oblique Stereographic	Bessel1814, WGS84	RD
Philippines	UTM	Clarke1866	Philippines, Mindanao
Polar Stereographic	Stereographic	WGS84	
Portugal	Gauss-Krüger	International1924	Datum73
Sinusoidal	Sinusoidal	Earth Radius	
South Africa	TM	WGS84	
Spain	UTM	International1924	Europe50, ED50 (7 parameters)
Sri Lanka	TM	Everest	Kandawala
Stereographic	Oblique Stereographic	WGS84	
Switzerland	CHOM	Bessel1814	CH1903, CH1903+, WGS84, ITRF93, ETRS89, CHTRF95
Turkey	Gauss-Krüger	Krassovsky	TDS
United Kingdom	TM	Airy	ICP, Graf
UPS	UPS	WGS84	

United States of America	UTM	Clarke1866, WGS84	East, West, Alaska
UTM-Global	UTM	WGS84	
Venezuela	UTM	WGS84	PSAD1956, Pulkovo, ITRF94

Note that:

– Some generic projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) require specific parameters to be adapted depending on the geographic location of the data to process (i.e. Latitude/Longitude scene position). In these cases the user is prompted to enter such parameters in the "Cartographic Parameters" panel (refer to the provided "References" for details).
– The cartographic information, when importing geocoded data in ENVI format 79, are automatically read from the ENVI header file (.hdr) only for GEOGLOBAL and UTM reference systems.
– The Albers projection is intended for data in polar regions.

References

Snyder, John P. 1987. Map projections: a working manual. USGS Professional Paper 1395. Washington, DC: United States Government Printing Office.

1.1.4 Frequently Asked Questions

Q. - Is it mandatory to have **ENVI** installed and licensed on the computer where **SARscape** is operated?

A. - Yes it is.

Q. - What are the **Operating Systems** which are supported for the SARscape installation?

A. - WINDOWS (Vista, 7, 8/8.1) 32 and 64 bit, and LINUX 64 bit.

Q. - I'm operating the software with a hardware based license (USB dongle). Is there the possibility to check which are the **SARscape modules** available in my license?

A. - You can double click on the "get_client_id.exe" file, which you find in the SARscape installation package. This will provide on screen the dongle related details (e.g. expiring date, available modules, etc.).

Q. - What is the oldest **ENVI version** which is fully compatible with SARscape?

A. - All SARscape functionalities are fully supported starting from ENVI 5.1.

Q. - Does the **SARscape LINUX** version perform better than the WINDOWS one?

A. - Yes, in most of the processing steps the LINUX platforms process faster than the same hardware configuration with a WINDOWS operating system. Yet, possible problems/errors, which are reported when processing very large files (several Gigabytes) under WINDOWS, are typically not encountered when operating under LINUX.

Q. - Is it mandatory to have **IDL** on the computer where **SARscape** is operated?

A. - No, it is not.

Q. - Starting from an image generated with **SARscape**, is it possible to make a processing in **ENVI** and afterwards re-import the file into **SARscape** for further processing?

A. - You can use the dedicated import functionality 81 for this purpose, which is aimed at restoring the information contained in the original SARscape product. Remember that, to use this functionality, the raster parameters (e.g. number of pixels and pixel depth) of the original SARscape product must haven't been modified as result of the ENVI processing.

Q. - Is there a way to define a **New Space-borne SAR Sensor** in SARSCAPE, in order to import data which are not currently supported and, afterwards, process them with SARscape and ENVI?

A. - Yes, you can import and use SAR data from own sensors, given that they comply with a generic format we defined for "custom" sensors. In case of focussed data, the SLC files shall be prepared as a standard SARscape product, with the data stored as a plain float-complex matrix and two associated header files: the .sml file with SAR-specific parameters (this is needed for the compatibility with SARscape) and the .hdr file with generic raster parameters (this is needed for the compatibility with ENVI).
The presence of the "SensorName>CUSTOM</SensorName" tag in the SARscape (.sml) header is intended to configure the software for working properly in all the steps that have sensor-specific dependencies (e.g. the radiometric calibration).

Q. - What to do in case a **Processing Error** is reported?

A. - A processing error can be due to different reasons, either related to wrong input products or incorrect processing executions or possibly related to software problems/bugs. Some basic suggestions should be followed in case a processing error is reported:

1) Check the error message content.
2) Check the information provided in the SARscape help documentation about the execution of the specific processing step. Verify the proper setting of the "Preferences". This shall enable to understand if the problem is related to a wrong setting of some processing parameter.
3) In case the origin of the problem is not identified, the error must be reported to your SARscape distributor. To do this simply follow the instructions provided automatically by the program once the

error is reported.
4) Send an e-mail to your software distributor and attach the previously saved Error Report 824.

Q. - The specific **Processing Parameter**, as well as the **Input/Output File List**, were stored in the output folder in the 4.0 version of SARscape. In the 4.1 release I do not find these files anymore. Are they stored in another folder?

A. - Since the 4.2 release most of the processing related parameters are stored in the SARscape Working Directory 756. This folder should be "cleaned" from time to time in order to avoid filling it with thousands of old processing related parameter files.

Q. - Are there any limitations in terms of **Screen Resolution Setting** to operate the software?

A. - The minimum screen resolution must be 1024X768. The use of lower resolution settings can disable some processing panels and buttons.

Q. - What is the minimum **Hardware Configuration**, which is needed to run SARscape?

A. - The following minimum hardware requirements are suggested: 2GBytes of RAM, 50 GBytes of Hard Disk, 1 GHertz Processor. In case the PC has less computing resources the software will work anyhow, but the processing time will be much longer and in some cases it shall fail (e.g. not enough memory available to carry out the "Phase Unwrapping" step; not enough disk space available for ScanSAR data focusing, etc.).

Q. - Does SARscape run on platform with **64 Bit Architecture**?

A. - SARscape is a 32 bit or 64 bit application for WINDOWS and 64 bit application for LINUX.

Q. - Is SARscape designed to take advantage of a **Multi-CPU Environment**?

A. - An update work, aimed at optimising the processing routines, is ongoing. Several functions are already optimized to perform much faster when Multi-CPU PCs are used.

Q. - Which are the **SAR Product Types/Formats** suggested to optimize the processing performance in order to achieve the best results?

A. - The products to choose are those which are still in the original acquisition geometry (i.e. slant range). These products are typically named Single Look Complex (SLC) data. In such data the information content, relevant to both acquisition geometry and radiometry, is best preserved.
On the opposite ground range products (e.g. ERS PRI, Radarsat-1 SGF, ENVISAT ASAR IMP or APP, etc.) should be avoided since in most of the cases the geometric and radiometric information content is permanently degraded; moreover a "partial" radiometric calibration has been generally carried out by considering the ellipsoidal height reference.
In addition to that, Single Look Complex data contain both intensity and phase information (while ground range products contain only the multilooked intensity); this makes them suitable for amplitude image

interpretation as well as for interferometric applications.

Q. - When performing any processing with Sarscape, the **Tiff Files** are automatically generated in an 8-bit format. How can I configure the software to generate automatically Tiff images in 32- or 16-bit format?

A. - The 8-bit Tiff files, which can be automatically or manually generated by SARscape, are intended only for visualisation purposes; for this reason they are properly scaled using a SAR-specific scaling strategy. The full information (e.g. the calibrated value after the Geocoding and Radiometric Calibration 142 step) is retained in the main data matrix (e.g. the _geo file after the geocoding), which is typically a 32-bit float-valued plain binary file plus 2 headers (.sml for SARscape and .hdr for ENVI). This main data matrix is fully compatible with ENVI, which means that you can use the ENVI own functionalities to export these data in either Tiff or GeoTiff (as 16- or 32-bit images) format or possibly any other binary format you should prefer.

Q. - Are data in **NITF Format** supported?

A. - The direct import in SARscape of data in NITF format is currently available only for SAR-Lupe 66 products. Other SAR data in NITF format can currently be imported by first exploiting the ENVI NITF import functionalities and then importing from ENVI to Sarscape 79 format.

Q. - What is the difference between **Zero-Doppler** and **Not-Zero-Doppler** data?

A. - Zero-doppler geometry means that the Doppler history of a pixel is compressed, during the focusing process, in the pixel position corresponding to the peak of the Doppler parabola. Not-Zero-Doppler (or squinted geometry) means that the position of the pixel corresponding to the peak of the backscattered signal is considered during the focusing. It is important to point out that in both cases the original phase and spectrum information is preserved.

Both geometries are handled in all SARscape modules, also in those cases when master and slave data acquired with different geometries are combined in the same process (e.g. Interferometric data pair).

Q. - Is it possible to process **Data Coming From** a previous processing in a **Different Software Environment**? For instance we have an interferogram generated with ROI_PAC and we want to use this for further processing in SARscape.

A. - It is possible to import such files (e.g. as generic binary 90 or tiff 84 format) within SARscape, but the original information (e.g. SAR-specific parameter like orbital data and many more which are normally stored in the SARscape .sml header), as well as associated files (e.g. master-slave amplitudes and others) are lost; consequently any further processing cannot be executed.

Q. - Why the **Input File/s** to enter in a processing step are not listed in the selection list of the relevant panel?

A. - Check the "File Type" sorting menu anytime you do not find the input file in the directory where it should be; only file names with selected extensions are listed (following the SARscape default nomenclature 21). In order to display all files just type * in the "File Name" box of the relevant processing panel.

Q. - Several "not required" **Output Files** are generated as processing result. Is it possible to avoid storing such files on disk?

A. - Some processing steps require the creation of temporary files. If these files have to be automatically cancelled at process completion, just check the "Delete Temporary Files" tick box in Preferences>General 759 panel.

Q. - Why the program automatically generates **Tiff File/s** as result of each processing step?

A. - The output Tiff files are intended essentially for visualization purposes, since they are smaller in size and possibly easier to be visually interpreted (either amplitude or phase related products). However the automatic generation of the output Tiff files can be disabled by de-selecting the Generate Tiff 759 flag in the relevant Preferences panel.

Q. - I'm working with **PALSAR FBS and FBD** data and, since the latter have a worse range resolution (a pixel that is a factor 2 coarser), I wonder how SARscape handles the different resolutions?

A. - The software handles this during the coregistration process and the output coregistered products result with the same pixel spacing. Both the Basic and the Interferometric processing chains allow combining FBS and FBD data. When a reference image is provided, the other one(s) is resampled onto the pixel spacing of the reference: by entering an FBS or FBD product as reference, this resampling implies respectively an over sampling or an under sampling of the slave(s) image. The number of looks specified in the panel always refer to the reference image sampling.

Q. - Why, after **Importing TerraSAR-X Single Look Complex** data, the output product is displayed with two bands?

A. - Some short complex format data, such as TerraSAR-X and Tandem-X, are imported by keeping the original data type (i.e. 16 bit for the real part, and
16 for the imaginary part) in order to avoid the generation of large size output files which would derive using a float complex format; smaller data are vice versa converted to float complex products, which are opened (and properly visualized) in ENVI as single band data. The output short complex data are split in two bands (1st band and 2nd band corresponding respectively to the real and the imaginary part) when displayed in ENVI, this does not affect in any way the SARscape process. It is possible to convert the short complex imported data, into float complex (i.e. "Data Type>Complex 32") products, by using the Tools>Transform Raster Data 696 functionality.

Q. - What is the advantage of using **Tandem-X** data acquired in **Bistatic** mode?

A. - Tandem-X is a satellite that is a copy of TerraSAR-X, so it can acquire data exactly as TS-X. This is fully transparent from the SARscape user point of view. This pair of satellites can acquire in a special so-called bistatic mode, where one of the two satellites is transmitting and receiving while the second is only receiving; this allows obtaining two simultaneous acquisitions, which means data without temporal decorrelation (i.e. very good for DEM generation).

Q. - What are the **Digital Elevation Models** supported and how can they be imported?

A. - In terms of data source (e.g. digitised maps, remote sensing data derived products, photogrammetric products, etc.), any kind of DEM can be used, taking into account that the DEM reliability is crucial to determine the quality of the relevant processing results. In terms of data format either Generic Binary 92 (i.e. Band Interleaved - BIL) or Tiff 84 data are supported; they can be imported by selecting the appropriate "Data Units" in the relevant "Data Import" panel.

Q. - I got an error while **Importing a DEM in Tiff Format**.

A. - Not all TIFF versions are directly supported by SARscape; in particular your DEM is stored in tiled format within the TIFF file and it can not be directly imported. What you should do it is first to convert the tiled file into a standard one (ENVI and/or IDL can be exploited for this purpose), then to import the new ENVI format file 79.

Q. - Do you have experience with the use of **ASTER derived Digital Elevation Models**? Are these products suitable for being used in the SARscape processing chain?

A. - We did an analysis concerning the quality of ASTER DEMs compared with the SRTM-3 and we found that in most of the cases SRTM is better (we actually identified several cases where "artefacts" can be detected in the ASTER products). In any case the SARscape processing chain does support any kind of input DEM, the only difference in between an SRTM-like and an ASTER-like product is that:
- the SRTM product can be ingested, and mosaiked automatically depending on the SAR image/s coverage, using the specific tool 657.
- the ASTER product, as well as any other user-provided DEM which is not among those supported by the "Tools>Digital Elevation Model Extraction" functionality, must be imported using the general data import functionality 92.

Q. - Is there a **Default Repository** folder where the downloaded tiles, for products such as SRTM-3 or GTOPO30, are stored?

A. - A specific folder for each supported DEM, which can be automatically downloaded from the internet, is automatically created by the software within the working directory (its default location is: "SARMAP SA \SARscape x.x.xxx\work"). In order to set the working directory in a different - user specific - folder, the relevant default parameters 756 must be modified.

Q. - Is there a **Default Repository** folder where the **Precise Orbits** can be stored and then automatically retrieved by the software?

A. - The folder, where the supported precise orbital data are stored by the user and then automatically retrieved and ingested by the software during the data import 43 (only for ENVISAT ASAR data), can be set (only for ENVISAT ASAR data) in the Preferences>Directories 756.

Q. - Is it possible to use the **Update Orbital Data** 724 functionality on image subsets?

A. - Yes, this functionality can be run using the full frame or a part of it. The image subsetting must have been previously performed using the Sample Selection 740 tool.

Q. - Is it possible to use **Precise Satellite Orbits** when processing SAR data? What are the main advantages?

A. - The use of precise orbits is supported for ERS, ENVISAT ASAR and RADARSAT-2 products. The original orbits can be updated with the precise ones using the relevant SARscape tool 723 or directly ingested during the "Data Import" or during the Data Focusing (for level 0 products).

Main advantages of using precise orbits are related to improvements in the interferometric processing, especially in relationship with the removal of orbital related fringes in the interferogram; these are typically reported when there is an error (even very small, in the order of tens of centimeters) in the satellite position. It must be noted that the use of precise orbits allows improving the accuracy of the state vectors only; vice versa they are not useful to apply any correction to those parameters, which are crucial in terms of scene geolocation accuracy, such as the acquisition start time, the slant range distance, the pulse repetition frequency (PRF), the carrier frequency, etc. In case these parameters were wrong, the problem can be corrected by either using a Ground Control Point in the processing steps where it is foreseen (e.g. Geocoding and Radiometric Calibration 142, Interferogram Flattening 465, Orbit Correction 722, etc.) or by automatically calculating - and applying - the correction parameters with the relevant Orbit Correction 719 tool.

Q. - The automatically estimated **Multilooking Factors** generate an output image whose resolution is coarser than the Single Look original pixel sampling. How are these factors calculated?

A. - The "Looks" button is intended to calculate the most appropriate range and azimuth multi-looking factors. This calculation is performed, on the basis of both the original pixel sampling in azimuth/range direction and the incidence angle, by taking into account the "Cartographic Grid Size" which is set in the Preferences>General 759 (i.e. the bigger the "Cartographic Grid Size" value, the larger the suggested range and azimuth multi-looking factors the coarser the output multilooked image resolution).

Q. - Do the criteria for the **Multilooking Factors** calculation change in case of data acquired in **Spotlight Mode**, due to the fact the the SAR beam is steered to observe a smaller area with higher spatial resolution?

A. - Being the beam steering performed in azimuth direction during the Spotlight acquisition, it has not influence on the multilooking factor calculation, since the incidence look angle (and consequently the ground range resolution) can be treated in the same way as for a Stripmap or a ScanSAR acquisition. It has to be noted that actually the variation of the incidence angle in range direction (for any kind of acquisition mode), which involves a variation in terms of ground range resolution, is optimally accounted for (both in terms of geometry and radiometry) only using the Geocoding>Optimal Resolution 142 resampling method on single look input data.

Q. - Is there any difference in how the software treats **Stripmap and Spotlight Mode** acquisitions? Are there differences that need to be taken into account during the processing?

A. - From the processing point of view, the main difference between Stripmap and Spotlight data is the variability of the Doppler Centroid along the azimuth direction (very limited for the first and significant for the second). The import functionality automatically identifies the acquisition mode in order to properly annotate in the SARscape header (.sml) all the necessary parameters to handle the Doppler Centroid variations. Once properly annotated, the data are handled in the same way by the same routines, that will for example use the Doppler Centroid information to modulate the azimuth interpolation filter (coregistration process) or the common bandwidth filter according to the local value. In general all these procedures are transparent to the user and no specific step shall be undertaken depending on the different acquisition mode.

Q. - Can I run the **Image Coregistration** using any overlapping image, which is acquired by the same sensor?

A. - A mandatory requirement

Q. - Is it possible to perform the **Data Coregistration** using the **Orbital Parameters** only?

A. - In order to use nothing else than the orbits you must set off the "Orbit Accuracy", "Estimate from Amplitude" and "Estimate from Coherence" Preferences 770 flags, whilst the "Initialization from Orbit" flag must be checked.
It is worthwhile to mention that, when the "Orbit Accuracy" flag is checked, the program automatically performs an orbital reliability check by means of the amplitude cross-correlation on 9 large windows (their dimension can not be modified). It allows, in case the "Estimate from Amplitude" flag is set off, to refine the constant term (in range and azimuth direction) of the orbit-based shift.

Q. - What changes if I use the **Basic Module** or the **Interferometry Module** for the generation of **Coregistered Intensity** (_pwr and _rsp) images?

A. - The processes performed in the Interferometry and in the Basic are very similar but not exactly the same. The Interferometry Module considers both the amplitude cross-correlation and the phase (only available in the SLCs data) to get a very precise estimate of the shift parameters, which must ensure at least 1/10 of pixel of accuracy (it is needed in order to get good interferograms). Note that this same approach is also adopted for the data coregistration in the Basic Module>Feature Extraction>Coherence 163. Vice versa, to coregister only the intensity (Basic Module), an accuracy of half pixel is sufficient; therefore the coregistration process of the Basic module exploits only the amplitude cross-correlation and not the phase.
Furthermore, in the Interferometry Module, a spectral shift filter is implemented during the SLC data coregistration, which is aimed at optimizing the coherence. This takes some signal "away" from the two images, which is not a problem for the interferometric processing, whilst it affects the intensity values and consequently the data calibration 142 process. That's why the "Geocoding and Radiometric

Calibration" must not be performed on intensity data generated in the Interferometry module.

Q. - What is the meaning of **Ellipsoidal Height**?

A. - The ellipsoidal height is the vertical distance above the reference ellipsoid. It is measured, along the ellipsoidal normal, from the point to the ellipsoid surface.

Q. - What is the meaning of **Orthometric Height**?

A. - The orthometric - or equipotential - height is the vertical distance above the geoid. It is measured, along a line of force, from the point to the geoid surface.

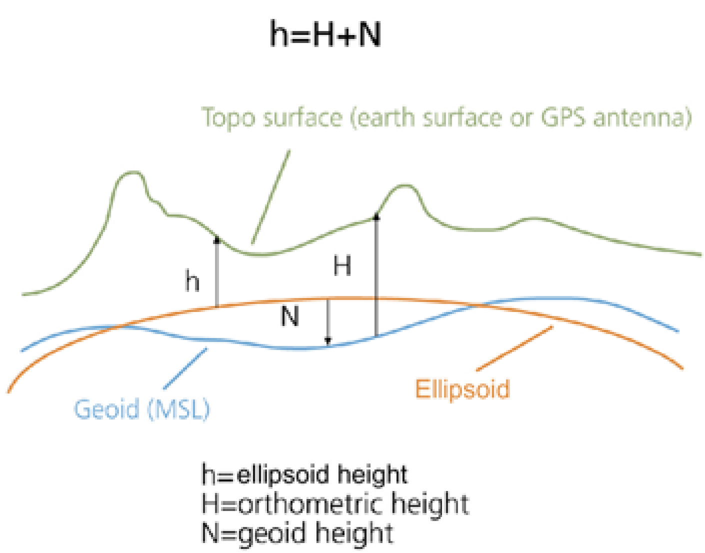
Q. - What is the **Geoid**?

A. - The Geoid is the level of the Earth's surface. The geoid would have the shape of an oblate ellipsoid, centred on the Earth's centre of mass, if the Earth was of uniform density and the Earth's topography did not exist.

Q. - The results I obtain are different if I use a **Digital Elevation Model** referred to the ellipsoid or to the geoid. What is the best one to adopt?

A. - DEMs with ellipsoidal height have to be preferred in order to avoid errors related to the use of geoids, which differ depending on the specific geographic location. Vice versa the adoption of ellipsoidal heights ensure consistency with most of the current satellite systems, whose measurements and parameters are referred to earth center.

The scheme below shows the difference between geoidal or ellipsoidal references.



Q. - What are the **Geoids** used (and eventually subtracted) in the Digital Elevation Models 657 imported by

SARscape?

A. - The following two Geoids are used:

- The EGM96 Geoid for the ACE 657, GTOPO30 665 and the SRTM-3 671 Digital Elevation Models.
- The OSU91A Geoid for the RAMP 669 Digital Elevation Model.

Q. - What is the meaning of the **Datum Shift**?

A. - The Datum Shift parameters are used to convert the ellipsoid's origin into the Earth's centre.

Q. - Several SARscape panels (e.g Coregistration, Geocoding, Cartographic Transformations, etc.) enable different **Resampling\Interpolation Methods**. Is there any rule to choose the one which better performs with specific processing and/or input data?

A. - In general it should be noted that:

- The Nearest Neighbour considers only the closest pixel; it is suitable especially for under sampling classified data.
- The Bilinear, the 3th Cubic Convolution and the 4th Cubic Convolution consider respectively 4, 8 and 16 surrounding pixels. In general the higher order interpolator provides better results, however in some cases the appearance of pixels with negative values has been reported on data resampled with the 4th Cubic Convolution.
- The Sinc is the one which better approximate an ideal interpolator, it considers the 256 surrounding pixels, however it can introduce negative values especially when it get close to strong scatterers; for this reason attention should be paid when applying this resampling method to Intensity data.
- The Optimal Resolution, which is specific for the Geocoding 142 step, is typically applied to Single Look data in order to have an optimal result in terms of both radiometry and geometry preservation, especially when imaging hilly or mountainous zones.

Q. - Why the **Cartographic Grid Size** of the output of geocoded product is 25 meter also when the input data (i.e. RADARSAT-2 fine beam) is better than 5 meter?

A. - The default geocoded output product grid size is set in the Preferences>General>Cartographic Grid Size 759. This value (i.e. 25 meters) will appear as default grid size in all processing panels where the output is a geocoded product (e.g. Basic>Geocoding and Radiometric Calibration 142, Interferometry>Phase to Height Conversion and Geocoding 314, Interferometry>Phase to Displacement Conversion and Geocoding 320 and others). Of course the user can change this value also from the specific processing panel and in such case the new entered grid size will be used for the output product generation.

Q. - How do I have to enter the **Geographic Co-ordinates**: degrees, min. and sec. or rather decimal degrees?

A. - Geographic co-ordinates are inputted in decimal degrees. Co-ordinate decimal values must be entered using the dot (e.g. 29.30) and not the comma (e.g. 29,30) character.

Q. - Where and how are the **Ground Control Points** used in the SARscape processing chain?

A. - There are some functions, such as the Geocoding, the Interferogram Flattening, the "Geometry GCP" File in the PS 490 and SBAS 519 modules, and others where the GCP(s) are used to correct a scene location error in azimuth direction (i.e. wrong scene azimuth start time) and/or in range direction (i.e. wrong slant range distance). These corrections are not performed using an affine polynomial transformation, but the rigorous range-doppler approach; it means that one single and precise GCP is needed and sufficient for a proper execution of this correction process (in case more GCPs are used the same kind of correction will be executed, with the difference that the final shift parameters will come from the average calculated on all GCPs).
However there are errors in the data, which are not corrected when the above mentioned processes are performed; for instance if a wrong Pulse Repetition Frequency (PRF) is annotated in the original product, another tool 728 must be adopted for the correction, which relies on the use of at least two GCPs that are eventually considered for the correction of the pixel spacing in azimuth direction. Also large orbital inaccuracies causing macroscopic scene rotations can not be corrected.
One practical thing which deserves to be mentioned is that, when the "nominal geolocation error" (i.e. error reported when an image is geocoded without using any GCP) is hard to be visually detected (e.g. 1 pixel or less), then it will be difficult to find a GCP so much accurate to correct such small error.

There is also another kind of GCP file, which is the "Orbital GCP" that is used during processes such as the "Refinement and Re-flattening" performed in several interferometric steps (Refinement and Re-flattening 308, PS 490, SBAS Interferometric Stacking 519, etc.); in this case more GCP are needed to correct even the smallest orbital inaccuracies.

Q. - How SARscape products can be **Interactively Edited**?

A. - An editing functionality 470, which is specifically designed for the Interferometric Phase editing can be exploited for editing any other SARscape file.

Q. - How SARscape handles those **Files**, which have been **Generated by ENVI** own processing functions?

A. - In order to process any file by SARscape, the specific data must previously be imported using the relevant import functionality. Two possibilities are foreseen:

- The ENVI own file comes from a previous process within SARscape and its raster parameters have not changed; in this case the SARscape header (.sml) information can be recovered; the ENVI>SARscape Original 81 import has to be used.
- The ENVI own file does not come from a previous process within SARscape or its raster parameters have been changed due to the ENVI processing; the ENVI>ENVI Original 79 import has to be used.

Q. - What is the difference between using **UPS or Stereographic Projection**?

A. - The UPS is a gnomonic projection, which is specifically adopted for polar area representation; the projection plane is tangent to the surface of the sphere, the point of projection is at the sphere center. The Stereographic is an azimuthal orthomorphic projection, which is more suitable to be applied at different latitudes since its parameters can be adapted (Cartographic System 6 >Cartographic Parameters) depending on the geographic location.

Q. - The **Color Composite**, which is generated with three SAR calibrated acquisitions using the relevant SARscape Tool 704, shows a dominant red color even if the acquisition assigned to the red channel should not be characterised by an overall higher backscatter. How can this behaviour be explained?

A. - The RGB composites are something which is often quite tricky from the interpretation point of view. Indeed, depending on how the original calibrated values are rescaled from the original floating format to the 24 bit (8 per colour channel) RGB tiff image, the appearance of the RGB representation changes.

In particular, in the "Generate Color Composite" tool, we have the possibility either to scale independently the three channels (default setting) or to apply a common scaling ("common scaling" or "mean in common scaling" flags) to the 3 layers; this last option is actually the best to preserve the original information. Nevertheless it often happens that we deal with backscatter changes, which are not only due to surface roughness local variation (e.g. flooded areas, vegetation growth, clear cuts, etc.), but also to the dielectric constant variation in most of the imaged area.
As an example, if we are looking at the backscatter changes due to a flood event, and we assume that the RGB is generated by assigning the "flooded acquisition/s" to the red and green channel, we often have a dominant yellow colour in most of the imaged area (where the surface roughness is not "flattened" by the floods, but the dielectric constant - and consequently the backscatter - increased due to the higher humidity in the soil, vegetation and also in the air...). Vice versa we'll have a dominant blue color where the terrain was actually covered by the flooding waters and thus the backscattered signal was approaching to zero in the red and green channels.

In order to solve this "visual interpretation" problem, once the RGB composite has been generated, we can manually stretch the histograms (independently for the three colour channels) until we get a grey tone, which means that there is not a dominant colour, in the areas where there was not change.

It remains that the real backscatter measure (temporal signature computed on the floating format calibrated products) should be adopted for a more reliable interpretation and change detection assessment, instead of using the general visual assessment that we can achieve by observing the RGB composite.

Q. - Is it possible to implement **Data Masking**?

A. - The approaches which are usually adopted for masking

Q. - Processing functionalities - and more in general any software command - are disabled whether a processing step is running; is there any way to **Interact with the Program when Another Processing is Going On**?

A. - It is possible to operate any functionality, from either ENVI or SARscape, if the SARscape processing is executed in batch mode 802 instead of being launched directly from the panel "start" button. It is important to note that, when more batch processes have to be executed in parallel on the same machine, the working directory 756 must be set on a different location for each batch sequence.

Q. - It is not so easy to choose the right **File Names** (extensions) when preparing a sequential **Batch Processing Chain**?

A. - This process typically becomes easier when users become more familiar with SARscape products and related naming conventions. Useful indications about the output naming extensions can be gained by reading the Nomenclature 22 section.

Q. - We try to derive **Forest Variables** from **Coherence** data. Clear-cut areas have higher coherence than areas with vegetation and trees. However, we see that coherence is influenced also by topography and backscatter intensity. Is there a way to reduce the coherence dependency from topography?

A. - The spectral shift filter 780, which is normally set as default, is one of the processing parameters useful for this purpose; it is performed during the Interferogram Generation as follows: when the "Coregistration with DEM" flag is checked, the filtering is adapted to the local slope; vice versa when the "Coregistration with DEM" flag is not checked, a flat earth is considered without any local slope dependency.

Moreover the slope dependency can be reduced by checking the Remove Residual Phase Frequency 776 (default parameter); this setting is implemented during the execution of the "Adaptive Filter and Coherence Generation" step.

Finally, for a proper use of the coherence to derive (or model) forest related parameters, a useful input is the Local Incidence Angle map (_lia). This is generated, when the relevant flag is checked, during the geocoding 142 step; the geocoded Local Incidence Angle map can eventually be converted in slant range geometry by using the Map to Slant Range Image Transformation 151 tool.

Q. - Is there any reference manual to introduce **Marine Application** using SAR data?

A. - The SAR Marine User's Manual is to lay out, for a wide range of users, the types of information that may be obtained from SAR images of the ocean, and methods of analyzing these data. It is intended for non-expert - but scientifically literate workers - who wish to use SAR data in their studies.

1.1.5 Installation Directories

After the software installation, the following folders are created in ".../SARMAP SA/SARscape X.X.XXX" directory:

config_file
Installation configuration files useful for defining and modify the software license type.

description_files
Format description files, calibration files, reference FTP addresses, and other auxiliary info relevant to supported products.

envi_extensions
Files relevant to the visibility of SARscape functionalities under the ENVI mainframe.

exe_envi
C++ executable files to run different processing functions.

key_files
Format description files used for reading header and data files.

mandatory
Mandatory file structure.

Map_files
Details of the cartographic projection systems supported.

work
Default working directory. It contains those files where all processing related information are stored. The work directory can be changed from the Preferences 756.

xml_schema_files
Reference schemes to define the input parameters.

1.1.6 Data Format

Description

This chapter provides information relevant to the default naming convention (i.e. Nomenclature 22) and Units of Measure 28, which characterise each SARscape product. Further details can be found in the specific help reference.

The SARscape products are represented by the following data types:

- Binary data (usually float, complex and byte) containing the data matrix.
- ASCII header including ancillary data information. The header is available in two different formats:
  - .sml (or _hdr for versions older than 3.0.000) containing all information mandatory for the data processing.
  - .hdr corresponding to the ENVI header format. This enables the product compatibility within ENVI.

- Shape files containing vector information in form of polygons or points.

Section Content

1.1.6.1 Nomenclature

Different file extensions are automatically added (as suffixes) to the output file names in order to easily sort out the data relevant to any specific processing functionality. The list below is a reference (in alphabetical order) of the default file extensions used in all SARscape modules; details specific to each product can be found in the relevant help documentation.

The following suffixes are used to identify the processing output products:

Atmospheric Phase Delay	**_atm**
Auxiliary files	**_auxiliary**
Baseline estimated values	**_eb**
Baseline (horizontal) estimated values	**_eb_H**
Baseline (vertical) estimated values	**_eb_V**
Classified output of the Shape import 99	**_map**
Coefficient of Variation image	**_cov**
Coherence image	**_cc**
Coherence image (only Amplitude Tracking 335)	**_coh**
Co-ordinates of the Scene Corners (XML format)	**.xml**
Coregistered/Resampled/Interpolated/Resized images	**_rsp**
Coregistered master ScanSAR Intensity image 562	**_mml_pwr**
Coregistered slave ScanSAR Intensity image 562	**_sml_pwr**
Coregistered polarimetric data	**_rsp_slc**
Coregistration shift	**_off**
Coregistration shift (ASCII format)	**_off_out.xls**
Coregistration shift (Shape format)	**_off.shp**
Cross Correlation image (Amplitude Tracking 335)	**_cc**
Dielectric correction factor	

	_cal_dielectric
Digital Elevation Model (DEM)	_dem
Digital Elevation Model in slant range	_srdem
Digital Elevation Model in slant range (ScanSAR Interferogram 562)	_synt_srdem
Digital Elevation Model (Wavelet Combination 685)	_w_c_dem
Displacement map	_disp
Displacement acceleration (SBAS Inversion)	_acc
Displacement acceleration variation (SBAS Inversion)	_delta_acc
Displacement fitted (SBAS Inversion)	_disp_fit
Displacement Map - slope direction (Phase to Displacement 320)	_SD
Displacement Map - custom direction (Phase to Displacement 320)	_UD
Displacement Map - vertical direction (Phase to Displacement 320)	_VD
Displacement velocity (Dual Pair Interferometry 325 and SBAS Inversion 529)	_vel
Displacement velocity legend - ASCII format (SBAS Inversion 529)	_density_slice_
Doppler Centroid Difference (Baseline Estimation 451)	_dop_diff
ENVI imported files	_envi
Features - Gradient image	_grad
Features - Maximum difference	_maxD
Features - Maximum increment	_maxI
Features - Maximum ratio	_maxR
Features - Maximum value	_max
Features - Median image	_med
Features - Mean image	_mea
Features - Minimum ratio	_minR
Features - Minimum value	_min
Features - Span difference	_spanD
Features - Span ratio	_spanR
Features - Standard deviation	_std
Filtered image	_fil
Generic Binary/Tiff imported files	_bin

Google Earth Exchange file	**.klm**
Ground Control Point file (ASCII format)	**.pts**
Ground Control Point file (XML format)	**.xlm**
Header file copy with not updated orbital parameters 723	**_OLD...**
Interferogram	**_int**
Interferogram filtered	**_fint**
Interferogram flattened	**_dint**
Interferogram Module component	**_mod**
Interferogram Phase component	**_phase**
Jpeg file	**.jpg**
Line of Sight Azimuth angle	**_ALOS**
Line of Sight Incidence angle	**_ILOS**
Local Incidence Angle map	**_lia**
Mask file	**_mask**
Meta file - It is used to provide more layers/information in the same file	**_meta**
Mosaiced image	**_msc**
Multilooked Complex Data	**_ml**
Orbital parameters	**_orb.sml**
Phase and Module combination 692	**_out**
Point Target Analysis parameters	**_pta.txt**
Polarimetric Calibration	**_cal_slc**
Polarimetric Decomposition (entropy)	**_entropy**
Polarimetric Decomposition (alpha)	**_alpha**
Polarimetric Decomposition (anisotropy)	**_anisotropy**
Polarimetric Entropy/Alpha/Anisotropy file list	**.list**
Polarimetric Decomposition (decomposition - Red)	**_red**
Polarimetric Decomposition (decomposition - Green)	**_green**
Polarimetric Decomposition (decomposition - Blue)	**_blue**
Polarimetric Features (Span image)	**_span**
Polarimetric Features (HH HH*)	**_hh_hh**
Polarimetric Features (VV VV*)	**_vv_vv**
Polarimetric Features (HV HV*)	**_hv_hv**
Polarimetric Features (Re {HH VV*})	**_re_hh_vv**
Polarimetric features (Im {HH VV*})	**_im_hh_vv**

Polarimetric Features (Re {HV VV*})	**_re_hv_vv**
Polarimetric Features (Im {HV VV*})	**_im_hv_vv**
Polarimetric Features (Re {HH HV*})	**_re_hh_hv**
Polarimetric Features (Im {HH HV*})	**_im_hh_hv**
Polarimetric Features (Polarization Ratio)	**_polrat**
Polarimetric Features (Linear Depolarization Ratio)	**_ldr**
Polarimetric Pauli decomposition (HH + VV)	**_pauli_k1_slc**
Polarimetric Pauli decomposition (HH - VV)	**_pauli_k2_slc**
Polarimetric Pauli decomposition (HV + VH)	**_pauli_k3_slc**
Polarimetric Pauli color composite (K2, K3, K1 in RGB)	**_pauli_rgb.tif**
Polarimetric Signature (co-polarization)	**_co_signature**
Polarimetric Signature (cross-polarization)	**_cross_signature**
Polarimetric Signature (calibration errors)	**_signature.txt**
Polarization Synthesis (circular/left-left)	**_ll_slc**
Polarization Synthesis (circular/left-right)	**_lr_slc**
Polarization Synthesis (circular/right-left)	**_rl_slc**
Polarization Synthesis (circular/right-right)	**_rr_slc**
Polarization Synthesis (linear/45° horizontal - 45° horizontal)	**_xx_slc**
Polarization Synthesis (linear/45° horizontal - 45° vert.)	**_xy_slc**
Polarization Synthesis (linear/45° vert. - 45° horizontal)	**_yx_slc**
Polarization Synthesis (linear/45° vertical - 45°vertical)	**_yy_slc**

Polarization Synthesis (elliptical/co-polarization)	**_00_slc**
Polarization Synthesis (elliptical/cross-polarization)	**_01_slc**
Polarization Synthesis (elliptical/cross-polarization)	**_10_slc**
Polarization Synthesis (elliptical/co-polarization)	**_11_slc**
Precision file (Phase to Height 314 and Phase to Displacement 320)	**_precision**
Processing parameters	**_parameter_...**
Processing parameters	**.par**
Post-calibrated image	**_cal**
Processing File Input/Output list	**_list**
Ratio image	**_rto**
Refinement and Re-flattening shape file ("Residual Phase" Preferences 775 option)	**_phase_refinemet.shp**
Refinement and Re-flattening shape file ("Orbital" Preferences 775 option)	**_orbital_refinemet.shp**
Residual Height (D. P. Differential Interferometry 325 and SBAS Inversion)	**_height**
Resolution file (Phase to Height 314)	**_resolution**
SAR Calibrated image (dB units)	**_dB**
SAR Calibrated image in the original geometry	**_srcal**
SAR Calibrated and Normalized image in the original geometry	**_srcal_norm**
SAR Geocoded image	**_geo**
SARscape Header file (ENVI compatibility)	**.hdr**
SARscape Header file (new format)	**.sml**
SARscape Header file (old format)	**_hdr**
SAR Intensity image	**_pwr**
SAR Multi-look Ground Range image	**_gr**
SAR RAW data	**_raw**
SAR Single Look Complex data	**_slc**
SBAS report for pair connections	**_report**
SBAS selected pairs	**_thresholde**

	d_pairs
SBAS spatial (normal) Baselines	_norm_baseline
SBAS temporal Baselines	_temp_baseline
Scattering area	_area
Slant Range Distance 451	_R
Slant Range transformed Shape file	_slant.shp
Slope azimuth direction (Phase to Displacement 320)	_ADF
Slope inclination (Phase to Displacement 320)	_IDF
Slope image (from a DEM)	_slope
Statistic parameters	_sta
Synthetic Phase	_sint
Synthetic Phase (ScanSAR Interferogram)	_synt_sint
Temporary processing parameters (XML format)	_par.sml
Text file	.txt
Tiff file	_ql.tif
Tiff RGB imported file (Red channel)	_R
Tiff RGB imported file (Green channel)	_G
Tiff RGB imported file (Blue channel)	_B
Unwrapped Phase	_upha
Unwrapped Phase Edited	_edit_upha
Vector Data Base file associated with a Shape (.shp)	.dBf
Vector Drawing Interchange file associated with a Shape (.shp)	.dxf
Vector file in ENVI Classic format	.evf
Vector Shape file	.shp

Note that, in case multiple consecutive processing steps are carried out, the relevant file suffix is added to the previous one. An example of concatenated suffixes, which would appear as file name extension after multilooking, filtering and geocoding, is _pwr_fil_geo.

1.1.6.2 Unit of Measure

Depending on the specific processing functionality the Unit of Measure can be:

- Decimal Degrees **[°]**
- Dimensionless **[nd]**
- Meters **[m]**
- Millimeters **[mm]**
- Millimeter/Year **[mm/y]**
- Millimeter/Year^2 **[mm/y^2]**
- Millimeter/Year^3 **[mm/y^3]**
- Pixel Units **[pu]**
- Radians **[Rad]**, equivalent to 180/π degrees.

The list below is a reference (in alphabetical order) of the Unit of Measure, which are typical of each product. In some cases, specific settings of the processing parameter can influence the Unit of Measure of the output product; details specific to each processing functions can be found in the relevant help documentation.

Unit of Measure

The following units characterise the SARscape products:

Atmospheric Phase Delay	**[Rad]**
Baseline	**[m]**
Coefficient of Variation	**[nd]**
Coherence	**[nd]**
Coregistered data	**[nd]**
Coregistration shift	**[pu]**
Cross Correlation image	**[nd]**
Dielectric correction factor	**[nd]**

Digital Elevation Model (DEM)

[m]

Displacement acceleration (SBAS Inversion 529)

[mm/y^2]

Displacement acceleration variation (SBAS Inversion 529)

[mm/y^3]

Displacement history (Persistent Scatterers 502 and SBAS Inversion 529)

[mm]

Displacement Map (Phase to Displacement 320, D. P. Differential Interferometry 325, SBAS Inversion 529)

[m]

Displacement Velocity (Persistent Scatterers 502, SBAS Inversion 529 and D. P. Differential Interferometry 325)

[mm/y]

Displacement Velocity Precision measurement (Persistent Scatterers 502 and SBAS Inversion 529)

[mm]

Features

[nd]

Filtered image

[nd]

Generic Binary/Tiff imported files

[nd]

Height Precision measurement (Persistent Scatterers 502 and SBAS Inversion 529)

[m]

Interferogram Module component

[nd]

Interferogram Phase component

[Rad]

Interpolated/Resampled/Resized data

[nd]

Line of Sight Azimuth angle

[°]

Line of Sight Incidence angle

[°]

Local Incidence Angle map

[°]

Masks

[nd]

Mean/Standard Deviation ratio (Persistent Scatterers 490)

[nd]

Phase and Module combination 692

[nd]

Polarimetric Calibration

[nd]

Polarimetric Decomposition (entropy)

[nd]

Polarimetric Decomposition (alpha)

[°]

Polarimetric Decomposition (anisotropy)

[nd]

Polarimetric Decomposition (Pauli)

[nd]

Polarimetric Features

[nd]

Polarimetric Signature

[nd]

Polarization Synthesis

[nd]

Precision file (Phase to Height 314 and Phase to Displacement 320)

[m]

Residual Height file (InSAR Dual Pair 325, Persistent Scatterers 502 and SBAS Inversion)

[m]

Resolution file (Phase to Height 314)

[m]

Post-calibrated image

[nd]

Ratio image

[nd]

SAR Calibrated image

[nd]

SAR Intensity image

	[nd]
SAR Multi-look Ground Range image	[nd]
SAR RAW data	[nd]
SAR Single Look Complex data	[nd]
Scattering area	[m^2]
Slant Range Distance 451	[m]
Slope image (from a DEM)	[°]
Span (i.e Range 171) image	[nd]
Standard Deviation image	[nd]
Synthetic Phase	[Rad]
Unwrapped Phase	[Rad]

1.2 Import Data

Section Content

1.2.1 SAR Spaceborne

Purpose

Standard products are ingested by means of sensor-specific processing interfaces. Either single file input or input file lists are supported.

Section Content

1.2.1.1 ALOS PALSAR

Purpose

Standard products are imported into the SARscape Data Format 21 for further processing.

Technical Note

In case of RAW data, the import is carried out by the Focusing module 219.

In case the input is a list of files, all products must be of the same type (refer to the "Supported Products" section) and all mandatory inputs (e.g. Trailer files, Leader files, etc.) must be provided in the same order from the first to the last imported product.

In case of JAXA Products the "Trailer list" field is disabled; only the "Leader list" (*LED* file name prefixes) and "Data list" (*IMG* file name prefixes) inputs must be entered.

In case of ERSDAC Products the following inputs are possible:

- **Level 1.1** data, which are generated by the Vexcel processor. These are imported by entering the "Param list" (*.SLC.par* file name suffixes) and "Data list" (*.SLC* file name suffixes).
- **Level 1.5**, **4.1** and **4.2** data, which are in CEOS format. These are imported by entering the "Trailer list" (*.tra* file name suffixes), the "Leader list" (*.lea* file name suffixes) and "Data list" (*.dat* file name suffixes).

It is worthwhile to note that, once the data in ERSDAC format (zero doppler) and in JAXA format (not zero doppler) have been imported, it is possible to combine them both in the amplitude/intensity processing (e.g. coregistration 121, time series filtering 135, etc.) and in the interferometric processing.

Supported Products

JAXA products

FBD	level 1.1	Single Look Complex Dual Polarisation.
FBD15G	level 1.5	Geo-code Dual Polarisation.
FBD15R	level 1.5	Geo-reference Dual Polarisation.
FBS	level 1.1	Single Look Complex Single Polarisation.
FBS15G	level 1.5	Geo-code Single Polarization.
FBS15R	level 1.5	Geo-reference Single Polarization.
PLR	level 1.1	Single Look Complex Polarimetric Mode.
PLR15G	level 1.5	Geo-code Polarimetric Mode.
PLR15R	level 1.5	Geo-reference Polarimetric Mode.
WB115G	level 1.5	Geo-code Single Polarization ScanSAR.
WB115R	level 1.5	Geo-reference Single Polarization ScanSAR.

Further information at http://www.eorc.jaxa.jp/ALOS/en/about/palsar.htm

ERSDAC products

FBS	level 1.1	Single Look Complex Single Polarisation.
FBD	level 1.1	Single Look Complex Dual Polarisation.
PLR	level 1.1	Single Look Complex Polarimetric Mode.
PSG	level 4.1	Multi-look Slant Range Polarimetric Combination.
SCN	level 4.2	Geo-code Single Polarization ScanSAR.
SGF	level 1.5	Geo-reference Single Polarization.
SGP	level 4.1	Geo-code Polarimetric Combination.

Further information at http://www.palsar.ersdac.or.jp/e/index.shtml

Input Files

Input File list
Input file name(s) of the original data. These files are mandatory.

Parameters - Principal Parameters

Data Type
Specify acquisition mode and product type relevant to the data to import.

Rename The File Using Parameters
If set to true, only relevant information will be copied from the input name(s) to the output name(s), the full root name otherwise.

Parameters - Global

It brings to the general section of the Preferences759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file list
Output file name(s) of the imported data. These files are mandatory.

Root name or assembled name of the imported file(s) and associated header files (.sml, .hdr). Specific file suffixes21 are added according to the data type.

SARscapeParameterExtracted.sml
Xml file containing temporary processing parameters.

.shp
Shape file and associated header files (.sml, .hdr) containing the image perimeter in geographic co-ordinates.

.kml
ASCII file containing the image perimeter in geographic co-ordinates. Double clicking on this file will automatically position the boundaries of the scene into the Google Earth environment.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.1.2 ALOS PALSAR 2

Purpose

Standard products are imported into the SARscape Data Format 21 for further processing.

Technical Note

In case of RAW data, the import is carried out by the Focusing module 219.

In case the input is a list of files, all products must be of the same type (refer to the "Supported Products" section) and all mandatory inputs (e.g. Trailer files, Leader files, etc.) must be provided in the same order from the first to the last imported product.

In case of JAXA Products the "Trailer list" field is disabled; only the "Leader list" (*LED* file name prefixes) and "Data list" (*IMG* file name prefixes) inputs must be entered.

In case of ERSDAC Products the following inputs are possible:

- **Level 1.1** data, which are generated by the Vexcel processor. These are imported by entering the "Param list" (*.SLC.par* file name suffixes) and "Data list" (*.SLC* file name suffixes).

It is worthwhile to note that, once the data in ERSDAC format (zero doppler) and in JAXA format (not zero doppler) have been imported, it is possible to combine them both in the amplitude/intensity processing (e.g. coregistration 121, time series filtering 135, etc.) and in the interferometric processing.

Supported Products

JAXA products

FBD	level 1.1	Single Look Complex Dual Polarisation.
FBS	level 1.1	Single Look Complex Single Polarisation.
PLR	level 1.1	Single Look Complex Polarimetric Mode.

Further information at http://www.eorc.jaxa.jp/ALOS/en/about/palsar.htm

ERSDAC products

FBS	level 1.1	Single Look Complex Single Polarisation.
FBD	level 1.1	Single Look Complex Dual Polarisation.
PLR	level 1.1	Single Look Complex Polarimetric Mode.

Further information at http://www.palsar.ersdac.or.jp/e/index.shtml

Input Files

Input File list

Input file name(s) of the original data. These files are mandatory.

Parameters - Principal Parameters

Data Type
Specify acquisition mode and product type relevant to the data to import.

Rename The File Using Parameters
If set to true, only relevant information will be copied from the input name(s) to the output name(s), the full root name otherwise.

Parameters - Global

It brings to the general section of the Preferences759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file list
Output file name(s) of the imported data. These files are mandatory.

Root name or assembled name of the imported file(s) and associated header files (.sml, .hdr). Specific file suffixes21 are added according to the data type.

SARscapeParameterExtracted.sml
Xml file containing temporary processing parameters.

.shp
Shape file and associated header files (.sml, .hdr) containing the image perimeter in geographic co-ordinates.

.kml
ASCII file containing the image perimeter in geographic co-ordinates. Double clicking on this file will automatically position the boundaries of the scene into the Google Earth environment.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.1.3 ALOS PALSAR KC

Purpose

ALOS PALSAR data provided from JAXA within the Kyoto and Carbon (K&C) Initiative must be imported into the SARscape Data Format 21 for further processing.

Technical Note

Doppler file
These data are provided with several tens of polynomial, which are used depending on the different azimuth position. The "Doppler file" is considered to apply the most appropriate Doppler polynomial depending on the variable azimuth position within the processed scene.

Azimuth Shift
Processing testing performed on a large amount of such products shown that several data are affected by a certain constant shift in azimuth direction. In order to overcome this problem, which affects the geocoding accuracy, the shift can be measured and taken into account during the data import. Actually a

first processing iteration - using nominal geocoding parameters - is needed in order to check if a geolocation error exists and to eventually measure its magnitude; afterward the data will be imported again by specifying the previously measured azimuth shift (in meters).

Since these products are already provided as Gamma Nought, any further data calibration/normalization cannot be performed.

Supported Products

Wide Swath (i.e. ScanSAR) and Stripmap products, in slant range geometry, are supported (JAXA format).

Input Files

Input file
Intensity image. This file is mandatory.

Input Parameters file
File name of the acquisition parameters (facter_m.dat). This file is mandatory.

Input Orbit file
File name of the orbital data (dataf_m.dat). This file is mandatory.

Input Doppler file
File name containing the Doppler polynomial (fdfdd.dat). This file is optional. If it is not used a single average polynomial, which is provided in the "Parameter file", is applied for the whole scene.

Parameters - Principal Parameters

Data Type
Specify the acquisition mode (i.e. Stripmap or ScanSAR) of the data to import.

Azimuth Shift
Shift offset (in meters) to be applied, in azimuth direction, during the data geocoding.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and

stored for further processing sessions.

Output Files

Output file
Output file name of the imported data. This file is mandatory.

_pwr
Slant range Intensity image and associated header files (.sml, .hdr).

_pwr_gcp1.xml
Xml file containing the Ground Control Point for the image geocoding.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.1.4 COSMO-SkyMed

Purpose

Standard products, acquired by any of the COSMO-SkyMed constellation satellites, are imported into the SARscape Data Format 21 for further processing.

Technical Note

The import functionality requires only the input Parameter file(s) to be entered. The relevant data type is automatically identified.

In case the input is a list of files, all products must be of the same type (refer to the "Supported Products" section).

For ScanSAR data, the SCS_U format has to be preferred in order to obtain accurate radiometric corrected products.

Supported Products

DGM	Multi-look Ground Range.
GEC	Ellipsoidal Geocoded.
GTC	Geocoded and Terrain Corrected using a Digital Elevation Model.
SCS	Single Look Complex.

Further information at http://www.cosmo-skymed.it/en/products.htm

Input Files

Input file list
Input file name(s) of the original data (.h5). These files are mandatory.

Parameters - Principal Parameters

Rename The File Using Parameters
If set to true, only relevant information will be copied from the input name(s) to the output name(s), the full root name otherwise.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file list
Output file name(s) of the imported data. These files are mandatory.

Root name of the imported file(s) and associated header files (.sml, .hdr). Specific file suffixes 21 are added according to the data type.

.shp
Shape file and associated header files (.sml, .hdr) containing the image perimeter in geographic co-ordinates.

.kml
ASCII file containing the image perimeter in geographic co-ordinates. Double clicking on this file will automatically position the boundaries of the scene into the Google Earth environment.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.1.5 ENVISAT ASAR

Purpose

Standard products are imported into the SARscape Data Format 21 for further processing.

Technical Note

In case of RAW data, the import is carried out by the Focusing module.

In case the input is a list of files, all products must be of the same type (refer to the "Supported Products" section) and all mandatory inputs (e.g. Orbit files, XCA files, etc.) must be provided in the same order from the first to the last imported product.

It must be noted that the input list is not allowed for Wide Swath Single look complex products (WSS). These products must be imported as single files.

DORIS (this file is mandatory when importing WSS data)
DORIS (Doppler Orbitography and Radiopositioning Integrated by Satellite) data provide precise orbital information for ENVISAT ASAR. Two versions of DORIS data are available:

- The VOR (Verified ORbits) are the most precise ones, but they are made available not earlier than one month after the actual satellite acquisition.
- The POR (Precise ORbits) are slightly less precise than the VOR, but they are made available together with the ASAR data.

Access to DORIS data is provided by the ESA Earth Observation Help Desk.

If the relevant DORIS files are already stored in an existing folder, which has been defined as DORIS Directory 757, they do not have to be inputted in the import processing panel since they are automatically retrieved by the program.

XCA
Auxiliary ASAR file containing external calibration data. This file is delivered with the SARscape installation package and it is read in a fully automatic way, hence typically there is not need to enter it as input. However, in case the most recent XCA files are not included in the installation package, a warning message will appear advising to download this file from the relevant ESA web site. Once the missing XCA

file(s) have been downloaded, the specific ASAR acquisitions must be re-imported by either inputting the newly downloaded files (XCA input list) or by copying these files under the ".../SARMAP SA/SARscape X.X.XXX/description_files" directory.

Supported Products

ASA APM	Alternating Polarization Medium Resolution Ground Range.
ASA APS	Alternating Polarisation Single Look Complex.
ASA APP	Alternating Polarisation Multi-look Ground Range.
ASA GM1	Global Monitoring Multi-look Ground Range.
ASA IMM	Single Polarisation Medium Resolution Ground Range.
ASA IMP	Single Polarisation Multi-look Ground Range.
ASA IMS	Single Polarisation Single Look Complex.

Input Files

Input File list
Input file name(s) of the original data. These files are mandatory.

Optional Input Orbit File List
Input file name(s) of the original DORIS data. This file is important especially if the interferometric processing shall be carried out.

Parameters - Principal Parameters

Data Type
Specify acquisition mode and product type relevant to the data to import.

Rename The File Using Parameters
If set to true, only relevant information will be copied from the input name(s) to the output name(s), the full root name otherwise.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file list
Output file name(s) of the imported data. These files are mandatory.

Root name of the imported file(s) and associated header files (.sml, .hdr). Specific file suffixes 21 are added according to the data type.

SARscapeParameterExtracted.sml
Xml file containing temporary processing parameters.

.shp
Shape file and associated header files (.sml, .hdr) containing the image perimeter in geographic co-ordinates.

.kml
ASCII file containing the image perimeter in geographic co-ordinates. Double clicking on this file will automatically position the boundaries of the scene into the Google Earth environment.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.1.6 ENVISAT ASAR WSS

Purpose

Standard products are imported into the SARscape Data Format 21 for further processing.

Technical Note

In case of RAW data, the import is carried out by the Focusing module.

DORIS (this file is mandatory when importing WSS data)
DORIS (Doppler Orbitography and Radiopositioning Integrated by Satellite) data provide precise orbital information for ENVISAT ASAR. Two versions of DORIS data are available:

- The VOR (Verified ORbits) are the most precise ones, but they are made available not earlier than one month after the actual satellite acquisition.
- The POR (Precise ORbits) are slightly less precise than the VOR, but they are made available together with the ASAR data.

Access to DORIS data is provided by the ESA Earth Observation Help Desk.

If the relevant DORIS files are already stored in an existing folder, which has been defined as DORIS Directory 757, they do not have to be inputted in the import processing panel since they are automatically retrieved by the program.

XCA
Auxiliary ASAR file containing external calibration data. This file is delivered with the SARscape installation package and it is read in a fully automatic way, hence typically there is not need to enter it as input. However, in case the most recent XCA files are not included in the installation package, a warning message will appear advising to download this file from the relevant ESA web site. Once the missing XCA file(s) have been downloaded, the specific ASAR acquisitions must be re-imported by either inputting the newly downloaded files (XCA input list) or by copying these files under the ".../SARMAP SA/SARscape X.X.XXX/description_files" directory.

Supported Products

ASA WSS	ScanSAR Single Look Complex.

Input Files

Input File
Input file name of the original data. This file is mandatory.

Input Orbit File
Input file name of the original DORIS data. This file is mandatory.

Output Files

Output file
Output file name of the imported data. This file is mandatory.

Root name of the imported file(s) and associated header files (.sml, .hdr). Specific file suffixes 21 are added according to the data type.

SARscapeParameterExtracted.sml
Xml file containing temporary processing parameters.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.1.7 ENVISAT MERIS

Purpose

Standard products are imported into the SARscape Data Format 21 for further processing.

Technical Note

These products are mostly intended to correct atmospheric disturbances 456 in ENVISAT ASAR interferometric pairs.

Once imported all spectral bands are saved as separate files in a folder with the output file name; the required products are automatically sorted out by the program once the "_file_list.txt" is inputted in the relevant Interferometry module tool 456.

Supported Products

MER_FR_2P	Full Resolution Product.
MER_RR_2P	Reduced Resolution Product.

Further information at http://envisat.esa.int/dataproducts/asar/CNTR2-1.htm

Input Files

Input File List
Input file name(s) of the original data. These files are mandatory.

Parameters - Principal Parameters

Data Type
Specify the product type (Full Resolution or Reduced Resolution) relevant to the data to import.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file list
Output file name(s) of the imported data. These files are mandatory.

Root name folder containing all imported channels.

_file_list.txt
Text file(s), corresponding to each imported image, used to retrieve the relevant channels from the related output folder.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.1.8 ERS SAR

Purpose

Standard products, acquired by ERS-1 and ERS-2 satellites, are imported into the SARscape Data Format 21 for further processing.

Technical Note

In case of RAW data, import is carried out within the Focusing module 233.

CEOS ("default" version and "NRSC" version) and ENVISAT formats are both supported.

Orbit File 725
These data (precise "PRC" or preliminary "PRL" orbits), which are made available through the DLR ftp server, provide precise orbital information for ERS-1/2 acquisitions.

Access to these data can be required to the ESA Earth Observation Help Desk. The precise orbital data, which are typically available in Zip format, must be unzipped before they are entered as processing input. The file name refers to the start date/orbit validity.

If the relevant precise orbit files are already stored in an existing folder, which has been defined as PRC/PRL Directory 757, they do not have to be inputted in the import processing panel since they are automatically retrieved by the program.

XCA (required only for ERS products in ENVISAT format)
Auxiliary ASAR file containing external calibration data. This file is delivered with the SARscape installation package and it is read in a fully automatic way, hence typically there is not need to enter it as input. However, in case the most recent XCA files are not included in the installation package, a warning message will appear advising to download this file from the relevant ESA web site. Once the missing XCA file(s) have been downloaded, the specific ERS acquisitions must be re-imported by either inputting the newly downloaded files (XCA input list) or by copying these files under the ".../SARMAP SA/SARscape X.X.XXX/description_files" directory.

Special formatting parameters characterize data coming from some archive and processing facilities; these are selectable, by using the "version" pull down menu, for the following stations:

- The **NRSC** (National Remote Sensing Centre – India) format is supported for SLC "Data Types".

- The **Bangkok** (Thailand) station format is supported for PRI data.

- The **ASF** (Alaska SAR Facility) format is supported for SLC "Data Types".

It must be finally noted that some processing problems, due to data formatting issues, can be experienced using products generated at ACRES (Australia) station.

Supported Products

ERS PRI	Multi-look Ground Range.
ERS SLC	Single Look Complex.

Further information at http://earth.esa.int/object/index.cfm?fobjectid=4001

Input Files

Input File list
Input file name(s) of the original data. These files are mandatory.

Optional Input Orbit File list
Input file name(s) of the original precise (or preliminary) orbit data. This file is important especially if the interferometric processing shall be carried out. These files are optional.

Parameters - Principal Parameters

Data Type
Specify acquisition mode and product type relevant to the data to import.

Rename The File Using Parameters
If set to true, only relevant information will be copied from the input name(s) to the output name(s), the full root name otherwise.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file list
Output file name(s) of the imported data. These files are mandatory.

Root name of the imported file(s) and associated header files (.sml, .hdr). Specific file suffixes 21 are added according to the data type.

SARscapeParameterExtracted.sml
Xml file containing temporary processing parameters.

.shp
Shape file and associated header files (.sml, .hdr) containing the image perimeter in geographic co-ordinates.

.kml
ASCII file containing the image perimeter in geographic co-ordinates. Double clicking on this file will automatically position the boundaries of the scene into the Google Earth environment.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.1.9 JERS-1 SAR

Purpose

Standard products are imported into the SARscape Data Format 21 for further processing.

Technical Note

In case of RAW data, import is carried out within the Focusing module 233.

Special formatting parameters characterize data coming from **ASF** (Alaska SAR Facility); these data can be imported by selecting the appropriate "version" from the pull down menu.

Supported Products

JERS-1 SLC	Single Look Complex

Input Files

Input File list
Input file name(s) of the original data. These files are mandatory.

Parameters - Principal Parameters

Data Type
Only SLC can be selected.

Rename The File Using Parameters
If set to true, only relevant information will be copied from the input name(s) to the output name(s), the full root name otherwise.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file list
Output file name(s) of the imported data. These files are mandatory.

_slc
Single Look Complex data and associated header files (.sml, .hdr).

SARscapeParameterExtracted.sml
Xml file containing temporary processing parameters.

.shp
Shape file and associated header files (.sml, .hdr) containing the image perimeter in geographic co-ordinates.

.kml
ASCII file containing the image perimeter in geographic co-ordinates. Double clicking on this file will automatically position the boundaries of the scene into the Google Earth environment.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.1.10 KOMPSAT 5

Purpose

Standard products, acquired by the KOMPSAT-5 mission, are imported into the SARscape Data Format 21 for further processing.

Technical Note

The import functionality requires only the input Parameter file(s) to be entered. The relevant data type is automatically identified.

In case the input is a list of files, all products must be of the same type (refer to the "Supported Products" section).

Supported Products

DSM	Detected, Slant Range,Multi-looked
DGM	Multi-look Ground Range.
GEC	Ellipsoidal Geocoded.
GTC	Geocoded and Terrain Corrected using a Digital Elevation Model.
SCS	Single Look Complex.

Input Files

Input file list
Input file name(s) of the original data (.h5). These files are mandatory.

Parameters - Principal Parameters

Rename The File Using Parameters
If set to true, only relevant information will be copied from the input name(s) to the output name(s), the full root name otherwise.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file list
Output file name(s) of the imported data. These files are mandatory.

Root name of the imported file(s) and associated header files (.sml, .hdr). Specific file suffixes 21 are added according to the data type.

.shp
Shape file and associated header files (.sml, .hdr) containing the image perimeter in geographic co-ordinates.

.kml
ASCII file containing the image perimeter in geographic co-ordinates. Double clicking on this file will automatically position the boundaries of the scene into the Google Earth environment.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.1.11 RADARSAT-1

Purpose

Standard products are imported into the SARscape Data Format 21 for further processing.

Technical Note

Special formatting parameters characterize SLC data coming from some archive and processing facilities; these are selectable, by using the "version" pull down menu, for the following stations:

- The Alaska Satellite Facility format is imported using the "radarsat_slc_asf" version.

- the ScanEx Facility format is imported using the "radarsat_slc_scanex" version.

SCN (ScanSAR) data can be provided as 8 or 16 bit products, a different "version" is provided to import one or the other.

It must be finally noted that some processing inaccuracy has been identified in some multi-look ground range data (i.e. SGF format) generated at GISTDA (Thailand); they cause scene location errors once these products are geocoded.

Supported Products

SCN	ScanSAR Narrow Beam Multi-look Ground Range.
SCW	ScanSAR Wide Beam Multi-look Ground Range.
SGF	Multi-look Ground Range Fine.
SLC	Single Look Complex.

Further information at http://sm.mdacorporation.com/what_we_do/radarsat_1.html

Input Files

Input File list
Input file name(s) of the original data. These files are mandatory.

Parameters - Principal Parameters

Data Type
Specify product type relevant to the data to import.

Rename The File Using Parameters
If set to true, only relevant information will be copied from the input name(s) to the output name(s), the full root name otherwise.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file list
Output file name(s) of the imported data. These files are mandatory.

Root name of the imported file(s) and associated header files (.sml, .hdr). Specific file suffixes 21 are added according to the data type.

SARscapeParameterExtracted.sml
Xml file containing temporary processing parameters.

.shp
Shape file and associated header files (.sml, .hdr) containing the image perimeter in geographic co-ordinates.

.kml
ASCII file containing the image perimeter in geographic co-ordinates. Double clicking on this file will automatically position the boundaries of the scene into the Google Earth environment.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.1.12 RADARSAT-2

Purpose

Standard products are imported into the SARscape Data Format 21 for further processing.

Technical Note

The import functionality requires, as mandatory input, only the Parameter file(s). The original data structure must be kept as in the original standard product.

Orbit File
This is an optional input, which is intended for using the precise orbits instead of the standard ones. RADARSAT-2 orbit files can be requested when the standard products are ordered. If orbit files are not initially requested they may be obtained at any time by contacting the MDA client services department. This input can be used only importing SLC products.

If the relevant precise orbit files are already stored in an existing folder, which has been defined as

RADARSAT-2 Directory 758, they do not have to be inputted in the import processing panel since they are automatically retrieved by the program.

Data in NITF format are also supported. To ingest them, the following procedure must be adopted:

1. Import the data using the ENVI own functionality "File>Open External File>Military>NITF>NITF".
2. Save the imported image in ENVI format using "File>Save file as>ENVI Standard". Before saving you must cancel the ".NITF" proposed extension from the output file name.
3. Import the data in SARscape using this module.

Supported Products

SCN	ScanSAR Narrow Beam Multi-look Ground Range.
SCW	ScanSAR Wide Beam Multi-look Ground Range.
SGC	Multi-look Ground Range Coarse.
SGF	Multi-look Ground Range Fine.
SGX	Geo-referenced Extra-fine.
SLC	Single Look Complex.
SPG	Precision Geo-corrected.
SSG	Systematic Geo-corrected.

Further information at http://sm.mdacorporation.com/what_we_do/radarsat_2.html

Input Files

Input File list
Input file name(s) of the original input file (.xml). These files are mandatory.

Optional Input Orbit File list
Input file name(s) of the original precise orbit data. This file is important especially if the interferometric processing shall be carried out. These files are optional.

Parameters - Principal Parameters

Data Type
Specify product type relevant to the data to import.

Rename The File Using Parameters
If set, only relevant information will be copied from the input name(s) to the output name(s), the full root name otherwise.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file list
Output file name(s) of the imported data. These files are mandatory.

Root name of the imported file(s) and associated header files (.sml, .hdr). Specific file suffixes 21 are added according to the data type.

SARscapeParameterExtracted.sml
Xml file containing temporary processing parameters.

.shp
Shape file and associated header files (.sml, .hdr) containing the image perimeter in geographic co-ordinates.

.kml
ASCII file containing the image perimeter in geographic co-ordinates. Double clicking on this file will automatically position the boundaries of the scene into the Google Earth environment.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.1.13 RISAT-1

Purpose

Standard products, acquired by the RISAT-1 satellite, are imported into the SARscape Data Format 21 for further processing.

Technical Note

Only data in CEOS format are supported.

Inaccuracies have been reported, in terms of scene location, when these data are geocoded 142 with their nominal orbital parameters (without GCPs); therefore the use of a ground control point is necessary in order to achieve a precisely georeferenced image.

Supported Products

CRS	Coarse Resolution ScanSAR Mode, Multi-look Ground Range.
MRS	Medium Resolution ScanSAR Mode, Multi-look Ground Range.
FRS-1	Fine Resolution Mode, Single Look Complex (slant range) or Multi Look (ground range).

Further information at http://www.nrsc.gov.in/

Input Files

Input File list
Input file name(s) of the original imagery (*DAT* prefix) data. These files are mandatory.

Parameters - Principal Parameters

Data Type

Specify product type (Single Look Complex or Ground Range) relevant to the data to import.

Rename The File Using Parameters
If set, only relevant information will be copied from the input name(s) to the output name(s), the full root name otherwise.

Parameters - Global

It brings to the general section of the Preferences759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file list
Output file name(s) of the imported data. These files are mandatory.

Root name of the imported file(s) and associated header files (.sml, .hdr). Specific file suffixes21 are added according to the data type.

SARscapeParameterExtracted.sml
Xml file containing temporary processing parameters.

.shp
Shape file and associated header files (.sml, .hdr) containing the image perimeter in geographic co-ordinates.

.kml
ASCII file containing the image perimeter in geographic co-ordinates. Double clicking on this file will automatically position the boundaries of the scene into the Google Earth environment.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser[802] button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.1.14 Sentinel-1

Purpose

Standard products, acquired by the SENTINEL-1A mission, are imported into the SARscape Data Format[21] for further processing.

Technical Note

The import functionality requires only the input Parameter file(s) to be entered. The relevant data type must be specified.

In case the input is a list of files, all products must be of the same type (refer to the "Supported Products" section).

Supported Products

SM SLC	Stripmap Mode. Slant Range, Single-Look, Complex Products (SLC).
IW SLC	Interferometric Wide Swath Mode. Slant Range, Single-Look, Complex Products (SLC).
EW SLC	Extra-Wide Swath Mode. Slant Range, Single-Look, Complex Products (SLC).
SM GRD	Stripmap Mode. Ground Range, Multi-Look, Detected Products (GRD).
IW GRD	Interferometric Wide Swath Mode. Ground Range, Multi-Look, Detected Products

	(GRD).
EW GRD	Extra-Wide Swath Mode. Ground Range, Multi-Look, Detected Products (GRD).

Further information on SENTINEL-1A data are available at: https://earth.esa.int/web/guest/missions/esa-future-missions/sentinel-1

Input Files

Input Parameters File list
Input file name(s) of the original Parameter file(s) (manifest.safe). These files are mandatory.

Parameters - Principal Parameters

Data Type
Specify acquisition mode and product type relevant to the data to import. The special entry must be selected for SENTINEL-1A data acquired in bistatic mode.

Rename Output Using Parameters
If set, only relevant information will be copied from the input name(s) to the output name(s), the full root name otherwise.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file list
Output file name(s) of the imported data. These files are mandatory.

Root name of the imported file and associated header files (.sml, .hdr). Specific file suffixes 21 are added according to the data type.

.shp
Shape file and associated header files (.sml, .hdr) containing the image perimeter in geographic co-

ordinates.

.kml
ASCII file containing the image perimeter in geographic co-ordinates. Double clicking on this file will automatically position the boundaries of the scene into the Google Earth environment.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.1.15 SAR-Lupe

Purpose

Standard products are imported into the SARscape Data Format 21 for further processing.

Technical Note

The import functionality requires only the input Data file(s) to be entered. The input data must be provided in NITF format.

Supported Products

SLC Single Look Complex.

Further information at: https://www.ohb-system.de/sar-lupe-english.html.

Input Files

Input File list
Input file name(s) of the original data. These files are mandatory.

Output Files

Output file list
Output file name(s) of the imported data. These files are mandatory.

Root name of the imported file(s) and associated header files (.sml, .hdr). Specific file suffixes 21 are added according to the data type.

SARscapeParameterExtracted.sml
Xml file containing temporary processing parameters.

.shp
Shape file and associated header files (.sml, .hdr) containing the image perimeter in geographic co-ordinates.

.kml
ASCII file containing the image perimeter in geographic co-ordinates. Double clicking on this file will automatically position the boundaries of the scene into the Google Earth environment.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch

processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.1.16 SICD

Purpose

Original products, provided in SICD format, are imported into the SARscape Data Format [21] for further processing.

Technical Note

Only Single Look Complex data, which are made of a real and an imaginary component are supported (Phase + Module complex products are not yet supported).

Tiled products are not supported.

In some cases, inaccuracies have been reported when these data are geocoded [142] using the nominal orbital parameters (without GCPs); therefore the use of a ground control point could be needed in order to achieve a precisely georeferenced image.

Supported Products

SLC	Single Look Complex

Further information at http://www.gwg.nga.mil/ntb/baseline/docs/SICD/

Input Files

Input file list
Input file name(s) of the original data. These files are mandatory.

Output Files

Output file list
Output file name(s) of the imported data. These files are mandatory.

_slc
Single Look Complex data and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.1.17 TerraSAR-X and Tandem-X

Purpose

Standard products, acquired by TerraSAR-X and Tandem-X satellites, are imported into the SARscape Data Format 21 for further processing.

Technical Note

The data data can be provided in two different formats:

COSAR (.cos), which are marked by the "SSC" (Slant Range) prefix in the "Data Type" selection list. This is the only format supported for Tandem-X data.

Tiff, which are marked by "MGD" (Ground Range), "GEC" (Geocoded on the Ellipsoid) or "EEC" (Geocoded using a Digital Elevation Model), prefixes in the "Data Type" selection list.

Version

When the "default_ssc_format" is adopted (available only for SSC products), one of the auxiliary files (i.e. "GEOREF.xml") is used to extract atmospheric related factors from the "Signal Propagation Effects" section; these factors are considered for the correction of both the Scene Start Time and Slant Range Distance.

TerraSAR-X and **Tandem-X data**

These data, if acquired in bistatic mode (one satellite sends the signal which is received by both), are typically provided already coregistered. For these data the coregistration step is automatically disabled by checking the special flag in the Preferences 772.

The original product is provided with 3 different parameter files (.xml):

TDX...xml > this has not to be entered in the input "Parameter list".

TSX...xml > this has not to be entered in the input "Parameter list".

TDM...xml > this has to be entered in the input "Parameter list".

It is important to know that, very often, the full path name of the original product is too long and in such case the import process ends with an error. This problem can be solved by reducing the input path name as illustrated in the following example:

Original product > dims_op_oc_dfd2_369820592_8\TDM.SAR.COSSC\1032760_002
\TDM1_SAR__COS_BIST_SM_D_SRA_20110609T083746_20110609T083751

Shortened path > 1032760_002
\TDM1_SAR__COS_BIST_SM_D_SRA_20110609T083746_20110609T083751

In any case the original product structure and content of the data folder (1032760_002 in the example above) must not be manually modified. This is true for both TerraSAR-X and Tandem-X products.

When TerraSAR-X and Tandem-X data are acquired in bistatic mode (i.e. interferometric image pair) the imported output products are identified one by the _MASTER and one by the _SLAVE extension. It is important that, once these imported data are processed in interferometric mode, the master and slave inputs are entered as indicated by the SARscape extensions.

Supported Products

HS	Spotlight High Resolution (Slant Range, Ground Range or Geocoded) Single, Dual and Quad Polarization.
SC	ScanSAR (Ground Range or Geocoded).
SL	Spotlight (Slant Range, Ground Range or Geocoded) Single, Dual and Quad Polarization.
SM	Stripmap (Slant Range, Ground Range or Geocoded) Single, Dual and Quad Polarization. This is the only product supported for Tandem-X bistatic data.

Further information on TerraSAR-X data are available at: http://www.infoterra.de/tsx/index.php

Further information on Tandem-X data are available at: http://www.dlr.de

Input Files

Input Parameters File list
Input file name(s) of the original Parameter file(s) (.xml). These files are mandatory.

Parameters - Principal Parameters

Data Type
Specify acquisition mode and product type relevant to the data to import. The special entry must be selected for Tandem-X data acquired in bistatic mode.

Make Additional Products
Beta Calibrated?
Beta Calibrated and dB?

Rename Output Using Parameters
If set, only relevant information will be copied from the input name(s) to the output name(s), the full root name otherwise.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and

stored for further processing sessions.

Output Files

Output file list
Output file name(s) of the imported data. These files are mandatory.

Root name of the imported file and associated header files (.sml, .hdr). Specific file suffixes 21 are added according to the data type.

SARscapeParameterExtracted.sml
Xml file containing temporary processing parameters.

.shp
Shape file and associated header files (.sml, .hdr) containing the image perimeter in geographic co-ordinates.

.kml
ASCII file containing the image perimeter in geographic co-ordinates. Double clicking on this file will automatically position the boundaries of the scene into the Google Earth environment.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.2 SAR Airborne

Section Content

1.2.2.1 Astrium Airborne SAR

Purpose

Astrium Airborne SAR in ground range format (.fpi) must be imported into the SARscape Data Format 21 for further processing.

Note that at present only ground range data is supported. The module is a preliminary version.

Technical Note

None.

Supported Products

Astrium Airborne SAR in ground range format (.fpi).

Input Files

Input File List
Input file name(s) of the original ground range data. These files are mandatory.

Output Files

Output File List
Output file name(s) of the imported data. These files are mandatory.

Root Name of the imported file(s) and associated header files (.sml, .hdr). Specific file suffixes [21] are added according to the data type.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format [21] section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser [802] button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.2.2 OrbiSAR-1

Purpose

Amplitude and Single Look Complex OrbiSAR-1 data must be imported into the SARscape Data Format [21] for further processing.

Technical Note

None.

Supported Products

OrbiSAR-1 (X- and P-band) Single Polarization data. Single Look Complex as well as multilook amplitude products are supported.

Input Files

Input file
Amplitude (_amp) or Single Look Complex product (_slc). This file is mandatory.

Input Parameters file
Raster file related parameters such as pixel spacing, number of columns and rows, etc. (.para). This file is mandatory.

Input Orbit File
File containing flight information such as altitude and velocity (_nav). This file is mandatory.

Input Doppler File
File containing Slant range distance and Doppler related information (_dop). This file is mandatory.

Output Files

Output file
Output file name of the imported data. This file is mandatory.

_pwr
Multi-looked slant range Intensity image and associated header files (.sml, .hdr).

_slc
Single Look Complex data and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch

The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.2.3 TELAER

Purpose

TELAER amplitude data must be imported into the SARscape Data Format 21 for further processing.

Technical Note

None.

Supported Products

TELAER (X- band) slant range multi-look amplitude data.

Input Files

Input file
Amplitude image (_amp). This file is mandatory.

Input Parameters file
File containing raster parameters such as pixel spacing, number of columns and rows, etc. (.para). This file is mandatory.

Input Orbit File
File containing flight information such as altitude and velocity (_nav). This file is mandatory.

Input Doppler File
File containing Slant range distance and Doppler related information (_dop). This file is mandatory.

Output Files

Output file

Output file name of the imported data. This file is mandatory.

_pwr

Multi-looked slant range Intensity image and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch

The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close

The window will be closed.

Help

Specific help document section.

Specific Function(s)

None.

References

None.

1.2.2.4 E-SAR

Purpose

Single Look Complex E-SAR data must be imported into the SARscape Data Format 21 for further processing.

Technical Note

None.

Supported Products

E-SAR (X-, C-, L- and P-band) Single Look Complex data.

Input Files

Input File
File name of the original Single Look Complex product (_slc.dat). This file is mandatory.

Input Parameters file
File containing raster information such as pixel spacing, number of columns and rows, etc. (.txt). This file is mandatory.

Input Track File
File containing flight related information (.dat). This file is mandatory.

Input Description file
. This file is mandatory.

Output Files

Output file
Output file name of the imported data. This file is mandatory.

_slc
Single Look Complex data and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec

The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.3 ENVI Format

Section Content

1.2.3.1 ENVI Original

Purpose

Data in ENVI format must be imported into the SARscape Data Format 21 for further processing. This functionality is mostly intended for those data which have not been previously processed with SARscape.

Technical Note

Raster information and cartographic information (only for GEOGLOBAL and UTM reference systems) are automatically read from the ENVI header file (.hdr).

Only single layer data can be imported.

Supported Products

ENVI data.

Input Files

Input file list
Input file name(s). These files are mandatory.

Parameters - Principal Parameters

Data Units
One of the following data units must be selected:

Classification	Classification image.
Coherence	Interferometric Coherence image.
DEM	Digital Elevation Model.
DEM Slope	Slope image.
Digital Number	Generic image file.
Intensity	Radar reflectivity (or Power).
Amplitude	Square root of Intensity.

Dummy Value
Pixel no-value (so called dummy) in the input data.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file list
Output file name(s) of the imported data. These files are mandatory.

_envi
Imported image and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.3.2 SARscape Original

Purpose

Data in ENVI format must be imported into the SARscape Data Format 21 for further processing. This functionality is intended only for those data which have been previously processed with SARscape.

Technical Note

This functionality enables to recover the ancillary information, which are stored in the SARscape header (.sml) and are not saved in the ENVI header (.hdr) once a SARscape file is processed with an ENVI own functionality. Indeed inputs to this process consist of:

- **Input File** - The file generated using an ENVI own functionality
- **Reference File** - The file, with a SARscape header, which was used as input to the ENVI own processing functionality for the generation of the "Input File".

Only single layer data can be imported. The raster parameters (e.g. number of pixels and pixel depth) of "Input File" and "Reference File" must be the same.

Supported Products

ENVI data.

Input Files

Reference file
Input name of the SARscape file. It must have an .sml header, which is used for restoring the SARscape processing information. This file is mandatory.

Input file
Input name of the ENVI file. It does not have an .sml header. This file is mandatory.

Parameters - Principal Parameters

Data Units
One of the following data units must be selected:

Classification	Classification image.
Coherence	Interferometric Coherence image.
SLC	Single Look Complex data.
DEM	Digital Elevation Model.
DEM Slope	Slope image.
Digital Number	Generic image file.
Interferogram	Unflattened Interferogram (_int SARscape suffix).
Flattened Interferogram	Flattened Interferogram (_dint SARscape suffix).
Intensity	Radar reflectivity (or Power).
Amplitude	Square root of Intensity.

Dummy Value
Pixel no-value (so called dummy) in the input data.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file list
Output file name(s) of the imported data. It/they will be associated with an .sml header compliant with the "Reference File". This file is mandatory.
_envi
Imported image and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.4 Generic Format

Section Content

1.2.4.1 Tiff

Purpose

Single layer Tiff (or Geotiff) format, can be be imported. This is required if the data have to be further processed within SARscape.

Technical Note

None.

Supported Products

Data in Tiff (Tagged Image File Format) format.

Input Files

Input file
Input file name. This file is mandatory.

DEM/Cartographic System

Output Projection
In case that the Geocoded flag is set, following parameters are compulsory to specify the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection

Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Geocoded
Set this flag, if the input data refer to a cartographic reference system.

Data Units
One of the following data units must be selected:

Classification	Classification image.
Coherence	Interferometric Coherence image.
DEM	Digital Elevation Model.
DEM Slope	Slope image.
Digital Number	Generic image file.
Intensity	Radar reflectivity (or Power).
Amplitude	Square root of Intensity.

Dummy Value
Pixel no-value (so called dummy) in the input data.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file
Output file name of the imported data. This file is mandatory.

_bil
Imported single layer image and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.4.2 Tiff RGB

Purpose

RGB colour composites, in Tiff (or Geotiff) format, can be be imported. This is required if the data have to be further processed within SARscape.

Technical Note

Depending on the input file structure, one of the following three data formats must be specified when RGB colour composites are imported:

BIP - Band interleaved by pixel.

BIL - Band interleaved by line.

BSQ - Band sequential.

Supported Products

Data in Tiff (Tagged Image File Format) format.

Input Files

Input file
Input file name. This file is mandatory.

DEM/Cartographic System

Output Projection
In case that the Geocoded flag is set, following parameters are compulsory to specify the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Interleave Type
Set the appropriate RGB pixel interleave for the image (refer to the Technical Note for details).

Geocoded
Set this flag, if the input data refer to a cartographic reference system.

Data Units
One of the following data units must be selected:

Classification	Classification image.
Coherence	Interferometric Coherence image.
DEM	Digital Elevation Model.
DEM Slope	Slope image.
Digital Number	Generic image file.
Intensity	Radar reflectivity (or Power).
Amplitude	Square root of Intensity.

Dummy Value
Pixel no-value (so called dummy) in the input data.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file
Output file name of the imported data. This file is mandatory.

_bil
Imported single layer image and associated header files (.sml, .hdr).

_R
Imported Red channel, of an RGB composite, and associated header files (.sml, .hdr).

_G
Imported Green channel, of an RGB composite, and associated header files (.sml, .hdr).

_B
Imported Blue channel, of an RGB composite, and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.4.3 Generic Binary

Section Content

1.2.4.3.1 Generic Binary

Purpose

Generic binary data must be imported in the SARscape Data Format 21 for further processing.

Technical Note

None.

Supported Products

Single layer generic binary data.

Input Files

Input file list
Single layer binary file(s). These files are mandatory.

Parameters - Principal Parameters

Data Type
The input data type (in terms of pixel depth) must be specified.

Data Units
One of the following data units must be selected:

Classification	Classification image.
Coherence	Interferometric Coherence image.
DEM	Digital Elevation Model.
DEM Slope	Slope image.
Digital Number	Generic image file.
Interferogram	Interferometric Phase.
Intensity	Radar reflectivity (or Power).
Amplitude	Square root of Intensity.

Number of Lines
Number of rows in the input file.

Number of Columns
Number of columns in the input file.

Dummy Value
Pixel no-value (so called dummy) in the input data.

Header
Number of bytes to skip before the data matrix begin.

Row Prefix
Number of bytes to skip, for each line, before the first data value.

Row Suffix
Number of bytes to skip, for each line, after the last data values.

Byte Order
One of the two following byte coding schemes, which corresponds to the input data, must be specified:

MSBF (Motorola/Big Endian type)	Most significant byte first.
LSBF (Intel/Little Endian type)	Least significant byte first.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file list
Output file name of the imported data. These files are mandatory.

_bil
Imported image(s) and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.4.3.2 Generic Binary Geocoded

Purpose

Generic binary geocoded data must be imported in the SARscape Data Format 21 for further processing.

Technical Note

None.

Supported Products

Single layer generic binary geocoded data.

Input Files

Input file list
Single layer binary file(s). This file is mandatory.

DEM/Cartographic System

Output Projection
The following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Data Type
The input data type (in terms of pixel depth) must be specified.

Data Units
One of the following data units must be selected:

Classification	Classification image.
Coherence	Interferometric Coherence image.
DEM	Digital Elevation Model.
DEM Slope	Slope image.
Digital Number	Generic image file.
Intensity	Radar reflectivity (or Power).
Amplitude	Square root of Intensity.

Number of Lines
Number of rows in the input file.

Number of Columns
Number of columns in the input file.

Dummy Value
Pixel no-value (so called dummy) in the input data.

Header
Number of bytes to skip before the data matrix begin.

Row Prefix
Number of bytes to skip, for each line, before the first data value.

Row Suffix
Number of bytes to skip, for each line, after the last data values.

Byte Order
One of the two following byte coding schemes, which corresponds to the input data, must be specified:

MSBF (Motorola/Big Endian type)	Most significant byte first.
LSBF (Intel/Little Endian type)	Least significant byte first.

X upper left
Upper left corner Easting co-ordinate.

Y upper left
Upper left corner Northing co-ordinate.

X grid size
Easting grid size.

Y grid size
Northing grid size.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions..

Output Files

Output file list
Output file name(s) of the imported data. This file is mandatory.

_bil
Imported image and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.5 GPS

Purpose

GPS data are imported into the SARscape Data Format[21] for further processing.

Technical Note

GPS data can be used as input in the following processing steps:

- Refinement and Re-flattening (Interferometry[308] module and SBAS[525]). Here the points are exploited to flatten the interferometric phase by adapting the phase value to the GPS time series.
- SBAS inversion[535]. Here the points are exploited to adapt the displacement measurement to the GPS time series.

The imported data consist of an xml (SARscape GCP standard format) file in the selected "Cartographic System". Moreover a kml (geographic LAT/LONG co-ordinates) and a shape (.shp in the selected "Cartographic System") file are generated. In case the "Input Reference file" is entered, the shape file is generated also in the reference slant range geometry and the points falling outside the imaged area are automatically removed. It must be outlined that the shape and kml files are only for visualization purpose.

The shape file is intended to be visualized by means of the Time Series analyzer[746]; what is shown it is the measurement history (referred to the earliest measurement) along the vertical component; if the "LOS Time Series" flag is checked, the measurement history is displayed along the satellite line of sight (Input reference geometry).

If the GPS inputs are consistent in terms of number of measurements per point, they are converted in a single output shape file; otherwise the program generates a shape file for each point. It must be noted that, if the number of measurement exceeds 2000, the shape is wrongly created and the dbf associated file cannot be accessed; in such case the measurement history cannot be visualized. To solve this problem the imported xml file must be under-sampled by means of the appropriate tool[701].

Supported Products

SINEX (.snx)

GSI (.pos)

Input Files

Input Reference file
Input file of the reference slant range SAR image (_slc, _pwr). This file is optional.

Input file list

Input file name(s) of the original GPS data. These files are mandatory.

DEM/Cartographic System

Output Projection

The following parameters are compulsory to define the **Cartographic System** 6:

State

Definition of the country or general projection systems.

Projection

Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid

Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere

Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone

Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters

Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height

In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters

The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

GPS Type

Choice between Sinex and GSI format standards. This parameter is mandatory.

LOS Time Series

By setting this flag the time series of the shape files (.shp) is referred to the the input line of sight.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file
Output file name of the imported data. These file is mandatory.

.xml
Xml file containing the imported data.

_slant.shp
Shape file (plus .dbf and .shx) containing the measurement history in the input slant range geometry. This file is generated only if the "Input Reference file" is entered.

_geo.shp
Shape file (plus .dbf and .shx) containing the measurement history in the input "Cartographic System".

.kml
ASCII file containing the GPS points location in geographic co-ordinates. Double clicking on this file will automatically position the boundaries of the scene into the Google Earth environment.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.2.6 Shape

Purpose

Data in Shape (.shp) format must be imported into the SARscape Data Format 21 for further processing.

Technical Note

Using this functionality it is also possible to generate a classified raster product based on a specific field (column ID) of the input shape file; the "Class name", which corresponds to the shape field of interest, must be entered for this purpose (in case the "Class name" is left empty, a sequential ID is automatically assigned to each output class).

The dimension of the classified raster product (_map) is the same as the input "Reference file". The "Reference file" must contain the whole or part of the input shape file.

Supported Products

Data in Shape (.shp) format.

Input Files

Input file list
Input file name(s). This file is mandatory.

Reference file
Raster image with same cartographic reference system of the input shape file. This file is optional.

DEM/Cartographic System

Output projection

The following parameters are compulsory to specify the **Cartographic System** 6:

State

Definition of the country or general projection systems.

Projection

Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid

Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere

Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone

Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters

Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height

In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters

The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Class Name

Specify the field (column ID) of the input shape, which will be considered for the generation of the output classified raster product. This parameter is optional.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions

Output Files

Output file list
Output file name(s) of the imported data. This file is mandatory.

_imp.shp
Imported shape file (plus .dbf and .shx) and associated header file (.sml).

_map
Shape based classified product and associated header files (.sml, .hdr). This file is generated only if the "Reference file" is inputted.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.3 Basic Module

Section Content

1.3.1 Overview

A Note on the Basic module for SAR Intensity data processing

There is no standard processing chain. In primis, the processing depends upon how SAR data have been acquired (acquisition modes and available SAR systems). The type of product that is envisaged determines, additionally, how intermediate SAR products (for instance terrain geocoded backscattering coefficient data) will be further processed.

With respect to the first point – assuming the availability of a multi-temporal SAR raw data set – three processing procedures can be applied:

1. Single-sensor, Single-mode, Multi-temporal Approach

   This is the classical one. Multi-temporal SAR data are acquired in the same mode (for instance ENVISAT ASAR Image Mode 4). Since the geometry remains the same, following steps should be considered:
   – Focusing
   – Multi-looking
   – coregistration
   – Multi-temporal speckle filtering (for instance De Grandi)
   – Terrain geocoding, radiometric calibration and normalization

2. Single-sensor, Multi-mode, Multi-temporal Approach

   This is the most appropriate one in case of single-sensor data availability. SAR data are acquired in different geometries and thereby data acquisitions are not linked to standard repeat-pass cycle geometry (ERS-1/2 like). Since the acquisition geometry is different, following steps should be at the best considered:

- Focusing
- Generation of 1-look Intensity
- Terrain geocoding, radiometric calibration and normalization
- Multi-temporal speckle filtering (for instance Anisotropic Non-Linear Diffusion)

3. Multi-sensor, Multi-mode, Multi-temporal Approach

   This is the most advanced one, since based on the principle of satellite's constellation. SAR data are acquired in different geometries by different sensors. Therefore, data acquisitions can be optimized in terms of temporal, spatial (and spectral) resolution. In this scenario, the processing chain corresponds to the previous one. Note that particularly in this case, it is imperative that the data are accurately absolutely radiometrically calibrated.

The following functions, included in this module, support any of the procedures above:

Import Data
SAR data, Optical data, Digital Elevation Model, Shape data are imported either as standard or generic binary formats. The execution of this functionality is mandatory, as external data are converted into the SARscape data format 21.

Multilooking
A multi-look detected (Intensity) image is generated from Single Look Complex data by averaging the Intensity in azimuth and/or range direction.

Coregistration
When a multiple image data sets is acquired with the same viewing geometry, it can be coregistered in order pixels in different images to correspond with sub-pixel accuracy.

Filtering
The most appropriate filter can be chosen (typically depending on the application and data type) among a number of single image and multi-temporal SAR specific and generic filters.

Feature Extraction
Different features, which can be further used for classification purposes, are extracted from single date or multi-temporal data. They are based on first order and time-series statistics. SAR coherence (interferometric correlation) is an additional feature.

Geocoding, Radiometric Calibration and Normalisation
Ellipsoidal or terrain geocoding, using nominal parameters or ground control points, allows the transformation from SAR co-ordinates into a given cartographic reference system using a Range-Doppler approach. The radiometric calibration and normalisation can also be performed.

Note that:

- In case of SAR RAW products, the data must be imported and focussed (refer to Focusing

module 215).
- Default setting for selected parameters can be specified in the Preferences panel.
- The SAR Tutorial, which includes basic knowledge on SAR theory and data processing, complements the online help.
- Data geocoded to GEO-GLOBAL cartographic reference system can be automatically displayed into the Google Earth environment by double clicking on the output .kml file.
- Co-ordinate decimal values must be entered using the dot (e.g. 29.30) and not the comma (e.g. 29,30) character.

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1.3.2 Frequently Asked Questions

Q. - In the **Data Import** (Generic Binary 90 or Generic Binary Geocoded 92), how can I know if the byte order of the input data is MSBF or LSBF?

A. - This information is generally provided in the data header file: MSBF corresponds to Motorola or Big Endian data type; LSBF corresponds to Intel or Little Endian data type. It must be noted that the byte order of an imported file can be transformed (from MSBF to LSBF and vice versa) using the relevant SARscape tool 696.

Q. - Can I run the **Image Coregistration** using any overlapping image, which is acquired by the same sensor?

A. - A mandatory requirement for image coregistration is that the "reference file" (master image) and the "input files" (images to be coregistered onto the master) are acquired with the same viewing geometry. It means that the data must have been acquired from the same satellite track and with the same incidence angle (i.e. same beam mode).

Q. - What to do if the automatic **Image Coregistration** process fails?

A. - Whether the coregistration process fails using the default Preferences 770, the number of windows (and if necessary also their size), in range and azimuth direction, should be increased. A manual location of the coregistration window 121 can also be done.

Q. - I have been able to perform the **Image Coregistration** in SARscape with a completely automatic process. Is there a way to perform this process manually and when it can be eventually needed?

A. - The automatic coregistration process is successful in most of the cases and a sub pixel accuracy is achieved. However it can happen that large portions of the scene (typically homogeneous areas such as water, forest, sand, etc.) lack of spatial features, which are required for calculating the cross-correlation function between Input and Reference files. In these cases it is possible to manually locate points (Coregistration file 121), representing the center of the coregistration windows, in those areas where cross-correlation features (e.g. scatterers such as rocks, urban settlements and other man made objects) exist.

Q. - Is it possible to **Coregister** data acquired in different modes (e.g. Stripmap, Spotlight, ScanSAR) or by different satellites?

A. - It makes no sense to coregister data acquired with different geometries and the program will end with an error if the "reference file" and the "input files" are acquired from different satellite tracks or with different incidence angles. The way to have data, acquired with different geometries, comparable in terms of pixel location, it is to geocode 142 them onto the same cartographic reference system.

Q. - Is it possible to **Coregister** SAR images acquired with the same viewing geometry but with different polarization? For instance an HH-HV acquisition with VV-VH acquisition?

A. - This can be done for instance by coregistering the co-polarization of the two acquisitions (HH - VV) and then apply the calculated "Shift Parameter file" for the coregistration of the cross-polarisations (HV - VH). It must be recalled that, if the "Shift Parameter file" is entered as input, the "Compute Shift Parameters" flag must be set off.

Q. - Which **Damping Factor** is used in the **Frost Filter**?

A. - The "dumping" factor is not specified in the SARscape implementation; this implementation actually foresees an "alpha" factor, which is automatically estimated by the program.

Q. - The result of the **Anisotropic Non-Linear Diffusion Filtering** shows regularly distributed horizontal striping/banding. What is the reason and how can it be avoided?

A. - The banding effect is due to border conditions on the speed-up Additive Operator Splitting scheme used for the Non-Linear diffusion steps. It is generally removed (or strongly reduced) be increasing the number of "Anisotropic Iterations" and possibly also the number of "Non-Linear Iterations".

Q. - What can I do to identify, in the **Slant Range** image geometry, a small area that I know in terms of **Cartographic Co-ordinates**?

A. - An automatic transformation, from cartographic to slant (or ground) range co-ordinates, can be carried out by means of the Geocoding>Map to Slant/Ground Point Conversion 153; likewise a geocoded image can be re-projected in slant (or ground) range geometry using the Geocoding>Map to Slant Range Image Transformation 151. These two approaches enable to locate a know geographic area (in form of map, image or points) in the SAR image viewing geometry. It must be noted that the accuracy of this transformation depends on the quality of the orbital parameters in the input SAR image.

Q. - The PC got stuck while **Geocoding** a COSMO-SkyMed stripmap product?

A. - The problem is possibly due to the "Block Size" dimension, which is set in the Geocoding Preferences 766. Using very high resolution data this parameter should be reduced in order to avoid memory allocation problems.

Q. - **Geocoding** ALOS PALSAR level 1.5 products, as well other ground range or geocoded original data, does not provide very accurate "geo-located" results?

A. - The range-doppler approach, which is normally applied in SARscape for the geocoding process, cannot be directly applied when ground range or geocoded products are inputted. In such case the map to slant transformation polynomial, which are included in the original product, are used to restore the original slant range geometry; if the conversion polynomial are not precise also the geocoding is not accurate. For this reason we strongly recommend to work with slant range (i.e. Single Look Complex) original data.

Q. - Can I convert a **Geocoded Image** into a SAR **Slant Range Image** viewing geometry?

A. - There is a specific functionality 151, in the Geocoding menu, to perform this process.

Q. - I've just acquired **ALOS PALSAR FBD** (level 1.1) data and I want to **Geocode** them. Are the orbits accurate enough to allow precise geocoding even without GCP or orbital correction 719?

A. - As far as our experience is with ALOS data, the orbits are precise enough to allow accurate geocoding of PALSAR products without any GCP and without applying any orbital correction; of course we recommend to use a DEM in input to the geocoding (and radiometric calibration) process in order to properly represent the geometry and radiometry of your output geocoded and calibrated product.

Q. - Why some **ALOS PALSAR Level 1.0 Products** (i.e. RAW data) are affected by **Geolocation Inaccuracies**?

A. - An error in the scene acquisition time, which is one of the parameters used for the image Geocoding 142, in some instances has been found in the data focussed 219 with SARscape. The problem has been solved in the 4.1 release of the software. In case this problem was still reported, the use of a GCP in the geocoding process is required. Users reporting such problems are kindly asked to contact us and provide relevant data samples in order to optimize the software performance.

Q. - I want to improve the **Geolocation Accuracy** of **Optical Data** by means of **Ground Control Points** collected on SAR very high resolution images? What is the precision I can achieve using data such as COSMO-SkyMed or TerraSAR-X?

A. - The geolocation accuracy of both CSK and TSX data processed in nominal mode (i.e. geocoded without GCPs) is very good, in the order of the pixel. This means that you can use such products for your purposes.
Of course, in presence of relief, it is important to have a reference DEM in order to properly represent (and locate) the pixels on slopes. In the geocoding process, it would be ideal to use a DEM whose grid size is comparable with the SAR input data (i.e. better than 10 m resolution); however, in case this is not available, also the SRTM-3 can be fruitfully exploited.

Q. - What is the difference between **Coregistered** and **Geocoded** products?

A. - Both products (i.e. a coregistered temporal series or a geocoded temporal series) have the characteristic that each image of the series spatially match with the other images. The difference is that, coregistered data are referred to a relative system (i.e. the Reference acquisition geometry) and the pixel spacing is driven by the Reference file; geocoded data are referred to an absolute system (i.e. the cartographic reference system) and the pixel spacing depends on the real ground spatial resolution of each image of the series.

Q. - How does SARscape calculate the **Incidence Angle** when the DEM is not provided as input to the Geocoding 142 process?

A. - In such case the program uses an ellipsoid whose reference height 147 is entered, together with the other input cartographic parameters.

Whatever is the SAR input image (PALSAR, ASAR, etc.), the local incidence angle can be computed with or without an input DEM. In the first case its variation depends both on the pixel position in range direction (since the incidence angle varies from a minimum in near range to a maximum in far range) and on the local topography; in the second case the angle variation depends only on the pixel position in range direction (it resembles a ramp).
It is possible, by checking the Local Incidence Angle 148 flag, to output the incidence angle map corresponding, pixel by pixel, to the geocoded image.
Of course the incidence angle depends on the SAR acquisition geometry (changing from the steepest to the least steep beam, the angle in the scene center varies from around 20° to around 50°). Moreover the angle variation, from near to far range, increases from Spotlight to Stripmap to ScanSAR acquisition modes.

Q. - I am working on assessing temporal signals with a SAR temporal series acquired with the same viewing geometry. If I adopt the **Multitemporal De Grandi Filter**, is there any risk to wash out the temporal signal?

A. - The De Grandi multitemporal filter has the peculiarity to preserve the temporal signature at the best and to dramatically reduce the speckle at the same time; this is especially evident when you have a set of 5, 6 or more coregistered images in input. However it can happen that, if you are using a temporal series where the differences among each acquisition are exceptionally strong in most of the imaged area extent, the temporal signal can be somewhere mixed.

Q. - Is it possible to **Orthorectify** images and what are the data/formats supported?

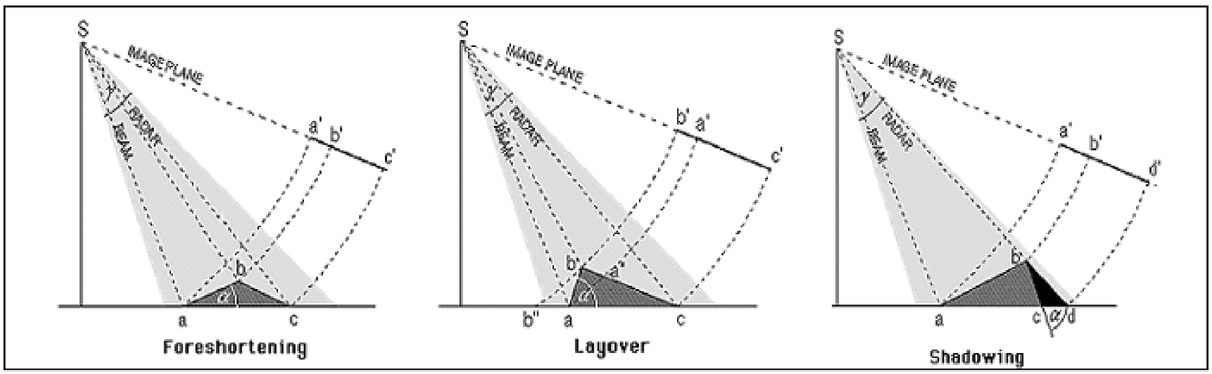
A. - All supported SAR sensors are suitable for orthorectification. The process is carried out once a Digital Elevation Model is entered in input to the Geocoding 142 step. Slant as well as ground range products can be orthorectified; geocoded and georeferenced data (e.g. GEC products) cannot be, since they have already been corrected (i.e. projected) using a reference ellipsoid. In general the utilisation of ellipsoid geocoded products should be avoided, whilst slant range format (i.e. SLC) should always be adopted in order to achieve, using SARscape, an excellent geometric and radiometric data calibration based on an input Digital Elevation Model.

Q. - What is the advantage of using the **Optimal Resolution** approach with respect to the other interpolation methods?

A. - Using an interpolation method other than the "Optimal Resolution", the pixel values geocoded in a given map coordinate system are obtained (with respect to the interpolation part) using common resampling methods, which are approximations of a sinc-function. Whenever the "Optimal Resolution" approach is selected, the 4 range-azimuth positions corresponding to the 4 vertexes of the output pixel (typically the DEM) are determined and, subsequently, the average of the pixel values contained in the polygon is computed. This means that the size and shape of the slant-range polygon is locally adapted according to the local topography, which is not the case if the multilooking 119 process is performed prior to the geocoding. Finally it is worth mentioning that the "Optimal Resolution" approach should be adopted only when single look data are geocoded to a significantly lower spatial resolution; in the other cases the "4th Cubic Convolution" resampling method is recommended.

Q. - Why the **Layover** area, in geocoded and radiometrically calibrated SAR amplitude images as well as in the layover map, is much bigger than the actual slope extent?

A. - The layover effect, which characterizes those slopes whose inclination is steeper than the radar look angle, extends far beyond than the slope itself. The zone affected by the layover corresponds to that area where the sensor-target distance decreases (i.e. the top of the slope is imaged before than its foot), while it should increase assuming a "flat earth". For this reason the beginning of the layover area is before the foot of the slope and its end is after the top of the slope (see figure below).



It must be noted that the quality - and reliability - of the geocoded products 142 (i.e. SAR image and layover/shadow mask) depends on quality and resolution of the input DEM. The layover and shadow map can be generated starting from slant as well as ground range products; it cannot be done starting from geocoded data (e.g. GEC products).

Q. - Are the **Layover and Foreshortening** areas corrected as result of the Geocoding and Radiometric Calibration 142 step?

A. - The foreshortening areas are corrected in terms of both radiometry and geometry. Vice versa the process can not resolve the ambiguities due to the representation of several points on the ground by one single point on the image (layover conditions); in these areas the information is missing and thus it cannot be recovered.

Q. - I see some strange artifacts in the **Layover and Shadow Mask**, which is generated in the Geocoding and Radiometric Calibration 142 step; I also have the impression, by comparing the mask with the geocoded SAR image, that the extent of the masked areas does not exactly correspond to the layover/shadow zones. What is the reason of the mask artifacts and discrepancies?

A. - The the quality of the layover shadow mask depends only on the input reference DEM. One cannot

expect a better mask by using a SAR image with a better resolution, if the input DEM remains the same and, in case of artifacts in the DEM, they will come up also in the layover shadow mask. The SAR input data are considered only for what concerns the acquisition geometry and in particular for the calculation of the Local Incidence Angle.
Concerning the extent of the masked areas, what typically happens it is that, if you visually compare the very bright and very dark areas in your SAR image with respectively red and blue pixels in the mask, you perceive an underestimation of the masked areas, but if you go to check the local incidence angle values (_lia output product) you discover that these are the only pixels actually affected by layover or shadow.

Q. - Why is the **Calibrated Value** dimensionless?

A. - The calibrated value is a backscatter coefficient, which corresponds to the ratio between the transmitted and the reflected power; this explains why it is a dimensionless number. SARscape normally generates the calibrated data in linear scale (for a distributed target you would expect a value between 0 and 1), but you have also the optional flag to additionally generate outputs in dB.

Q. - I have a Radarsat-2 Wide Swath full polarimetric acquisition in SLC format. I want to know how to get a **Calibrated Product** in dB units.

A. - The calibration process - independently from the satellite, acquisition mode and polarization and also independently from the original data format - is performed during the geocoding and radiometric calibration 142 step. The default calibrated value is a normalized dimensionless number (linear units); the corresponding value in dB ($10*\log_{10}$ of the linear value) can be additionally generated by checking the relevant flag in the processing panel. The calibrated output is normally generated as georeferenced products, but you can also choose to have it in the original satellite viewing geometry (slant range, not geocoded image) by checking the relevant flag in the panel. The default calibrated value is Sigma Nought, nonetheless the Gamma Nought and
Beta Nought can be (additionally or alternatively) generated by setting the appropriate flag in the Preferences>Geocoding (Backscatter Value section) 766.

Q. - What are the parameters which are taken into account when the **Data Calibration** is carried out?

A. - The data calibration parameters are provided, for some sensors (e.g. Radarsat-1), in the standard product header file; in other cases the calibration parameters are annotated within ancillary files (e.g. XCA file for ENVISAT ASAR data), which must be inputted during the Data Import 43 step in order to be used later on during the "Geocoding and Radiometric Calibration 142" step. SARscape can calibrate any supported SAR product (both in slant range and ground range geometry), following the radar equation principle.

The radiometric calibration, which is carried out in SARscape for distributed targets, involves corrections for:

1. the scattering area - each output pixel is normalized for the actual illuminated area of each resolution cell, which may be different due to varying topography.
2. the antenna gain pattern - the effects of the variation of the antenna gain in range are corrected,

taking into account the real topography (DEM) or a reference height.
3. the range spread loss - the received power must be corrected for the distance changes in range direction.

It must be noted that, in case the objective is to precisely estimate the data calibration parameters (both for point targets and distributed targets) and/or to assess the product quality in terms of radiometry and geometry, then a specific tool should be adopted. Such "Quality Assessment Tool" has been recently developed as SARscape additional module.

Q. - I would expect to obtain a **Radiometrically Calibrated Product** where the pixel values are either positive or negative, while I only obtain positive values whose majority is between 0 and 1.

A. - It is correct that, if you are analysing a calibrate image in dB, the values shall be either positive or negative. Vice versa, if you are analysing a calibrated image in linear units (this is the standard/default setting in SARscape), the backscatter of distributed targets usually varies from 0 to 1 (you can have values higher than 1 in case of very bright scatterers or point targets, but you'll never get negative values). In order to generate the output in dB, you have to flag the "Additional Output dB" flag in the geocoding panel and you have to analyse the output products which is marked by the extension "_dB".

Q. - Why the **Radiometric Calibration** is performed in the data geocoding 142 step, particularly when the calibration parameters are included in the metadata?

A. - The radiometric calibration of SAR data depends both on some sensor-related calibration factors contained in the metadata and on geometric factors that depend on the local topography of each pixel (e.g. pixel scattering area, incidence angle related with the true local height). Therefore, while the first group of calibration factors can be applied in any step, for the second case the knowledge of the real topography that corresponds to each imaged pixel is necessary to be able to carry out the calibration (without just considering a constant reference height, therefore introducing severe approximations and errors in the calibration of non-flat areas), and this information is available at best during the geocoding step (when the relationship between each pixel in SAR coordinates and the corresponding location in a cartographic reference system over a DEM is computed). In particular concerning the calibration factors contained in the metadata, they are ingested (and written in the .sml header file) during the data import, to be properly accounted for afterwards during the "Geocoding and Radiometric Calibration" step.

Q. - Concerning the Antenna Gain pattern and the Range Spread Loss, are the **Single Look Complex Standard Products** already provided (original products from official distributors) as **Calibrated** , or this correction is performed inside the SARscape processing chain?

A. - The adopted procedure usually depends on the different sensors; in few cases, also for the same sensor, there are some standard/original products which are provided already corrected, while some others are not. As an example in case of the PALSAR 1.1 product the data come already corrected in terms of antenna gain and range spread loss (this happens also for other SLC data such as most of the COSMO-SkyMed standard products, even if there are some exceptions for what concerns the ScanSAR SLC data...). In other cases, such as ASAR or ERS, the correction is done during the geocoding process. A different way is followed when RADARSAT data are processed: here the correction is performed during the import step.

Q. - What is the best way (Local Incidence Angle or True Area) to compute the **Scattering Area for the Radiometric Calibration**?

A. - The "True Area" method is doubtless more rigorous, but it is also more time consuming and the output product quality strongly depends on the accuracy of the input Digital Elevation Model. The "Local Incidence Angle" method is more simplistic, but much faster in terms of processing time; as a matter of fact, in case of a coarse input DEM (with respect to the SAR data pixel sampling), the results provided by the two methods are very similar and thus in such case the "Local Incidence Angle" is often preferred.

Q. - I'm using the **True Area** method for the **Calibration** of a Radarsat-2 image, using a 10 meters resolution Digital Elevation Module. I see that some topographic effects are still visible, mainly on top of hillsides facing towards the satellite, which get very bright. Can these effects be corrected?

A. - The True Area approach implements an oversampling of the input DEM, which is aimed at precisely estimating the scattering area. The strong brightness on the slopes facing the sensor can be eventually better corrected by increasing the oversampling factor 766 to 6 or more.

Q. - What does the **Sigma Nought** value represent?

A. - The sigma nought is the scattering coefficient, the conventional measure of the strength of radar signals reflected by a DISTRIBUTED (not point) scatterer. In SARscape it is typically presented in linear units; the corresponding value in dB can be calculated as: $10*\log_{10}$ (calibrated pixel linear value).

Q. - How can be the linear (decimal figure) **Calibrated** value transformed into dB value?

A. - The db value can be calculated by applying $10*\log_{10}$ to the corresponding decimal unit (linear varying measure).

Q. - How can be the **Calibrated** dB value converted in linear (decimal figure) units?

A. - The conversion is obtained by applying $10^{dB/10}$; where the "dB" exponent is the backscatter value measured in dB.

Q. - Why **Calibrated** data contain values higher than 1?

A. - The SARscape calibration is conceived to work on distributed targets; for this reason the calibrated value of local scatterers is not reliable. Local strong scatterers can have values higher than 1.

Q. - Why the **ENVISAT ASAR Calibration** parameters are often updated and new **XCA Files** are consequently released by ESA? How SARscape takes into account for the updated calibration parameters?

A. - The release of updated XCA files is based on the results of ESA calibration campaigns, where possible variations in the instrument performance are taken into account by tuning the relevant parameters. As a matter of fact what usually changes is the antenna gain pattern (AGP), rather than the calibration constant (K). This is often due to deterioration or damages affecting the antenna hardware itself, which in most of the cases affects the antenna gain in a different way depending on the acquisition mode.

SARscape uses the XCA parameters, which are stored in the "description_files 20" directory within the program installation folder (these are updated with the latest XCA released by ESA until the date of the SARscape release). If the required XCA file is not available within the installation package, a warning message will appear advising to download this file from the relevant ESA web site. It is suggested to store this new XCA file within the "description_files 20" directory in order to make it available for further ASAR data.

Q. - Where are the **Look Up Tables**, which come with the original **Radarsat-1** product, used for the **Data Calibration**?

A. - The Look Up Tables (lutBeta.xml) are ingested and accounted for when the original product is imported 57.

Q. - What are the data formats mostly suitable for **Data Calibration** purposes?

A. - Original Single Look Complex data are suggested to derive absolutely radiometric calibrated values. Level 0 product (i.e. RAW data) have not to be used if the objective is to get a meaningful calibrated image, since some crucial parameters such as the antenna gain are not properly taken into account when the data are focussed with SARscape. It is possible to experience any anomalous and unexpected behaviour of the intensity data when level 0 products are focussed with SARscape and afterwards calibrated and normalised.

Q. - How to choose the optimal **Radiometric Normalization** method and factor? Are there specific values to set depending on the acquisition sensor?

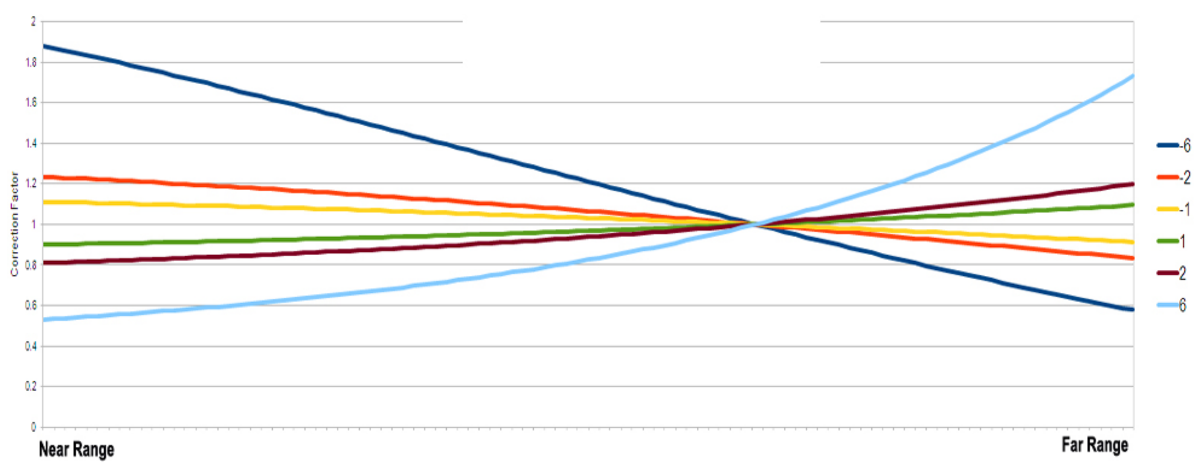
A. - The difference between the "Semi-empirical correction" method and the "Cosine correction" method is that the first one implements an automatic procedure (linear regression between the cosine of the local incidence angle and the backscattering coefficient in logarithmic form) to estimate and compensate the dependency of the backscatter from the cosine of the local incidence angle referred to the topography; the second method uses an empirical correction factor (Normalisation Degree) 766 to compensate the backscattering coefficient for range variations only (the topography is not taken into account); there is not a fixed value for the correction factor, it must be tuned proportionally to the incidence angle variation from near to far range: the larger is the incidence angle difference between near and far range the bigger the normalization degree must be. Being the normalization degree an empirical parameter, the optimal setting can be found by checking the similarity between the values of same land cover type in the near and in the far range of the output calibrated (and normalised) image.

Q. - Why the pixel value does not change between **Radiometrically Calibrated** and **Radiometrically Calibrated + Normalized** product?

A. - The [Normalisation](142) is intended to empirically correct the dependency of the backscattered signal from the incidence angle, which varies with the topography and with the position in range direction. This implies that the calibrated values does not change dramatically with respect to calibrated + normalised values; in particular the change between the two values is expected higher in the near/far range positions and smaller in the mid range position.

Q. - I'm doing the **Normalization** (cosine correction method) of an ASAR WS level 0 image that I've previously **Focussed** with SARscape, I achieved the best results by using the value -2, which I guess should not be valid. Can you explain why?

A. - As reported in the relevant section of the online help, the data calibration (and normalization as well) is not reliable when the processing is performed on original RAW data, which are focussed with SARscape. This is essentially due to the fact that the implemented focusing algorithm does not have the possibility to update important parameters such as antenna gain, calibration constant and others. The cosine correction method is intended to apply an empirical correction factor; positive factors allow increasing the original value from the near to the far range of the image, normalizing in this way a "ramp" that is normally going from higher vales in near range to lower values in far range (this ramp being due to the different scattering mechanism of the same targets, when observed with different viewing angles). It can happen that this ramp has an "unexpected" inclination when some calibration related parameters, such as the antenna gain or others, are incorrect; this can be the case when the processing is performed starting from original RAW data. In particular, in your example, the ramp was actually inverted with respect to the normal trend; that's why the negative factor worked well. The graph below shows how the correction varies, from the near to the far range, depending on the different factor which is entered for the normalization. The graph reports the curves relevant to factors ±6, ±2 and ±1.



1.3.3 Intensity Time Series Workflow

Purpose

This functionality enables to execute, in a single iteration, the following processing sequence:

- Multilooking 119.
- Coregistration 121.
- De Grandi Multi-temporal Filtering 135.
- Geocoding and Radiometric Calibration 142.
- Multi Temporal Features 171.

The final purpose of this processing chain is to enable the generation of terrain geocoded sigma nought data.

Technical Note

Details specific to each step implemented here are described in their respective reference guide section. We recommend to read them carefully.

Input

Input Files

Input File List
Input file name(s) of the Single Look Complex (_slc) or slant range (_pwr) Intensity data. Ground range Intensity data are not allowed. This file list is mandatory.

DEM/Cartographic System

Reference Type
The choice is given between the three following options:

- *Input DEM*: the provided "Input Digital Elevation Model" file is used in the process;

- *Reference Height*: in case that the Digital Elevation Model is not used, the parameters needed to define the Cartographic System 6, the pixel spacing and the reference height are compulsory;

- *DEM Download*: The Digital Elevation Model Extraction 657 tool is used to download an online digital elevation model. Various sources are available, see this section 657 for further information.

note that the choice of one source is compulsory.

Parameters

Grid Size

The grid size of the output data must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Mean

By setting this flag the output pixel value represents the average calculated from all input data.

Span Difference

By setting this flag the output pixel represents the difference between the maximum value and the minimum value of all input data.

Gradient

By setting this flag the output pixel value represents the maximum absolute variation between consecutive acquisition dates. The sign of the variation (i.e. increment or decrement) is not taken into account.

Coefficient of Variation

By setting this flag the output pixel represents the standard deviation/mean ratio.

Min

By setting this flag the output pixel represents the minimum value extracted from all input data.

Max

By setting this flag the output pixel represents the maximum value extracted from all input data.

Multilooking

It brings to the principal parameters of the Multilooking 120 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Coregistration

It brings to the principal parameters of the Coregistration 124 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

De Grandi Multi-temporal Filtering

It brings to the principal parameters of the De Grandi Multi-temporal Filtering 136 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Geocoding and Radiometric Calibration

It brings to the principal parameters of the Geocoding and Radiometric Calibration 148 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Multi Temporal Features

It brings to the principal parameters of the Multi Temporal Features 172 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Output

Output Root Name
Name of the output root. This file is mandatory.

Delete Temporary Files
By setting this flag, temporary files which are created in the intermediate steps, are automatically removed. All of the intermediate files are kept otherwise, refer to the Output lists relevant to each processing step for further information.

_spanD
Span difference and associated header files (.sml, .hdr).

_spanR
Span ratio and associated header files (.sml, .hdr).

_cov
Coefficient of variation and corresponding header files (.sml, .hdr).

_mea
Mean image and associated header files (.sml, .hdr).

_med
Median image and associated header files (.sml, .hdr).

_max
Maximum value and associated header files (.sml, .hdr).

_min
Minimum value and associated header files (.sml, .hdr).

muSigma
MuSigma value and associated header files (.sml, .hdr).

_grad
Gradient image and associated header files (.sml, .hdr).

_maxD
Maximum decrement and associated header files (.sml, .hdr).

_maxI
Maximum increment and associated header files (.sml, .hdr).

_maxR
Maximum ratio and associated header files (.sml, .hdr).

_minR
Minimum ratio and associated header files (.sml, .hdr).

_std
Standard deviation and associated header files (.sml, .hdr).

_CovMin_grad_rgb.tif
TIFF image of the assembled RGB imageand associated header files (.hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section

General Function(s)

Preview
By setting this flag, the temporary files are made available to visualise after a single step in the chain.

References

Consult the reference guide specific to each processing step.

1.3.4 Reference Guide

1.3.4.1 Intensity Processing

Section Content

Post Calibration 159

1.3.4.1.1 Multilooking

Purpose

The SAR signal processor can use the full synthetic aperture and the complete signal data history in order to produce the highest possible resolution, albeit very speckled, Single Look Complex (SLC) SAR image product. Multiple looks Intensity images may be generated by averaging over range and/or azimuth resolution cells. For an improvement in radiometric resolution using multiple looks there is an associated degradation in spatial resolution.

Technical Note

The number of looks is a function of pixel spacing in azimuth, pixel spacing in slant range, and incidence angle. The goal is to obtain in the multi-looked image approximately squared pixels considering the ground range resolution (and not the pixel spacing in slant range) and the pixel spacing in azimuth. In order to avoid over- or under-sampling effects in the geocoded image, it is recommended to generate a multi-looked image corresponding to approximately the same spatial resolution foreseen for the geocoded image product. The ground resolution in range is defined as:

$$\text{ground range resolution} = \frac{\text{pixel spacing slant range}}{\sin(\text{incidence angle})}$$

Example

ERS-1/2 Single Look Complex data are processed with the following parameters:

pixel spacing azimuth = 3.99 m
pixel spacing slant range = 7.90 m
incidence angle scene centre = 23°

This information is available in the _slc.sml file in the following fields:

[Processing section]PixelSpacingAz
[Processing section]PixelSpacingRg
[ChannelInfo section]LookAngle

The multi-looking factors in range and azimuth will be:

- ground resolution = 7.90 / sin(23°) = 20.21 m, corresponding to 1 look in range.
- A similar resolution in azimuth is obtained by applying a multi-looking factor of 5 (pixel spacing azimuth multi-looked = 3.99 · 5 =19.95 m).

Input Files

Input file list
Input file name(s) of the Single Look Complex (_slc) or slant range (_pwr) Intensity data. Ground range Intensity data are not allowed. This file list is mandatory.

Parameters - Principal Parameters

Range looks
Number of looks in range.

Azimuth looks
Number of looks in azimuth.

Grid Size for Suggested Looks
The grid size, in meters, used to tune range and azimuth looks. If the other parameters are manually set, the grid size will not imply a change in their values.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file list
Output file name(s) of the multi-looked Intensity data. This file list is mandatory.

_pwr
Multi-looked slant range Intensity image and associated header files (.sml, .hdr).

_pwr.xml
Xml file containing the geographic co-ordinates of the scene corners.

_pwr.shp
Shape file and associated header files (.sml, .hdr) containing the image perimeter in geographic co-ordinates.

_pwr.kml
ASCII file containing the image perimeter in geographic co-ordinates. Double clicking on this file will automatically position the boundaries of the scene into the Google Earth environment.

_par.sml
Xml file containing temporary processing parameters.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.3.4.1.2 Coregistration

Purpose

When multiple images cover the same region and, in particular, a speckle filtering based on time-series will be performed, or image ratio (or similar operations) are required in slant (alternatively ground) range geometry, SAR images must be coregistered. This requires spatial registration and potentially resampling (in cases where pixel sizes differ) to correct for relative translational shift, rotational and scale differences. Note that coregistration is simply the process of superimposing, in the slant range geometry, two or more SAR images having same acquisition geometry. This process must not to be confused with geocoding, which is the process of converting each pixel from the slant range geometry to a cartographic reference system.

It is important to point out that, in case of ENVISAT-ERS data sets, it is mandatory to enter the Digital Elevation Model as input to the process.

Technical Note

This step is performed in an automatic way, according to the following procedure:

- A local non-parametric shift estimate is computed on the basis of the orbital data and the Digital Elevation Model (if provided in input). In case of inaccurate orbits a large central window (Cross-correlation Central Window 770) is used instead.

- A set of windows (Cross-correlation Grid 770) is found on the reference image.

- The input data cross-correlation function is computed for each window.

- The maximum of the cross-correlation function indicates the proper shift for the selected location.

- The residual parametric shift, which is summed to the original local non-parametric estimate, is calculated by a polynomial depending on the azimuth and range pixel position.

- In case the input SAR data are represented by SLC products, the residual parametric shift is further refined by computing "mini-interferograms" on small windows (Fine Shift Parameters 770) distributed throughout the image. If the coherence is too low, the number of points for the fine shift estimate can be not sufficient to optimize the coregistration process. In such case the coregistration will be carried out using the local non-parametric shift and an improved cross correlation based fit (Fine Shift Parameters>Cross Correlation Oversampling 770), which allow a coregistration with sub-pixel accuracy. The output coregistered data are Single Look Complex.

- In case the input is represented by SAR Amplitude or Intensity (not SLC products) data, the improved cross correlation based fit (Fine Shift Parameters>Cross Correlation Oversampling 770), which allow a coregistration with sub-pixel accuracy, is always performed.

The reference flowchart provides a schematic representation of the coregistration process.

It is worthwhile to note that:

- It is possible to perform the coregistration in a manual way, by manually locating the center of the windows (i.e. Cross-correlation Grid 770 and Fine Shift Parameters 770) in the Input reference file (see input "Coregistration file" below).

- In case the images are very much different in terms of areal coverage, the smallest one should be used as "Input reference file" in order to avoid the coregistration windows to be located in areas with null pixel values, which can eventually cause the coregistration process to fail.

- The use of the Digital Elevation Model in input (optional), enables to improve the data coregistration accuracy especially working with high resolution data and in mountainous or hilly areas. The use of this input can be considered important in the following cases: i) Data long stripes (i.e. segments of orbit instead of single frames); ii) Data acquired at high latitudes; iii) Non zero-Doppler annotated data (especially in case of long wavelength such as ALOS PALSAR). It is suggested **not to use the DEM** when the orbital parameters of the input SAR data are inaccurate.

  It must be noted that the use of an input Digital Elevation Model considerably increases the processing time. In general, with or without an input DEM, the amount of computation resources and the processing time increase linearly with the image size.

- In case of inaccuracy in the satellite orbits or in the Digital Elevation Model geolocation, a Ground Control Point (GCP file) is required to correct the SAR data (i.e. Input reference file) with respect to the reference Digital Elevation Model. In this case the shift calculated in the coregistration process is combined with the Ground Control Point shift in order to correct the data of the Input file list according to the Input reference file.

  It is important to note that:
  - In case the Input reference file has already been corrected with the the manual 722 or the automatic 719 procedure the "GCP file" is not needed.
  - In case the Input reference file is correct (i.e. the nominally geocoded image fits with the DEM), while the orbital parameters of any of the Input files are not accurate (i.e. the nominally geocoded image does not fit with the DEM), the "GCP file" is not needed but the flag "Automatic Slave Orbit Correction", in the Preferences>Flattening 775, must be checked.

It has to be outlined that:

- The coregistration can be performed when all input data (i.e reference and input files) are acquired with the same incidence angle and same swath.

- ERS and ENVISAT ASAR data can be coregistered only when the last ones are acquired, from the same satellite track and in IS2 mode. The "Input reference file" must be an ASAR image.

- Inaccurate coregistration results may be expected when reference and input files are acquired with co- and cross-polarization (e.g. HH and HV).

Input Files

Input reference file
File name of the reference image to which the other input files will be coregistered. The input reference file can be a slant or ground range Intensity or Complex image (e.g. _pwr, _pri, _sgf, _slc). This file list is mandatory.

Input file list
Input file name(s) of all file(s) to be coregistered to the reference image. Input reference file must be a slant or ground range Intensity image (e.g. _pwr, _pri, _sgf, _slc). This file list is mandatory.

Optional Files

Digital Elevation Model file
Name of the Digital Elevation Model file. This should be referred to the ellipsoid. This file is optional. In case it is omitted, the coregistration is carried out without considering the topography.

Coregistration file
A previously created Ground Control Point file (.xml), with the points used for the manual coregistration (.xml), is automatically loaded. These points represent the center of the coregistration windows. This file is optional.

Shift Parameter file
Name of the file with the shift parameters used for the coregistration (_par). If the Compute shift parameter flag is set, it is generated as output.

Geometry GCP file
Either a previously created Ground Control Point file (.xml) can be loaded or the interface to create a new Ground Control Point file is automatically loaded (refer to the "Tools>Generate Ground Control Point 747" for details). This file is optional; it can be entered only whether the "Digital Elevation Model file" is used in input.

Parameters - Principal Parameters

Always compute shift
By setting this flag it is assumed that all the images in the input file list are not already coregistered each other. Unset this flag if the images in the input file list are already coregistered each other, but they are not coregistered to the reference file; in such case the first image in the input file list will be considered for the calculation of the coregistration parameters.

Compute Shift Parameters
By setting this flag, the coregistration shifts between master and slave image are calculated and saved into the _par file.

Compute Shift Parameters only
By setting this flag only the coregistration shift parameters are calculated and saved into the _par file.

The input data are not actually coregistered.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Coregistration

It brings to the coregistration section of the Preferences 770 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Flattening

It brings to the flattening section of the Preferences 775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output reference file
Output reference image to which the other input files will be coregistered (_rsp). This file list is mandatory.

Output file list
Output file name(s) of all coregistered file(s). The number of output files must be equal to the number of input files. This file list is mandatory.

_rsp
coregistered slant or ground range - detected or complex - images and associated header files (.sml, .hdr).

_rsp_par.sml
Xml file containing temporary processing parameters.

_meta
This file allows to load the specific processing results together with the input reference file.

_par
ASCII file containing the coregistration shift parameters in range and azimuth.

_orb.sml
Xml file containing the scene orbital parameters. This file is generated only if an input Digital Elevation Model is entered.

_orbit_off.shp
Shape file with the points used to estimate the orbit - and DEM in case it is used among the inputs - based shift. This file contains the following information:

- Pixel position in range direction (Range), in original pixel units.
- Pixel position in azimuth direction (Azimuth), in original pixel units.
- Shift measured in range direction (Dr), in original pixel units.
- Shift measured in azimuth direction (Da), in original pixel units.
- Calculated polynomial fitted shift in range direction (Drfit), in original pixel units.
- Calculated polynomial fitted shift in azimuth direction (Dafit), in original pixel units.

_winCC_off.shp
Shape file with the points used to estimate the cross correlation based shift from the Intensity data. In addition to the information provided by the "_orbit_off.shp" file, which are updated on the basis of the cross correlation estimate, this file contains also the following information (provided that the DEM is used among the inputs):

- Residual shift in range direction (DrResidual), in original pixel units. This is the difference with respect to the previously measured (orbit_off.shp) shift.
- Residual shift in azimuth direction (DaResidual), in original pixel units. This is the difference with respect to the previously measured (orbit_off.shp) shift.
- Calculated polynomial fitted residual shift in range direction (DrFitRes), in original pixel units. This is the difference with respect to the previously fitted (orbit_off.shp) shift.
- Calculated polynomial fitted residual shift in azimuth direction (DaFitRes), in original pixel units. This is the difference with respect to the previously fitted (orbit_off.shp) shift.

_winCoh_off.shp - It is generated only when Single Look Complex data are used as input
Shape file with the points used to estimate the coherence based shift. The information provided in the "_winCC_off.shp" are updated by means the coherence based estimate. This file contains also the following additional information:

- Signal to Noise Ratio (SNR), which is a linear dimensionless value.
- Coherence value. It is dimensionless and it can vary from 0 to 1.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec

The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Meijering E. and M. Unser, A Note on Cubic Convolution Interpolation, IEEE Transactions on Image Processing, Vol. 12, No. 4, April 2004.

1.3.4.1.3 Filtering

Section Content

1.3.4.1.3.1 Filtering Single Image

Purpose

Images obtained from coherent sensors such as SAR (or Laser) system are characterized by speckle, This is a spatially random multiplicative noise due to coherent superposition of multiple backscatter sources within a SAR resolution element. In other words, speckle is a statistical fluctuation associated with the radar reflectivity of each pixel of a scene. A first step to reduce the speckle - at the expense of spatial resolution - is usually performed during the multi-looking, where range and/or azimuth resolution cells are averaged.

Technical Note

For fully developed speckle it is well know that a multiplicative fading random process F is an appropriate model:

$$I = R \cdot F$$

where I is the observed intensity (speckled measured radiance), R is the random radar reflectivity process (unspeckled radiance), F is a stationary fading random process statistically independent of R, with unit mean $\langle F \rangle = 1$ and whose variance is inversely proportional to the effective number of looks L. The mean intensity $\langle I \rangle = R$ is proportional to the backscattering coefficient of the pixel.

Speckle Specific Filters

The most well known adaptive linear filters are based on the multiplicative model and the use of the local statistics. The Frost filter is an adaptive Wiener filter, and convolves the pixel values within a fixed size window with an adaptive exponential impulse response. The Lee filters perform a linear combination of the observed intensity and of the local average intensity value within the fixed window. They are all adaptive as a function of the local coefficient of variation and can be enhanced by fixing a minimum value for better speckle smoothing and an upper limit texture or point target preservation. The coefficient of variation is a good indicator of the presence of some heterogeneity within the window; it is well adapted when only isotropic texture is present and it can be assisted by ratio operators for anisotropic oriented textural features.

Input Files

Input file list

Input file names (e.g. _pwr, _rsp, _geo). This file(s) is mandatory.

Parameters - Principal Parameters

Depending on the chosen filtering method, one or more of the following fields will be activated.

Azimuth window size

Size – in pixel units – of the moving window in azimuth.

Range window size

Size – in pixel units – of the moving window in range.

Equivalent number of looks (ENL)

The Equivalent Number of Looks is equivalent to the number of independent Intensity values averaged per pixel during the multi-looking process. This parameter can be easily estimated over a homogeneous (stationary) sample in the input Intensity data according to:

ENL = $mean^2$ / standard $deviation^2$

In case that ENL is not set, the Number of Looks (NL) used during the multi-looking process is considered.

Note that, to tune the strength of speckle filtering and the level of preservation of scene details, it is preferable to adjust the value of the ENL, rather than to change the size of the processing window:

- To reduce the strength of speckle filtering, with the aim to preserve the thinnest details of the scene, enter a ENL value slightly higher than the calculated one;
- Inversely, to improve the filtering of the speckle (possibly at the cost of the thinnest details of the scene), enter a ENL value slightly lower than the calculated one.

Iteration number
Iteration times.

Directionality number
Depending upon the window size, different directions – in degree unit – can be considered during the filtering. An increase in the number of directions corresponds to a better preservation of the structures.

Filter method:
Mean, Median, Mode. Active parameters:

- Azimuth window size

- Range window size

Edge Preserving Smoothing. Active parameters:

- Azimuth window size
- Range window size

- Iterations Number
- Directionality Number

Frost, Lee, Refined Lee. Active parameters:

- Azimuth window size
- Range window size

- Equivalent Number of Looks (ENL)

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file list
Output file names. This file(s) is mandatory.

_fil
Filtered Intensity image and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Aspert F., M. Bach Cuadra, J.P. Thiran, A. Cantone, and F. Holecz: "Time-varying segmentation for mapping of land cover changes". Proceeding of ESA Symposium, Montreux, 2007.

Frost V.S., J. Stiles, K. Shanmugan and J. Holtzman: "A model for radar images and its application to adaptive digital filtering of multiplicative noise". Transactions on Pattern Analysis and Machine Intelligence, Vol. 4, No. 2, 1982.

Lee J.S.: "Speckle suppression and analysis for SAR images". Optical Engineering, Vol. 25, No. 5, 1986.

Nagao M. and Matsuyama: "Edge Preserving Smoothing". Computer Graphics and Image Processing, Vol. 9, 1979.

1.3.4.1.3.2 Filtering Single Image ANLD

Purpose

Images obtained from coherent sensors such as SAR (or Laser) system are characterized by speckle, This is a spatially random multiplicative noise due to coherent superposition of multiple backscatter sources within a SAR resolution element. In other words, speckle is a statistical fluctuation associated with the radar reflectivity of each pixel of a scene. A first step to reduce the speckle - at the expense of spatial resolution - is usually performed during the multi-looking, where range and/or azimuth resolution cells are averaged.

Technical Note

For fully developed speckle it is well know that a multiplicative fading random process F is an appropriate model:

$$I = R \cdot F$$

where I is the observed intensity (speckled measured radiance), R is the random radar reflectivity process (unspeckled radiance), F is a stationary fading random process statistically independent of R, with unit mean $\langle F \rangle = 1$ and whose variance is inversely proportional to the effective number of looks L. The mean intensity $\langle I \rangle = R$ is proportional to the backscattering coefficient of the pixel.

Non-Speckle Specific Filters

Many filters have been proposed in the past. In homogeneous area the average (or box) is very efficient. However, it suffers on many points: it blurs edges, lines, strong point targets or high frequency texture variations. Other heuristic filters, as the Median and the Edge Preserving Smoothing filter, generally perform well, but with poor adaptation and no relevant physical meaning.

Anisotropic Non-Linear Diffusion filters – first introduced for single optical images – allows a high level of regularization in homogenous areas while preserving the relevant features ultimately used for segmentation (edges or more generally discontinuities). For a continuous image, diffusion on image may be enacted by the partial differential equation:

$$\frac{\partial \mathbf{I}}{\partial t} = \mathrm{div}[c(\|\nabla \mathbf{I}_\sigma\|) \cdot \nabla \mathbf{I}_\sigma]$$

where ∇ is the gradient, *div(.)* is the divergence operator, and *c*, the conduction coefficient, is a matrix of diffusion coefficients of the same size as $\mathbf{I}$. *c* is designed to be a non-linear function of the smoothed image gradient magnitude $\nabla(\mathbf{I}_\sigma)$. As demonstrated in several studies, an optimum diffusivity function is:

$$c(\|\nabla \mathbf{I}_\sigma\|, \lambda) = \begin{cases} \frac{1}{2}[1 - (\frac{\|\nabla \mathbf{I}_\sigma\|}{\lambda})^2]^2 & \|\nabla \mathbf{I}\| \leq \lambda \\ 0 & \text{otherwise} \end{cases}$$

Anisotropic where λ refers to the sensitivity parameter. However, the main drawback of nonlinear diffusion is that such a technique leaves the edge features unfiltered. To overcome this situation, an edge-direction sensitive diffusion has been implemented. The amount of diffusion is controlled by a matrix **D** (also called diffusion tensor) of values specifying the diffusion importance in the features direction. The anisotropic diffusion is thus described by:

$$\frac{\partial \mathbf{I}}{\partial t} = div[\mathbf{D}(\nabla \|\mathbf{I}_\sigma\|) \cdot \nabla \mathbf{I}_\sigma], \qquad \mathbf{D} = \begin{pmatrix} a & b \\ b & c \end{pmatrix}$$

where,

$$\begin{aligned} a &= \phi_1 \cos^2\alpha + \phi_2 \sin^2\alpha, \\ b &= (\phi_1 - \phi_2)\sin\alpha\cos\alpha, \\ c &= \phi_1 \sin^2\alpha + \phi_2 \cos^2\alpha. \end{aligned}$$

where α is the direction of the gradient (maximum variation angle), ϕ_1 controls the diffusion along the gradient, whereas ϕ_2 will be in charge of the filtering process perpendicular to this gradient. Therefore ϕ_1 will be chosen to behave in the same way as c in nonlinear diffusion. ϕ_2 will be fixed to a constant value as we require edges to be smoothed uniformly.

Input Files

Input file list
Input file names (e.g. _pwr, _rsp, _geo). This file(s) is mandatory.

Parameters - Principal Parameters

In order to optimally exploit the potential of the Anisotropic Non-Linear Diffusion filter, the eight parameters listed here below shall be set/tuned depending on the input data. For instance different setting has to be considered when different data types (e.g. SAR amplitude, SAR Interferometric coherence, Optical images, etc.) or data with different spatial resolution are used as input.

Gaussian Blur Kernel Variance
This parameter describes the size and amount of Gaussian applied to the image before performing the diffusion. Increasing the size of the kernel will lead to strongly smoothed image but also to the loss of image small details.

Window Size
The algorithm performs an adaptive threshold selection across the image in order to retrieve the adequate gradient values for preserving the edges. This is done by dividing the image in square windows where an individual threshold value is computed. Small windows will better keep fine details, while big windows will smooth more preserving only the most evident structures.

Anisotropy
This value can vary from 0 to 1. It tunes the amount of filter diffusion along the edges. Higher values increase the filtered edges sharpness, but possibly introduce edge deformations. Changing this parameter has an effect only whether some Anisotropic iterations are specified.

Step Size
This parameter is a positive integer that can be used to reshape the gradient sensitivity function of the diffusion. Low values of this parameters produce smooth curves (isotropic diffusion decreases slowly around edges) whereas high values lead to sharper curves (isotropic diffusion decreases quickly around edges).

Global Iterations
It determines the number of processing iterations (both non-linear and anisotropic diffusion steps).

Non-Linear Iterations
It determines the number of non-linear diffusion iterations. This part of the algorithm leaves the high gradient zones unfiltered. Therefore, it preserves the maximum of details while smoothing homogenous areas. It must be noted that, to have an evident effect in terms of filtering variation, the iterations number has to be modified with steps of 5.

Anisotropic Iterations
It determines the number of nonlinear diffusion iterations. This part of the algorithm smoothes the high gradient zones. It must be noted that, to have an evident effect in terms of filtering variation, the iterations number has to be modified with steps of 5.

Threshold Recomputation
Among the algorithm steps, the most time consuming is certainly the threshold estimation. This parameter adds the possibility to recompute the threshold for the number of iterations specified by the user. Setting it to values higher than 1 can considerably decrease the image processing time (especially when inputting large images) since the threshold are recomputed less times.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file list
Output file names. This file(s) is mandatory.

_fil
Filtered Intensity image and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Aspert F., M. Bach Cuadra, J.P. Thiran, A. Cantone, and F. Holecz: "Time-varying segmentation for mapping of land cover changes". Proceeding of ESA Symposium, Montreux, 2007.

Frost V.S., J. Stiles, K. Shanmugan and J. Holtzman: "A model for radar images and its application to adaptive digital filtering of multiplicative noise". Transactions on Pattern Analysis and Machine Intelligence, Vol. 4, No. 2, 1982.

Lee J.S.: "Speckle suppression and analysis for SAR images". Optical Engineering, Vol. 25, No. 5, 1986.

Nagao M. and Matsuyama: "Edge Preserving Smoothing". Computer Graphics and Image Processing, Vol. 9, 1979.

1.3.4.1.3.3 Filtering Multi-temporal

Purpose

Images obtained from coherent sensors such as SAR (or Laser) system are characterized by speckle, This is a spatially random multiplicative noise due to coherent superposition of multiple backscatter sources within a SAR resolution element. In other words, speckle is a statistical fluctuation associated with the radar reflectivity of each pixel a scene. A first step to reduce the speckle - at the expense of spatial resolution - is usually performed during the multi-looking, where range and/or azimuth resolution cells are averaged.

Whenever two or more images of the same scene taken at different times are available, multi-temporal speckle filtering – which exploits the space-varying temporal correlation of speckle between the images – should be applied, in order to reduce this system inherent multiplicative noise.

Technical Note

De Grandi Filter
Within this multi-temporal filtering an optimum weighting filter is introduced to balance differences in reflectivity between images at different times. It has to be pointed out that this multi-temporal filtering is based on the assumption that the same resolution element on the ground is illuminated by the radar beam in the same way, and corresponds to the same co-ordinates in the image plane (sampled signal) in all images of the time series. In other words the SAR geometry is the same for all acquisitions. The reflectivity can of course change from one time to the next due to a change in the dielectric and geometrical properties of the elementary scatters, but should not change due to a different position of the resolution element with respect to the radar. Therefore proper spatial coregistration of the SAR images in the time series is condition sine qua non and of paramount importance.

For what concerns the ENL setting, it is suggested to leave it as default (i.e. -1) for single look data; vice versa in case of multilook data it is better to estimate it on a homogeneous area of the image.

The Coregistration 121 step must be performed prior the execution of this filter. Input data must be in the satellite view geometry; geocoded (_geo) data are not admitted.

Input Files

Input file list
Input file names of coregistered (_pwr, _rsp) or geocoded (_geo) data. This file list is mandatory.

Parameters - Principal Parameters

Equivalent Number of Looks (ENL)
The Equivalent Number of Looks is equivalent to the number of independent Intensity values averaged per pixel during the multi-looking process. This parameter can be easily estimated over a homogeneous (stationary) sample in the input Intensity data according to:

ENL = $mean^2$ / standard $deviation^2$

In case that ENL is not set, the Number of Looks (NL) used during the multi-looking process is considered.

Note that, to tune the strength of speckle filtering and the level of preservation of scene details, it is preferable to adjust the value of the ENL, rather than to change the size of the processing window:

- To reduce the strength of speckle filtering, with the aim to preserve the thinnest details of the scene, enter a ENL value slightly higher than the calculated one;
- Inversely, to improve the filtering of the speckle (possibly at the cost of the thinnest details of the scene), enter a ENL value slightly lower than the calculated one.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file list
Output file list of the filtered data. This file list is mandatory.

_fil
Filtered Intensity image and associated header files (.sml, .hdr).

_meta
It allows to load the processing results as a single file.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

De Grandi G.F., M. Leysen, J.S. Lee and D. Schuler, Radar reflectivity estimation using multiplicative SAR scenes of the same target: technique and applications, Proceedings IGARSS, 1997.

1.3.4.1.3.4 Filtering Multi-temporal ANLD

Purpose

Images obtained from coherent sensors such as SAR (or Laser) system are characterized by speckle, This is a spatially random multiplicative noise due to coherent superposition of multiple backscatter sources within a SAR resolution element. In other words, speckle is a statistical fluctuation associated with the radar reflectivity of each pixel a scene. A first step to reduce the speckle - at the expense of spatial resolution - is usually performed during the multi-looking, where range and/or azimuth resolution cells are averaged.

Whenever two or more images of the same scene taken at different times are available, multi-temporal speckle filtering – which exploits the space-varying temporal correlation of speckle between the images – should be applied, in order to reduce this system inherent multiplicative noise.

Technical Note

Multi-temporal Anisotropic Non-Linear Diffusion Filter

Single-date and multi-temporal SAR filtering methods, based on probability density functions, perform well under strictly controlled conditions, but they are often limited with respect to sensor synergy – where complex joint probability density functions must be considered – and to the temporal aspect. The drawback of existing multi-temporal speckle filters is that they are strongly sensor and acquisition mode dependant, because based on statistical scene descriptors. Moreover, if features masks are used, an accuracy loss can be introduced when regarding particular shape preservation, mainly due to the lack of a priori information about size and type of the features existent in the image. Therefore, in order to take advantage of the redundant information available when using multi-temporal images acquired with different geometries, while being fully independent regarding the data source, a hybrid multi-temporal anisotropic diffusion scheme can be applied. In this case, the multi-temporal SAR data set must be either geocoded (different acquisition geometries case) or co-registered (same SAR sensor with the same acquisition geometry).

In case of geocoded data, the grid size must be the same for all the images in the multi-temporal series.

With respect to the approach described for the Single Image>Anisotropic Non-Linear Diffusion filters 127, in the multi-temporal case the choice is made to measure the gradient using the whole set of images. The most natural choice is then to use the reliable formulation for gradient computation with vector data, which takes the gradient as two dimensional manifold embedded in $\Re^m$, obtaining the following First Fundamental Form (FFF):

$$d\mathbf{f}^2 = \begin{pmatrix} dx \\ dy \end{pmatrix}^{\mathbf{T}} \begin{pmatrix} g_{11} & g_{12} \\ g_{12} & g_{22} \end{pmatrix} \begin{pmatrix} dy \\ dy \end{pmatrix}$$

Where,

$$\begin{cases} g_{11} & = & \sum_{i=1}^{m} \nabla \mathbf{I}^2_{\sigma,(i,x)}, \\ g_{12} & = & \sum_{i=1}^{m} \nabla \mathbf{I}_{\sigma,(i,x)} \nabla \mathbf{I}_{\sigma,(i,y)}, \\ g_{22} & = & \sum_{i=1}^{m} \nabla \mathbf{I}^2_{\sigma,(i,y)}. \end{cases}$$

where $\mathbf{I}^2_{\sigma}(i,x)$ and $\mathbf{I}^2_{\sigma}(i,y)$ stands respectively for gradient estimation along columns and lines. The direction and magnitude of the maximum and minimum rate of change corresponding to the computed gradient directions can be then extracted from the FFF eigenvalues and eigenvectors. Finally, the practical framework of the anisotropic diffusion process can be written as:

$$\begin{cases} \frac{\partial \mathbf{I}_1}{\partial t} & = & \mathrm{div}[\mathbf{D} \cdot \nabla \vec{\mathbf{I}}] \\ & \vdots & \\ \frac{\partial \mathbf{I}_n}{\partial t} & = & \mathrm{div}[\mathbf{D} \cdot \nabla \vec{\mathbf{I}}] \end{cases}$$

where $\mathbf{I}$ corresponds to the whole multi-temporal image sequence and $\mathbf{I}_i$ is the *i*th image in the sequence. Therefore, each image is filtered separately using the global sequence information, taking into account features from all images.

Input Files

Input file list
Input file names of coregistered (_pwr, _rsp) or geocoded (_geo) data. This file list is mandatory.

Parameters - Principal Parameters

In order to optimally exploit the potential of the Anisotropic Non-Linear Diffusion filter, the eight parameters listed here below shall be set/tuned depending on the input data. For instance different setting has to be considered when different data types (e.g. SAR amplitude, SAR Interferometric coherence, Optical images, etc.) or data with different spatial resolution are used as input.

Gaussian Blur Kernel Variance
This parameter describes the size and amount of Gaussian applied to the image before performing the diffusion. Increasing the size of the kernel will lead to strongly smoothed image but also to the loss of image small details.

Window Size
The algorithm performs an adaptive threshold selection across the image in order to retrieve the adequate gradient values for preserving the edges. This is done by dividing the image in square windows where an individual threshold value is computed. Small windows will better keep fine details, while big windows will smooth more preserving only the most evident structures.

Anisotropy
This value can vary from 0 to 1. It tunes the amount of filter diffusion along the edges. Higher values increase the filtered edges sharpness, but possibly introduce edge deformations. Changing this parameter has an effect only whether some Anisotropic iterations are specified.

Step Size
This parameter is a positive integer that can be used to reshape the gradient sensitivity function of the diffusion. Low values of this parameters produce smooth curves (isotropic diffusion decreases slowly

around edges) whereas high values lead to sharper curves (isotropic diffusion decreases quickly around edges).

Global Iterations
It determines the number of processing iterations (both non-linear and anisotropic diffusion steps).

Non-Linear Iterations
It determines the number of non-linear diffusion iterations. This part of the algorithm leaves the high gradient zones unfiltered. Therefore, it preserves the maximum of details while smoothing homogenous areas. It must be noted that, to have an evident effect in terms of filtering variation, the iterations number has to be modified with steps of 10.

Anisotropic Iterations
It determines the number of nonlinear diffusion iterations. This part of the algorithm smoothes the high gradient zones, improving the image edge appearance. It must be noted that, to have an evident effect in terms of filtering variation, the iterations number has to be modified with steps of 10.

Threshold Recomputation
Among the algorithm steps, the most time consuming is certainly the threshold estimation. This parameter adds the possibility to recompute the threshold for the number of iterations specified by the user. Setting it to values higher than 1 can considerably decrease the image processing time (especially when inputting large images) since the threshold are recomputed less times.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file list
Output file list of the filtered data. This file list is mandatory.

_fil
Filtered Intensity image and associated header files (.sml, .hdr).

_meta
It allows to load the processing results as a single file.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

Anisotropic Non-Linear Diffusion

- **Commit**
  The new input parameters are stored.

- **Restore**
  The default parameter setting is reloaded.

- **Cancel**
  The window will be closed.

References

Aspert F., M. Bach Cuadra, J.P. Thiran, A. Cantone, and F. Holecz, Time-varying segmentation for mapping of land cover changes, Proceeding of ESA Symposium, Montreux, 2007.

1.3.4.1.4 Geocoding

Section Content

1.3.4.1.4.1 Geocoding and Radiometric Calibration

Purpose

SAR systems measure the ratio between the power of the pulse transmitted and that of the echo received. This ratio (so-called backscatter) is projected into the slant range geometry. Geometric and radiometric calibration of the backscatter values are necessary for inter-comparison of radar images acquired with different sensors, or even of images obtained by the same sensor if acquired in different modes or processed with different processors.

Technical Note

Geocoding

Due to the completely different geometric properties of SAR imagery in range and azimuth direction, across- and along-track directions have to be considered separately to fully understand the acquisition geometry of SAR systems. According to its definition, SAR images are characterised by large distortions in range direction. They are mainly caused by topographic variations and they can be relatively easily corrected. The distortions in azimuth are much smaller but more complex.

A backward solution, which considers an input Digital Elevation Model, is used to convert the positions of the backscatter elements into slant range image coordinates. The transformation of the three-dimensional object coordinates - given in a cartographic reference system - into the two-dimensional row and column coordinates of the slant range image, is performed by rigorously applying the Range and Doppler equations. This requires to know position and velocity vectors of both sensor and backscatter elements as well as Doppler frequencies and pulse transit times used for SAR image processing. Using the satellite tracking data, sensor positions and velocity vectors (state vectors) are computed for each azimuth position of the SAR image. Knowing the Doppler centroid, which is used as azimuth reference, the sensor position can be determined for any backscatter element; for each backscatter element with a corresponding estimated sensor position, the slant range and the Doppler frequency is computed considering the Range-Doppler equations (Meier et al, 1993):

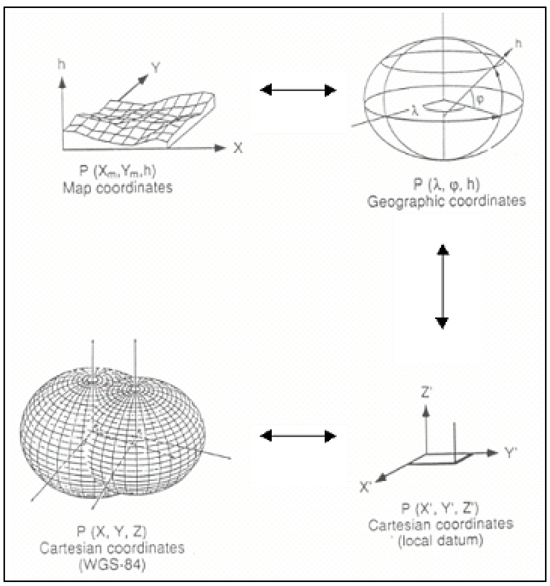
$$R = S - P$$
$$f_D = \frac{2 f_0 (v_p - v_s) R_s}{c |R_s|}$$

where R_S is the slant range, *S* and *P* are the spacecraft and backscatter element position, v_S and v_p are the spacecraft and backscatter element velocity, f_0 is the carrier frequency, *c* the speed of light and f_D is processed Doppler frequency.

In general it shall be noted that:

- Data processed with Zero-Doppler and Non-Zero-Doppler annotations are supported.
- Pixel accuracy can be achieved, even without using any Ground Control Point, if proper processing is performed and accurate orbital parameters are considered.
- One Ground Control Point is sufficient to correct orbital inaccuracies of the input file(s). It is important to note that, in case the Input file(s) has already been corrected with the the manual 722 or the automatic 719 procedure the GCP is not needed.

During the geocoding procedure, geodetic and cartographic transforms (refer to figure below) are considered in order to convert the geocoded image from the Global Cartesian coordinate system (WGS-84) into the local Cartographic Reference System (e.g. UTM-32, Gauss-Krueger, Oblique Mercator, etc.).



In case of precise satellite orbits, the geocoding process is run in a fully automatic way. However, in case of inaccuracy in the satellite orbits, a Ground Control Point is required to precisely geolocate the input SAR data. As said above, the GCP is not needed if the manual 722 or the automatic 719 correction procedure has been previously executed.

Local Incidence Angle and Layover/Shadow

It represents the angle between the normal to the backscattering element and the incoming radiation.

This angle assumes negative values on "active layover" areas, while values higher than 90° correspond to "active shadow" areas. It must be noted that the entire layover zone - as well as the entire shadow zone - extends beyond the respective "active" areas.

On the basis of what above the "Layover/Shadow" mask contains the following classes:

- Active Layover.
- Near Passive Layover - near range portion of the passive area.
- Far Passive Layover - far range portion of the passive area.
- Active Shadow.
- Passive Shadow.
- Layover Shadow - pixels where layover and shadow overlap.

Where the imaged area is not affected by either layover or shadow, the "Layover/Shadow" mask shows the Local Incidence Angle values in discrete intervals.

Radiometric Calibration

Radars measure the ratio between the power of the transmitted pulse and the power of the received echoes. This ratio is called backscatter. The calibration of the backscatter values is necessary to compare radar data acquired with different sensors, in different acquisition modes, at different times, or generated by different processors.

The radiometric calibration of SAR data is carried out by following the radar equation law. It involves corrections for:

- The scattering area (*A*) - Each output pixel is normalised for the real illuminated area of each resolution cell, which may change depending on topography and incidence angle. It is important to mention that this area can be: i) estimated considering the sine of the "local incidence angle"; ii) determined by computing the "true area".
- The antenna gain pattern (G^2) - The antenna gain variations in range are corrected taking into account the actual topography (Digital Elevation Model) or the reference ellipsoidal height. The antenna gain can be expressed as the ratio between the received signal and the transmitted signal or by comparing a real antenna to an isotropic antenna; it is measured in dB.
- The range spread loss (R^3) - The received power (backscattered signal) is corrected by taking into account the sensor-to-ground distance variation from the near range to the far range.

The formula applied for the radiometric calibration is (Holecz et al., 1993 and 1994):

$$P_d = \frac{P_t \cdot G_t^A(\theta_{el}, \theta_{az}) \cdot G_r^A(\theta_{el}, \theta_{az}) \cdot \lambda^3 \cdot G_r^E \cdot G_p}{(4\pi)^3 \cdot R^3 \cdot L_s \cdot L_a} \cdot A \cdot \sigma^o + P_n$$

where P_d is the received power for distributed scatterers, P_t is the transmitted power, P_n is the additive power, G^A is the transmitted and received antenna gain, G^E is the electronic gain in radar receiver, G_p is the processor constant, R is the range spread loss, θ_{el} is the antenna elevation angle, θ_{az} is the antenna azimuth angle, L are atmospheric (a) and system (s) losses, A is the scattering area.

In order to properly determine all required geometric parameters, which are used in the radar equation –

and especially for the calculation of the local values – a Digital Elevation Model must be inputted; for this reason the calibration is performed during the data geocoding step, where the required parameters are already calculated.

The calibrated value is a normalized dimensionless number (linear units); the corresponding value in dB ($10*log_{10}$ of the linear value) can be additionally generated by checking the relevant flag. The calibrated value can be generated as Sigma Nought, Gamma Nought and Beta Nought, by setting the appropriate flag in the Preferences>Geocoding 766 (Backscatter Value section).

Area file

When the scattering area is estimated, by applying the "True area" approach, it is saved among the output products. Afterwards this "Area file" can be entered as input for processing, with the same area estimate approach, SAR data which have been previously coregistered 121. This allows saving a lot of computation time when geocoding coregistered time series; indeed in this case the "Area file" shall be computed only once, for the coregistration reference file, and then used as input for the radiometric calibration of all the coregistered data.

In order to precisely estimate the scattering area, the input DEM is oversampled during the execution of the "True area" approach; the "Oversampling factor" shall be set depending on both the input DEM resolution and the input SAR image pixel sampling (refer to the specific Technical Note 766 for additional details).

Radiometric Normalization

Even after a rigorous radiometric calibration, backscattering coefficient variations are clearly identifiable in range direction and in presence of topography. Note that these variations are an intrinsic property of each imaged object, and thus might be compensated, but it may not be corrected in absolute terms. Two ways can be pursued in order to equalize these variations:

1. Cosine correction - a correction factor, which is based on a modified cosine model (Ulaby and Dobson, 1989), is applied to the backscattering coefficient to compensate for range variations according to:

$$\sigma^o_{norm} = \sigma^o_{cal} (\cos \vartheta_{norm} / \cos \vartheta_{inc})^n$$

   where n is a weighting factor, typically ranging from 2 to 7 depending upon the image acquisition mode (i.e the larger the incidence angle difference from the near to the far range, the higher n factor shall be set); ϑ_{norm} is the incidence angle in the scene center (default setting); ϑ_{in} is the local incidence angle referred to the ellipsoid. The n factor can be set in the Preferences>Normalisation Factor 766. If a $\vartheta_{norm\ angle}$ different from the scene center angle is required, it can be specified in the Preferences>Normalisation Angle 766.

2. Semi-empirical correction - the dependency of the backscatter from the cosine of the local incidence angle referred to the topography is estimated and compensated with respect to the

incidence angle in the scene center (default setting). If a normalization angle different from the scene center is required, it can be specified in the Preferences>Normalisation Angle 766. The backscatter dependency is estimated by computing a linear regression between the cosine of the local incidence angle and the backscattering coefficient in logarithmic form: the sampling can be defined in the Preferences>Geocoding>Radiometric Normalization 766.

Resampling
The peculiarity of the Optimal Resolution approach is that it allows avoiding the multi-looking step and it optimizes the resampling step (in geometric and radiometric terms). The four corner coordinates of each pixel in the Digital Elevation Model are independently projected (based on the range-Doppler equation) into the 1-look slant range geometry to form a polygon. The values of the pixels included within the polygon are subsequently added and the resulting averaged value, after the radiometric calibration and normalization, is assigned to the SAR geocoded output pixel. In this way, especially in hilly or mountainous terrain, the radiometry is preserved at the best. This approach should be used exclusively when single look data are geocoded to a significantly lower spatial resolution; in the other cases, the 4th Order Cubic Convolution method is recommended.

It is important to note that, if a Digital Elevation Model is used in input, it is automatically resampled to the output geocoding grid size using the 4th Order Cubic Convolution method.

Atmospheric Corrections
For some products, such as TerraSAR-X-1 and Tandem-X data, atmospheric related information are stored in one of the auxiliary files (i.e. "GEOREF.xml"). In this case, during the data import, the relevant factors are extracted from the "Signal Propagation Effects" section in order to be used for the correction of both the Scene Start Time and Slant Range Distance aimed at improving the product geolocation accuracy.

GCP file
In case a list of input files is entered, the data must be previously coregistered 121.

Meta file
This file is generated only when the "Input File List" contains more than 1 file and when the dimension of all the output files is the same. The meta file name prefix is the same as the first image in the input list.

Input Files

Input File List
Input file name(s) of all data to be geocoded. Intensity, amplitude as well as any other data type (coherence, interferogram, etc.) in slant or ground range geometry can be used. This file list is mandatory.

Optional Files

Geometry GCP file

Either a previously created Ground Control Point file (.xml) is loaded (Load GCP file) or the interface to create a new Ground Control Point file is automatically loaded (Create GCP file, refer to the "Tools>Generate Ground Control Point 747" for details). This file is optional.

Input Area file

Scattering area estimated with the "True area" method. This file is optional. In case a list of input files is entered, and a previously generated "Area file" is inputted, the data in the "Input file list" must be previously coregistered and consistent with the "Area file" dimension/extent. If it is omitted, an independent "Area file" is generated for each input file.

DEM/Cartographic System

Digital Elevation Model file

Digital Elevation Model file name. This should be referred to the ellipsoid. In case a list of input files is entered, the DEM must cover the whole imaged area. This file is optional.

Output Projection

In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters

The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

X Grid Size

The Easting (X) grid size of the output data must be defined; the default unit of measure is meters.

Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Y Grid Size

The Northing (Y) grid size of the output data must be defined; the default unit of measure is meters.

Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Radiometric Calibration

By setting true this parameter radiometric calibration is performed.

Scattering Area

It can be determined using two different methods:

- Local incidence angle - this is the fastest approach in terms of processing time, but it is not the most accurate way to calibrate the data in presence of topography.
- True area - it requires more computing resources, but it is the most accurate approach to calibrate the data in presence of topography. It makes sense to apply this method when a good (in terms of quality and spatial resolution) Digital Elevation Model is available.

Radiometric Normalization

By setting this flag radiometric normalization is performed.

Normalization Method

It can be determined using two different methods:

- Cosine correction - backscatter coefficient variations are compensated only in range direction.
- Semi-empirical correction - the backscatter coefficient variations are compensated by considering both the range position and the dependency on the topographic conditions.

Local Incidence Angle

By setting this flag the map of the local incidence angle – in degree – is generated.

Layover/Shadow
By setting this flag a layover and shadow map is generated.

Additional original geometry
By setting this flag the output calibrated products are generated also in the input slant- or ground-range geometry.

Additional output dB
By setting this flag the output calibrated products are generated also in dB units (default setting is linear units only).

Parameters - Global

It brings to the general section of the Preferences759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file list
Output file name(s) of all geocoded file(s). The number of output files must be equal to the number of input files. This file list is mandatory.

_geo
Geocoded Intensity image and associated header files (.sml, .hdr). In case that radiometric calibration is selected, the output will contain geocoded backscattering coefficient values.

_meta
It allows to load the geocoded outputs as a single file.

_dB
Calibrated product in dB units and corresponding header file (.sml, .hdr). This file is generated only if the "Additional output dB" flag is selected.

_srcal
Calibrated product in the input geometry and corresponding header file (.sml, .hdr). This file is generated only if the "Additional original geometry" flag is selected.

_srcal_norm

Calibrated and normalized product in the input geometry and corresponding header file (.sml, .hdr). This file is generated only if the "Additional original geometry" and the "Radiometric Normalization" flags are selected.

_area
Scattering area estimated with the "True area" approach and corresponding header file (.sml, .hdr). This file is generated only if the "True area" flag is selected.

_geo_lia
Geocoded Local Incidence Angle Map and corresponding header file (.sml, .hdr). This file is generated only if the "Local Incidence Angle" flag is selected.

_geo_ls_mask
Geocoded Layover and Shadow mask and corresponding header file (.sml, .hdr). This file is generated only if the "Layover/Shadow" flag is selected.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

Residual
The residual analysis – in pixel units – is calculated only if the Ground Control Point file is entered and the number of Ground Control Points is more than one. It represents the residual error remaining after the correction for each GCP has been applied. The residual analysis results are available in the Process.log 825 file.

References

Ulaby F.T. and C. Dobson: "HandBook of Radar Scattering Statistics for Terrain". Artech House, 1989.

Walter G. Kropatsch and Dieter Strobl: "The Generation of SAR Layover and Shadow Maps from Digital Elevation Models". IEEE Transactions on Image Processing, Vol. 28, No. 1, January 1990.

Frei U., C. Graf ,E. Meier: "Cartographic Reference Systems, SAR Geocoding". Data and System, Wichmann Verlag, 1993.

Meier E., Frei U., and D. Nuesch: "Precise Terrain Corrected Geocoded Images, SAR Geocoding". Data and System, Wichmann Verlag, 1993.

Holecz F., E. Meier, J. Piesbergen, and D. Nüesch: "Topographic effects on radar cross section, SAR Calibration Workshop". Proceedings of CEOS Calibration Sub-Group, ESTEC, Noordwijk, 1993.

D. Small, F. Holecz, E. Meier, and D. Nüesch, Absolute radiometric correction in rugged terrain: a plea for integrated radar brightness, IGARSS Symposium Seattle, 1998.

D. Small, F. Holecz, E. Meier, and D. Nüesch, Radiometric normalization for multimode image comparison, EUSAR Symposium Friedrichshafen, 1998.

Meijering E. and M. Unser: "A Note on Cubic Convolution Interpolation". IEEE Transactions on Image Processing, Vol. 12, No. 4, April 2004.

1.3.4.1.4.2 Map to SAR Image Conversion

Purpose

The usual way is to convert – based on a range-Doppler approach – slant or ground range SAR data into a cartographic reference system. However, in some cases the inverse transform is requested, in particular when data – for instance Digital Elevation Model or Optical image – available in a cartographic reference system should be projected into the slant or ground range SAR geometry; this is the purpose of this functionality.

Technical Note

In case of precise orbits and accurately "Geocoded file", this process is run in a fully automatic way. However, in case of inaccuracy in the satellite orbits or in the "Geocoded file" geolocation, a Ground Control Point is required to correct the SAR data with respect to the "Geocoded file". The Ground Control Point must be identified on the "Slant/Ground range file". The GCP is not needed if the manual 722 or the automatic 719 correction procedure has been previously executed.

Input Files

Geocoded file
File name of the data (SAR, Optical, image, Digital Elevation Model, etc.) in the cartographic reference system. This file is mandatory.

Slant/Ground range file
File name of the slant or ground range data, onto which the geocoded file shall be converted. This file is mandatory.

Digital Elevation Model file
Digital Elevation Model file name. This should be referred to the ellipsoid. This file is optional.

Optional Files

Geometry GCP file
Either a previously created Ground Control Point file (.xml) is loaded (Load GCP file) or the interface to create a new Ground Control Point file is automatically loaded (Create GCP file, refer to the "Tools>Generate Ground Control Point 747" for details). This file is optional.

Parameters - Principal Parameters

Reference Height
In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file

Output file name of the slant or ground range projected data. This file is mandatory.

_rsp
Data in slant or ground range SAR geometry and associated header files (.hdr, .sml).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Frei U., C. Graf, and E. Meier: "Cartographic Reference Systems, SAR Geocoding". Data and System, Wichmann Verlag, 1993.

Meier E., Frei U., and D. Nuesch: "Precise Terrain Corrected Geocoded Images, SAR Geocoding". Data and System, Wichmann Verlag, 1993.

1.3.4.1.4.3 Map to SAR Point Conversion

Purpose

The usual way is to convert – based on a range-Doppler approach – slant or ground range SAR data into a cartographic reference system. However, in some cases the inverse transform is requested, in particular when points – for instance Ground Control Points – in a cartographic reference system should be projected into the slant or ground range SAR geometry; this is the purpose of this functionality.

Technical Note

None.

Input Files

Slant/Ground range file
File name of the slant or ground range data, onto which the point shall be converted. This file is mandatory.

DEM/Cartographic System

Output Projection
The following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters

The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Easting / X Coordinate
Easting or X coordinate in meter or degree depending upon the selected reference system.

Northing / Y Coordinate
Northing or Y coordinate in meter or degree depending upon the selected reference system.

Height / Z Coordinate
Ellipsoidal height in meter.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Outputs

Slant or ground range co-ordinates (range, azimuth). The values are shown on screen.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Frei U., C. Graf, and E. Meier: "Cartographic Reference Systems, SAR Geocoding". Data and System, Wichmann Verlag, 1993.

Meier E., Frei U., and D. Nuesch: "Precise Terrain Corrected Geocoded Images, SAR Geocoding". Data and System, Wichmann Verlag, 1993.

1.3.4.1.4.4 Map to SAR Shape Conversion

Purpose

This functionality is aimed at transforming a geocoded shape file (.shp) into a slant or ground range input SAR image.

Technical Note

In case of precise orbits and accurately geocoded shape file, this process is run in a fully automatic way. However, in case of inaccuracy in the satellite orbits or in the geocoded shape file, a Ground Control Point is required to correct the SAR data (i.e. "Reference file") with respect to the input shape file. The Ground Control Point must be identified on the "Slant/Ground range file". The GCP is not needed if the manual722 or the automatic719 correction procedure has been previously executed.

In case the height information is provided both by the "Input file" and by the Digital Elevation Model, the shape (i.e. "Input file") values will be used for the co-ordinates conversion.

Input Files

Input file
File name of the shape file (.shp) in a supported cartographic reference system. This file is mandatory.

Input Reference file
File name of the slant or ground range SAR data, onto which the geocoded shape file shall be converted. This file is mandatory.

Optional Files

Geometry GCP File
Either a previously created Ground Control Point file (.xml) is loaded (Load GCP file) or The interface to create a new Ground Control Point file is automatically loaded (Create GCP file, refer to the "Tools>Generate Ground Control Point747" for details). This file is optional.

DEM/Cartographic system

Digital Elevation Model file
Digital Elevation Model file name. This should be referred to the ellipsoid. This file is optional.

Output Projection
In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System**6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Output Files

Output file
Output file name of the slant or ground range projected data. This file is mandatory.

_slant.shp
Shape file in slant or ground range SAR geometry.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Frei U., C. Graf, and E. Meier: "Cartographic Reference Systems, SAR Geocoding". Data and System, Wichmann Verlag, 1993.

Meier E., Frei U., and D. Nuesch: "Precise Terrain Corrected Geocoded Images, SAR Geocoding". Data and System, Wichmann Verlag, 1993.

1.3.4.1.5 Post Calibration

Purpose

It is well known that the radar backscatter depends upon the object's roughness and its dielectric properties. A useful rule-of-thumb in analysing radar images is that the higher the backscatter, the rougher the surface being imaged. Concerning the object's electrical properties, in dry conditions, the dielectric constant is low, hence contributing in a limited way to the backscatter response. On the contrary, wetness of soil or vegetated surfaces produce a notable increase (up to 10 times) in the radar reflectivity, thereby making the radar system attractive to infer moisture (or wetness in a qualitative way). However, if the final goal is to obtain a land cover map, this particular sensitivity has a negative impact on the classification result. In this case, it is therefore of advantage to remove the dielectric related effects – typically resulting from rain events – on the backscattering coefficient.

Beside dielectric constant related changes, data can be affected also by absolute and range dependent radiometric distortions, which can be related to anomalous SAR antenna behaviors. These distortions are corrected as well using the Post Calibration functionality.

Technical Note

In a first step, i) range dependent radiometric losses and/or, ii) dielectric related effects on the radar backscatter, iii) absolute radiometric variations are derived in a statistical way from a multi-temporal geocoded, radiometrically calibrated (and optionally normalized) data set. In a subsequent step, the estimated two dimensional image dependent correction factors are applied on each image independently.

Range correction
It can happen that SAR images, even after radiometric calibration and normalisation, remain affected by backscatter variations in range. The correction is typically done by identifying same land cover areas (in form of a distributed shape files) in different range positions, which are used as reference in the correction process. It is also possible to draw the shape file as a single large homogeneous area instead of several small ones. In case the shape file is not provided the program will homogeneously collect the calibration samples in range direction to perform the correction.

Dielectric correction
Distortions related to dielectric constant temporal changes are corrected using at least one reference image not affected by these effects (best results are achieved if more reference images are available). It is worth mentioning that the resulting dielectric correction factor (which are saved in form of raster images) can be further used as qualitative wetness indicator.

Absolute correction
This correction should be executed on the entire data set in case a multi-temporal analysis has to be carried out. A mean value temporal equalisation is performed (among all input files) in order to remove possible radiometric mean value anomalies affecting the entire imaged area.

The radiometric corrections (i.e. dielectric component, range dependency and absolute variations) can be carried out in an independent or combined way; in any case the processing sequence is the following: 1) range correction, 2) dielectric correction, 3) absolute correction.

Input Files

Input file list
File list of the geocoded, radiometrically calibrated (and optionally normalized) Intensity images (_geo), which have to be post-calibrated. More than one file is required in case the absolute correction is selected. The use of this file list is mandatory.

Dielectric correction list
File list of images not affected by large dielectric constant variations. These are used as reference for the dielectric correction. The use of this file list (1 image is the minimum) is mandatory only if the dielectric correction is carried out.

Optional Files

Absolute correction file
Name of the shape file (.shp, .xml) defining the area to be used as reference for the mean value calculation. Homogeneous areas, not affected by temporal and/or spatial variations of the radar backscatter, are to be selected (typically densely forested areas). The use of this file is mandatory only if the absolute correction is carried out.

Range correction file
Name of the shape file (.shp, .xml) defining the near to far range reference. Homogeneous zones, not affected by spatial variations of the radar backscatter, are to be selected. This file is optional.

Parameters - Principal Parameters

Absolute Correction
By setting this flag, absolute radiometric variations are corrected.

Range Correction
By setting this flag, range dependent radiometric variations are corrected.

Dielectric Correction
By setting this flag, radiometric variations related to dielectric constant changes are corrected.

Range correction threshold
The range correction is applied only to those pixels, which are below this backscatter value.

Range correction degree

Degree of the polynomial applied for the range correction. Using a 1st order polynomial at least two shapes are required, which are contained by any of the input images. In case of higher polynomial order it is important that the entire range image extent is covered in order to avoid anomalous trends of the corrected backscatter values.

Dielectric correction threshold
Minimum ratio between the input image and the reference one, for the correction to be applied.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Output root name of the selected feature(s). This root name is mandatory.

Output file list
File names of the Post Calibrated Intensity images. The use of this file list is mandatory.

_cal
Post calibrated data and associated header files (.hdr, .sml).

dielectric_mask
Mask file corresponding to the high frequencies areas in the dielectric correction list and associated header files (.hdr, .sml). Values equal to 255 are not corrected. This file is removed by setting the *Delete intermediate files* flag.

_cal_dielectric
Data containing the dielectric correction factors and associated header files (.hdr, .sml). These files are removed by setting the *Delete intermediate files* flag.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.3.4.2 Feature Extraction

Section Content

1.3.4.2.1 Coherence

Purpose

Single-date and multi-temporal features based on first order statistics Intensity image(s) or interferometric image pairs can be derived from SAR data. These features enable, depending upon the targeted product, to detect and extract structures or temporal changes, which can be additionally used for segmentation and/or classification purposes.

Technical Note

Given two coregistered complex SAR images (S_1 and S_2), one calculates the interferometric coherence (γ) as a ratio between coherent and incoherent summations. Note that the observed coherence - which ranges between 0 and 1 - is, in primis, a function of systemic spatial de-correlation, the additive noise, and the scene de-correlation that takes place between the two acquisitions.

$$\gamma = \frac{\left|\sum s_1(x) \cdot s_2(x)^*\right|}{\sqrt{\sum \left|s_1(x)\right|^2 \cdot \sum \left|s_2(x)\right|^2}}$$

The estimated coherence - which ranges between 0 and 1 - is function of:

- Systemic spatial de-correlation (i.e. the additive noise).
- Temporal de-correlation between master and slave acquisitions.

The coherence product has essentially a twofold purpose:

- To determine the quality of the measurement (i.e. interferometric phase). As a rule of thumb, InSAR pairs with low coherence should not be used to derive reliable phase related measurements.
- To extract thematic information relevant to the ground features properties and their temporal changes. This information is enhanced when coupled with the backscattering coefficient (σ^o) of the master and slave Intensity data.

As a general rule it can be assumed that the coherence decreases with increasing master-slave acquisition time distance. The relationship between the coherence (γ) and the Signal to Noise Ratio (SNR) is:

$$SNR = \gamma^2/1-\gamma^2$$

In case the two images are very much different in terms of areal coverage, the smallest one should be used as "Input Master file" in order to avoid the coregistration windows to be located in areas with null pixel values, which can eventually cause the coregistration process to fail. For details about the coregistration process, refer to the relevant Technical Note 121.

In case of baseline conditions - or topographic conditions - which cause the coherence to get lost due to the very fast change of the interferometric phase, it is suggested to over sample the range pixel size by entering negative values in the Range Multilooking (Preferences>Interferometry>Multilooking 779). As an example using ERS-ASAR interferometric tandem pairs, which are characterized by a very small ambiguity height (hence very dense/frequent interferometric fringes), the Interferometric multilooking factors shall be set to -2 and 3 (respectively in Range and Azimuth).

The use of the Digital Elevation Model in input (optional) enables to generate the coherence image using the interferogram flattened on the basis of the known topography.

In case of inaccuracy in the satellite orbits or in the Digital Elevation Model geolocation, a Ground Control Point (i.e. "GCP" file) is required to correct the SAR data (i.e. "Input Master SLC" file) with respect to the reference Digital Elevation Model. In this case the shift calculated in the coregistration process is combined with the Ground Control Point shift in order to correct the data of the Input file list according to the Input reference file.

It is important to note that:

- In case the "Input Master SLC file" has already been corrected with the the manual 722 or the automatic 719 procedure the GCP is not needed.
- In case the "Input Master SLC file" is correct (i.e. the nominally geocoded image fits with the DEM), while the orbital parameters of the "Input Slave SLC file" are not accurate (i.e. the nominally geocoded image does not fit with the DEM), the GCP is not needed but the flag "Automatic Slave Orbit Correction", in the Preferences>Flattening 775, must be checked.

The coherence image can be generated from the input unfiltered interferogram or from the filtered one, using one of the available filtering methods. The selected option can be specified in the relevant Preferences 784.

Input Files

Input Master file
Input file name of the (not coregistered) Single Look Complex (_slc) Master data. This file is mandatory.

Input Slave file
Input file name of the (not coregistered) Single Look Complex (_slc) Slave data. This file is mandatory.

Optional Files

Geometry GCP file
Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File) or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the "Tools>Generate Ground Control Point 747" for details). This file is optional.

Shift Parameter file
Name of the file with the shift parameters used for the coregistration (_par). This file is mandatory. If the Compute shift parameter flag is set, it is generated as output.

DEM/Cartographic System

Digital Elevation Model file
Name of the Digital Elevation Model file. This should be referred to the ellipsoid. This file is optional.

Output Projection
In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Range looks

Number of looks in range.

Azimuth looks
Number of looks in azimuth.

Grid Size for Suggested Looks
The grid size, in meters, used to tune range and azimuth looks. If the other parameters are manually set, the grid size will not imply a change in their values.

Compute Shift Parameters
By setting this flag, the coregistration shifts between master and slave image are calculated and saved into the _par file.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Interferogram

It brings to the Interferometry section of the Preferences 779 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Flattening

It brings to the Flattening section of the Preferences 775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Filtering

It brings to the Adaptive Filtering section of the Preferences 783 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Coregistration

It brings to the coregistration section of the Preferences 770 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file
Output file name of the Coherence data. This file is mandatory.
_cc
Coherence and associated header files (.sml, .hdr).

_par
ASCII file containing the coregistration shift parameters in range and azimuth. This file is generated only if the shift parameters are calculated.

_orbit_off.shp
Shape file with the points used to estimate the orbit based shift. This file contains the following information:

- Pixel position in range direction (Range), in original pixel units.
- Pixel position in azimuth direction (Azimuth), in original pixel units.
- Shift measured in range direction (Dr), in original pixel units.
- Shift measured in azimuth direction (Da), in original pixel units.
- Calculated polynomial fitted shift in range direction (Drfit), in original pixel units.
- Calculated polynomial fitted shift in azimuth direction (Dafit), in original pixel units.

The file is multilooked (i.e. Azimuth and Range looks) as specified in the Input Parameters.

_winCC_off.shp
Shape file with the points used to estimate the cross correlation based shift from the Intensity data. The information provided by the "_orbit_off.shp" file are updated on the basis of the cross correlation estimate

The file is multilooked (i.e. Azimuth and Range looks) as specified in the Input Parameters.

_winCoh_off.shp
Shape file with the points used to estimate the coherence based shift. The information provided in the "_winCC_off.shp" are updated by means the coherence based estimate. This file contains also the following additional information:

- Signal to Noise Ratio (SNR), which is a linear dimensionless value.
- Coherence value. It is dimensionless and it can vary from 0 to 1.

The file is multilooked (i.e. Azimuth and Range looks) as specified in the Input Parameters.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Gatelli F., A. Monti Guarnieri, F. Parizzi, P. Pasquali, C. Prati, F. Rocca, The Wavenumber Shift in SAR Interferometry, IEEE Transactions on Geoscience and Remote Sensing, Vol. 32, No. 4, 1994.

Stebler O., P. Pasquali, D. Small, F. Holecz, and D. Nuesch, Analysis of ERS-SAR tandem time-series using coherence and backscattering coefficient, , Proceedings of Fringe '96 workshop, ESA SP-406, 1997.

1.3.4.2.2 Coefficient of Variation

Purpose

Single-date and multi-temporal features based on first order statistics Intensity image(s) or interferometric image pairs can be derived from SAR data. These features enable, depending upon the targeted product, to detect and extract structures or temporal changes, which can be additionally used for the segmentation and/or classification purposes.

Technical Note

The Coefficient of Variation – defined as the local Intensity standard variation normalised by its average – enables, in a single image, to extract information about the local texture.

Input Files

Input file
Input file name of the Intensity data. This file is mandatory.

Parameters - Principal Parameters

Azimuth Window Size
Odd size – in pixel unit – in Azimuth of the moving window.

Range Window Size
Odd size – in pixel unit – in Range of the moving window.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file
Output file name of the Coefficient of Variation data. This file is mandatory.

_cov
Cofficient of Variation and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch

The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.3.4.2.3 Ratio

Purpose

Single-date and multi-temporal features based on first order statistics Intensity image(s) or interferometric image pairs can be derived from SAR data. These features enable, depending upon the targeted product, to detect and extract structures or temporal changes, which can be additionally used for the segmentation and/or classification purposes.

Technical Note

Performing the ratio between coregistered or geocoded multi-temporal Intensity images enables to easily visualize the temporal changes. The input images must have the same pixel size and number.

In case more than 2 input files are entered, the ratio is performed on the pairs of subsequent input images (1st/2nd, 2nd/3rd, etc.); the output files are named with progressive numbers from 0 onwards.

Input Files

Input file list
Input file list of the coregistered or geocoded (_geo) Intensity data. This file list is mandatory.

Output Files

Output file
Output root name of the Ratio data. This root name is mandatory.

_rto
Ratio data and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.3.4.2.4 Multi Temporal Features

Purpose

Single-date and multi-temporal features, based on first order statistics, can be derived from SAR intensity data. These features enable, depending upon the targeted product, to detect and extract structures or temporal changes, which can be additionally used for segmentation and/or classification purposes.

Technical Note

Temporal features are extracted on coregistered or geocoded time-series Intensity images.

The "Input file list" is automatically sorted in chronological order before generating the required products.

Input Files

Input file list
Input file list of the coregistered or geocoded (_geo) multi-temporal Intensity data. This file list is mandatory.

Parameters - Principal Parameters

Mean
By setting this flag the output pixel value represents the average calculated from all input data.

Std
By setting this flag the output pixel value represents the standard deviation calculated from all input data.

Median
By setting this flag the output pixel value represents the median value (the central value in the ordered series) calculated from all input data.

Gradient
By setting this flag the output pixel value represents the maximum absolute variation between consecutive acquisition dates. The sign of the variation (i.e. increment or decrement) is not taken into account.

Max
By setting this flag the output pixel represents the maximum value extracted from all input data.

Min
By setting this flag the output pixel represents the minimum value extracted from all input data.

Span Difference
By setting this flag the output pixel represents the difference between the maximum value and the minimum value of all input data.

Max Increment
By setting this flag the output pixel value represents the maximum increment between consecutive acquisition dates.

Max Decrement

By setting this flag the output pixel value represents the maximum decrement between consecutive acquisition dates.

Span Ratio

By setting this flag the output pixel represents the ratio calculated between the maximum value and the minimum value of all input data.

Max Ratio

By setting this flag the output pixel represents the maximum value (max backscatter increment) among all ratios calculated between consecutive acquisition dates.

Min Ratio

By setting this flag the output pixel represents the minimum value (max backscatter decrement) among all ratios calculated between consecutive acquisition dates.

MuSigma

By setting this flag the output pixel represents the mean/standard deviation ratio.

Coefficient of Variation

By setting this flag the output pixel represents the standard deviation/mean ratio.

Make cmg RGB

By setting this flag an RGB image containing the Coefficient of Variation, the Minimum and the Gradient will be generated.

Normalization

By setting this flag the selected feature(s) is normalized with respect to the "mean".

dB

By setting this flag the output is in dB (logarithmic scale instead on linear scale).

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Output root name of the selected feature(s). This root name is mandatory.

_spanD
Span difference and associated header files (.sml, .hdr).

_spanR
Span ratio and associated header files (.sml, .hdr).

_cov
Coefficient of variation and corresponding header files (.sml, .hdr).

_mea
Mean image and associated header files (.sml, .hdr).

_med
Median image and associated header files (.sml, .hdr).

_max
Maximum value and associated header files (.sml, .hdr).

_min
Minimum value and associated header files (.sml, .hdr).

muSigma
MuSigma value and associated header files (.sml, .hdr).

_grad
Gradient image and associated header files (.sml, .hdr).

_maxD
Maximum decrement and associated header files (.sml, .hdr).

_maxI
Maximum increment and associated header files (.sml, .hdr).

_maxR
Maximum ratio and associated header files (.sml, .hdr).

_minR
Minimum ratio and associated header files (.sml, .hdr).

_std
Standard deviation and associated header files (.sml, .hdr).

_CovMin_grad_rgb.tif
TIFF image of the assembled RGB imageand associated header files (.hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data

Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.4 Gamma and Gaussian Filtering Module

Section Content

1.4.1 Overview

A Note on the Gamma and Gaussian Filtering module

This module is aimed at providing a whole family of SAR specific filters, which are particularly efficient to reduce speckle noise, while preserving the radar reflectivity, the textural properties and the spatial resolution, especially in strongly textured SAR images. The algorithms, developed by PRIVATEERS N.V. (Private Experts in Remote Sensing), have been implemented in the most rigorous way, in order to exploit at the best the speckle suppression capabilities.

Actually one of the major source of errors in the estimation of soil roughness and soil wetness, which are both crucial parameters for SAR data analysis related to a number of application domains (i.e. agriculture, forestry, snow mapping, etc.), is the presence of speckle. Four Bayesian vector speckle filters have been implemented in order to optimize the speckle removal procedure, depending on the input data type.

Note that:

- In case of SAR RAW products, the data must be imported and focussed (refer to Focusing module 215).
- Default setting for selected parameters can be specified in the Preferences panel.
- The SAR Tutorial, which includes basic knowledge on SAR theory and data processing, complements the online help.
- Data geocoded to GEO-GLOBAL cartographic reference system can be automatically displayed into the Google Earth environment by double clicking on the output .kml file.
- The module has been jointly developed by sarmap s.a. and PRIVATEERS N.V. (Private Experts in Remote Sensing).

Technical Note

In presence of scene texture, to preserve the useful spatial resolution - for instance to restore the spatial fluctuations of the radar reflectivity (texture) - an A Priori first order statistical model is needed. With regard to SAR clutter, it is well known that the Gamma-distributed scene model is the most appropriate approach in case of data acquired over natural areas (not artificial objects) without too rough morphology. Under such conditions the Gamma-distributed scene model, modulated by either an independent complex-Gaussian speckle model (for SAR Single Look Complex data), or by a Gamma speckle model (for multi-looked SAR Intensity images), gives rise to a K-distributed clutter.

Note that the (real) Gaussian distributed scene model remains still popular, mainly for mathematical tractability of the inverse problem in case of multi-channel detected SAR images (multivariate A Priori scene distributions). Nevertheless, in the presence of strong mixed texture or strong relief or artificial object - especially processing Very High Resolution data - it may be hazardous to make an assumption about the statistical distribution of the radar reflectivity under the form of an analytical first order statistical model such as the Gamma distribution; this is why one may wish to make the alternative choice to introduce a Maximum Entropy constraint on texture (“Distribution Entropy”, DE).

In this context, the following filter families has been developed:

Single Look Complex
- SLC Gaussian DE MAP filter.
- Gaussian Gamma MAP filter.
- Gaussian DE MAP filter.

Single Channel Intensity
- Gamma Gamma MAP filter.
- Gamma DE MAP filter.
- Gamma A Posteriori Mean filter.

Multi Channel Intensity
- Gamma Gaussian MAP filter for uncorrelated speckle.
- Gaussian Gaussian MAP filter for correlated speckle.
- Gaussian DE MAP filter for correlated speckle.

Polarimetric
- Wishart Gamma MAP filter.
- Wishart DE MAP filter.

References

Nezry E., A. Lopes, and F. Yakam-Simen. "Prior scene knowledge for the Bayesian restoration of mono and multi-channel SAR images". Proceedings of IGARSS’97 Symposium, 1997.

E. Nezry and F. Yakam Simen, 1999: "New distribution-entropy Maximum A Posteriori speckle filters for detected, complex, and polarimetric SAR data". Proceedings of IGARSS'99 Symposium, Vol.3, 3 p., Hamburg (Germany), 28 June - 02 July 1999.

E. Nezry and F. Yakam Simen, 1999: "A family of distribution-entropy MAP speckle filters for polarimetric SAR data, and for single or multi-channel detected and complex SAR images". Proceedings of the CEOS SAR Workshop, ESA SP-450, pp.219-223, Toulouse (France), 26-29 October 1999.

1.4.2 Reference Guide

1.4.2.1 Single Look Complex

Section Content

[Single Look Complex Gaussian DE MAP](178)

[Single Look Complex Gaussian Gamma MAP](181)

[Single Look Complex SLC Gaussian DE MAP](184)

1.4.2.1.1 Single Look Complex Gaussian DE MAP

Purpose

Single Look Complex data can be filtered using any of the following procedures:

- SLC Gaussian DE MAP.
- Gaussian Gamma MAP.
- Gaussian DE MAP.

Optimal results can be achieved by choosing the appropriate filter depending on the land morphology and scene texture, this last to be considered also in relationship with the data spatial resolution. The availability of a multi-temporal series is also a condition to consider when choosing the most appropriate filter.

Technical Note

Gaussian Distribution-Entropy MAP (Gaussian DE MAP)
It is suitable for separate SLC's (for example series of N SLC SAR images acquired with same viewing geometry) in the presence of strong mixed texture or strong relief. The result is a speckle filtered, and possibly multi-looked, Intensity image where the pixel values are a weighted average of the N individual acquisitions. The input data must be previously coregistered 121.

Input Files

Input File List
Input file names of Single Look Complex (_slc) data. These files are mandatory.

Parameters - Principal Parameters

Window Size in Azimuth and Range
Filter window size (square or rectangular). The signal samples to be used for the computation of the local statistics are collected within a neighborhood where the autocorrelation function of the radar reflectivity is significant, in order to avoid taking samples within areas of a different nature than the pixel under process. In practice, this means that signal samples will not be collected farther than a certain

distance - the decorrelation length - from the pixel under process. For SLC data, this distance rarely exceeds more than 12 pixels in azimuth and 4 pixels in range, i.e. it is useless to use a window size larger than 31 x 9 (azimuth/range) pixels. In theory a processing window size of 25 x 9 (azimuth/range) pixels is sufficient; in practice, with new sensors, a window size of 7 x 7 is sufficient.

Equivalent Number of Looks (ENL)

The Equivalent Number of Looks is equivalent to the number of independent Intensity values averaged per pixel during the multi-looking process. This parameter can be easily estimated over a homogeneous (stationary) sample in the input Intensity data according to:

$$ENL = mean^2 / standard\ deviation^2$$

In case that ENL is not set, the Number of Looks (NL) used during the multi-looking process is considered.

Note that, to tune the strength of speckle filtering and the level of preservation of scene details, it is preferable to adjust the value of the ENL, rather than to change the size of the processing window:

- To reduce the strength of speckle filtering, with the aim to preserve the thinnest details of the scene, enter a ENL value slightly higher than the calculated one;
- Inversely, to improve the filtering of the speckle (possibly at the cost of the thinnest details of the scene), enter a ENL value slightly lower than the calculated one.

Azimuth Looks

The azimuth multi-looking factor can be entered only if Gaussian Gamma MAP or Gaussian DE-MAP filters are selected.

Range Looks

The range multi-looking factor can be entered only if Gaussian Gamma MAP or Gaussian DE-MAP filters are selected.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output File List

Output file names of the filtered (possibly multi-looked) Intensity data. These files are mandatory.

_fil
Filtered data and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Lopes A., E. Nezry, R. Touzi, and H. Laur: "Structure detection and statistical adaptive speckle filtering in SAR images". International Journal of Remote Sensing, Vol. 14, 1993.

E. Nezry, M. Leysen, and G. De Grandi: "Speckle and scene spatial statistical estimators for SAR image filtering and texture analysis: some applications to agriculture, forestry, and point targets detection". Proceedings of SPE, Vol. 2584, 1995.

Lopes A., J. Bruniquel, F. Sery, and E. Nezry: "Optimal Bayesian texture estimation for speckle filtering of detected and polarimetric data". Proceedings of IGARSS'97 Symposium, 1997.

Nezry E., A. Lopes, and F. Yakam-Simen. "Prior scene knowledge for the Bayesian restoration of mono and multi-channel SAR images". Proceedings of IGARSS'97 Symposium, 1997.

Nezry E. and F. Yakam Simen: "Control systems principles applied to speckle filtering and geophysical information extraction ion multi-channel SAR images". Proceedings of IGARSS'97 Symposium, 1997.

Nezry E., F. Zagolsky, F. Yakam-Simen, and I. Supit: "Control systems principles applied to speckle filtering and to the retrieval of soil physical parameters through ERS and Radarsat-1 SAR data fusion", 1998.

E. Nezry and F. Yakam Simen: "New distribution-entropy Maximum A Posteriori speckle filters for detected, complex, and polarimetric SAR data". Proceedings of IGARSS'99 Symposium, 1999.

Nezry E. and F. Yakam Simen: "A family of distribution-entropy MAP speckle filters for polarimetric SAR data, and for single or multi-channel detected and complex SAR images". Proceedings of the CEOS SAR Workshop, ESA SP-450, 1999.

1.4.2.1.2 Single Look Complex Gaussian Gamma MAP

Purpose

Single Look Complex data can be filtered using any of the following procedures:

- SLC Gaussian DE MAP.
- Gaussian Gamma MAP.
- Gaussian DE MAP.

Optimal results can be achieved by selecting the appropriate filter depending on the land morphology and scene texture, this last to be considered also in relationship with the data spatial resolution. The availability of a multi-temporal series is also a condition to consider when choosing the most appropriate filter.

Technical Note

Gaussian Gamma MAP
It is suitable for separate SLC's (for example series of N SLC SAR images acquired with same viewing geometry) in the presence of regular texture and moderate relief. The result is a speckle filtered, and possibly multi-looked, Intensity image where the pixel values are a weighted average of the N individual acquisitions.

Input Files

Input File List
Input file names of Single Look Complex (_slc) data. These files are mandatory.

Parameters - Principal Parameters

Window Size in Azimuth and Range

Filter window size (square or rectangular). The signal samples to be used for the computation of the local statistics are collected within a neighborhood where the autocorrelation function of the radar reflectivity is significant, in order to avoid taking samples within areas of a different nature than the pixel under process. In practice, this means that signal samples will not be collected farther than a certain distance - the decorrelation length - from the pixel under process. For SLC data, this distance rarely exceeds more than 12 pixels in azimuth and 4 pixels in range, i.e. it is useless to use a window size larger than 31 x 9 (azimuth/range) pixels. In theory a processing window size of 25 x 9 (azimuth/range) pixels is sufficient; in practice, with new sensors, a window size of 7 x 7 is sufficient.

Equivalent Number of Looks (ENL)

The Equivalent Number of Looks is equivalent to the number of independent Intensity values averaged per pixel during the multi-looking process. This parameter can be easily estimated over a homogeneous (stationary) sample in the input Intensity data according to:

$$ENL = mean^2 / standard\ deviation^2$$

In case that ENL is not set, the Number of Looks (NL) used during the multi-looking process is considered.

Note that, to tune the strength of speckle filtering and the level of preservation of scene details, it is preferable to adjust the value of the ENL, rather than to change the size of the processing window:

- To reduce the strength of speckle filtering, with the aim to preserve the thinnest details of the scene, enter a ENL value slightly higher than the calculated one;
- Inversely, to improve the filtering of the speckle (possibly at the cost of the thinnest details of the scene), enter a ENL value slightly lower than the calculated one.

Azimuth Looks

The azimuth multi-looking factor can be entered only if Gaussian Gamma MAP or Gaussian DE-MAP filters are selected.

Range Looks

The range multi-looking factor can be entered only if Gaussian Gamma MAP or Gaussian DE-MAP filters are selected.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output File List
Output file names of the filtered (possibly multi-looked) Intensity data. These files are mandatory.

_fil
Filtered data and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Lopes A., E. Nezry, R. Touzi, and H. Laur: "Structure detection and statistical adaptive speckle filtering in SAR images". International Journal of Remote Sensing, Vol. 14, 1993.

E. Nezry, M. Leysen, and G. De Grandi: "Speckle and scene spatial statistical estimators for SAR image filtering and texture analysis: some applications to agriculture, forestry, and point targets detection".

Proceedings of SPE, Vol. 2584, 1995.

Lopes A., J. Bruniquel, F. Sery, and E. Nezry: "Optimal Bayesian texture estimation for speckle filtering of detected and polarimetric data". Proceedings of IGARSS'97 Symposium, 1997.

Nezry E., A. Lopes, and F. Yakam-Simen. "Prior scene knowledge for the Bayesian restoration of mono and multi-channel SAR images". Proceedings of IGARSS'97 Symposium, 1997.

Nezry E. and F. Yakam Simen: "Control systems principles applied to speckle filtering and geophysical information extraction ion multi-channel SAR images". Proceedings of IGARSS'97 Symposium, 1997.

Nezry E., F. Zagolsky, F. Yakam-Simen, and I. Supit: "Control systems principles applied to speckle filtering and to the retrieval of soil physical parameters through ERS and Radarsat-1 SAR data fusion", 1998.

E. Nezry and F. Yakam Simen: "New distribution-entropy Maximum A Posteriori speckle filters for detected, complex, and polarimetric SAR data". Proceedings of IGARSS'99 Symposium, 1999.

Nezry E. and F. Yakam Simen: "A family of distribution-entropy MAP speckle filters for polarimetric SAR data, and for single or multi-channel detected and complex SAR images". Proceedings of the CEOS SAR Workshop, ESA SP-450, 1999.

1.4.2.1.3 Single Look Complex SLC Gaussian DE MAP

Purpose

Single Look Complex data can be filtered using any of the following procedures:

- SLC Gaussian DE MAP.
- Gaussian Gamma MAP.
- Gaussian DE MAP.

Optimal results can be achieved by selecting the appropriate filter depending on the land morphology and scene texture, this last to be considered also in relationship with the data spatial resolution. The availability of a multi-temporal series is also a condition to consider when choosing the most appropriate filter.

Technical Note

SLC Gaussian Distribution-Entropy MAP (SLC Gaussian DE MAP)
It is the appropriate speckle filter in the case of a single date Single-Look Complex (SLC) SAR image. The

result is a speckle filtered Single Look Intensity image.

Input Files

Input File List
Input file names of Single Look Complex (_slc) data. These files are mandatory.

Parameters - Principal Parameters

Window Size in Azimuth and Range
Filter window size (square or rectangular). The signal samples to be used for the computation of the local statistics are collected within a neighborhood where the autocorrelation function of the radar reflectivity is significant, in order to avoid taking samples within areas of a different nature than the pixel under process. In practice, this means that signal samples will not be collected farther than a certain distance - the decorrelation length - from the pixel under process. For SLC data, this distance rarely exceeds more than 12 pixels in azimuth and 4 pixels in range, i.e. it is useless to use a window size larger than 31 x 9 (azimuth/range) pixels. In theory a processing window size of 25 x 9 (azimuth/range) pixels is sufficient; in practice, with new sensors, a window size of 7 x 7 is sufficient.

Equivalent Number of Looks (ENL)
The Equivalent Number of Looks is equivalent to the number of independent Intensity values averaged per pixel during the multi-looking process. This parameter can be easily estimated over a homogeneous (stationary) sample in the input Intensity data according to:

$$ENL = mean^2 / standard\ deviation^2$$

In case that ENL is not set, the Number of Looks (NL) used during the multi-looking process is considered.

Note that, to tune the strength of speckle filtering and the level of preservation of scene details, it is preferable to adjust the value of the ENL, rather than to change the size of the processing window:

- To reduce the strength of speckle filtering, with the aim to preserve the thinnest details of the scene, enter a ENL value slightly higher than the calculated one;
- Inversely, to improve the filtering of the speckle (possibly at the cost of the thinnest details of the scene), enter a ENL value slightly lower than the calculated one.

Azimuth Looks
The azimuth multi-looking factor can be entered only if Gaussian Gamma MAP or Gaussian DE-MAP filters are selected.

Range Looks
The range multi-looking factor can be entered only if Gaussian Gamma MAP or Gaussian DE-MAP filters are selected.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output File List
Output file names of the filtered (possibly multi-looked) Intensity data. These files are mandatory.

_fil
Filtered data and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Lopes A., E. Nezry, R. Touzi, and H. Laur: "Structure detection and statistical adaptive speckle filtering in SAR images". International Journal of Remote Sensing, Vol. 14, 1993.

E. Nezry, M. Leysen, and G. De Grandi: "Speckle and scene spatial statistical estimators for SAR image filtering and texture analysis: some applications to agriculture, forestry, and point targets detection". Proceedings of SPE, Vol. 2584, 1995.

Lopes A., J. Bruniquel, F. Sery, and E. Nezry: "Optimal Bayesian texture estimation for speckle filtering of detected and polarimetric data". Proceedings of IGARSS'97 Symposium, 1997.

Nezry E., A. Lopes, and F. Yakam-Simen. "Prior scene knowledge for the Bayesian restoration of mono and multi-channel SAR images". Proceedings of IGARSS'97 Symposium, 1997.

Nezry E. and F. Yakam Simen: "Control systems principles applied to speckle filtering and geophysical information extraction ion multi-channel SAR images". Proceedings of IGARSS'97 Symposium, 1997.

Nezry E., F. Zagolsky, F. Yakam-Simen, and I. Supit: "Control systems principles applied to speckle filtering and to the retrieval of soil physical parameters through ERS and Radarsat-1 SAR data fusion", 1998.

E. Nezry and F. Yakam Simen: "New distribution-entropy Maximum A Posteriori speckle filters for detected, complex, and polarimetric SAR data". Proceedings of IGARSS'99 Symposium, 1999.

Nezry E. and F. Yakam Simen: "A family of distribution-entropy MAP speckle filters for polarimetric SAR data, and for single or multi-channel detected and complex SAR images". Proceedings of the CEOS SAR Workshop, ESA SP-450, 1999.

1.4.2.2 Single Channel Detected

Section Content

1.4.2.2.1 Single Channel Detected Gamma APM Filtering

Purpose

Single channel Intensity data can be filtered using any of the following procedures:

- Gamma MAP.
- Gamma DE MAP.
- Gamma APM.

Optimal results can be achieved by selecting the appropriate filter depending on the land morphology and scene texture, this last to be considered also in relationship with the data spatial resolution.

Technical Note

Gamma A Posteriori Mean (Gamma APM)
The scene texture is statistically modeled at the first order by a Gamma distribution. What differs from the Gamma MAP filter is the kind of Bayesian estimation technique: instead of a Maximum A Posteriori estimate, this filter provides an A Posteriori Mean estimate. This last estimate is radiometrically unbiased, and has the Minimum Mean Square Error of all Bayesian estimators. Therefore, this filter restores the radar reflectivity with a better accuracy, but is slightly worse to preserve the textural contrast; it has to be adopted if the final aim is to invert a physical model (e.g. soil moisture, soil roughness, biomass, etc.).

Input Files

Input File List
Input file names of Intensity (_pwr or _rsp) data. These files are mandatory.

Parameters - Principal Parameters

Equivalent Number of Looks (ENL)
The Equivalent Number of Looks is equivalent to the number of independent Intensity values averaged per pixel during the multi-looking process. This parameter can be easily estimated over a homogeneous (stationary) sample in the input Intensity data according to:

$$ENL = mean^2 / standard\ deviation^2$$

In case that ENL is not set, the Number of Looks (NL) used during the multi-looking process is considered.

Note that, to tune the strength of speckle filtering and the level of preservation of scene details, it is preferable to adjust the value of the ENL, rather than to change the size of the processing window:

- To reduce the strength of speckle filtering, with the aim to preserve the thinnest details of the scene, enter a ENL value slightly higher than the calculated one;

- Inversely, to improve the filtering of the speckle (possibly at the cost of the thinnest details of the scene...), enter a ENL value slightly lower than the calculated one.

Window Size
Filter window size. The signal samples to be used for the computation of the local statistics are collected within a neighborhood where the autocorrelation function of the radar reflectivity is meaningful, in order to avoid taking samples within areas of a different nature than the pixel under process. In practice, this means that signal samples will not be collected farther than a certain distance - the de-correlation length - from the pixel under process. For 3/4-looks satellite images this distance rarely exceeds more than 4 pixels in both azimuth and range, i.e. it is useless to use a window size larger than 9 x 9 pixels (5 x 5 in case of very high resolution multi look data).

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output File List
Output file names of filtered Intensity data. These files are mandatory.

_fil
Filtered data and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close

The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Lopes A., E. Nezry, R. Touzi, and H. Laur: "Structure detection and statistical adaptive speckle filtering in SAR images". International Journal of Remote Sensing, Vol. 14, 1993.

E. Nezry, M. Leysen, and G. De Grandi: "Speckle and scene spatial statistical estimators for SAR image filtering and texture analysis: some applications to agriculture, forestry, and point targets detection". Proceedings of SPE, Vol. 2584, 1995.

Lopes A., J. Bruniquel, F. Sery, and E. Nezry: "Optimal Bayesian texture estimation for speckle filtering of detected and polarimetric data". Proceedings of IGARSS'97 Symposium, 1997.

Nezry E., A. Lopes, and F. Yakam-Simen: "Prior scene knowledge for the Bayesian restoration of mono and multi-channel SAR images". Proceedings of IGARSS'97 Symposium, 1997.

Nezry E., F. Zagolsky, F. Yakam-Simen, and I. Supit: "Control systems principles applied to speckle filtering and to the retrieval of soil physical parameters through ERS and Radarsat-1 SAR data fusion", 1998.

E. Nezry and F. Yakam Simen: "New distribution-entropy Maximum A Posteriori speckle filters for detected, complex, and polarimetric SAR data". Proceedings of IGARSS'99 Symposium, 1999.

Nezry E. and F. Yakam Simen: "A family of distribution-entropy MAP speckle filters for polarimetric SAR data, and for single or multi-channel detected and complex SAR images". Proceedings of the CEOS SAR Workshop, ESA SP-450, 1999.

1.4.2.2.2 Single Channel Detected Gamma MAP Filtering

Purpose

Single channel Intensity data can be filtered using any of the following procedures:

- Gamma MAP.
- Gamma DE MAP.
- Gamma APM.

Optimal results can be achieved by selecting the appropriate filter depending on the land morphology and scene texture, this last to be considered also in relationship with the data spatial resolution.

Technical Note

Gamma MAP

The scene texture is statistically modelled at the first order by a Gamma distribution. The validity of this hypothesis is today widely recognized in the case of natural vegetated areas such as agriculture fields and natural forests located over flat terrain or gentle slopes. In such conditions, the filter restores Gamma distributed scene texture very close to the original. Nevertheless, this hypothesis becomes questionable and reaches its limitations in the presence of mixed textures or very strong relief.

Input Files

Input File List

Input file names of Intensity (_pwr or _rsp) data. These files are mandatory.

Parameters - Principal Parameters

Equivalent Number of Looks (ENL)

The Equivalent Number of Looks is equivalent to the number of independent Intensity values averaged per pixel during the multi-looking process. This parameter can be easily estimated over a homogeneous (stationary) sample in the input Intensity data according to:

$$ENL = mean^2 / standard\ deviation^2$$

In case that ENL is not set, the Number of Looks (NL) used during the multi-looking process is considered.

Note that, to tune the strength of speckle filtering and the level of preservation of scene details, it is preferable to adjust the value of the ENL, rather than to change the size of the processing window:

- To reduce the strength of speckle filtering, with the aim to preserve the thinnest details of the scene, enter a ENL value slightly higher than the calculated one;
- Inversely, to improve the filtering of the speckle (possibly at the cost of the thinnest details of the scene...), enter a ENL value slightly lower than the calculated one.

Window Size

Filter window size. The signal samples to be used for the computation of the local statistics are collected within a neighborhood where the autocorrelation function of the radar reflectivity is meaningful, in order to avoid taking samples within areas of a different nature than the pixel under process. In practice, this means that signal samples will not be collected farther than a certain distance - the de-correlation length - from the pixel under process. For 3/4-looks satellite images this distance rarely exceeds more than 4 pixels in both azimuth and range, i.e. it is useless to use a window size larger than 9 x 9 pixels (5 x 5 in case of very high resolution multi look data).

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output File List
Output file names of filtered Intensity data. These files are mandatory.

_fil
Filtered data and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Lopes A., E. Nezry, R. Touzi, and H. Laur: "Structure detection and statistical adaptive speckle filtering in SAR images". International Journal of Remote Sensing, Vol. 14, 1993.

E. Nezry, M. Leysen, and G. De Grandi: "Speckle and scene spatial statistical estimators for SAR image filtering and texture analysis: some applications to agriculture, forestry, and point targets detection". Proceedings of SPE, Vol. 2584, 1995.

Lopes A., J. Bruniquel, F. Sery, and E. Nezry: "Optimal Bayesian texture estimation for speckle filtering of detected and polarimetric data". Proceedings of IGARSS'97 Symposium, 1997.

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E. Nezry and F. Yakam Simen: "New distribution-entropy Maximum A Posteriori speckle filters for detected, complex, and polarimetric SAR data". Proceedings of IGARSS'99 Symposium, 1999.

Nezry E. and F. Yakam Simen: "A family of distribution-entropy MAP speckle filters for polarimetric SAR data, and for single or multi-channel detected and complex SAR images". Proceedings of the CEOS SAR Workshop, ESA SP-450, 1999.

1.4.2.2.3 Single Channel Detected Gamma DE MAP Filtering

Purpose

Single channel Intensity data can be filtered using any of the following procedures:

- Gamma MAP.
- Gamma DE MAP.
- Gamma APM.

Optimal results can be achieved by selecting the appropriate filter depending on the land morphology and scene texture, this last to be considered also in relationship with the data spatial resolution.

Technical Note

Gamma Distribution-Entropy MAP (Gamma DE-MAP)

The first order statistical properties of the local scene texture are estimated from the local first order statistical properties of the SAR image de-convoluted from the SAR impulse response, using a Maximum Entropy technique. In this way, the restoration of the local textural properties of the scene does not depend on any assumption regarding the form of its statistical distribution. Although this restoration process is slightly less accurate than with the Gamma MAP filter over natural vegetated areas located on flat terrain, it gives superior results in areas exhibiting mixed textures (i.e. mixed forests imaged at high and very high spatial resolution) or in presence of strong relief.

Input Files

Input File List

Input file names of Intensity (_pwr or _rsp) data. These files are mandatory.

Parameters - Principal Parameters

Equivalent Number of Looks (ENL)

The Equivalent Number of Looks is equivalent to the number of independent Intensity values averaged per pixel during the multi-looking process. This parameter can be easily estimated over a homogeneous (stationary) sample in the input Intensity data according to:

$$ENL = mean^2 / standard\ deviation^2$$

In case that ENL is not set, the Number of Looks (NL) used during the multi-looking process is considered.

Note that, to tune the strength of speckle filtering and the level of preservation of scene details, it is preferable to adjust the value of the ENL, rather than to change the size of the processing window:

- To reduce the strength of speckle filtering, with the aim to preserve the thinnest details of the scene, enter a ENL value slightly higher than the calculated one;
- Inversely, to improve the filtering of the speckle (possibly at the cost of the thinnest details of the scene...), enter a ENL value slightly lower than the calculated one.

Window Size

Filter window size. The signal samples to be used for the computation of the local statistics are collected within a neighborhood where the autocorrelation function of the radar reflectivity is meaningful, in order to avoid taking samples within areas of a different nature than the pixel under process. In practice, this means that signal samples will not be collected farther than a certain distance - the de-correlation length - from the pixel under process. For 3/4-looks satellite images this distance rarely exceeds more than 4 pixels in both azimuth and range, i.e. it is useless to use a window size larger than 9 x 9 pixels (5 x 5 in case of very high resolution multi look data).

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output File List
Output file names of filtered Intensity data. These files are mandatory.

_fil
Filtered data and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Lopes A., E. Nezry, R. Touzi, and H. Laur: "Structure detection and statistical adaptive speckle filtering in SAR images". International Journal of Remote Sensing, Vol. 14, 1993.

E. Nezry, M. Leysen, and G. De Grandi: "Speckle and scene spatial statistical estimators for SAR image filtering and texture analysis: some applications to agriculture, forestry, and point targets detection". Proceedings of SPE, Vol. 2584, 1995.

Lopes A., J. Bruniquel, F. Sery, and E. Nezry: "Optimal Bayesian texture estimation for speckle filtering of detected and polarimetric data". Proceedings of IGARSS'97 Symposium, 1997.

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E. Nezry and F. Yakam Simen: "New distribution-entropy Maximum A Posteriori speckle filters for detected, complex, and polarimetric SAR data". Proceedings of IGARSS'99 Symposium, 1999.

Nezry E. and F. Yakam Simen: "A family of distribution-entropy MAP speckle filters for polarimetric SAR data, and for single or multi-channel detected and complex SAR images". Proceedings of the CEOS SAR Workshop, ESA SP-450, 1999.

1.4.2.3 Multi Channel Detected

Section Content

1.4.2.3.1 Multi Channel Detected Gamma Gaussian MAP

Purpose

Multi channel Intensity data can be filtered using any of the following procedures:

- Gamma Gaussian MAP (for uncorrelated speckle).
- Gaussian Gaussian MAP (for correlated speckle).
- Gaussian DE MAP (for correlated speckle).

Optimal results can be achieved by selecting the appropriate filter depending on the land morphology and scene texture, this last to be considered also in relationship with the data spatial resolution.

Technical Note

Gamma Gaussian MAP
The speckle in every individual image of a multi-channel Intensity SAR dataset is statistically modeled at the first order by a Gamma distribution, which is an exact representation. Nevertheless, note that this representation does not account for an eventual correlation of the speckle between the individual SAR images of the dataset. This filter is applicable to sets of either single-look (1-look), or multi-look Intensity images. The scene texture is statistically modeled at the first order by a multivariate Gaussian distribution. This hypothesis, though an approximation, is still acceptable in the case of natural vegetated areas such as agriculture fields and natural forests located over flat terrain or gentle slopes. In such conditions, the filter restores Gaussian distributed scene texture very close to the original. Nevertheless, this hypothesis becomes questionable and reaches its limitations in the presence of mixed textures or very strong relief.

The input data must be previously coregistered 121.

Input Files

Input File List
Input file names of Intensity images (_pwr, _rsp). These files are mandatory.

Parameters - Principal Parameters

Window Size
Filter window size. The signal samples to be used for the computation of the local statistics are collected within a neighborhood where the autocorrelation function of the radar reflectivity is significant, in order to avoid taking samples within areas of a different nature than the pixel under process. In practice, this means that signal samples will not be collected farther than a certain distance - the decorrelation length - from the pixel under process. For 3/4-looks satellite images this distance rarely exceeds more than 4 pixels in both azimuth and range, i.e. it is useless to use a window size larger than 9 x 9 pixels.

Equivalent Number of Looks (ENL)
The Equivalent Number of Looks is equivalent to the number of independent Intensity values averaged per pixel during the multi-looking process. This parameter can be easily estimated over a homogeneous (stationary) sample in the input Intensity data according to:

$$ENL = mean^2 / standard\ deviation^2$$

In case that ENL is not set, the Number of Looks (NL) used during the multi-looking process is considered.

Note that, to tune the strength of speckle filtering and the level of preservation of scene details, it is preferable to adjust the value of the ENL, rather than to change the size of the processing window:

- To reduce the strength of speckle filtering, with the aim to preserve the thinnest details of the scene, enter a ENL value slightly higher than the calculated one;
- Inversely, to improve the filtering of the speckle (possibly at the cost of the thinnest details of the scene...), enter a ENL value slightly lower than the calculated one.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output files
Output file names of filtered Intensity data. These files are mandatory.

_fil
Filtered data and associated header files (.sml, .hdr).

_meta
This file allows to load the specific processing results.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Lopes A., E. Nezry, R. Touzi, and H. Laur: "Structure detection and statistical adaptive speckle filtering in SAR images". International Journal of Remote Sensing, Vol. 14, 1993.

E. Nezry, M. Leysen, and G. De Grandi: "Speckle and scene spatial statistical estimators for SAR image filtering and texture analysis: some applications to agriculture, forestry, and point targets detection". Proceedings of SPE, Vol. 2584, 1995.

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Nezry E., F. Zagolsky, F. Yakam-Simen, and I. Supit: "Control systems principles applied to speckle filtering and to the retrieval of soil physical parameters through ERS and Radarsat-1 SAR data fusion", 1998.

E. Nezry and F. Yakam Simen: "New distribution-entropy Maximum A Posteriori speckle filters for detected, complex, and polarimetric SAR data". Proceedings of IGARSS'99 Symposium, 1999.

Nezry E. and F. Yakam Simen: "A family of distribution-entropy MAP speckle filters for polarimetric SAR data, and for single or multi-channel detected and complex SAR images". Proceedings of the CEOS SAR

Workshop, ESA SP-450, 1999.

Nezry E., F. Zagolsky, F. Yakam-Simen, and I. Supit: "Control systems principles applied to speckle filtering and to the retrieval of soil physical parameters through ERS and Radarsat-1 SAR data fusion", 1998.

1.4.2.3.2 Multi Channel Detected Gaussian Gaussian MAP

Purpose

Multi channel Intensity data can be filtered using any of the following procedures:

- Gamma Gaussian MAP (for uncorrelated speckle).
- Gaussian Gaussian MAP (for correlated speckle).
- Gaussian DE MAP (for correlated speckle).

Optimal results can be achieved by selecting the appropriate filter depending on the land morphology and scene texture, this last to be considered also in relationship with the data spatial resolution.

Technical Note

Gaussian Gaussian MAP
The speckle of a multi-channel Intensity dataset is statistically modeled at the first order by a multivariate (real) Gaussian distribution, which is an approximate representation, this is typically suitable for SAR datasets made of multi-look images. Therefore, this filter is not suggested for speckle filtering in multi-channel datasets of single-look detected SAR images. This statistical representation of the speckle enables to take into account the correlation of speckle between the individual Intensity images (i.e. repeat-pass, tandem, and in general interferometric SAR datasets) in order to achieve a better speckle filtering and a better restoration of the thin details (e.g. structure detection). The statistical modeling applied here becomes questionable and reaches its limitations in the presence of mixed textures or very strong relief.

The input data must be previously coregistered 121.

Input Files

Input File List
Input file names of Intensity images (_pwr, _rsp). These files are mandatory.

Parameters - Principal Parameters

Window Size
Filter window size. The signal samples to be used for the computation of the local statistics are collected within a neighborhood where the autocorrelation function of the radar reflectivity is significant, in order to avoid taking samples within areas of a different nature than the pixel under process. In practice, this means that signal samples will not be collected farther than a certain distance - the decorrelation length - from the pixel under process. For 3/4-looks satellite images this distance rarely exceeds more than 4 pixels in both azimuth and range, i.e. it is useless to use a window size larger than 9 x 9 pixels.

Equivalent Number of Looks (ENL)
The Equivalent Number of Looks is equivalent to the number of independent Intensity values averaged per pixel during the multi-looking process. This parameter can be easily estimated over a homogeneous (stationary) sample in the input Intensity data according to:

$$ENL = mean^2 / standard\ deviation^2$$

In case that ENL is not set, the Number of Looks (NL) used during the multi-looking process is considered.

Note that, to tune the strength of speckle filtering and the level of preservation of scene details, it is preferable to adjust the value of the ENL, rather than to change the size of the processing window:

- To reduce the strength of speckle filtering, with the aim to preserve the thinnest details of the scene, enter a ENL value slightly higher than the calculated one;
- Inversely, to improve the filtering of the speckle (possibly at the cost of the thinnest details of the scene...), enter a ENL value slightly lower than the calculated one.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output files
Output file names of filtered Intensity data. These files are mandatory.

_fil
Filtered data and associated header files (.sml, .hdr).

_meta
This file allows to load the specific processing results.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Lopes A., E. Nezry, R. Touzi, and H. Laur: "Structure detection and statistical adaptive speckle filtering in SAR images". International Journal of Remote Sensing, Vol. 14, 1993.

E. Nezry, M. Leysen, and G. De Grandi: "Speckle and scene spatial statistical estimators for SAR image filtering and texture analysis: some applications to agriculture, forestry, and point targets detection". Proceedings of SPE, Vol. 2584, 1995.

Lopes A., J. Bruniquel, F. Sery, and E. Nezry: "Optimal Bayesian texture estimation for speckle filtering of detected and polarimetric data". Proceedings of IGARSS'97 Symposium, 1997.

Nezry E., A. Lopes, and F. Yakam-Simen. "Prior scene knowledge for the Bayesian restoration of mono and multi-channel SAR images". Proceedings of IGARSS'97 Symposium, 1997.

Nezry E. and F. Yakam Simen: "Control systems principles applied to speckle filtering and geophysical information extraction ion multi-channel SAR images". Proceedings of IGARSS'97 Symposium, 1997.

Nezry E., F. Zagolsky, F. Yakam-Simen, and I. Supit: "Control systems principles applied to speckle filtering and to the retrieval of soil physical parameters through ERS and Radarsat-1 SAR data fusion", 1998.

E. Nezry and F. Yakam Simen: "New distribution-entropy Maximum A Posteriori speckle filters for detected, complex, and polarimetric SAR data". Proceedings of IGARSS'99 Symposium, 1999.

Nezry E. and F. Yakam Simen: "A family of distribution-entropy MAP speckle filters for polarimetric SAR data, and for single or multi-channel detected and complex SAR images". Proceedings of the CEOS SAR Workshop, ESA SP-450, 1999.

Nezry E., F. Zagolsky, F. Yakam-Simen, and I. Supit: "Control systems principles applied to speckle filtering and to the retrieval of soil physical parameters through ERS and Radarsat-1 SAR data fusion", 1998.

1.4.2.3.3 Multi Channel Detected Gaussian DE MAP

Purpose

Multi channel Intensity data can be filtered using any of the following procedures:

- Gamma Gaussian MAP (for uncorrelated speckle).
- Gaussian Gaussian MAP (for correlated speckle).
- Gaussian DE MAP (for correlated speckle).

Optimal results can be achieved by selecting the appropriate filter depending on the land morphology and scene texture, this last to be considered also in relationship with the data spatial resolution.

Technical Note

Gaussian Distribution-Entropy MAP (Gaussian DE MAP)
The speckle of a multi-channel Intensity dataset is statistically modeled at the first order by a multivariate (real) Gaussian distribution, which is an approximate representation, valid only for SAR datasets made of multi-look images. This filter is not suitable for speckle filtering in multi-channel datasets of single-look detected SAR images. This statistical representation of the speckle enables to take into account the correlation of speckle between the individual Intensity images (i.e. repeat-pass, tandem, and in general interferometric SAR datasets) in order to achieve a better speckle filtering and a better restoration of the thin details. Differently from the Gaussian Gaussian MAP, the first order statistical properties of the local scene texture are estimated from the local first order statistical properties of the SAR image de-convoluted from the SAR impulse response, using a Maximum Entropy technique. In this way, the restoration of the local textural properties of the scene does not depend on any assumption regarding the

shape of its statistical distribution. Although this restoration process is slightly less accurate than with the Gamma Gaussian MAP or the Gaussian Gaussian MAP filters over natural vegetated areas on gently slope terrain, it gives superior results in areas exhibiting mixed textures (i.e. mixed forests imaged at high spatial resolution) or over strong relief or artificial targets (especially with very high resolution data).

The input data must be previously coregistered 121.

Input Files

Input File List
Input file names of Intensity images (_pwr, _rsp). These files are mandatory.

Parameters - Principal Parameters

Window Size
Filter window size. The signal samples to be used for the computation of the local statistics are collected within a neighborhood where the autocorrelation function of the radar reflectivity is significant, in order to avoid taking samples within areas of a different nature than the pixel under process. In practice, this means that signal samples will not be collected farther than a certain distance - the decorrelation length - from the pixel under process. For 3/4-looks satellite images this distance rarely exceeds more than 4 pixels in both azimuth and range, i.e. it is useless to use a window size larger than 9 x 9 pixels.

Equivalent Number of Looks (ENL)
The Equivalent Number of Looks is equivalent to the number of independent Intensity values averaged per pixel during the multi-looking process. This parameter can be easily estimated over a homogeneous (stationary) sample in the input Intensity data according to:

$$ENL = mean^2 / standard\ deviation^2$$

In case that ENL is not set, the Number of Looks (NL) used during the multi-looking process is considered.

Note that, to tune the strength of speckle filtering and the level of preservation of scene details, it is preferable to adjust the value of the ENL, rather than to change the size of the processing window:

- To reduce the strength of speckle filtering, with the aim to preserve the thinnest details of the scene, enter a ENL value slightly higher than the calculated one;
- Inversely, to improve the filtering of the speckle (possibly at the cost of the thinnest details of the scene...), enter a ENL value slightly lower than the calculated one.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output files
Output file names of filtered Intensity data. These files are mandatory.

_fil
Filtered data and associated header files (.sml, .hdr).

_meta
This file allows to load the specific processing results.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Lopes A., E. Nezry, R. Touzi, and H. Laur: "Structure detection and statistical adaptive speckle filtering in

SAR images". International Journal of Remote Sensing, Vol. 14, 1993.

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1.4.2.4 Polarimetric

Section Content

1.4.2.4.1 Polarimetric Wishart Gamma MAP

Purpose

Polarimetric data can be filtered using any of the following procedures:

- Wishart Gamma MAP.
- Wishart DE MAP.

Optimal results can be achieved by selecting the appropriate filter depending on the land morphology and scene texture, this last to be considered also in relationship with the data spatial resolution.

Technical Note

Wishart Gamma MAP
It is suitable for fully polarimetric (single-look or multi-look, complex) SAR data. It is best performing in presence of regular texture and moderate relief. The filter operates under the assumption (verified in practice for the vast majority of SAR scenes) of target reciprocity (i.e. HV=VH). The output speckle filtered Polarimetric Vector (or equivalently Covariance Matrix) contains all the polarimetric information required for further computation of phase differences, degrees of coherence, polarimetric synthesis, polarimetric indices, etc., all of them resulting speckle filtered.

Input Files

Input HH File
Input file name of Single Look Complex (_slc) data for the HH channel. This file is mandatory.

Input VV File
Input file name of Single Look Complex (_slc) data for the VV channel. This file is mandatory.

Input HV VH File
Input file name of Single Look Complex (_slc) data for either the HV or VH channel. This file is mandatory.

Parameters - Principal Parameters

Window Size in Azimuth and Range
Filter window size (use of square windows is suggested). The signal samples to be used for the computation of the local statistics are collected within a neighborhood where the autocorrelation function of the radar reflectivity is meaningful, in order to avoid taking samples within areas of a different nature than the pixel under process. In practice, this means that signal samples will not be collected farther than a certain distance - the de-correlation length - from the pixel under process.

Equivalent Number of Looks (ENL)

The Equivalent Number of Looks is equivalent to the number of independent Intensity values averaged per pixel during the multi-looking process. This parameter can be easily estimated over a homogeneous (stationary) sample in in the input Intensity data according to:

$$ENL = mean^2 / standard\ deviation^2$$

In case that ENL is not set, the Number of Looks (NL) used during the multi-looking process is considered.

Note that, to tune the strength of speckle filtering and the level of preservation of scene details, it is preferable to adjust the value of the ENL, rather than to change the size of the processing window:

- To reduce the strength of speckle filtering, with the aim to preserve the thinnest details of the scene, enter a ENL value slightly higher than the calculated one.
- Inversely, to improve the filtering of the speckle (possibly at the cost of the thinnest details of the scene...), enter a ENL value slightly lower than the calculated one.

Span Equivalent Looks
The equivalent number of looks of the Span image (HH+VV+2·HV) is usually set as two times the ENL.

Azimuth Looks
Azimuth number of looks for the output products.

Range Looks
Azimuth number of looks for the output products.

Grid Size for Suggested Looks
The grid size, in meters, used to tune range and azimuth looks. If the other parameters are manually set, the grid size will not imply a change in their values.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output HH File

Output file name of the filtered (possibly multi-looked) Intensity data for the HH channel. This file is mandatory.

Output VV File
Output file name of the filtered (possibly multi-looked) Intensity data for the VV channel. This file is mandatory.

Output HV VH File
Output file name of the filtered (possibly multi-looked) Intensity data for eithe the HV or the VH channel. This file is mandatory.

_fil
Filtered data (HH, VV, and HV or VH) and associated header files (.sml, .hdr).

_fil_polv_...
Filtered Polarimetric Vector / Polarimetric Covariance Matrix and associated header files (.sml, .hdr). These are:
- Shh.Shh*
- Svv.Svv*
- Shv.Shv*
- Re{Shh.Svv*}
- Im{Shh.Svv*}
- Re{Shh.Shv*}
- Im{Shh.Shv*}
- Re{Svv.Shv*}
- Im{Svv.Shv*}

_slc_span
Filtered "Span" image - where Span = (HH+VV+2·HV) - and associated header files (.sml, .hdr).

_rgb.tif
Multi polarization RGB composite - where HH, HV and VV are respectively in Red, Green and Blue - and corresponding header file (.sml).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch

processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

A. Lopes, S. Goze and E. Nezry: "Polarimetric speckle filters for SAR data". Proceedings of IGARSS'92 Symposium, 1992.

Lopes A., E. Nezry, R. Touzi, and H. Laur: "Structure detection and statistical adaptive speckle filtering in SAR images". International Journal of Remote Sensing, Vol. 14, 1993.

E. Nezry, M. Leysen, and G. De Grandi: "Speckle and scene spatial statistical estimators for SAR image filtering and texture analysis: some applications to agriculture, forestry, and point targets detection". Proceedings of SPE, Vol. 2584, 1995.

Lopes A., J. Bruniquel, F. Sery, and E. Nezry: "Optimal Bayesian texture estimation for speckle filtering of detected and polarimetric data". Proceedings of IGARSS’97 Symposium, 1997.

E. Nezry and F. Yakam Simen: "New distribution-entropy Maximum A Posteriori speckle filters for detected, complex, and polarimetric SAR data". Proceedings of IGARSS'99 Symposium, 1999.

Nezry E. and F. Yakam Simen: "A family of distribution-entropy MAP speckle filters for polarimetric SAR data, and for single or multi-channel detected and complex SAR images". Proceedings of the CEOS SAR Workshop, ESA SP-450, 1999.

Nezry E., F. Yakam Simen, F. Zagolsky, and I. Supit: "On the preservation of polarimetric signatures and polarimetric texture signatures by fully polarimetric MAP filters". Proceedings of IGARSS’99 Symposium, 1999.

1.4.2.4.2 Polarimetric Wishart Gamma DE MAP

Purpose

Polarimetric data can be filtered using any of the following procedures:

- Wishart Gamma MAP.
- Wishart DE MAP.

Optimal results can be achieved by selecting the appropriate filter depending on the land morphology and scene texture, this last to be considered also in relationship with the data spatial resolution.

Technical Note

Wishart Distribution-Entropy MAP (Wishart DE MAP)
It is suitable for fully polarimetric (single-look or multi-look, complex) SAR data. It is best performing in presence of strong mixed texture or strong relief. The filter operates under the assumption (verified in practice for the vast majority of SAR scenes) of target reciprocity (i.e. HV=VH). The output speckle filtered Polarimetric Vector (or equivalently Covariance Matrix) contains all the polarimetric information required for further computation of phase differences, degrees of coherence, polarimetric synthesis, polarimetric indices, etc., all of them resulting speckle filtered.

Input Files

Input HH File
Input file name of Single Look Complex (_slc) data for the HH channel. This file is mandatory.

Input VV File
Input file name of Single Look Complex (_slc) data for the VV channel. This file is mandatory.

Input HV VH File
Input file name of Single Look Complex (_slc) data for either the HV or VH channel. This file is mandatory.

Parameters - Principal Parameters

Window Size in Azimuth and Range
Filter window size (use of square windows is suggested). The signal samples to be used for the computation of the local statistics are collected within a neighborhood where the autocorrelation function of the radar reflectivity is meaningful, in order to avoid taking samples within areas of a different nature than the pixel under process. In practice, this means that signal samples will not be collected farther than a certain distance - the de-correlation length - from the pixel under process.

Equivalent Number of Looks (ENL)

The Equivalent Number of Looks is equivalent to the number of independent Intensity values averaged per pixel during the multi-looking process. This parameter can be easily estimated over a homogeneous (stationary) sample in in the input Intensity data according to:

$$ENL = mean^2 / standard\ deviation^2$$

In case that ENL is not set, the Number of Looks (NL) used during the multi-looking process is considered.

Note that, to tune the strength of speckle filtering and the level of preservation of scene details, it is preferable to adjust the value of the ENL, rather than to change the size of the processing window:

- To reduce the strength of speckle filtering, with the aim to preserve the thinnest details of the scene, enter a ENL value slightly higher than the calculated one.
- Inversely, to improve the filtering of the speckle (possibly at the cost of the thinnest details of the scene...), enter a ENL value slightly lower than the calculated one.

Span Equivalent Looks
The equivalent number of looks of the Span image (HH+VV+2·HV) is usually set as two times the ENL.

Azimuth Looks
Azimuth number of looks for the output products.

Range Looks
Azimuth number of looks for the output products.

Grid Size for Suggested Looks
The grid size, in meters, used to tune range and azimuth looks. If the other parameters are manually set, the grid size will not imply a change in their values.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output HH File

Output file name of the filtered (possibly multi-looked) Intensity data for the HH channel. This file is mandatory.

Output VV File
Output file name of the filtered (possibly multi-looked) Intensity data for the VV channel. This file is mandatory.

Output HV VH File
Output file name of the filtered (possibly multi-looked) Intensity data for eithe the HV or the VH channel. This file is mandatory.

_fil
Filtered data (HH, VV, and HV or VH) and associated header files (.sml, .hdr).

_fil_polv_...
Filtered Polarimetric Vector / Polarimetric Covariance Matrix and associated header files (.sml, .hdr). These are:
- Shh.Shh*
- Svv.Svv*
- Shv.Shv*
- Re{Shh.Svv*}
- Im{Shh.Svv*}
- Re{Shh.Shv*}
- Im{Shh.Shv*}
- Re{Svv.Shv*}
- Im{Svv.Shv*}

_slc_span
Filtered "Span" image - where Span = (HH+VV+2·HV) - and associated header files (.sml, .hdr).

_rgb.tif
Multi polarization RGB composite - where HH, HV and VV are respectively in Red, Green and Blue - and corresponding header file (.sml).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch

processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

A. Lopes, S. Goze and E. Nezry: "Polarimetric speckle filters for SAR data". Proceedings of IGARSS'92 Symposium, 1992.

Lopes A., E. Nezry, R. Touzi, and H. Laur: "Structure detection and statistical adaptive speckle filtering in SAR images". International Journal of Remote Sensing, Vol. 14, 1993.

E. Nezry, M. Leysen, and G. De Grandi: "Speckle and scene spatial statistical estimators for SAR image filtering and texture analysis: some applications to agriculture, forestry, and point targets detection". Proceedings of SPE, Vol. 2584, 1995.

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1.5 Focusing Module

Section Content

1.5.1 Overview

A Note on the Focusing module

This module provides the functionalities to process Synthetic Aperture Radar (SAR) data, in RAW format, acquired by the following spaceborne sensors: ERS-1/2, JERS-1, ENVISAT ASAR and ALOS PALSAR.

In the RAW data, the SAR signal energy reflected from one single point is spread along both azimuth and range direction; the purpose of SAR focussing is to collect this dispersed energy into a single pixel. This process, which involves a complex mathematical procedure, consists of:

- Data compression in range direction, where the transmitted chirp (pulse) is compressed in one range bin, while the echoes are spread along the azimuth direction.
- Data compression in azimuth direction, where all the energy backscattered by one single resolution cell on ground is compressed in one pixel.

The focusing process is carried out, by means of an ω-k processor, to obtain Single Look Complex data (SLC) where the signal Intensity is related to the ground electromagnetic reflectivity, while the phase is related to the acquisition geometry and to the ground topography.

Note that:

- Single Look Complex data generated with this module are not appropriate to derive absolutely radiometric calibrated values.
- The multitemporal combination (e.g. Persistent Scatterers module, multi-temporal filtering, etc.) of single look, ground range or geocoded SARscape products - coming from original Level 0 (i.e. RAW data) and Level 1 (i.e. SLC or Ground Range data) standard products - cannot be done due to not comparable digital numbers between.

Note that:

- Default setting for selected parameters can be specified in the Preferences panel.
- The SAR Tutorial, which includes basic knowledge on SAR theory and data processing,

complements the online help.

Technical Note

The ω-k processor, first developed by F. Rocca [1], [2], [3], represents the porting to Synthetic Aperture RADAR systems of the wavenumber-domain migration, an algorithm in use in the geophysics community since early 80's. It was R. Stolt in 78 [4], who derived a close form expression of a frequency domain interpolation scheme, namely "Stolt Interpolation", that allows the implementation of quite a simple focusing scheme that exploits a couple of 2D Fast Fourier Transform (FFT). Thanks to the Solt interpolation, a complicated space-varying performed by a simple, cost less, and quite efficient Fourier based, "Fast Convolution". The technique accuracy, due to the exactness of the transfer function, and at the same time its simplicity (just some 100 lines of C++ code), make the Stolt Interpolation based ω-k algorithm, one of the best candidates for SAR processing. Stolt migration has been applied for wavelength ranging from tenths of meters in geophysics, down to millimetres. Its capability to process data acquired within aperture from 0 to 89 deg. [5] makes it appealing for Ultra Wide Aperture (UWA) systems [6], [7], whereas its (theoretically) infinite depth of focusing makes it suited for Ultra Wide Band (UWB) systems, [7], [8], [9],[10]. Furthermore, it has been shown that the ω-k algorithm is quite suited to integrate a motion compensation scheme (when the sensor orbit is no longer straight) [11], [12], [13], and to be adapted to bistatic survey [9], [14], [15], [16]. The algorithm is naturally suited to process different kind of SAR acquisitions: from STRIPMAP [1], [17], [18], [19] to SPOTLIGHT [20] [21] and SCANSAR [22],[23]. Compared to the Range-Doppler algorithm, the ω-k is more efficient as it is a full 2D FFT approach (being an FFT based-approach, the gain in efficiency reduces as the impulse response becomes short, like for low resolution SARs), and has not the strong limitation in bandwidth and antenna aperture, as it does not involve approximations. Compared to other wave-number domain algorithms, like the Chirp-Scaling approach, the ω-k attains similar computational complexity, yet being simpler in its formulation (hence, to be implemented) and - at the same time – involving no approximations on antenna aperture and resolution [18]. That is the reason why the processor is preferred for high resolution or high aperture SARs. Compared to other exact wave-number domain algorithm, like the Exact Transfer Function [18], [24]. That is the reason the list of groups that proposed variant of the ω-k algorithm is large including, besides Politecnico di Milano and Politecnico di Bari [1], [2], [3], DLR (Germany) [25], [18], CNR-IREA (Italy) [17], Defence Research Establishment (FOA, Sweden), [8], University of British Columbia (UBC, Canada) [19], State University of New York [9], [26], Georgia Institute of Technology, [7], JRC (Ispra, Italy) [27], University of Illinois at Urbana [6], [5], Research Establishment for Applied Science (FGAN, Germany)[16]), etc.

It may occur that azimuth ambiguities, ghosts or similar image artifacts (especially visible in azimuth direction) are reported. These problems are generally more visible where the signal is very low (i.e. over water bodies).
These effect are typically related to variations in the SAR instrument performance, which are quite normal during the satellite life. The configuration of the focusing algorithm, which is designed in a way to obtain the best signal resolution by exploiting - in azimuth - the largest available bandwidth, depends on specific parameters which are different depending on sensor and acquisition mode (they are stored in the "description_files" folder of the SARscape installation directory). The sarmap technical team continuously

adapts these parameters upon known antenna performance variations; however, in case of any unexpected image artifact, users are kindly asked to contact us and provide relevant data samples in order to optimize the focusing performance.

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1.5.2 Frequently Asked Questions

Q. - Why focussed data are sometime affected by **Linear Disturbances and Local Artifacts**?

A. - In some data sets, the presence of scalloping - radiometry anomalies periodically distributed in azimuth direction - or the presence of azimuth ambiguities, ghosts or similar image artifacts can be reported due to discrepancies between the focusing configuration setting and the SAR antenna parameters. The configuration of the focusing algorithm, which is designed in a way to obtain the best signal resolution by exploiting - in azimuth - the largest available bandwidth, depends on specific parameters which are different depending on sensor and acquisition mode; these parameters are stored in sensor-specific files (SARscape installation directory>description_files folder). The sarmap technical team continuously adapts these parameters upon known antenna performance variations; however, in case such artifacts were reported, users are kindly asked to contact us and provide relevant data samples in order to optimize the software performance.

Q. - How do **SARscape Focusing Algorithms Compare to Data Provider Algorithms**? When it can be better to buy preprocessed data (i.e. SLC products) and when it is better to focus the data using SARscape?

A. - The quality of the focussed data strongly varies from data provider to data provider. Generally speaking, the SARscape focusing module does a very good job in preserving the phase information; thus for interferometric analysis it could be better to start from RAW data.

On the other hand "standard" SLC products, which are directly generated by official providers, enable a better absolute calibration 142 of the amplitude data. The absolute calibration carried out in SARscape is indeed not reliable if the processing starts from RAW data, due to the fact that the program does not take into account the update of several important parameters such as antenna gain, calibration constant and others.

Q. - The **Interferometric Processing** requires SLC products? Is the use of the Focusing module mandatory for the generation of these products?

A. - The Single Look Complex data to use as input in the SARscape Interferometric processing chain (e.g. Interferometry Module 250, Interferometric Stacking Module 474, ScanSAR Interferometry Module 554) can be either ordered as standard SLC product and then imported as such into SARscape or ordered as RAW product and then focussed using the dedicated SArscape module. It must be mentioned that not all original raw data are supported by SARscape.

1.5.3 Reference Guide

1.5.3.1 ALOS PALSAR Import and Focusing

Purpose

SAR RAW data (level 1.0 product) acquired by ALOS PALSAR must be focused to generate Single Look Complex (SLC) data, which can be used as first input for data processing in any other SARscape module.

Technical Note

PALSAR RAW data in CEOS standard format are required.

The supported acquisition modes are:

- PLR (Full Polarization mode). JAXA and ERSDAC data formats are both supported.
- FBD (Dual Polarization mode). JAXA and ERSDAC data formats are both supported.
- FBS (Single Polarization mode). JAXA and ERSDAC data formats are both supported.

ERSDAC data are supported as frame based or orbit-segment based (i.e. long) products.

It must be noted that Single Look Complex data, focused with this module, are generated with zero-Doppler annotation. Single Look Complex data provided by JAXA are generated with non zero-Doppler annotation.

Input Files

Input Leader file
File name of the original leader data (prefix "LED" for JAXA products; suffix "ldr" for ERSDAC products). This file is mandatory.

Input Co-Polar
File name of the original PALSAR RAW data. Depending on the chosen Data Type, the input has to be modified accordingly. It is mandatory to give either HH or VV data as input in the JAXA case. In the ERSDAC case, the mandatory input is the "raw" file only.

Input Cross-Polar
File name of the original PALSAR RAW data. Depending on the chosen Data Type, the input has to be modified accordingly. It is mandatory to give either HV or VH data as input in the JAXA case.

File name of the original PALSAR RAW data. Depending on the data provider, the following data structure can be found:

- JAXA products - The number of data files (prefix "IMG") may vary from 1 (single polarization) to 4 (full polarization).
- ERSDAC products - One data file (suffix "raw"), which contains 1 or more polarizations, is provided.

When dual or full polarization JAXA products are used, it is suggested to enter the HH polarization as Input Data file; this is because the Doppler Centroid is better estimated in the HH polarization.

These files are mandatory.

Parameters - Principal Parameters

Data Type
Specify the satellite/sensor relevant to the data to import.

Rename The File Using Parameters
If set, only relevant information will be copied from the input name(s) to the output name(s), the full root name otherwise.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file
Output file name of the focused data. In case of multi-polarization data, a suffix corresponding to the specific polarization is added to the name of each output file. This file is mandatory.

_slc
Zero-Doppler annotated Single Look Complex data and corresponding header files (.sml, .hdr).

.shp
Shape file containing the image perimeter in geographic co-ordinates.

.kml
ASCII file containing the image perimeter in geographic co-ordinates. Double clicking on this file will automatically position the boundaries of the scene into the Google Earth environment.

SARscapeParameterExtracted
Temporary processing parameters.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Refer to the module overview 215.

1.5.3.2 ENVISAT

Section Content

1.5.3.2.1 ENVISAT ASAR AP Import and Focusing

Purpose

SAR RAW data (level 0 product) acquired by ENVISAT ASAR must be focused to generate Single Look Complex (SLC) data, which can be used as first input for data processing in any other module.
This module supports ASAR Alternating Polarization (AP) acquisition mode data.

Technical Note

ENVISAT ASAR RAW (level 0) ESA standard format is required. The level 0 filename is formatted as ASA_AP_0*, where AP stands for Alternating Polarization.

The output product consists of Single Look Complex data.

DORIS
DORIS (Doppler Orbitography and Radiopositioning Integrated by Satellite) data provide precise orbital information for ENVISAT ASAR. Two versions of DORIS data are available:

- The VOR (Verified ORbits) are the most precise ones, but they are made available not earlier than one month after the actual satellite acquisition.
- The POR (Precise ORbits) are slightly less precise than the VOR, but they are made available together with the ASAR data.

Access to DORIS data is provided by the ESA Earth Observation Help Desk.

If the relevant DORIS files are already stored in an existing folder, which has been defined as DORIS Directory 757, they do not have to be inputted in the import processing panel since they are automatically retrieved by the program.

It is important to note that a notable amount of disk space is required for temporary files to be stored during the focusing process (this is especially true for ScanSAR data).

Technical details relevant to the data focusing process and algorithm are provided in the module overview 215.

Input Files

Input File
File name of the original ASAR raw data. This file is mandatory.

Optional Files

Input Orbit File
File name of the DORIS data. This file is optional.

Parameters - Principal Parameters

None.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

Image Portion to Process (%)
It is possible to focus only part of the input data. In this case the selected image portion is identified in terms of percentage from the top (**Perc of Image Start**) to the bottom (**Perc of Image End**) of the scene.

Output Files

Output file
Output file name of the focused data. A suffix corresponding to the specific polarization is added to the name of each output file. This file is mandatory.

_slc
Zero-Doppler annotated Single Look Complex data and corresponding header files (.sml, .hdr).

.shp
Shape file containing the image perimeter in geographic co-ordinates.

.kml
ASCII file containing the image perimeter in geographic co-ordinates. Double clicking on this file will automatically position the boundaries of the scene into the Google Earth environment.

SARscapeParameterExtracted
Temporary processing parameters.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser [802] button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Refer to the module overview [215].

1.5.3.2.2 ENVISAT ASAR WS Import and Focusing

Purpose

SAR RAW data (level 0 product) acquired by ENVISAT ASAR must be focused to generate Single Look Complex (SLC) data, which can be used as first input for data processing in any other module.
This module supports ASAR Wide Swath (WS) acquisition mode data.

Technical Note

ENVISAT ASAR RAW (level 0) ESA standard format is required. The level 0 filename is formatted as ASA_WS_0*, where WS stands for Wide Swath.

The output products consist of both Single Look Complex and multi-looked Intensity data. Since the swath of each ScanSAR acquisition is made of five different sub-swath, then five SLC output data (each corresponding to a sub-swath) are generated.

The output multi-looked Intensity contains all five sub-swaths in the same image. The multi-looking factors are automatically set to 3 looks in Azimuth and 5 looks in range. The product is in Slant Range geometry with ground pixel spacing of about 72 m in Range and 81 m in Azimuth. They are generated taking care of bursts overlapping, timings, swath overlapping, swath amplitude difference and swath PRF difference.

DORIS
DORIS (Doppler Orbitography and Radiopositioning Integrated by Satellite) data provide precise orbital information for ENVISAT ASAR. Two versions of DORIS data are available:

- The VOR (Verified ORbits) are the most precise ones, but they are made available not earlier than one month after the actual satellite acquisition.
- The POR (Precise ORbits) are slightly less precise than the VOR, but they are made available together with the ASAR data.

Access to DORIS data is provided by the ESA Earth Observation Help Desk.

If the relevant DORIS files are already stored in an existing folder, which has been defined as DORIS Directory 757, they do not have to be inputted in the import processing panel since they are automatically retrieved by the program.

It is important to note that a notable amount of disk space is required for temporary files to be stored during the focusing process (this is especially true for ScanSAR data). As an indication, focusing an ASAR WS full frame requires almost 10 GBytes of free disk space.

Technical details relevant to the data focusing process and algorithm are provided in the module overview 215.

Input Files

Input File
File name of the original ASAR raw data. This file is mandatory.

Optional Files

Input Orbit File
File name of the DORIS data. This file is mandatory.

Parameters - Principal Parameters

None.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

Image Portion to Process (%)
It is possible to focus only part of the input data. In this case the selected image portion is identified in terms of percentage from the top (**Perc of Image Start**) to the bottom (**Perc of Image End**) of the scene.

Output Files

Output file
Output file name of the focused data. An incremental number, ranging from 1 to 5, is added to the output filename for every focused sub-swath image. This file is mandatory.

_slc
Zero-Doppler annotated Single Look Complex data and corresponding header files (.sml, .hdr).

_pwr
Multi-looked slant range Intensity image and associated header files (.sml, .hdr). These files are generated only for ASAR_WS products.

_pwr_orb.sml
Xml file containing the scene orbital parameters. This file is generated only for ASAR_WS products.

.shp
Shape file containing the image perimeter in geographic co-ordinates.

.kml
ASCII file containing the image perimeter in geographic co-ordinates. Double clicking on this file will automatically position the boundaries of the scene into the Google Earth environment.

SARscapeParameterExtracted
Temporary processing parameters.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Refer to the module overview 215.

1.5.3.2.3 ENVISAT ASAR IM Import and Focusing

Purpose

SAR RAW data (level 0 product) acquired by ENVISAT ASAR must be focused to generate Single Look Complex (SLC) data, which can be used as first input for data processing in any other module.
This module supports ASAR Image Mode (IM) acquisition mode data.

Technical Note

ENVISAT ASAR RAW (level 0) ESA standard format is required. The level 0 filename is formatted as ASA_IM_0*, where IM stands for Image Mode.

The output product consists of Single Look Complex data.

DORIS
DORIS (Doppler Orbitography and Radiopositioning Integrated by Satellite) data provide precise orbital information for ENVISAT ASAR. Two versions of DORIS data are available:

- The VOR (Verified ORbits) are the most precise ones, but they are made available not earlier than one month after the actual satellite acquisition.

- The POR (Precise ORbits) are slightly less precise than the VOR, but they are made available together with the ASAR data.

Access to DORIS data is provided by the ESA Earth Observation Help Desk.

If the relevant DORIS files are already stored in an existing folder, which has been defined as DORIS Directory 757, they do not have to be inputted in the import processing panel since they are automatically retrieved by the program.

It is important to note that a notable amount of disk space is required for temporary files to be stored during the focusing process (this is especially true for ScanSAR data).

Technical details relevant to the data focusing process and algorithm are provided in the module overview 215.

Input Files

Input File List
File name(s) of the original ASAR raw data. These files are mandatory.

Optional Input Orbit File List
File name(s) of the DORIS data. These files are optional.

Parameters - Principal Parameters

Rename the File Using Parameters
If set, only relevant information will be copied from the input name(s) to the output name(s), the full root name otherwise.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output File List
Output file name(s) of the focused data. These files are mandatory.

_slc
Zero-Doppler annotated Single Look Complex data and corresponding header files (.sml, .hdr).

.shp
Shape file containing the image perimeter in geographic co-ordinates.

.kml
ASCII file containing the image perimeter in geographic co-ordinates. Double clicking on this file will automatically position the boundaries of the scene into the Google Earth environment.

SARscapeParameterExtracted
Temporary processing parameters.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Refer to the module overview 215.

1.5.3.2.4 ENVISAT Import Mosaic and Focusing

Purpose

SAR RAW data (level 0 product) acquired by ENVISAT ASAR must be focused to generate Single Look Complex (SLC) data, which can be used as first input for data processing in any other module. This functionality enables to mosaic consecutive frames acquired along the same satellite orbit, before carrying on the data focusing.

The supported acquisition mode is:

- ASAR IM (Image mode).

Technical Note

ENVISAT ASAR IM (level 0) ESA standard format is required.

The following sequential processing steps are performed:

1. Data Import.
2. RAW data mosaic.
3. Data focusing.

DORIS

DORIS (Doppler Orbitography and Radiopositioning Integrated by Satellite) data provide precise orbital information for ENVISAT ASAR. Two versions of DORIS data are available:

- The VOR (Verified ORbits) are the most precise ones, but they are made available not earlier than one month after the actual satellite acquisition.
- The POR (Precise ORbits) are slightly less precise than the VOR, but they are made available together with the ASAR data.

Access to DORIS data is provided by the ESA Earth Observation Help Desk.

If the relevant DORIS files are already stored in an existing folder, which has been defined as DORIS Directory 757, they do not have to be inputted in the import processing panel since they are automatically retrieved by the program.

Technical details relevant to the data focusing process and algorithm are provided in the module overview 215.

Input Files

Input DORIS file
File name of the DORIS data. This file is mandatory.

Input file list
Input file list of ASAR raw data. This file is mandatory.

Parameters - Principal Parameters

None.

Parameters - Global

It brings to the general section of the Preferences759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file
Output file name of the mosaiced and focused data. This file is mandatory.

_slc
Single Look Complex data and corresponding header files (.sml, .hdr).

_par.sml
Xml file containing temporary processing parameters.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Refer to the module overview 215.

1.5.3.3 ERS-JERS

Section Content

1.5.3.3.1 ERS, JERS-1 Import and Focusing

Purpose

SAR RAW data (level 0 product) acquired by ERS-1/2 and JERS-1, must be focused to generate Single Look Complex (SLC) data, which can be used as first input for data processing in any other module.

Technical Note

Input data in CEOS format, or in ENVISAT format for ERS data, are required. The output product consist of Single Look Complex image.

Technical details relevant to the data focusing process and algorithm are provided in the module overview 215.

Orbit File 725
These data (precise "PRC" or preliminary "PRL" orbits), which are made available through the DLR ftp server, provide precise orbital information for ERS-1/2 acquisitions.

Access to these data can be required to the ESA Earth Observation Help Desk. The precise orbital data, which are typically available in Zip format, must be unzipped before they are entered as processing input. The file name refers to the start date/orbit validity.

If the relevant precise orbit files are already stored in an existing folder, which has been defined as PRC/PRL Directory 757, they do not have to be inputted in the focusing processing panel since they are automatically retrieved by the program.

Input Files

Input Data File List
File name(s) of the original ERS data file(s). Depending on the input data, the following file prefixes are used:

- JERS-1 Prefix "IMOP".
- ERS Prefix "DAT".

these files are mandatory.

Optional Input Orbit File List
This file – if available – is intended to enter precise orbital information; it can be entered only importing ERS-1/2 data. This file is optional for data in CEOS format, while it is mandatory for data in ENVISAT format.

Parameters - Principal Parameters

Data Type
Specify the satellite/sensor relevant to the data to import.

Rename The File Using Parameters
If set, only relevant information will be copied from the input name(s) to the output name(s), the full root name otherwise.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and

stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output File List
Output file name(s) of the Single Look Complex data. These files are mandatory.

_slc
Zero-Doppler annotated Single Look Complex data and corresponding header files (.sml, .hdr).

_par.sml
Xml file containing temporary processing parameters.

SARscapeParameterExtracted
Temporary processing parameters.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Refer to the module overview 215.

1.5.3.3.2 ERS Import Mosaic and Focusing

Purpose

SAR RAW data (level 0 product) acquired by ERS-1/2 must be focused to generate Single Look Complex (SLC) data, which can be used as first input for data processing in any other module. This functionality enables to mosaic consecutive frames acquired along the same satellite orbit, before carrying on the data focusing.

Technical Note

Input data in CEOS format or in ENVISAT format are both supported.

The following sequential processing steps are performed:

1. Data Import.
2. RAW data mosaic.
3. Data focusing.

Technical details relevant to the data focusing process and algorithm are provided in the module overview 215.

Orbit File 725

These data (precise "PRC" or preliminary "PRL" orbits), which are made available through the DLR ftp server, provide precise orbital information for ERS-1/2 acquisitions.

Access to these data can be required to the ESA Earth Observation Help Desk. The precise orbital data, which are typically available in Zip format, must be unzipped before they are entered as processing input. The file name refers to the start date/orbit validity.

If the relevant precise orbit files are already stored in an existing folder, which has been defined as PRC/PRL Directory 757, they do not have to be inputted in the focusing processing panel since they are automatically retrieved by the program.

Input Files

Input Orbit File
This file is intended to enter precise orbital information. This file is mandatory.

Input File list
Input file list of ERS raw data. This file is mandatory.

Parameters - Principal Parameters

None.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output File
Output file name of the Single Look Complex data. This file is mandatory.

_slc
Single Look Complex data and corresponding header files (.sml, .hdr).

_par.sml
Xml file containing temporary processing parameters.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser[802] button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Refer to the module overview[215].

1.5.3.4 Generic Focusing

Purpose

SAR RAW data (level 0 product) must be focused to generate Single Look Complex (SLC) data, which can be used as input in any other SARscape module.

This functionality is intended for those raw products, which are different from the standard ones supported in the previous (i.e. sensor specific) focusing routines.

Technical Note

The input data must be provided in the SARscape specific format, which is described here below.

The binary file must have the following structure:

line 1 prefix	I11	Q11	...	I1n	Q1n
line 2 prefix	I21	Q21	...	I2n	Q2n
...	...	...	...	...	...
...	...	...	...	...	...
line m prefix	Im1	Qm1	...	Imn	Qmn

where **I*lc*** (*l* and *c* standing respectively for line and column) is the unsigned byte Real part of a pixel; **Q*lc*** is the unsigned byte Imaginary part of a pixel; **n** is the number of pixels in range (columns); **m** is the number of pixels in azimuth (lines).

For each line, the prefix is:

0	1	...	lcp	lcp+1	lcp+2	lcp+3	...	rp - 1
nu	nu	...	lc1	lc2	lc3	lc4	...	nu

Where **rp** is the line prefix length (in bytes), as annotated in the "RowPrefix" field of the associated .sml file 240 (xml format); **nu** corresponds to those bytes, which are not used; ***lcp*** (*l* and *c* standing respectively for line and column) is the position inside the line prefix of the Line Counter, as annotated in the in the "LineCounterFirstBytePos" field of the .sml file.

The Line Counter is stored, as unsigned long integer, with MSBF byte order:
lc1 = most significant byte of line counter
lc2 = second significant byte of line counter
lc3 = third significant byte of line counter
lc4 = less significant byte of line counter

Input Files

Input file
Input raw data. This file is mandatory.

Parameters - Principal Parameters

None.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file
Output Single Look Complex data. This file is mandatory.

_slc
Single Look Complex data and corresponding header files (.sml, .hdr).

_par.sml
Xml file containing temporary processing parameters.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.5.3.4.1 Example of the sml file


```
<?xml version="1.0" ?>
<HEADER_INFO xmlns="http://www.sarmap.ch/xml/SARscapeHeaderSchema"
            xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
            xsi:schemaLocation="http://www.sarmap.ch/xml/SARscapeHeaderSchema
            http://www.sarmap.ch/xml/SARscapeHeaderSchema/
SARscapeHeaderSchema_version_1.0.xsd">

  <!-- Registration Coordinates Information -->
```

```xml
<RegistrationCoordinates>
  <LatNorthing>47.183</LatNorthing>   <!-- Latitude coordinate of center of scene  -->
  <LonEasting>7.155</LonEasting>      <!-- Longitude coordinate of center of scene  -->
  <Units>DEGREES</Units>              <!-- Data units degrees  -->
</RegistrationCoordinates>

 <!-- Channel Information -->

<ChannelInfo>
  <!-- Carrier Frequency in Hertz  -->
  <CarrierFrequency>
    <VectorDouble NumberOfElements = "1">
      <ValueDouble ID = "0">5299999744</ValueDouble>
    </VectorDouble>
  </CarrierFrequency>

  <!-- Band Width in Hertz   -->
  <BandWidth>
    <VectorDouble NumberOfElements = "1">
      <ValueDouble ID = "0">15550000</ValueDouble>
    </VectorDouble>
  </BandWidth>

  <!-- Pulse Repetition Frequency (pulse / seconds)    -->
  <PRF>
    <VectorDouble NumberOfElements = "1">
      <ValueDouble ID = "0">1679.90640187183</ValueDouble>
    </VectorDouble>
  </PRF>


  <!-- Pulse Repetition Frequency (pulse / seconds)    -->
  <PRFExtracted>
    <VectorDouble NumberOfElements = "1">
      <ValueDouble ID = "0">1679.902</ValueDouble>
    </VectorDouble>
  </PRFExtracted>

  <!--  Chirp Pulse Duration (seconds)    -->
  <PulseDuration>
    <VectorDouble NumberOfElements = "1">
      <ValueDouble ID = "0">3.712e-005</ValueDouble>
    </VectorDouble>
  </PulseDuration>

  <!--  SamplingRate = Light speed /(2 * PixelSpacingRg)    -->
  <SamplingRate>
    <VectorDouble NumberOfElements = "1">
      <ValueDouble ID = "0">18962468</ValueDouble>
    </VectorDouble>
  </SamplingRate>

  <!-- Polarization : HH or HV or VH or VV    -->
```

```
      <Description>
        <VectorString NumberOfElements = "1">
          <ValueString ID = "0">VV</ValueString>
        </VectorString>
      </Description>

      <Polarization>VV</Polarization>    <!-- Polarization : HH or HV or VH or VV    -->
      <RangeLookAngle>29.5330009460449</RangeLookAngle>   <!-- Look Angle of center of scene
(degree)    -->
      <IncidenceAngle>33.6545219421387</IncidenceAngle>   <!-- Incidence Angle of center of scene
(degree)    -->

           <!--
                                                                  The following 4 parameters contain the
Antenna Gain Pattern
                                                                  Calibrated with AGP correction  =
Calibrated value / AGP value
      -->

          <GeneralFirstReferenceLookAngle>24.5330009460449</GeneralFirstReferenceLookAngle>  <!--
 The Look Angle connected to the first value of AGP array            :
GeneralTwoWayAntennaElevationPatternTable  -->
    <GeneralLastReferenceLookAngle>34.5330009460449</GeneralLastReferenceLookAngle>     <!-- The
Look Angle connected to the last value of AGP array         :
GeneralTwoWayAntennaElevationPatternTable  -->
    <GeneralTwoWayAntennaElevationPatternTableNbr>201</
GeneralTwoWayAntennaElevationPatternTableNbr>   <!-- Number of elements in  AGP array           :
GeneralTwoWayAntennaElevationPatternTable  -->

  <!-- Antenna Gain Pattern array in dB Optional not used in focussing  -->
          <GeneralTwoWayAntennaElevationPatternTable>
        <VectorDouble NumberOfElements = "201">
          <ValueDouble ID = "0">-24.0000991821289</ValueDouble>
          <ValueDouble ID = "1">-23.2440700531006</ValueDouble>
          <ValueDouble ID = "2">-22.467529296875</ValueDouble>
          <ValueDouble ID = "3">-21.6739501953125</ValueDouble>
          <ValueDouble ID = "4">-20.8668594360352</ValueDouble>
          <ValueDouble ID = "5">-20.0497608184814</ValueDouble>
          <ValueDouble ID = "6">-19.2261505126953</ValueDouble>
          <ValueDouble ID = "7">-18.3995609283447</ValueDouble>
          <ValueDouble ID = "8">-17.5734596252441</ValueDouble>
          <ValueDouble ID = "9">-16.7513904571533</ValueDouble>
          <ValueDouble ID = "10">-15.9368295669556</ValueDouble>
          <ValueDouble ID = "11">-15.1308698654175</ValueDouble>
          <ValueDouble ID = "12">-14.3392000198364</ValueDouble>
          <ValueDouble ID = "13">-13.5681295394897</ValueDouble>
          <ValueDouble ID = "14">-12.8224000930786</ValueDouble>
          <ValueDouble ID = "15">-12.1051597595215</ValueDouble>
          <ValueDouble ID = "16">-11.4179601669312</ValueDouble>
          <ValueDouble ID = "17">-10.7608003616333</ValueDouble>
          <ValueDouble ID = "18">-10.1320400238037</ValueDouble>
          <ValueDouble ID = "19">-9.52851009368896</ValueDouble>
          <ValueDouble ID = "20">-8.94540023803711</ValueDouble>
```

<ValueDouble ID = "21">-8.38547992706299</ValueDouble>
<ValueDouble ID = "22">-7.84940004348755</ValueDouble>
<ValueDouble ID = "23">-7.33611011505127</ValueDouble>
<ValueDouble ID = "24">-6.84475994110107</ValueDouble>
<ValueDouble ID = "25">-6.37474012374878</ValueDouble>
<ValueDouble ID = "26">-5.92564010620117</ValueDouble>
<ValueDouble ID = "27">-5.49729013442993</ValueDouble>
<ValueDouble ID = "28">-5.08969020843506</ValueDouble>
<ValueDouble ID = "29">-4.70312023162842</ValueDouble>
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    <Spectrum>NORMAL</Spectrum>      <!--  Type of Spectrum  NORMAL or REVERSE -->
    <Baseband>YES</Baseband>         <!--  Baseband Flag                    -->
    <AzimuthAngle>90</AzimuthAngle>  <!--  Azimuth Look Angle 90 for Right looking and -90 for Left
Looking -->
    <SamplingMode>IQ</SamplingMode>  <!--  Sampling Mode.  IQ is suported -->
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image -->
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raster image (in this prefix is stored the progressive line counter) -->
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raster image  -->
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value must be always set to 0.0 -->
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LSBF : Least Significant Byte First -->

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         <!--   Two way satellite to near range time (s)       -->
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    <AzimuthStopTime>23-OCT-1995 10:22:26.186000</AzimuthStopTime>    <!--   Acquisition End
time UTC  example  "23-OCT-1995 10:22:26.186000"        -->

    <LineCounterFirstBytePos>210</LineCounterFirstBytePos>   <!--   Position of the firtst byte in row
prefix where is stored as 32 bit integer MSBF the progressive line number used to find the missing lines
(32)             -->
    <FromInImageAzimuthLooks>1</FromInImageAzimuthLooks><!--   This value must be always set to
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1                    -->
    <FromInImageRangeLooks>1</FromInImageRangeLooks>     <!--   This value must be always set to
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  <InitialGeometry>
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     <OrbitConfiguration>DESCENDING</OrbitConfiguration> <!-- "ASCENDING" or "DESCENDING"
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         <!--                                                     State Vector reference  TYPE

                                                          "ECR"    :  Earth Centered Rotating
WGS84
                                                          "IRS"    :   Inertial Referene System

                                                          "ECR_ITRF2000"    :  Earth Centered
Rotating ITRF 2000
          -->
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    <nStateVectors>5</nStateVectors> <!-- Number of State Vectors          -->
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"22-FEB-2009 07:05:47.522382"     -->
    <TimeDelta>4.167</TimeDelta> <!-- Time interval between one state  vector to the next one in
seconds             -->

          <!-- Vector of position coordinates in Reference System  -->
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          <!-- Vector of velocities coordinates in Reference system  -->
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1.6 Interferometry Module

Section Content

1.6.1 Overview

A Note on the Interferometry module

This module supports the processing of:

- Interferometric SAR data (2-pass Interferometry, InSAR) for the generation of Digital Elevation Model (DEM) and related coherence.
- Differential Interferometric SAR data (n-pass Interferometry, DInSAR) for the generation of Land Displacement maps and related coherence.

The following basic requirements have to be fulfilled in an interferometric pair (either for InSAR or DInSAR processing):

- Master and slave data must be acquired by the same sensor. Exception to this rule is for data acquired by ERS-1, ERS-2 and ENVISAT. Indeed these sensors can be combined together in the same pair.
- Master and slave data must be acquired with the same viewing geometry.
- In case of multi-polarization acquisitions, the same polarization must be selected as master and slave. It must be noted that it is possible to combine, in the same pair, a single polarization with a multi-polarization acquisition; for instance, in case of ALOS PALSAR data, we can make a pair using the HH channel of a Fine Beam Single (FBS) and the HH channel of a Fine Beam Dual (FBD).

Apart from the conditions mentioned above, other interferometry related parameters, such as the normal baseline and the doppler centroid difference, are suitable. These parameters, relevant to specific Interferometric pairs, are provided by the Baseline Estimation 451 functionality.

Assuming appropriate data pairs, the following processing sequences are proposed:

1. **Digital Elevation Model generation**, typically includes the following steps:

   – Flattened Interferogram Generation.

- Adaptive Filter and Coherence Generation.
- Phase Unwrapping.
- *Phase Editing* 470 *(if required)*.
- Refinement and Re-flattening.
- Phase to Height Conversion and Geocoding.

2. **Land Displacement Mapping**, typically includes the following steps:

- Flattened Interferogram Generation.
- Adaptive Filter and Coherence Generation.
- Phase Unwrapping.
- *Phase Editing* 470 *(if required)*.
- Refinement and Re-flattening.
- Phase to Displacement Conversion and Geocoding.

The following functions, included in this module, support any of the procedures above:

Baseline Estimation
Information related to baseline, orbital shift (in range and azimuth) and other system parameters are provided. The use of this optional functionality is exclusively to assess the InSAR pair quality. The baseline values for all possible master-slave combinations in a multi-temporal SAR acquisitions series can be extracted by using the Multi Baseline Calculation 454 (Interferometry Tools).

Interferogram Generation
A multi-looked flattened interferogram is generated together with the coregistered master and slave intensity data, the original unflattened interferogram, the synthetic phase and the slant range projected Digital Elevation Model.

Adaptive Filter and Coherence Generation
The phase noise in the flattened interferogram is filtered and the corresponding coherence is generated.

Phase Unwrapping
The flattened, filtered interferogram is unwrapped in order to solve the 2π ambiguity.

Refinement and Re-flattening
Possible inaccuracies in the satellite orbits as well as the phase offset are corrected.

Phase to Height Conversion and Geocoding
The Digital Elevation Model is generated.

Phase to Displacement Conversion and Geocoding
The Land Displacement Map is generated.

Note that:

- SAR data must be imported (see Basic module 32).
- In case of SAR RAW products, the data must be imported and focussed (refer to Focusing

module 215).

- Master and Slave acquisitions must remain in the same order throughout the whole interferometric processing.
- The sequence going from the Interferogram Generation to the Phase Unwrapping can be executed by means of a single "multi-step" interferometric workflow 293.
- Default setting for selected parameters can be specified in the Preferences panel.
- The SAR Tutorial, which includes basic knowledge on SAR theory and data processing, complements the online help.
- Data geocoded to GEO-GLOBAL cartographic reference system can be automatically displayed into the Google Earth environment by double clicking on the output .kml file.
- Co-ordinate decimal values must be entered using the dot (e.g. 29.30) and not the comma (e.g. 29,30) character.

References

InSAR Principles: Guidelines for SAR Interferometry Processing and Interpretation (ESA TM-19).

M. Richards: "A Beginner's Guide to Interferometric SAR Concepts and Signal Processing". IEEE Aerospace and Electronic, Vol. 22, No. 9, September 2007.

D. Small, P.Pasquali, and S.Fuglistaler: "A Comparison of Phase to Height Conversion Methods for SAR Interferometry". Proceedings of IGARSS 1996 – Lincoln, Nebraska – USA – 27-31 May 1996.

Gatelli F., A. Monti Guarnieri, F. Parizzi, P. Pasquali, C. Prati, F. Rocca, The Wavenumber Shift in SAR Interferometry, IEEE Transactions on Geoscience and Remote Sensing, Vol. 32, No. 4, 1994.

1.6.2 Frequently Asked Questions

Q. - The **Interferometric Processing** requires SLC products? Is the use of the Focusing module 215 mandatory for the generation of these products?

A. - The Single Look Complex data to use as input in the SARscape Interferometric processing chain (e.g. Interferometry Module 250, Interferometric Stacking Module 474, ScanSAR Interferometry Module 554) can be either ordered as standard SLC product and then imported as such into SARscape or ordered as RAW product and then focussed using the dedicated SArscape module. It must be mentioned that not all original raw data are supported by SARscape.

Q. - Can I do **Interferometry** using any SAR acquisition pair where the two images cover the same geographical area?

A. - In general master and slave data must be acquired by the same sensor, in the same acquisition mode, with the same viewing geometry (same satellite track, same incidence angle) and with the same signal polarization; limitations related to baseline and doppler centroid difference must also be taken into account for a proper interferometric pair selection. Exception to these rules are:

- Data acquired by ERS-1, ERS-2 and ENVISAT can be used in the same pair. In case of ENVISAT-ERS/2 pairs, it is mandatory to execute the Interferogram Generation 294 step by checking the flag "Coregistration with DEM"; it's worthwhile to mention that only pairs acquired during ESA dedicated ENVISAT-ERS/2 CInSAR tandem campaigns are suitable for interferometric processing.
- Two acquisitions with same polarization, coming from a single or multi-polarization data set, can be used in the same pair.
- ASAR Wide Swath 554 and Image Mode acquisitions can be used in the same pair.

Q. - Can I do **Interferometry** using SAR data acquired by different sensors?

A. - In general you cannot form an interferogram between data obtained from different platforms, with different central frequencies and many other different parameters (e.g. orbits -> baseline, height; bandwidth etc.). The spectrum of the terrain reflectivity for a distributed target is generally completely uncorrelated from one frequency to any other one (even with just few Hertz apart), so for the Spectral Shift frequency you cannot mix data obtained with different central frequency.

An exception is combining ERS-2 and ASAR data. Here the two sensors have 30MHz of difference between the two central frequencies. In principle you could not form a coherent interferogram between two images from the two sensors (flying with 30min separation on the same orbit) since their bandwidth is around 16MHz (smaller than the center frequency difference), hence beyond the limits of the spectral shift. Nevertheless, with a baseline of around 2 km (ESA did dedicated campaigns for that) and knowing the spectral shift, it is possible to compensate for this difference and obtain interesting interferograms.

Q. - Is it possible to run **Three or Four Pass Interferometry**?

A. - Two, Three or Four Pass Interferometry are possible approaches to perform Differential Interferometric processing. What is implemented in SARscape is based on the use of a reference Digital Elevation Model (if this is not available, the use of the ellipsoid reference is also supported) for subtracting the topography (or simply the flat earth) from the initial interferogram (_int). Depending on how the reference DEM has been generated (i.e. InSAR techniques or other sources) the program executes the 2-, 3-, or 4- pass Differential Interferometry approach.
The removal of the phase component due to the topography is needed in order to "isolate" the phase component due to the displacement.

Q. - How can I properly select a data set for the **Dual Pair Differential Interferometry** processing and how is it implemented?

A. - This module allows to provide as input two slaves and one or two masters (i.e. 3- or 4-pass approach respectively); the functionality allows to automatically perform all the steps from the interferogram generation to the phase unwrapping for the two pairs and, at the end, the program generates at once the Digital Elevation Model 314 and of the Displacement Map 320 from the two unwrapped interferograms by inverting a simple linear system (the concept is similar to that implemented in the SBAS 508 using a more robust approach, since the SBAS uses an over-determined system with many measures to make the estimation more accurate and reliable); all products are finally geocoded.

Concerning the "ideal" input dataset, it is represented by: i) a pair good for DEM generation (e.g. temporal separation as short as possible to get high coherence, no displacement between the two dates and baseline not too small to have good height sensitivity), which we can call the "DEM pair"; ii) a pair good for displacement detection (e.g. a co-seismic pair, with one acquisition before and one after an earthquake and possibly a quite small baseline), which we can call the "DInSAR pair". The functionality allows to select different possible models depending on the displacement type/dynamics: for instance the "linear model" is suitable to describe subsidence phenomena; the "step model" for acquisitions spanning an earthquake event; the "no model" configuration, where the first pair (used for the DEM generation) did not record any displacement which was vice versa captured by the second pair (used for the Displacement Map generation).

Q. - Is it possible to process data with the same polarization acquired in **Single and Multi-polarization Mode**?

A. - It is possible to combine, in the same interferometric pair, a single polarization with a multi-polarization acquisition; for instance, in case of ALOS PALSAR data, we can make a pair using the HH channel of a Fine Beam Single (FBS) and the HH channel of a Fine Beam Dual (FBD).

Q. - When working with **PALSAR FBD InSAR** pairs, what is the best polarization to use for DEM generation?

A. - In general, independently from the acquisition wavelength, it is better to use one of the two co-polarisations (HH or VV) and, between the two, the HH has usually a stronger backscatter and a better coherence.

Q. - What is the **Accuracy/Precision** achievable using InSAR techniques for Digital Elevation Modeling?

A. - The accuracy (in terms of interferometric phase reliability/quality) depends essentially on the coherence of the InSAR data pair. The accuracy (intended as DEM precision/resolution) will be driven by several factors, among which the most important are:

- Pixel spacing (the smaller the better precision in x and y direction).
- Height of ambiguity (the smaller the better precision in z direction), which depends mostly on acquisition baseline and wavelength. A reasonably good result is to generate a DEM with a precision (in the height estimate) between 1/10 and 1/20 of the 2π ambiguity.

Q. - The height figures provided with the final Digital Elevation Model are **Absolute or Relative Values**?

A. - They are absolute elevation values. It has to be pointed out that the final output DEM will be referred to the ellipsoid if the reference (i.e. input DEM), was provided with ellipsoidal heights (geoid subtracted). Nonetheless a specific tool 655 is available to add the geoid component to an ellipsoidal DEM.

Q. - The **Baseline** values which are estimated with different versions of the software are slightly different each other and also different from those which are reported in the data provider catalogue. Why this happens and does this influence the interferometric processing accuracy?

A. - The normal baseline is an approximate and indicative value (coming from a linearization performed around a certain reference point, e.g. center scene with given reference height); that allows to get good general information on a certain interferometric pair, but it is never used during the "real processing" (e.g. interferogram generation and flattening, phase2heigh conversion, PS/SBAS processing etc.) within SARscape, in order not to introduce systematic errors due to the approximation; in the real processing the original orbits from the state vectors and their variation along the full frame, their non-parallelism and many other parameters must be carefully considered. When the geometry is concerned, during the SARscape processing the original Range-Doppler equations of the different acquisitions are used and jointly solved, without introducing any simplification (like the normal baseline).

Q. - How can I choose an **Appropriate Baseline** for doing InSAR or DInSAR processing?

A. - The criteria to select a SAR pair with an "optimal baseline" (we refer here to the perpendicular or normal baseline) differ depending on the objective of the interferometric processing.
When doing **InSAR** processing (i.e. Digital Elevation Model Generation) we would like to have a large baseline; in essence the larger the baseline the better the capability to detect small height changes (refer to the Ambiguity Height formula below). Theoretically speaking the maximum baseline limit, which can never be exceeded, is the critical baseline (refer to the Critical Baseline formula below); practically speaking one should avoid using baseline larger than half the critical value.

$$B_{cr} = \frac{\lambda\, R \tan(\theta)}{2\, R_r} \qquad\qquad H_{amb} = \frac{\lambda\, R \sin(\theta)}{2\, B_n}$$

Where B_{cr} is the Critical Baseline; B_n is the Normal Baseline; λ is the acquisition wavelength; R is the slant range distance; R_r is the pixel spacing in slant range; θ is the acquisition incidence angle; H_{amb} is the Ambiguity Height. Of course the more the land cover/topography conditions are critical (i.e. dense vegetation/steep slopes) for the interferometric technique application, the more problems shall be introduced by using an InSAR pair with large baseline...

When doing **DInSAR** processing (i.e. Displacement Mapping) we would like to get a very small baseline (best being a 0 meter baseline) in order not to have topography induced fringes in the interferogram.

Information related to Critical Baseline, Normal Baseline and Ambiguity Height of a SAR pair can be retrieved by using the Baseline Estimation 451 functionality.

Q. - What is the meaning of the **2π Ambiguity Height** and how is this value computed?

A. - It represents the height value, which provides a phase variation of 2π (one interferometric cycle). It is inversely proportional to the baseline and it depends on the wavelength, incidence angle and other acquisition parameters. If we are observing a topographic phase, which means that we have flattened our interferogram using only a flat earth (without DEM), our interferometric fringes resemble contour lines separated each other by a 2π ambiguity distance.

Q. - What is the meaning of **Interferometric Cycle**?

A. - Observing a black and white flattened interferogram, we see all the iso-tone lines ("fringes") that correspond to the wrapping of the phase. If we consider a mountain side, and we assume we move ("climb") from one black phase pixel through all the gray levels up to white phase and then back down to black, we move from one phase value to another that is 2π radians (or one interferometric cycle) larger than the first one.

Q. - What is the meaning of **Critical Baseline**?

A. - The critical baseline is the theoretical maximum value above which, specifically for the input data set, distributed targets are not correlated anymore (i.e. coherence=0).

Q. - If I have a **Data Temporal Series** (i.e. 20 acquisitions), which I want to process in interferometric mode, but I'm interested only on a small portion of the full frame; is it possible to define the area of interest in one scene/acquisition and get the other 19 images automatically cut on the same area?

A. - This can be done using the Sample Selection 737 from the Interferometry module tools. Using this functionality the area of interest is defined in the first acquisition of the input list, then the program will coregister the other input data and will execute the subset on the same geographical area.

Q. - In case I have to perform the **PRF Correction**, when should it be done: on SLC data before the Interferogram Generation step, or rather on coregistered data after the Interferogram Generation step?

A. - We found that in some cases geocoding Radarsat-1 data with 1 GCP produced an accurate geolocation close to the GCP while the product became shifted if observed in areas far from the GCP (this was evident when moving, from the GCP position, in azimuth direction). We attributed this problem to a wrong value reported for the Pulse Repetition Frequency (PRF) and, for this reason, we introduced the PRF Correction tool. Considered that, we would suggest to check - running a Geocoding 142 process - whether the above mentioned geolocation problem exists using one GCP only; if it does not, you do not need to correct the PRF. Vice versa if you identify a geocoded product shift in areas far from the GCP it means that you must correct the PRF. This correction has to be executed before running the Interferogram Generation step.

Q. - I am trying to make an interferogram in an area of **High Relief** and I am checking the "Coregistration with DEM" flag in the Interferometric Workflow. The output _dint and _fint files still show a **Phase Ramp**; is it possible to get rid of it?

A. - The main purpose of the "Coregistration with DEM" option is to improve the slave to master coregistration in areas of strong relief; this is especially effective when processing very high resolution data (e.g. COSMO-SkyMed, TerraSAR-X) or working with long orbit segments or working with ENVISAT-ERS/2 pairs or processing data acquired at high latitudes or using non zero-Doppler annotated data (especially with long wavelength). Nevertheless, in case you have a phase ramp due to orbital inaccuracies, it will not be removed unless you execute the Refinement and Re-flattening 308 step (after the "Phase Unwrapping"). It is possible to automatically remove the residual phase, which possibly still exists after the removal of the phase component due to topography and/or flat earth (_dint and _fint files), by checking the "Remove Residual Phase" flag in the Preferences>Flattening 775 panel or by executing the Remove Residual Phase Tool 470 on the differential interferogram (_dint or _fint).

Q. - Do I need to **Coregister Master and Slave Data** of my interferometric pair, using the relevant Basic module functionality, before initiating the interferometric processing?

A. - You do not need to run the Basic module Coregistration 121, since the slave to master coregistration is performed during the "Interferogram Generation" step.

Q. - How can I check the **Coregistration Accuracy** of the slave to master interferometric data?

A. - A first visual check can be done by displaying - in two linked viewers - the master and slave coregistered images (Multilooked or Single Look Complex products), which are generated as output of the"Interferogram Generation" step.
A more in depth analysis can be carried out by analysing the output shape file (_winCoh_off.shp), which is generated as output of the "Interferogram Generation" step. This provides information related to the signal/noise ratio and coherence values relevant to each coregistration window, as well as the the shift calculation in range and azimuth direction.

Q. - In the **Interferogram Generation** step, the program ends with an error message?

A. - The error message reported during the "Interferogram Generation" step, is typically due to a slave-to-master coregistration problem. This can be related to several reasons, which can be summarised as follows:

1. Large orbital inaccuracies, which cause a wrong shift calculation during the coregistration initialisation. In order to overcome this problem just open the Preferences>Coregistration 770 panel and deselect the "Initialisation from Orbit" flag. In case the coregistration should fail again, just increase the number of coregistration windows in azimuth and range direction (upper part of the "Set Default value>Coregistration" panel) up to respectively 30 and 20 or more.
2. The Cross Correlation Central Window 770 is not large enough (in azimuth and/or range direction) for the shift initialisation; this case can be reported when the "Initialisation from Orbit" flag is not selected. Note that the Cross Correlation Central Window must be at least two times bigger (in azimuth and range direction) than the distance between the same pixel in the master and slave not coregistered data.
3. Large portions of the scene (typically homogeneous areas such as water, forest, sand, etc.) lack of spatial features, which are required for calculating the cross-correlation function between Master and Slave file. In these cases it is possible to manually locate points (Coregistration file), representing the center of the coregistration windows, in those areas where cross-correlation features (e.g. scatterers such as rocks, urban settlements and other man made objects) exist.
4. A large difference in the doppler centroid of master and slave acquisitions. This kind of problem is sometime reported using ERS-2 data acquired after the year 2002, when the satellite started being operated without any gyroscope available (reduced satellite orbit stability). In order to check what the doppler centroid difference is, just execute the the "Baseline Estimation" step: in case the

Doppler centroid difference is higher than the critical one (i.e. value of the Pulse Repetition Frequency reported in the data header file - .sml) it means that the SAR pair is not suitable for interferometric processing.

5. A large temporal de-correlation between master and slave acquisitions. This is typically reported when most of the imaged area is made of features, such as densely vegetated areas or water, which are subject to changes if observed at a certain time distance (i.e. SAR interferometry multi-pass configuration); temporal de-correlation related problems tend to become more important when master and slave acquisitions are separated by very long time distances (i.e years). Generally the temporal de-correlation decreases by increasing the acquisition wavelength (e.g. from C band to L band).
6. The number of coregistration windows in azimuth and range direction, which are used for the fine shift estimate (Preferences>Coregistration>Fine Shift Parameters section 770), is not sufficient; this case is typical of poorly correlated data (see point n. 5). Increasing this value (e.g. 40 windows or more) can solve the problem; however it must be mentioned that poorly correlated data cannot provide reliable results in terms of interferometric phase.
7. Very large normal baseline (i.e. half of the critical value or more). The execution of the "baseline estimation" step allows calculating this value and comparing it with the critical one.

Q. - The **Flattened Interferogram** (_dint) seems to only have the "curved Earth" phase removed, not the topographic phase. Is that correct? Does SARscape produce a differential interferogram where also the topographic phase is removed?

A. - The differential interferogramcan be generated using an input Digital Elevation Model or the ellipsoid height (it can be 0 or else, depending on the mean altitude of the imaged area). In both cases the program removes, from the original unflattened interferogram (_int), the flat earth phase and, only when the DEM is provided in input, it also removes the phase component due to the known topography.
It must be mentioned that the topographic phase removal depends on the quality and accuracy of the input Digital Elevation Model as well as on the correspondance between the geolocation of DEM and SAR master image (see also the following answer).

Q. - Why the differential interferogram (_dint), shows up plenty of **Topographic Fringes**? Should not have they been separated as synthetic phase (_sint)?

A. - During the flattening process the reference input DEM is re-projected to the SAR Master acquisition geometry (slant range). In case this re-projection is not accurate, due for instance to inaccuracies in the orbital parameters, the slant range DEM will not fit with the SAR geometry; this introduces "flattening errors" (i.e. under-flattening and over-flattening fringes). For this reason the use of precise orbits is strongly recommended. In case precise orbits where not available and the standard ones were not enough accurate, then the use of a Ground Control Point 296 is required to successfully carry out the flattening process. It is important to note that the GCP is not needed if the manual 722 or the automatic 719 correction procedure has been previously executed.

Q. - Why the differential interferogram (_dint) shows several large fringes, resembling a **Phase Ramp**, regularly distributed throughout the image?

A. - This effect is due to orbital inaccuracies. The phase ramp (i.e. orbital fringes) is not present if precise orbits are used. Residual phase ramps can be removed by carrying out the Refinement and Re-flattening 308 step.

Q. - What the **Remove Residual Phase Frequency** step consists of?

A. - This step can be carried out either automatically (during the flattening process), whether the relevant flag in the Preferences 775 is checked, or manually (by means of the proper Interferometry Tool 470) using the _dint or _fint file as input. It is aimed at removing those residual fringes (phase ramp), which remain after the flattening process. The peak in the frequency domain (both in range and azimuth direction) is estimated by using a Fast Fourier Transform on each window whose dimensions are provided in the SARscape panel; afterwards a fitting is performed on the frequency values computed for each window in order to calculate the phase ramp to remove from the whole image.

Q. - What is the **Fake GCP**?

A. - This is a Ground Control Point, which is automatically generated by the software, during the interferogram flattening process, in order to correct the azimuth start time and the slant range distance of the slave image. It does not change any parameter of the master image.
This automatic procedure is activated, in the Interferometry Module, when the Automatic Slave Orbit Correction 776 flag is checked in the relevant Preferences; this is valid also for the Persistent Scatterers 490 processing. The automatic correction is always performed in the SBAS processing (i.e. independently from the Preferences setting).

Q. - Is there a way to find the **SNR** (System noise or Temperature noise) value, **Residual Topographic Phase Noise** value and **Processing Noise** value of an Interferogram?

A. - SARscape does not discriminate among the different types of noise. The SNR value is related to the interferometric coherence (γ) on the basis of the following formula: SNR = $\gamma^2/1-\gamma^2$. The coherence value, which is reported in the "..._cc" output of the "Adaptive Filter and Coherence Generation" step, can vary from 0 to 1; this value is inversely proportional to the systemic spatial de-correlation (i.e. the additive noise) and to the temporal de-correlation between master and slave acquisitions.

Q. - In the **Adaptive Filter** and Coherence Generation step, which of the three proposed approaches (i.e. Boxcar or Adaptive window and Goldstein) has to be preferred and when one method can perform better than the others?

A. - In most of the cases the best choice is for the Boxcar (very high coherence pairs) or the Goldstein. The Adaptive approach can be adopted in case one wants to adapt the filtering window to take into account for the stability (or stationarity) of the backscatter value (i.e. SAR amplitude); this method, which typically requires several trials in order to find the optimal processing parameters, can provide better results with very high resolution data (e.g. TerraSAR-X or COSMO-SkyMed).
The use of the Goldstein filter is recommended especially in those cases where the fringe pattern is hard to detect due to temporal or baseline related decorrelation or to challenging land cover or morphology

conditions. This approach is often preferred for its adaptability to different coherence conditions.

Q. - I am using the **Goldstein** filter during the Adaptive Filter and Coherence Generation step. I noted that, in the resulting coherence image, the value of every pixel is 1. Do you have any suggestion about what might have caused this strange coherence behavior?

A. - Whether the filtering action is quite strong, like in the case of the Goldstein filter, and the processing parameters are set in order to dramatically reduce the phase noise, most of the pixels in the resulting coherence image can be saturated to 1. To avoid this, the coherence can be generated by:

1. Setting the Goldstein filter parameters in order to reduce the filtering strength.
2. Using the Boxcar approach.
3. Uncheck the "Coherence from Fint" flag in order to get the coherence generated from the unfiltered interferogram (dint).

The newly generated coherence can be used in association with the previously generated filtered interferogram.

Q. - I noted anomalous "square-box" like features in the interferogram, which was filtered using the **Goldstein** method. What can be the reason and how can be these artifacts possibly avoided?

A. - It can happen that, depending also on the quality of the input interferogram, a strong filtering setting can introduce such artifacts. These are possibly avoided (or reduced) by increasing the "Windows Overlap Percentage" parameter.

Q. - Reading the reference literature available for the **Goldstein** filter, it appears that the alpha value typically lies in the range of [0, 1]. Why the default range of alpha variability (Preferences>Adaptive Filter>Goldstein Interferogram Filtering 783) considers values which can be much higher than 1?

A. - The alpha value can possibly exceed the typical range of [0, 1]. This happens where the coherence is very low and the interferogram is eventually very noisy. As a matter of fact the SARscape default alpha max, which is used where the coherence is 0, is higher than 1 (around 2.5 or more); nevertheless the value which is adopted in coherent areas is always lower than 1, as it varies linearly from the alpha min (high coherence zones) to the alpha max (not coherent zones).

Q. - How the interferometric fringes can be displayed in colour?

A. - A standard RGB colour table, which is typically used to represent the interferometric fringes, is applied when transforming the complex interferogram (_int, _dint or _fint) into an output 8 bit Tiff image using the relevant SARscape Tool 710.

Q. - Is it possible to **Mosaic Interferograms** generated from InSAR pairs of overlapping scenes?

A. - The Mosaic 712 tool works for geocoded real data. It means that, in order interferograms to be mosaiced, the following two processing steps must be previously carried out:

- Geocode 142 the complex interferogram.
- Split 691 the complex interferogram into phase and module components.

The phase and the module components have to be mosaiced separately; afterward the mosaiced phase and the mosaiced module shall be combined again 692 to form a complex interferogram.

Q. - Is it possible to make a **Difference between two Interferograms**?

A. - The Interferogram Difference 464 can be used for this purpose.

Q. - We see that the **Coherence** is influenced also by topography and backscatter intensity. Is there a way to get rid of these influences?

A. - One possibility is to check Spectral Shift Filter 780 flag, which is the default SARscape setting. Moreover it is possible to modify the default parameters relevant to the Local Frequency Removal

Q. - A **Coherence Threshold** can be set in different step of the processing chain. Is it better to apply always the same threshold value or it is better to apply different thresholds?

A. - In general it is better to adopt different coherence thresholds depending on the specific processing steps, in particular:

- In the Phase Unwrapping 305 a low threshold (e.g. around 0.2) shall be preferred in order to leave more freedom to the region growing algorithm to diffuse without blockages (i.e. low coherence areas). This will reduce the possibility to have "phase jumps", which should be edited 470 afterward.
- In the Phase to Height Conversion and Geocoding 314 as well as in the Phase to Displacement Conversion and Geocoding 320, a higher threshold can be set in order to mask - in the final interferometric product - those areas where the coherence is low and consequently the phase measurement is less reliable; thus the specific value here depends on the reliability one wants to associate with the DEM or the Displacement Map. Value of 0.3 or more generally provide reliable results.

Q. - The **Phase Unwrapping** step failed due to a memory allocation error. Why this happens and how can the problem be solved?

A. - The error is due to a limitation of the WINDOWS operative system in handling the unwrapping operation of large data (in terms of file size). This problem can be overcame by multilooking and undersampling the data, using the "Decomposition Levels" option.

Q. - Does the **Minimum Cost Flow Unwrapping** method implement the SNAPHU algorithm or something similar?

A. - The Minimum Cost Flow algorithm implemented in SARscape is derived from the published work of Mario Costantini (i.e. "A novel phase unwrapping method based on network programming"). Unlike the SNAPHU program, which works by decomposing the image in tiles without modifying the original pixel spacing, the SARscape implementation foresees the use of the **Decompositions Levels**. This implementation enables to iteratively decrease the resolution (i.e. a factor 3 multilook and under sample for each decomposition level) in order to both enable the processing of large data and homogenize the unwrapping process of the entire imaged area. The original resolution is reconstructed by iteratively

recovering the information from the previously multilooked and under sampled "Decompositions Levels". In case the phase image to unwrap is characterized by very frequent displacement variation, the "Decomposition Level" option must be handled with care; indeed in this case the displacement variations can be aliased, and this happens especially when the number of decompositions is set higher than 2.
It has to be pointed out that the "Decomposition Levels" approach can be adopted either with the Region Growing or with the Minimum Cost Flow method.
The use of the Delaunay triangulation779 method can be considered in case of diffused low coherence areas.

Q. - Is there an easy way to create the **Orbital GCP File**, which is used as input in the **Refinement and Re-flattening** step? What is the process, which the program performs during this step?

A. - The most important concept in the identification of the ground control points collected for the "Orbital GCP file" it is to locate them in areas where there is no evidence of residual topographic fringes and far from eventual displacement areas; for this reason one of the SAR interferometric products useful for this purpose it is the flattened (and possibly filtered) interferogram (_dint or _fint). Moreover the points have not to be located over "phase islands" since the program works on the unwrapped interferogram and thus erroneous phase jumps are erroneously interpreted during this step; for this reason another SAR interferometric product to check during the point collection process it is the unwrapped phase (_upha). Finally it is important to spread as much as possible the points throughout the imaged area.
The points can be found in the SAR image geometry, without entering any displacement or height value; in such case the program will consider zero displacement and the height value written in the reference DEM. The points can be also entered in cartographic co-ordinates, this is for instance an option when the same points have to be adopted for different interferometric pairs located in the same geographical area (e.g. an ascending pair and a descending pair); in such case the program will automatically re-project, in the slant SAR viewing geometry, the range and azimuth position of each point.
It is possible to choose between two methods for the re-flattening process: i) the orbit correction (more precise since it relies on the satellite orbital position); ii) the residual phase removal (more robust, but also more rough since it can only remove a phase ramp or a constant phase offset depending on the polynomial degree adopted). The default process adopted by the program it is to attempt by the first method and, if the orbit correction it is not sufficiently precise or the two orbits are too close each other (i.e. small normal baseline, which means the impossibility to find "realistic" solutions) switch automatically to the second method. However it is possible to force the program adopting one or the other method as well as to modify the polynomial degree or the automatic checks, which the program performs to estimate the GCP location accuracy; this can be done by changing the default setting in the Input Parameters>Refinement and Re-flattening775 section.
The minimum required number of points actually depends on both the Refinement Method777 and the Residual Phase Polynomial Degree778, which have been set in the relevant Preferences: when the "Residual Phase" refinement method is checked, the number of points must be at least equal to the "Residual Phase Poly Degree"; when the "Orbital" refinement method is checked, the number of points must be at least equal to 7; when the "Default" refinement method is checked, the software automatically set the refinement method depending also on the number of points. In any case a number of points higher than the minimum is recommended, in such case the solution will be an averaged and more reliable correction.

Q. - What is the reason why I observe **Phase Islands** after the unwrapping process and it is possible to avoid them?

A. - Actually, either inside or outside these "islands", the unwrapping is "locally" well performed. However it remains a discontinuity (i.e. a finite number of 2π phase cycles) on the island border. This kind of problems typically appears when the phase is noisy along the border, or when the interferometric fringes are very dense (i.e. the phase change is very fast) and thus the correct phase jump is wrongly estimated. It must be also noted that in some instances the jumps are correct since there is a real phase discontinuity. The use of the Delaunay unwrapping method 305 is generally the best choice for limiting these phase artifacts.

Q. - How is it possible to check the quality of the **Refinement and Re-flattening** step?

A. - Once this processing step is completed the Root Mean Square error (BFRMSerror), which is calculated from the difference between the height value of the Ground Control Points and the corresponding value in the interferometric phase, is provided. Root Mean Square errors ranging from around 2 to around 10 are a good preliminary indication that the Refinement and Re-flattening 308 was successfully executed (i.e. good GCPs). A further possibility to visually check the quality of the result, it is to inspect the re-flattened interferogram in order to see if the orbital related fringes have been removed from the original flattened interferogram (i.e. _dint or _fint file).
The orbital refinement step (that has in any case to be performed, also in case of precise orbits, to estimate the absolute phase offset) produces corrected orbits which are not necessarily the one closest to the true ones; the "refined" orbits are those which describe the phase data at the best, compared with the input DEM.
It must be noted that the "Refinement and Re-flattening" using pairs with small baseline values (i.e. less than around 50 meters) is critical.

Q. - In the **Refinement and Re-flattening** step, is it preferable to manually enter the co-ordinates and height of Ground Control Points accurately collected on the ground (or onto a topographic map) or to use the reference Digital Elevation Model previously 465 transformed in the master image slant range geometry?

A. - During this processing step we compare the height obtained from the SAR phase with the reference one from the GCP (and/or from the reference DEM). We know that, even with very good coherence, and with quite large baselines, we will never get from the SAR interferograms a height with an accuracy of 1 cm, but say of few meters. This means that, if we compare a GCP height with a precision of 1 cm with a “phase height” with a final expectable accuracy of few meters, we see that there is not reason to look for the "super-accuracy" of our GCPs. In other words, in most of the cases, the result of the processing with a good reference DEM (e.g. often already SRTM-3) is good enough.
It must also be considered that, once the orbital refinement is applied, we do not estimate just phase 2D polynomials to subtract (as estimation of the residual phase from the orbits), but we use an orbital model to correct the inaccuracies. This means that we do not apply all possible corrections, but only those in agreement with a physically consistent orbital configuration.

Q. - I have compared a DEM generated with SARscape against a validated high accuracy **DEM**. I observed a strange and may be **Systematic Difference** between their height values. Can you explain why?

A. - There are two possible arguments to explain the discrepancies between the height in your SARscape product with respect to that reported in the high accuracy reference DEM:

1. It is related to the GCP location in the "Refinement and Re-Flattening" step. It is worthwhile to recall that, once the "Refinement and Re-Flattening" processing step is completed, you can do a first "quality assessment" by means of the: a) "Root Mean Square error", which is calculated from the difference between the height value of the Ground Control Points and the corresponding value in the interferometric phase (an error ranging from around 2 to around 10 is a good preliminary indication that the GCPs have been properly selected); b) "Absolute Phase Offset", which represents the difference between the interferometric phase value and the fitted value based on GCPs; c) "_refinement.shp" file, which contains additional and useful information for the assessment of the correction parameters calculated from the input GCPs (refer to the online help for more details).
2. It is related to the reference surface of your SARscape product. In the Interferogram Flattening process, where the the know topographic phase component (_sint) is separated from the unknown/ differential phase (_dint), the input DEM is normally referred to the ellipsoid. This means that the final InSAR DEM will be referred to the ellipsoid and this could explain the systematic difference with respect to your reference precise height, which is probably referred to the geoid. It is worthwhile to mention that it is possible to add the geoid 655 component to a SARscape DEM.

Q. - If I generate two times a DEM, with exactly the same data and same processing configuration, but with a different set of GCP points in the **Refinement and Re-flattening** step, the output DEMs could have notably different elevation values (up to 20 meter differences have been found). Are such differences expected and is it possible to prevent them?

A. - The Refinement and Re-flattening can be a really "delicate and sensitive" tool... What happened in your case is that, choosing a different set of GCPs, a different phase offset has been estimated and a different average height has been eventually associated to the two DEMs that you've generated.
Therefore, much attention must be paid when the GCPs are selected (the most important selection criteria are described in the relevant section 309 of this document). A possible reason of the differences that you measured, it can be due to the fact that one or more GCPs have been located in areas where there is some residual topography in the differential phase (i.e. _dint, _fint or _upha).
It is worthwhile to recall that the input GCPs can be entered either in SAR geometry or in any supported cartographic reference system. In this second case the program automatically takes care to convert the co-ordinates of each point into the reference slant range reference geometry.

Q. - How is it possible to check and verify the **Absolute Phase Offset** (in radians), which is calculated in the Refinement and Re-flattening step?

A. - One of the output products, which are generated in the Refinement and Re-flattening 308 step, is the _refinement.shp. It provides information useful for the assessment of the correction parameters calculated from the input GCPs. In particular the "AbsPhDiff" and the "PhaseDiff" represent respectively the absolute and the relative difference (in radians) between the real phase and its fitted value based on GCPs.

Q. - The fringe pattern changes dramatically when going from the _int (original "raw" interferogram) to the _dint (flattened interferogram) through the _upha (unwrapped phase) and all the way to the final DEM; what is the **Overall Processing Approach** and the philosophy behind it?

A. - The approach adopted in SARscape it is not aimed at a linear combination of Flat-Earth + DEM phase; the objective is to go back to the full interferometric (absolute) phase (adding the _sint , the _upha and the absolute phase offset) in order to exploit the original physics of the acquisitions (i.e. the combined master and slave, Range and Doppler equations). In this perspective the InSAR DEM is basically equivalent (and precise) when exploiting a reference DEM for the flattening or just a constant reference height.

Q. - What is the approach used in the **Wavelet Combination DEM** 685?

A. - The standard wavelet approach is applied with the assumption that, typically in an interferometric high resolution DEM, the atmospheric artifacts (as well as possible height offsets and residual ramps) affect mostly the low frequencies. These artifacts can be removed (or reduced) by means of a reference low resolution DEM (e.g. GTOPO30 or others), which is used to correct the low frequency of the high resolution product while keeping untouched the spatial detail coming from the high frequencies.

Q. - I want to generate an **InSAR DEM** over a tropical (densely vegetated) area in **Cameron**; the objective is to detect the **Coastline**. I plan to use **ALOS PALSAR FBS** data. Do you have any helpful suggestion?

A. - The main problem is definitely related to the very dense vegetation, which most probably characterize your area, thus I would suggest minimizing the temporal de-correlation by choosing the minimum possible time interval (46 days) for your PALSAR pair. Moreover, if there is the chance, do select an acquisition period when the rains are not to heavy and persistent. It is finally worthwhile to mention that a good help in detecting (and characterising in terms of land cover) the coastline can also be provided by the use of amplitudes and coherence data.

Q. - I want to generate an **InSAR DEM over Iceland**. Do you have any special advice to provide?

A. - In general the usual criteria apply also in this case: i) the temporal distance between the two acquisitions should be as short as possible; ii) data should be acquired in a season of the year when atmospheric conditions are stable and major meteorological perturbations (e.g. storms, snow falls, etc.) are not expected. Moreover, in this special case (high latitudes, i.e. Iceland), an important issue is related to the ice motion; indeed some fringe patterns over glaciers can be misinterpreted as height while being related to movement.

Q. - I'm implementing the high resolution TerraSAR-X images to get InSAR DEM for the **Estimate of Building Heights**, but I'm not happy with the output product accuracy; can you provide any suggestion on this topic?

A. - The use of SAR data for building height estimate in urban areas is not the most suitable approach, especially due to the continuous alteration of layover and shadow areas, which are due to the buildings themselves; moreover the unwrapped phase typically requires extended manual corrections (phase editing 470).

Q. - How to **Combine Two Geocoded Displacement Maps** in order to get a single output product?

A. - If the two maps are partially overlapping while being acquired on two different locations, it is possible to mosaic them by checking the option "Precision" in the SARscape>Tools>Mosaicing>Conventional_Mosaicing 712 functionality. In this way the two maps are combined by weighting the pixels on the basis of the "..._precision" file, which is generated among the outputs of the Phase to Displacement Conversion and Geocoding 320 step.
The _precision output is derived from parameters such as coherence and wavelength; it provides an estimate (i.e. standard deviation value) of the measurement precision. The higher this value the lower the measurement precision.
If the two maps are fully overlapping (same location/coverage of the imaged area) and the objective is get a single better map, then the option "Mean" in the SARscape>Tools>Mosaicing>Conventional Mosaicing 712 functionality can be used. This approach can be exploited for instance in order to fill some low coherence areas of one map with data that might be present in the other one, while averaging the areas covered by both maps and then reducing some noise there.

Q. - What are the criteria (and the limitations) to convert the **Line Of Sight Displacement Into A Displacement On A User Defined Direction**?

A. - SAR is measuring the LOS (Line of Sight) displacement, that means the component of the full displacement D (a 3D vector) projected onto the LOS direction. Assuming a certain angle (we can call it β) between the LOS and the D direction, we measure a displacement |LOS| = |D| * cosβ, which represents the scalar product between the LOS and D vector. This means that, knowing the direction of the D vector and using the acquisition geometry to get the direction of the LOS, we can estimate the original magnitude of the full displacement as |D| = |LOS| / cosβ
As an example, if we have an area affected by subsidence phenomena and we want to estimate its magnitude, we can assume that the direction of the D vector is in this case vertical, and we can easily solve the conversion problem.
Vice versa, if the real displacement did not occur along the vertical direction (or more in general along an a-priori well known direction), there are infinite vectors (one for each possible value of β) that projected onto the LOS give the value we measure; each of them has a different original magnitude and each of them has a different component when projected onto the user defined direction; this means that in this case, and using only one acquisition geometry, we cannot assess the real displacement.
In other words, it makes sense to use this option only if the real displacement on the ground occurred along a direction that can be accurately determined; otherwise not only the re-projected displacement direction, but also its magnitude will be wrongly estimated.

Q. - Is it possible to **Merge the Intensity Data with the Interferometric Fringes** in order to visualise them in the same image?

A. - RGB combinations showing the interferometric fringes draped onto the SAR amplitude features can be obtained by following the steps below:

1. Separate the filtered complex interferogram (_fint) into phase and module components (Tools>Conversion - Complex to Phase and Module 691)
2. Use the amplitude (master or slave image) as module for regenerating a complex datum with the previously separated interferometric phase (Tools>Conversion - Phase and Module to Complex 692); note the amplitude image can be previously despeckled (_pwr_fil) for a better visualisation.
3. Generate the Tiff file (Tools>Generate Tiff 710) by properly setting the "scale" and "exponent" factors (values of respectively 0.3 and 0.5 are typically suitable for this purpose): an optimal tuning of the histogram stretching enables to have the best visualization of both the interferometric fringes and the amplitude image texture. Note that an enhanced visibility of the amplitude features is usually achieved by reducing the "scale" or increasing the "exponent".

Q. - Is it possible to calculate the **Velocity of a Large River** using SAR interferometry?

A. - If the river is not frozen, any repeat-pass interferometric pair (with temporal distance larger than a few seconds between the two acquisitions) will have not coherence over the water, so none possibility of measuring any meaningful phase with any interferometric technique. The only option to measure such effects is with “quasi-simultaneous”, “along-track” acquisitions, like those that can be obtained (from satellite) with the experimental split-antenna modes of TerraSAR-X and Radarsat-2, and in some of the orbits from the TanDEM-X constellation. Having such data (or airborne data with a specific along-track baseline configuration between two antennas) one can directly use the available SARscape modules for InSAR and DInSAR processing to obtain such measure.

Q. - Is it possible to **Monitor Subsidence** phenomena (also on the basis of historical data), whose rate reached peak values of few meters per year. The area of interest, which is exploited for coal mining extraction since about 20 years, is partially covered by dense vegetation and forest. Could you also give a rough **Estimation of the Accuracy** that we can achieve?

A. - You can definitely exploit different kind of SAR interferometric techniques (from the classical two dates approach to the more advanced Persistent Scatterers 482 and Small Baseline 508 methods) for your purposes.
One of the major factors, which drive the displacement measurement accuracy that you can reach with SAR Interferometry, is the observation wavelength; indeed you can apply this technique on SAR data acquired in X-band, C-band or L-band data. In general we can say the the displacement measurement accuracy is in the order of the cm for the classical two dates interferometry and in the order of the mm for the Interferometric Stacking (PS or SBAS); note that, in order to apply the Interferometric Stacking methods (mm accuracy), you have to rely on an interferometric temporal series and thus you first need to check how many data acquired in interferometric mode are available on your area of interest.
Therefore you have to check the archive data (e.g. ENVISAT ASAR, ALOS PALSAR or other satellites) availability over your area of interest. These archive data are essential to build a kind of reference baseline map of the subsidence distribution in the past years: typically, in coal mining area, the subsidence follows - with some temporal delay - the underground extraction direction.
Afterwards you can think about future acquisition planning to monitor the current subsidence distribution and rate. In my opinion, before deciding on topics such as the most suitable satellite/wavelength, the best temporal frequency, etc., it is better to analyse the past subsidence distribution and detection with the

available SAR archive data (see previous point); this will also give you a better and more realistic framework of the spatial distribution of the subsidence in your area, which in the end is crucial to properly plan future SAR acquisitions.
In particular, considered that the area you are interested in is affected by a displacement rate which is so large in magnitude (meters per year is really a strong subsidence...), you could exploit also data with longer wavelengths (L-band ALOS PALSAR for instance). This allows to dramatically reduce the problem you would face in vegetated areas due to low interferometric coherence.

Q. - Is it possible to monitor **Landslides** with TerraSAR-X data? Are there special recommendations in terms of acquisition incidence angle?

A. - Landslide monitoring with SAR Interferometry is quite a challenging objective, essentially for two reasons: the slope inclination and the possible lack of coherence.
If the slope is not too steep, the first problem can be overcame by properly defining the acquisition look angle; in general we could say that large angles have to be preferred when you observe a slope facing the sensor (to avoid layover conditions), while steeper angles are better when the landslide is located in the shadow side (slope not facing the sensor).
The second problem exists when the landslide area is covered by vegetation; keep into account that even sparse vegetation can cause temporal decorrelation problems (i.e. low coherence) when observing with a short wavelength (X band in your case).
It is important to carefully analyse the slope geometry (orientation, inclination and dimension) before planning the InSAR pair acquisition beam.
If the landslide can be detected and the interferometric coherence is good, you can also plan to acquire an interferometric time series, which eventually allows both to observe the movement with a better accuracy and to better characterize the landslide dynamics by means of the SBAS or PS 474 approach.
A very important issue, especially with VHR SAR data, is the availability of a reliable high resolution Digital Elevation Model. It allows to properly remove the topography during the interferometric processing.

1.6.3 Reference guide

1.6.3.1 InSAR Digital Elevation Model Workflow

Purpose

This functionality enables to execute, in a single iteration, the following processing sequence:

- Interferogram Generation and Flattening 293.
- Adaptive Filter and Coherence Generation 300.
- Phase Unwrapping 305.
- Refinement and Re-flattening 308.
- Phase to Height Conversion and Geocoding 314.

The final purpose of this processing chain is the generation of an Interferometric Digital Elevation Model.

Technical Note

Details specific to each step implemented here are described in their respective reference guide section. We recommend to read them carefully.

Input

Input Files

Input Master file
File name of the master data (_slc). This file is mandatory.

Input Slave file
File name of the slave data (_slc). This file is mandatory.

DEM/Cartographic System

Reference Type
The choice is given between the three following options:

- *Input DEM*: the provided "Input Digital Elevation Model" file is used in the process;
- *Reference Height*: in case that the Digital Elevation Model is not used, the parameters needed to define the Cartographic System 6, the pixel spacing and the reference height are compulsory;
- *DEM Download*: The Digital Elevation Model Extraction 657 tool is used to download an online digital elevation model. Various sources are available, see this section 657 for further information.

note that the choice of one source is compulsory.

Parameters

Grid Size
The grid size of the output data must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Interferogram Generation

It brings to the principal parameters of the Interferogram Generation 297 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Adaptive Filter and Coherence

It brings to the principal parameters of the Adaptive Filter and Coherence Generation 302 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Phase Unwrapping

It brings to the principal parameters of the Phase Unwrapping 306 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

GCP Selection

Refinement GCP file
Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File) or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the "Tools>Generate Ground Control Point 747" for details). This file is mandatory.

Refinement and Re-flattening

It brings to the principal parameters of the Refinement and Re-flattening 312 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Phase to Height Conversion and Geocoding

It brings to the principal parameters of the Phase to Height Conversion and Geocoding 317 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Output

Output Root Name
Name of the output root. This file is mandatory.

Delete Temporary Files
By setting this flag, temporary files which are created in the intermediate steps, are automatically removed. All of the intermediate files are kept otherwise, refer to the Output lists relevant to each processing step for further information.

_dem
Digital Elevation Model with the associated header files (.sml, .hdr).

_dem.shp
Digital Elevation Model in shape format and associated header files (.sml, .hdr).

_cc_geo
Geocoded coherence with the associated header files (.sml, .hdr).

_precision
Estimate of the data quality with the associated header files (.sml, .hdr). This file is used during the Digital Elevation Model mosaicing (Tools 712).

_resolution
Spatial resolution based on the local incidence angle with the associated header files (.sml, .hdr). This file is used during the Digital Elevation Model mosaicing (Tools 712).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Function(s)

Preview
By setting this flag, the temporary files are made available to visualise after a single step in the chain.

References

Consult the reference guide specific to each processing step.

1.6.3.2 InSAR TanDEM-X bistatic DEM Workflow

Purpose

This processing chain is meant to be used with TanDEM-X data only, for general purpose please use the InSAR Digital Elevation Model Workflow 268 tool.

This functionality enables to execute, in a single iteration, the following processing sequence:

- Interferogram Generation and Flattening 293.
- Adaptive Filter and Coherence Generation 300.
- Phase Unwrapping 305.
- Phase to Height Conversion and Geocoding 314.

The final purpose of this processing chain is the generation of an Interferometric Digital Elevation Model.

Technical Note

Details specific to each step implemented here are described in their respective reference guide section. We recommend to read them carefully.

Input

Input Files

Input Master file
File name of the master data (_slc). This file is mandatory.

Input Slave file
File name of the slave data (_slc). This file is mandatory.

DEM/Cartographic System

Reference Type
The choice is given between the three following options:

- *Input DEM*: the provided "Input Digital Elevation Model" file is used in the process;
- *Reference Height*: in case that the Digital Elevation Model is not used, the parameters needed to define the Cartographic System 6, the pixel spacing and the reference height are compulsory;
- *DEM Download*: The Digital Elevation Model Extraction 657 tool is used to download an online digital elevation model. Various sources are available, see this section 657 for further information.

note that the choice of one source is compulsory.

Parameters

Grid Size
The grid size of the output data must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Interferogram Generation

It brings to the principal parameters of the Interferogram Generation 297 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Adaptive Filter and Coherence

It brings to the principal parameters of the Adaptive Filter and Coherence Generation 302 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Phase Unwrapping

It brings to the principal parameters of the Phase Unwrapping 306 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Phase to Height Conversion

It brings to the principal parameters of the Phase to Height Conversion and Geocoding 317 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Output

Output Root Name
Name of the output root. This file is mandatory.

Delete Temporary Files
By setting this flag, temporary files which are created in the intermediate steps, are automatically removed. All of the intermediate files are kept otherwise, refer to the Output lists relevant to each processing step for further information.

_dem
Digital Elevation Model with the associated header files (.sml, .hdr).

_dem.shp
Digital Elevation Model in shape format and associated header files (.sml, .hdr).

_cc_geo
Geocoded coherence with the associated header files (.sml, .hdr).

_precision
Estimate of the data quality with the associated header files (.sml, .hdr). This file is used during the Digital Elevation Model mosaicing (Tools 712).

_resolution
Spatial resolution based on the local incidence angle with the associated header files (.sml, .hdr). This file is used during the Digital Elevation Model mosaicing (Tools 712).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Function(s)

Preview
By setting this flag, the temporary files are made available to visualise after a single step in the chain.

References

Consult the reference guide specific to each processing step.

1.6.3.3 Stereo Digital Elevation Model Workflow

Purpose

This functionality enables to execute, in a single iteration, the following processing sequence:

- Stereo Matching Process 353.
- Shift Refinement and Re-flattening 359.
- Shift to Height Conversion and Geocoding 364.

The final purpose of this processing chain is the generation of a Radargrammetric Digital Elevation Model.

Technical Note

Details specific to each step implemented here are described in their respective reference guide section. We recommend to read them carefully.

Input

Input Files

Input Master file
File name of the master data (_slc). This file is mandatory.

Input Slave file
File name of the slave data (_slc). This file is mandatory.

DEM/Cartographic System

Reference Type
The choice is given between the three following options:

- *Input DEM*: the provided "Input Digital Elevation Model" file is used in the process;
- *Reference Height*: in case that the Digital Elevation Model is not used, the parameters needed to define the Cartographic System 6, the pixel spacing and the reference height are compulsory;
- *DEM Download*: The Digital Elevation Model Extraction 657 tool is used to download an online digital elevation model. Various sources are available, see this section 657 for further information.

note that the choice of one source is compulsory.

Parameters

Grid Size
The grid size of the output data must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Stereo Matching Process

It brings to the principal parameters of the Stereo Matching Process 356 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

GCP Selection

Refinement GCP file
Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File) or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the "Tools>Generate Ground Control Point 747" for details). This file is mandatory.

Shift Refinement and Re-flattening

It brings to the principal parameters of the Shift Refinement and Re-flattening 362 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Shift to Height Conversion and Geocoding

It brings to the principal parameters of the Shift to Height Conversion and Geocoding 367 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Output

Output Root Name
Name of the output root. This file is mandatory.

Delete Temporary Files
By setting this flag, temporary files which are created in the intermediate steps, are automatically removed. All of the intermediate files are kept otherwise, refer to the Output lists relevant to each processing step for further information.

_dem
Digital Elevation Model with the associated header files (.sml, .hdr).

_dem.shp
Digital Elevation Model in shape format and associated header files (.sml, .hdr).

_cc_geo
Geocoded coherence with the associated header files (.sml, .hdr).

_precision
Estimate of the data quality with the associated header files (.sml, .hdr). This file is used during the Digital Elevation Model mosaicing (Tools 712).

_resolution
Spatial resolution based on the local incidence angle with the associated header files (.sml, .hdr). This file is used during the Digital Elevation Model mosaicing (Tools 712).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Function(s)

Preview
By setting this flag, the temporary files are made available to visualise after a single step in the chain.

References

Consult the reference guide specific to each processing step.

1.6.3.4 DInSAR Displacement Workflow

Purpose

This functionality enables to execute, in a single iteration, the following processing sequence:

- Interferogram Generation and Flattening 293.
- Adaptive Filter and Coherence Generation 300.
- Phase Unwrapping 305.
- Refinement and Re-flattening 308.
- Phase to Displacement Conversion and Geocoding 320.

The final purpose of this processing chain is the generation of interferometric displacement maps.

Technical Note

Details specific to each step implemented here are described in their respective reference guide section. We recommend to read them carefully.

Input

Input Files

Input Master file
File name of the master data (_slc). This file is mandatory.

Input Slave file
File name of the slave data (_slc). This file is mandatory.

DEM/Cartographic System

Reference Type
The choice is given between the three following options:

- *Input DEM*: the provided "Input Digital Elevation Model" file is used in the process;

- *Reference Height*: in case that the Digital Elevation Model is not used, the parameters needed to define the Cartographic System 6, the pixel spacing and the reference height are compulsory;

- *DEM Download*: The Digital Elevation Model Extraction 657 tool is used to download an online digital elevation model. Various sources are available, see this section 657 for further information.

note that the choice of one source is compulsory.

Parameters

Grid Size

The grid size of the output data must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Interferogram Generation

It brings to the principal parameters of the Interferogram Generation 297 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Adaptive Filter and Coherence

It brings to the principal parameters of the Adaptive Filter and Coherence Generation 302 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Phase Unwrapping

It brings to the principal parameters of the Phase Unwrapping 306 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

GCP Selection

Refinement GCP file
Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File) or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the "Tools>Generate Ground Control Point 747" for details). This file is mandatory.

Refinement and Re-flattening

It brings to the principal parameters of the Refinement and Re-flattening 312 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Phase to Displacement Conversion and Geocoding

It brings to the principal parameters of the Phase to Displacement Conversion and Geocoding 322 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Output

Output Root Name
Name of the output root. This file is mandatory.

Delete Temporary Files
By setting this flag, temporary files which are created in the intermediate steps, are automatically removed. All of the intermediate files are kept otherwise, refer to the Output lists relevant to each processing step for further information.

_dem
Input Digital Elevation Model resampled onto the specified cartographic system and grid size, with the associated header files (.sml, .hdr). Its areal extent is the same as the output SAR products.

_cc_geo
Geocoded coherence with the associated header files (.sml, .hdr).

_ADF
Maximum slope direction values, with the associated header files (.sml, .hdr).

_IDF
Maximum slope inclination values, with the associated header files (.sml, .hdr).

_SD
Displacement values along the maximum slope direction, with the associated header files (.sml, .hdr).

_UD
Displacement values in the direction specified as azimuth and inclination degrees (i.e. custom direction), with the associated header files (.sml, .hdr).

_VD
Vertical displacement values, with the associated header files (.sml, .hdr).

_disp
Slant Range (satellite view direction) displacement values, with the associated header files (.sml, .hdr).

_precision
Estimate of the data quality with the associated header files (.sml, .hdr). This file is generated only if the coherence file is entered as input.

_ALOS
Azimuth Line of Sight with the associated header files (.sml, .hdr). Positive angles are measured clockwise from the North; negative angles are measured counterclockwise from the North.

_ILOS
Incidence angle of the Line of Sight with the associated header files (.sml, .hdr). The angle is measured between the Line Of Sight and the vertical on the ellipsoid (flat earth).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Function(s)

Preview
By setting this flag, the temporary files are made available to visualise after a single step in the chain.

References

Consult the reference guide specific to each processing step.

1.6.3.5 DInSAR MAI Displacement Workflow

Purpose

This functionality enables to execute, in a single iteration, the following processing sequence:

- MAI Interferometric Process 370.
- MAI Refinement and Re-flattening 378.
- MAI Phase to Displacement Conversion and Geocoding 384.

It is important to point out that, in case ENVISAT-ERS pairs are processed, the "Coregistration with DEM" flag must be checked in the interferogram generation process parameters.

The final purpose of this processing chain is the generation of a displacement map in both the azimuth (exploiting the Multi Aperture Interferometry approach) and line of sight directions.

Technical Note

Details specific to each step implemented here are described in the relevant section of the reference guide. We recommend to read it carefully.

MAI (Multi Aperture Interferometry)
It activates the decomposition of the original doppler bandwidth, in the master and slave data, into smaller portions of the full spectrum. The result of this process is the generation of an additional differential interferogram (_mai_fint), which represents the displacement observed in azimuth direction.

The input "factor" is aimed at defining how many *pieces* the original (full) doppler spectrum must be subdivided in: the higher the "factor" the more the *pieces*, which means noisier split interferograms (due to the limited doppler bandwidth exploited) but higher sensitivity to the azimuth displacement. It must be noted that in any case the sensitivity to the displacement is much coarser than in range direction. The larger the MAI factor, the higher the separation between the sub-apertures, hence the displacement sensitivity along the azimuth direction (satellite flight direction) while the band spectrum becomes smaller along with the SNR.

This functionality has been currently tested on ENVISAT ASAR, ALOS PALSAR and ERS data; the program can fail in case other sensors are used. The program requires data pairs characterized by a small doppler difference; large doppler variations can cause program failures.

Input

Input Files

Input Master file

File name of the master data (_slc). This file is mandatory.

Input Slave file

File name of the slave data (_slc). This file is mandatory.

DEM/Cartographic System

Reference Type

The choice is given between the three following options:

- *Input DEM*: the provided "Input Digital Elevation Model" file is used in the process;

- *Reference Height*: in case that the Digital Elevation Model is not used, the parameters needed to define the Cartographic System 6, the pixel spacing and the reference height are compulsory;

- *DEM Download*: The Digital Elevation Model Extraction 657 tool is used to download an online digital elevation model. Various sources are available, see this section 657 for further information.

note that the choice of one source is compulsory.

Parameters

Grid Size

The grid size of the output data must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

MAI Factor

Enter the number of pieces the original (full) doppler spectrum must be subdivided in.

Interferogram Generation

It brings to the principal parameters of the Interferogram Generation 297 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Adaptive Filter and Coherence Generation

It brings to the principal parameters of the Adaptive Filter and Coherence Generation 302 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Phase Unwrapping

It brings to the principal parameters of the Phase Unwrapping 306 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

GCP Selection

Refinement GCP file
Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File) or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the "Tools>Generate Ground Control Point 747" for details). This file is mandatory.

MAI Refinement and Re-flattening

It brings to the principal parameters of the MAI Refinement and Re-flattening 381 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

MAI Phase to Displacement and Geocoding

It brings to the principal parameters of the MAI Phase to Displacement Conversion and Geocoding 387 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Output

Output Root Name
Name of the output root. This file is mandatory.

Delete Temporary Files

By setting this flag, temporary files which are created in the intermediate steps, are automatically removed. All of the intermediate files are kept otherwise, refer to the Output lists relevant to each processing step for further information.

_dem
Input Digital Elevation Model resampled onto the specified cartographic system and grid size, with the associated header files (.sml, .hdr). Its areal extent is the same as the output SAR products.

_disp_cc_geo
Geocoded coherence in range direction with the associated header files (.sml, .hdr).

_mai_disp_cc_geo
Geocoded coherence in azimuth direction with the associated header files (.sml, .hdr).

_ADF
Maximum slope direction values, with the associated header files (.sml, .hdr).

_IDF
Maximum slope inclination values, with the associated header files (.sml, .hdr).

_SD
Displacement values along the maximum slope direction, with the associated header files (.sml, .hdr).

_UD
Displacement values in the direction specified as azimuth and inclination degrees (i.e. custom direction), with the associated header files (.sml, .hdr).

_VD
Vertical displacement values, with the associated header files (.sml, .hdr).

_disp
Slant Range (satellite view direction) displacement values, with the associated header files (.sml, .hdr).

_mai_disp
Azimuth (satellite flying direction) displacement values, with the associated header files (.sml, .hdr).

_disp_precision
Estimate of the data quality in range with the associated header files (.sml, .hdr). This file is generated only if the coherence file is entered as input.

_mai_disp_precision
Estimate of the data quality in azimuth with the associated header files (.sml, .hdr). This file is generated only if the coherence file is entered as input.

_disp_ALOS

Azimuth Line of Sight with the associated header files (.sml, .hdr). Positive angles are measured clockwise from the North; negative angles are measured counterclockwise from the North.

mai disp_ALOS
Satellite flying direction with the associated header files (.sml, .hdr). Positive angles are measured clockwise from the North; negative angles are measured counterclockwise from the North.

_disp_ILOS
Incidence angle of the Line of Sight with the associated header files (.sml, .hdr). The angle is measured between the Line Of Sight and the vertical on the ellipsoid (flat earth).

_mai_disp_ILOS
Incidence angle for the Satellite flying direction with the associated header files (.sml, .hdr). The angle is measured between the Flying Direction and the vertical on the ellipsoid (flat earth).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Function(s)

Preview
By setting this flag, the temporary files are made available to visualise after a single step in the chain.

References

Consult the reference guide specific to each processing step.

1.6.3.6 Amplitude Tracking Displacement Workflow

Purpose

This functionality enables to execute, in a single iteration, the following processing sequence:

- Amplitude Tracking 335.
- Shift Refinement and Re-flattening 341.
- Shift to Displacement Conversion and Geocoding. 347

The final purpose of this processing chain is to estimate the displacement by means of the amplitude (intensity) data.

Technical Note

Details specific to each step implemented here are described in their respective reference guide section. We recommend to read them carefully.

Input

Input Files

Input Master file
File name of the master data (_slc). This file is mandatory.

Input Slave file
File name of the slave data (_slc). This file is mandatory.

DEM/Cartographic System

Reference Type
The choice is given between the three following options:

- *Input DEM*: the provided "Input Digital Elevation Model" file is used in the process;
- *Reference Height*: in case that the Digital Elevation Model is not used, the parameters needed to define the Cartographic System 6, the pixel spacing and the reference height are compulsory;
- *DEM Download*: The Digital Elevation Model Extraction 657 tool is used to download an online digital elevation model. Various sources are available, see this section 657 for further information.

note that the choice of one source is compulsory.

Parameters

Grid Size
The grid size of the output data must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Amplitude Tracking

It brings to the principal parameters of the Amplitude Tracking 337 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

GCP Selection

Refinement GCP file
Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File) or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the "Tools>Generate Ground Control Point" for details). This file is mandatory.

Shift Refinement and Re-flattening

It brings to the principal parameters of the Shift Refinement and Re-flattening step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Shift to Displacement Conversion and Geocoding

It brings to the principal parameters of the Shift to Displacement Conversion and Geocoding step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Output

Output Root Name
Name of the output root. This file is mandatory.

Delete Temporary Files
By setting this flag, temporary files which are created in the intermediate steps, are automatically removed. All of the intermediate files are kept otherwise, refer to the Output lists relevant to each processing step for further information.

_dem
Input Digital Elevation Model resampled onto the specified cartographic system and grid size, with the associated header files (.sml, .hdr). Its areal extent is the same as the output SAR products.

_dr_disp_cc_geo
Geocoded coherence in range with the associated header files (.sml, .hdr).

_da_disp_cc_geo
Geocoded coherence in azimuth with the associated header files (.sml, .hdr).

_ADF
Maximum slope direction values, with the associated header files (.sml, .hdr).

_IDF

Maximum slope inclination values, with the associated header files (.sml, .hdr).

_SD
Displacement values along the maximum slope direction, with the associated header files (.sml, .hdr).

_UD
Displacement values in the direction specified as azimuth and inclination degrees (i.e. custom direction), with the associated header files (.sml, .hdr).

_VD
Vertical displacement values, with the associated header files (.sml, .hdr).

_dr_disp
Slant Range (satellite view direction) displacement values, with the associated header files (.sml, .hdr).

_da_disp
Azimuth (satellite flying direction) displacement values, with the associated header files (.sml, .hdr).

_dr_precision
Estimate of the data quality of the Range Shift with the associated header files (.sml, .hdr). This file is generated only if the coherence file is entered as input.

_da_precision
Estimate of the data quality of the Azimuth Shift with the associated header files (.sml, .hdr). This file is generated only if the coherence file is entered as input.

_dr_disp_ALOS
Azimuth Line of Sight with the associated header files (.sml, .hdr). Positive angles are measured clockwise from the North; negative angles are measured counterclockwise from the North.

_da_disp_ALOS
Satellite flying direction with the associated header files (.sml, .hdr). Positive angles are measured clockwise from the North; negative angles are measured counterclockwise from the North.

_dr_disp_ILOS
Incidence angle of the Line of Sight with the associated header files (.sml, .hdr). The angle is measured between the Line Of Sight and the vertical on the ellipsoid (flat earth).

_da_disp_ILOS
Incidence angle for the Satellite flying direction with the associated header files (.sml, .hdr). The angle is measured between the Flying Direction and the vertical on the ellipsoid (flat earth).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Function(s)

Preview

By setting this flag, the temporary files are made available to visualise after a single step in the chain.

References

Consult the reference guide specific to each processing step.

1.6.3.7 Coherence RGB Workflow

Purpose

This functionality enables to execute, in a single iteration, the following processing sequence:

- Coherence estimation. 163
- Multilooking 119.
- Coregistration 121.
- Powers and Coherence Geocoding 142.
- Color Composite Generation 704.

The final purpose of this processing chain is to generate an RGB color composite for the visualisation and identification of coherent temporal changes.

Technical Note

Details specific to each step implemented here are described in their respective reference guide section. We recommend to read them carefully.

Input

Input Files

Input Master file

File name of the master data (_slc). This file is mandatory.

Input Slave file

File name of the slave data (_slc). This file is mandatory.

DEM/Cartographic System

Reference Type
The choice is given between the three following options:

- *Input DEM*: the provided "Input Digital Elevation Model" file is used in the process;
- *Reference Height*: in case that the Digital Elevation Model is not used, the parameters needed to define the Cartographic System 6, the pixel spacing and the reference height are compulsory;
- *DEM Download*: The Digital Elevation Model Extraction 657 tool is used to download an online digital elevation model. Various sources are available, see this section 657 for further information.

note that the choice of one source is compulsory.

Parameters

Grid Size
The grid size of the output data must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Coherence

It brings to the principal parameters of the Coherence 165 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Multilooking

It brings to the principal parameters of the Multilooking 120 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Coregistration

It brings to the principal parameters of the Coregistration 124 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Powers and Coherence geocoding

It brings to the principal parameters of the Geocoding 148 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Generate Color Composite

It brings to the principal parameters of the Color Composite Generation 705 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Output

Output File List
Output file name(s) of all geocoded file(s). The number of output files must be equal to the number of input files. This file list is mandatory.

Output File
Name of the output root. This file is mandatory.

Delete Temporary Files
By setting this flag, temporary files which are created in the intermediate steps, are automatically removed. All of the intermediate files are kept otherwise, refer to the Output lists relevant to each processing step for further information.

_cc_geo
Geocoded coherence with the associated header files (.sml, .hdr).

_master_geo
Geocoded intensity with the associated header files (.sml, .hdr).

_slave_geo
Geocoded intensity with the associated header files (.sml, .hdr).

_rgb
Tiff image and corresponding header file (.sml). The coherence (1st input) and two Intensity images (2nd and 3rd input) must be provided as input. In the output RGB image (unsigned format) the Red channel is the coherence; the Green channel is the mean Intensity; the Blue channel is the Intensity difference (2nd - 3rd).

.tif
Tiff image and corresponding header file (.sml).

.kml
ASCII file containing the information to visualize the Tiff image in Google Earth. It is generated only for images geocoded using the GEO-GLOBAL reference system.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Function(s)

Preview
By setting this flag, the temporary files are made available to visualise after a single step in the chain.

References

Consult the reference guide specific to each processing step.

1.6.3.8 Coherence-CCD Workflow

Purpose

This functionality enables to execute, in a single iteration, the following processing sequence:

- Coherence 163 estimation.
- Coherence Geocoding 142

The final purpose of the CCD (Coherence Change Detection) processing chain is the generation of a geocoded coherence map.

Technical Note

Details specific to each step implemented here are described in their respective reference guide section. We recommend to read them carefully.

Input

Input Files

Input Master file
File name of the master data (_slc). This file is mandatory.

Input Slave file
File name of the slave data (_slc). This file is mandatory.

DEM/Cartographic System

Reference Type
The choice is given between the three following options:

- *Input DEM*: the provided "Input Digital Elevation Model" file is used in the process;
- *Reference Height*: in case that the Digital Elevation Model is not used, the parameters needed to define the Cartographic System 6, the pixel spacing and the reference height are compulsory;

DEM Download: The [Digital Elevation Model Extraction](657) tool is used to download an online digital elevation model. Various sources are available, see [this section](657) for further information.

note that the choice of one source is compulsory.

Parameters

Grid Size
The grid size of the output data must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Coherence

It brings to the principal parameters of the Coherence 165 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Coherence geocoding

It brings to the principal parameters of the Geocoding 148 step. Refer to the relevant section technical note for further information about the process and other Preferences parameters.

Output

Output file list
Output file name(s) of all geocoded file(s). The number of output files must be equal to the number of input files. This file list is mandatory.

Delete Temporary Files
By setting this flag, temporary files which are created in the intermediate steps, are automatically removed. All of the intermediate files are kept otherwise, refer to the Output lists relevant to each processing step for further information.

_cc_geo
Geocoded coherence image and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Function(s)

Preview
By setting this flag, the temporary files are made available to visualise after a single step in the chain.

References
Consult the reference guide specific to each processing step.

1.6.3.9 Phase Processing - Interferometry Single Steps

Purpose

This functionality enables to execute, step by step, the following processing sequence:

- Interferogram Generation and Flattening 293.
- Adaptive Filter and Coherence Generation 300.
- Phase Unwrapping 305.

References
Consult the reference guide specific to each processing step.

Section Content

1.6.3.9.1 1 - Interferogram Generation

Purpose

The distance difference between a point on the Earth and the sensor position on the two acquisitions can be measured by the phase difference (ϕ) between two complex coregistered SAR images. This is performed by multiplying one image by (the complex conjugate of) the other one, where an interferogram is formed.

The final output of this step is a flattened interferogram, where the constant phase (due to the acquisition geometry) and the topographic phase (if an input DEM is provided) have been removed.

It is important to point out that, in case ENVISAT-ERS pairs are processed, the "Coregistration with DEM" flag must be checked.

Technical Note

The interferometric phase is expressed as:

Phase = ATAN[Imag(I)/Real(I)]

Where Imag(I) and Real(I) are respectively the imaginary and real parts of the interferogram.

Spectral shift and common Doppler bandwidth filtering are performed during the interferogram generation. Spectral shift is needed due to the range spectra shift caused by the variable SAR viewing angle on distributed targets. The Doppler bandwidth filtering is required to compensate for different Doppler (squint angles), which produce shifted azimuth spectra. The azimuth filter applied during the interferogram generation enables to fully capture the scene's potential coherence.

The Interferogram Flattening is performed using an input reference Digital Elevation Model or the ellipsoidal model if the DEM is not inputted; the GCP file, if entered, is used to correct the master image onto the Digital Elevation Model. The better the reference Digital Elevation Model accuracy/resolution the better the result in terms of topography removal.

In case of ENVISAT-ERS pairs, when the reference Digital Elevation Model is very coarse and it is preferable to adopt an ellipsoidal model as reference, this step can be run without inputting the Digital Elevation Model; in such instance a Reference Height must be provided ("Cartographic System" section). In any case the "Input master file" must be the ASAR acquisition.

Coregistration with DEM
By checking this flag, the spectral shift filter is adapted to the local slope variations; this process can increase considerably the computing time. The coregistration accuracy, and consequently the coherence and interferometric phase, can be improved especially when very high resolution data are processed. This flag should be checked in the following cases: i) Data long stripes (i.e. segments of orbit instead of single frames); ii) Data acquired at high latitudes; iii) Non zero-Doppler annotated data (especially in case of long wavelength such as ALOS PALSAR).

It is recommended **not to check this flag** when the SAR data orbital parameters are inaccurate.

Details about the coregistration process are provided in the relevant Technical Note 121. The reference flowchart provides a schematic representation of the different steps involved.

In case of inaccuracy in the satellite orbits or in the Digital Elevation Model geolocation, a Ground Control Point (GCP file) is required to correct the SAR data (i.e. master acquisition of the interferometric pair) with respect to the reference Digital Elevation Model. In this case the shift calculated in the coregistration process is combined with the Ground Control Point shift in order to correct the slave data according to the master data. Note that the Ground Control Point must be referred to the master single look image (_slc).

It is important to note that:

- In case the "Input Master file" has already been corrected with the the manual 722 or the automatic 719 procedure the "GCP file" is not needed.
- In case the "Input Master file" is correct (i.e. the nominally geocoded image fits with the DEM), while the orbital parameters of the "Input Slave file" are not accurate (i.e. the nominally geocoded image does not fit with the DEM), the "GCP file" is not needed but the flag "Automatic Slave Orbit Correction", in the Preferences>Flattening 775, must be checked.

In case the two images are very much different in terms of areal coverage, the smallest one should be used as "Input Master file" in order to avoid the coregistration windows to be located in areas with null pixel values, which can eventually cause the coregistration process to fail.

In case of baseline conditions - or topographic conditions - which cause the interferometric phase to change very fast and to eventually get lost due to an aliasing problem, it is suggested to over sample the range pixel size by entering negative values in the Range Multilooking (Preferences>Interferometry>Multilooking 779). As an example using ERS-ASAR interferometric tandem pairs, which are characterized by a very small ambiguity height (hence very dense/frequent interferometric fringes), the Interferometric multilooking factors shall be set to -2 and 3 (respectively in Range and Azimuth).

As result of this step multi-looked products are generated (refer to the "Basic module>Multilooking 119" for more details). **It is important to know that, unlike the multi-looked intensity images generated in the "Basic module>Multilooking", these master and slave intensities cannot be radiometrically calibrated 142 due to the spatial varying effect introduced by the spectral shift filter**.

Input Files

Input Master file
File name of the master data (_slc). This file is mandatory.

Input Slave file
File name of the slave data (_slc). This file is mandatory.

Optional Files

Geometry GCP file

Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File) or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the "Tools>Generate Ground Control Point 747" for details). This file is optional.

Coregistration file

A previously created Ground Control Point file (.xml), with the points used for the manual coregistration (.xml), is automatically loaded. These points represent the center of the coregistration windows. This file is optional.

Shift Parameter file

Name of the file with the shift parameters used for the coregistration (_par). This file is mandatory. If the Compute shift parameter flag is set, it is generated as output.

DEM/Cartographic System

Digital Elevation Model file

Name of the Digital Elevation Model file. This should be referred to the ellipsoid.

Output Projection

In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System** 6:

State

Definition of the country or general projection systems.

Projection

Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid

Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere

Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone

Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters

Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height

In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be

provided. Default Reference Height is 0.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Range Looks
Number of looks in range.

Azimuth Looks
Number of looks in azimuth.

Grid Size for Suggested Looks
The grid size, in meters, used to tune range and azimuth looks. If the other parameters are manually set, the grid size will not imply a change in their values.

Compute Shift Parameters
By setting this flag, the coregistration shifts between master and slave image are calculated and saved into the _par file.

Compute Shift Parameters only
By setting this flag only the coregistration shift parameters are calculated and saved into the _par file.

Generate Coregistered SLC
By setting this flag, master and slave coregistered Single Look Complex data are generated among the output products. These files are over sampled of a factor 2 in range direction.

Coregistration with DEM
By setting this flag, the input Digital Elevation Model is used in the coregistration process.

Parameters - Global

It brings to the general section of the Preferences759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Flattening

It brings to the flattening section of the Preferences775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Interferogram

It brings to the interferometry section of the Preferences 779 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Coregistration

It brings to the coregistration section of the Preferences 770 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Name of the output root. This file is mandatory.

_int
Interferogram with the associated header files (.sml, .hdr).

_dint
Flattened interferogram with the associated header files (.sml, .hdr).

_sint
Synthetic phase with the associated header files (.sml, .hdr).

_srdem
Digital Elevation Model, in slant range geometry, with the associated header files (.sml, .hdr).

_slc_rsp
Coregistered Single Look Complex data. This file is generated only if the relevant flag is set.

_par
ASCII file containing the coregistration shift parameters in range and azimuth. This file is generated only if the shift parameters are calculated.

_pwr
Multi-looked master and slave image with the associated header files (.sml, .hdr).

_orb.sml
Xml file containing the scene orbital parameters.

_orbit_off.shp
Shape file with the points used to estimate the orbit based shift. This file contains the following information:

- Pixel position in range direction (Range), in Single Look pixel units.
- Pixel position in azimuth direction (Azimuth), in Single Look pixel units.
- Shift measured in range direction (Dr), in Single Look pixel units.
- Shift measured in azimuth direction (Da), in Single Look pixel units.
- Calculated polynomial shift, to apply in range direction (Drfit), in Single Look pixel units.
- Calculated polynomial shift, to apply in azimuth direction (Dafit), in Single Look pixel units.

The file, which is generated only when the shift parameters are calculated, is multilooked (i.e. Azimuth and Range looks) as specified in the Input Parameters.

_winCC_off.shp
Shape file with the points used to estimate the cross correlation based shift from the Intensity data. In addition to the information provided by the "_orbit_off.shp" file, this file contains also the cross-correlation value (CC), which is dimensionless and it can vary from 0 to 1.

The file, which is generated only when the shift parameters are calculated, is multilooked (i.e. Azimuth and Range looks) as specified in the Input Parameters.

_winCoh_off.shp
Shape file with the points used to estimate the coherence based shift from the complex data (fine shift estimate). In addition to the information provided by the "_orbit_off.shp", this file contains also the the following information:

- Signal to Noise Ratio (SNR), which is a linear dimensionless value.
- Coherence value. It is dimensionless and it can vary from 0 to 1.

The file, which is generated only when the shift parameters are calculated, is multilooked (i.e. Azimuth and Range looks) as specified in the Input Parameters.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch

processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

A. Monti Guarnieri, C. Cafforio, P. Guccione, D. Nüesch, D. Small, E. Meier, P. Pasquali, M. Zink, Y. L. Desnos: "Multi-mode ENVISAT ASAR Interferometry: Techniques and Preliminary Results". Proceedings of EUSAR Conference 2002.

1.6.3.9.2 2 - Adaptive Filter and Coherence Generation

Purpose

The filtering of the flattened interferogram enables to generate an output product with reduced phase noise. The Interferometric Coherence (which is an indicator of the phase quality) and the master Intensity filtered image, are also generated.

Technical Note

It is possible to select on of the following three filtering methods:

Adaptive
The coherence values are used to set the filter window size; the mean Intensity difference among adjacent pixels is used to identify a stationary area, which defines the maximum dimension (in any case not bigger than the input parameter setting) and the shape of the filtering windows. The process is aimed at preserving even the smallest interferometric fringe patterns.

This filtering procedure is quite expensive in terms of computing time as well as for what concerns the identification of the threshold value to use as Similarity Mean Factor (similarity between the backscatter values measured in the master and slave Intensity data). On the basis of this factor the areas of the

image where the signal intensity is considered stationary are identified. The selection of the pixels to include within each "stationary area", is based on the value of the difference between the mean of the pixels in that area (M_{all}) and the value of the new pixel (M_{new}), which is potentially candidate (this difference is normalized for M_{all}). The new candidate pixels are identified using a region growing approach.
The formula of the Similarity Mean Factor, which is represented by a digital number in linear scale, can be written as:

$$(M_{all} - M_{new}) / M_{all}$$

It must be noted that several process iterations are typically required in order to set the optimal Similarity Mean Factor. This threshold value can be set from the Preferences>Adaptive Filter>Adaptive Interferogram Filtering>Similarity Mean Factor 783.

Boxcar
The local fringe frequency is used in order to optimize the band pass filter. The process is aimed at preserving even the smallest interferometric fringe patterns. The processing parameters, which are not directly visible in this processing interface, can be accessed and modified from the Preferences>Adaptive Filter>Boxcar Interferogram Filtering 783.

Goldstein
The variable bandwidth of the filter, derived directly from the power spectrum of the fringes, smoothes in a selective way the noise frequencies and the signal frequencies. In order to optimize the filter performance the "alpha" parameter, which characterizes the strength of the filter, is handled in an adaptive way on the basis of the local scene coherence: the lower the coherence the stronger the filter.

Several processing parameters, which are not directly visible in this processing interface, can be accessed and modified from the Preferences>Adaptive Filter>Goldstein Interferogram Filtering 783.

This filtering approach, which is an extension of the Goldstein method, significantly improves fringe visibility and reduces the noise introduced by temporal or baseline related decorrelation. In this implementation the alpha 783 parameter is depending on the coherence: incoherent areas are filtered more than coherent zones. This implies a signal loss minimization, while strongly reducing the level of noise. The use of the coherence generated from the filtered interferogram (option enabled by setting the flag "Coherence from Fint"), must be carefully considered since the phase smoothing, which is produced by the filter itself, causes an over estimation of the coherence (the stronger the filter the higher the coherence values). If the objective is either not to unwrap areas which appear coherent but are actually very noisy or to use of the coherence data for other purposes (i.e. land cover classification or other qualitative/quantitative applications), the coherence shall be generated from the unfiltered interferogram or using the boxcar filtering approach.

The interferometric correlation or **Coherence** (γ) is the ratio between coherent and incoherent summations:

$$\gamma = \frac{\left|\sum s_1(x) \cdot s_2(x)^*\right|}{\sqrt{\sum |s_1(x)|^2 \cdot \sum |s_2(x)|^2}}$$

The estimated coherence - which ranges between 0 and 1 - is function of:

- Systemic spatial de-correlation (i.e. the additive noise).
- Temporal de-correlation between master and slave acquisitions.

When working with single look data (i.e. azimuth and range multilooking factors are both set to 1), it could make sense to increase the "Coherence Window Size" (in azimuth and range) in order to increase the number of samples and eventually avoid coherence overestimate problems.

The coherence product has essentially a twofold purpose:

- To determine the quality of the measurement (i.e. interferometric phase). As a rule of thumb, InSAR pairs with low coherence should not be used to derive reliable phase related measurements.
- To extract thematic information relevant to the ground features properties and their temporal changes. This information is enhanced when coupled with the backscattering coefficient (σ^o) of the master and slave Intensity data.

As a general rule it can be assumed that the coherence decreases with increasing master-slave acquisition time distance.

The coherence image can be generated from the input unfiltered interferogram or from the filtered one (refer to the "Input Parameters>Coherence from Fint").

Input Files

Interferogram file
File name of the flattened interferogram (_dint). This file is mandatory.

Input Master file
File name of the multi-looked master Intensity data (_pwr). This file is mandatory.

Input Slave file
File name of the multi-looked coregistered slave Intensity data (_pwr). This file is mandatory.

Parameters - Principal Parameters

Coherence Generation
By setting this flag, the coherence is generated.

Adaptive Filter
By setting this flag, the input interferogram is filtered. This flag is disabled when the "Local Frequency Removal (Range and Azimuth)" is set to a value higher than zero; indeed in this case the _fint file should have already been generated.

Filtering method
The choice is given between the following filtering methods according to the default values of the filtering section of the Preferences 783 parameters:

- *Adaptive window;*
- *Boxcar window;*
- *Goldstein.*

Refer to the Preferences 783 description for further information about these methods.

Coherence from Fint
By setting this flag, the coherence is computed using the filtered interferogram (_fint) instead of the unfiltered one (_dint).

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Filtering

It brings to the filtering section of the Preferences 783 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Name of the output root. This file is mandatory.

_fint

Filtered interferogram with the associated header files (.sml, .hdr). This file is generated only if the Adaptive Filter flag is selected.

_pwr_fil
Filtered Intensity - from master and slave combination - with the associated header files (.sml, .hdr). This file is generated only if the "Adaptive" filter is selected.

_cc
Estimated coherence with the associated header files (.sml, .hdr). This file is generated only if the Coherence Generation flag is selected.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

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Baran I., Stewart Mike P., Kampes Bert M., Perski Z., Lilly P.: "A Modification to the Goldstein Radar Interferogram Filter", IEEE Transactions on Geoscience and Remote Sensing, Vol. 41, No. 9, September

2003.

Ghulam A., Amer R., Ripperdan R.: "A filtering approach to improve deformation accuracy using large baseline, low coherence DInSAR phase images", Paper presented at IGARSS 2010.

1.6.3.9.3 3 - Phase Unwrapping

Purpose

The phase of the interferogram can only be modulo 2π; hence anytime the phase change becomes larger than 2π the phase starts again and the cycle repeats itself. Phase Unwrapping is the process that resolves this 2π ambiguity. Several algorithms (such as the branch-cuts, region growing, minimum cost flow, minimum least squares, multi-baseline, etc.) have been developed; in essence, none of these is perfect and different or combined approaches should be applied on a case by case basis to get optimal results.

Depending on specific data characteristics a further phase editing 470 could be required in order to correct errors in the unwrapped interferogram.

Technical Note

Two methods are implemented:

- **Region Growing** -> This is the default unwrapping algorithm. If this method is selected, it is suggested to avoid setting a high coherence threshold (good values are typically between 0.15 and 0.2) in order to leave enough freedom during the growing process; this shall limit the possibility to introduce erroneous phase jumps - "unwrapping islands" - in the output unwrapped phase image.
- **Minimum Cost Flow** -> This method should be adopted when the unwrapping process becomes difficult due to the presence of large areas of low coherence or other growing limiting factors; in such cases the Minimum Cost Flow algorithm enables to obtain better results than using the Region Growing method. This approach considers a square grid all over the image pixels. All pixels whose coherence is lower than the "Unwrapping Coherence Threshold" are masked out.
- **Delaunay MCF** (Minimum Cost Flow) -> It is the same approach of the previous method, with the only difference that the grid does not necessarily covers all image pixels, but only those above the "Unwrapping Coherence Threshold"; moreover it adopts the Delaunay triangular grid instead of square one. As result only the points with good coherence are unwrapped, without any influence from the low coherence pixels. The exploitation of the Delaunay triangulation is especially useful when there are several areas of low coherence (water bodies, densely vegetated areas, etc.) distributed throughout the image; in such case the others unwrapping approaches would eventually produce phase islands/jumps, while the Delaunay approach is able to minimize these jumps.

Decomposition Levels

The process is normally executed with the original pixel sampling (i.e. -1) or with the minimum decomposition level (i.e. 1). The use of the decomposition is intended to multilook and undersample the data in an iterative way: the interferogram is unwrapped at the lower resolution and then reconstructed back at the original resolution. The use of the decomposition can be of help to reduce unwrapping errors (e.g. in case of distributed low coherence areas) and it reduces the processing time and it limits the use of computer resources.

The user can specify the number of iterations (i.e. decompositions) to execute; each iteration corresponds to an undersampling factor of 3. We suggest to avoid setting this value higher than 3.

In case of very large displacements or very steep topography (fast phase/dense fringe distribution) the use of the decomposition can cause aliasing effects. In this case the decomposition process should be avoided by setting its value to -1.

Tandem-X Data
When these data are acquired in bistatic mode, the unwrapped phase (_upha) is automatically reflattened (_reflat_upha). Due to this the Refinement and Re-flattening step has not to be performed.

Input Files

Coherence file
File name of the coherence (_cc). This file is mandatory.

Interferogram file
File name of the flattened - and possibly filtered - interferogram (_fint). This file is mandatory.

Parameters - Principal Parameters

Unwrapping Method Type
The choice is given between the following unwrapping methods:

- *Region Growing*, the Region Growing unwrapping method is used;
- *Minimum Cost Flow*, the Minimum Cost Flow (square grid) unwrapping method is used;
- *Delaunay MCF*, the Minimum Cost Flow (triangular grid) unwrapping method is used.

Unwrapping Decomposition Level
The number of multilooking and undersampling iterations can be specified (refer to the Technical Note).

Unwrapping Coherence Threshold

Pixels with coherence values smaller than this threshold are not unwrapped.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Phase Unwrapping

It brings to the interferometry section of the Preferences 779 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Unwrapped Phase file
File name of the output unwrapped phase. This file is mandatory.

_upha
Unwrapped phase with the associated header files (.sml, .hdr).

_reflat_upha
Re-flattened unwrapped phase with the associated header files (.sml, .hdr). This file is generated only for Tandem-X bistatic Data.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Reigber A. and J. Moreira: "Phase Unwrapping by Fusion of Local and Global Methods". Proceedings of IGARSS'97 Symposium, 1997.

Costantini, M.: "A novel phase unwrapping method based on network programming". Geoscience and Remote Sensing, IEEE Transactions on, May 1998, 36(3), pp. 813 - 821.

1.6.3.9.4 4- Refinement and Re-flattening

Purpose

This step is crucial for a correct transformation of the unwrapped phase information into height (or displacement) values. It allows both to refine the orbits (i.e. correcting possible inaccuracies) and to calculate the phase offset (i.e. getting the absolute phase values), or remove possible phase ramps.

The execution of this step is mandatory for Digital Elevation Model generation 314 as well as for Displacement Mapping 320.

To execute this step a Ground Control Point file 747 must be previously created.

Technical Note

Depending on the specific processing parameter setting (Preferences>Flattening>Refinement and Re-flattening/Refinement Method 775), the polynomials and the correction factors are calculated and written in the header file of the unwrapped phase image (_upha.sml>interferometric_processing section) - as well as on a popup window when the process is not executed in batch mode - at the process completion; these correction factors/polynomials are:

- **ORShiftOrbitInX** - Orbital shift in X direction (in meters) - It is generated if the "Orbital 775" method is applied.

- **ORShiftOrbitInY** - Orbital shift in Y direction (in meters) - It is generated if the "Orbital 775" method is applied.
- **ORShiftOrbitInZ** - Orbital shift in Z direction (in meters) - It is generated if the "Orbital 775" method is applied.
- **ORAzShiftOrbitInX** - Dependency of the shift in X direction, from the azimuth position (in meters per pixel) - It is generated if the "Orbital 775" method is applied.
- **ORAzShiftOrbitInY** - Dependency of the shift in Y direction, from the azimuth position (in meters per pixel) - It is generated if the "Orbital 775" method is applied.
- **ORAzShiftOrbitInZ** - Dependency of the shift in Z direction, from the azimuth position (in meters per pixel) - It is generated if the "Orbital 775" method is applied.
- **ORPhaseOffset** - Absolute phase offset (in radians) - It is generated if the "Orbital 775" method is applied.
- **ORRMSError** - Root mean square error calculated as the difference between the height value of the Ground Control Points and the corresponding value in the interferometric phase (in meters) - It is generated if the "Orbital 775" method is applied.
- **PhaseError** - A-priori achievable root mean square error, calculated as average on the input GCPs (height in meters) - It is generated if the "Default" method flag is checked.
- **RPPPhasePolyDegree** - Degree of the polynomial used to estimate the phase ramp - It is generated if the "Polynomial Refinement 775" method is applied.
- **RPPPhasePoly** - The polynomial used to estimate the phase ramp - It is generated if the "Polynomial Refinement 775" method is applied.
- **RPPRMSE** - Root mean square error calculated as the difference between the height value of the Ground Control Points and the corresponding value in the interferometric phase (in meters) - It is generated if the "Polynomial Refinement 775" method is applied.

The popup window additionally provides, for each input Ground Control Point, the following values:

- Mean difference between SRDEM - slant range input DEM - and SAR DEM (in meters).
- Mean difference between Unwrapped Phase and calculated Phase Ramp (in radians)
- Standard Deviation between SRDEM and SAR DEM (meters).

Very large "ORRMSError" or "RPPRMSE" **-** root mean square errors - (in the order of hundreds or thousands) eventually bring to wrong results. Care must be paid also when very small "ORRMSError" values (less than 1) are reported; as a rule of thumb errors from some units to some tens are a good preliminary indication that the Ground Control Points have been properly located.
Large "ORRMSError" values can be reported when processing pairs with very small baseline (i.e. less than about 10 meters).

Ground Control Points located on null/dummy value pixels (NaN) are discarded.

The correction parameters are calculated depending on the specific "Refinement Setting 775" and they are applied to rebuild the following input files:

- Unwrapped Phase (_upha).
- Flattened Interferogram (_dint or _fint).
- Synthetic Phase (_sint).

The points ("Refinement Ground Control Point file") used to calculate the correction parameters (Refinement Setting), shall be selected on the input flattened interferogram (_dint, _fint) in order to avoid areas where topographic fringes remained "unflattened" and "moving areas". The Ground Control Points must be well distributed throughout the entire scene.

An indication about the Ground Control Points quality can be obtained by inspecting the "_refinement.shp" (see "Output" product description below).

If the Interferogram Flattening has been performed using a reference Digital Elevation Model, it is not necessary to specify the co-ordinates of each Ground Control Point; in this case the cartographic co-ordinates (easting, northing and height on the reference DEM) of each GCP are written in the log file825 at the end of this processing step.
Areas with good coherence should be preferred for the Ground Control Points location. In any case the importance of each GCP is weighted by the program on the basis of its coherence value.

If errors exist in the unwrapped phase image, they must be corrected before running this step. Otherwise wrongly unwrapped areas (disconnected phase "islands") have to be discarded for the Ground Control Points location.

Input Files

Coherence file
Name of the coherence image (_cc). This file is mandatory if a "Refinement Method"775 is selected.

Input Master file
File name of the multi-looked master Intensity data (_pwr). This file is mandatory.

Input Slave file
File name of the multi-looked coregistered slave Intensity data (_pwr). This file is mandatory.

Unwrapped Phase file
Name of the unwrapped phase (_upha). This file is mandatory.

Synthetic Phase file
Name of the synthetic phase (_sint). This file is mandatory.

Slant Range Digital Elevation Model file
Name of the Digital Elevation Model in slant range geometry (_srdem).

Refinement GCP file
Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File), or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the "Tools>Generate Ground Control Point747" for details). This file is mandatory if a "Refinement Method"775 is selected.

Optional Files

Interferogram file
Name of the flattened phase (_fint, _dint). This file is optional.

DEM/Cartographic System

Digital Elevation Model file
Name of the Digital Elevation Model file (geocoded reference DEM). This file is mandatory if it had been used as input for the flattened interferogram generation. If the Digital Elevation Model is omitted, an ellipsoidal height including the cartographic reference system must be set.

Output Projection
In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Refinement method
The choice is given between the following refinement methods:

- *Automatic Refinement;*
- *Polynomial Refinement;*
- *Orbital Refinement.*

Refer to the flattening section of the Preferences 775 for further information about these methods.

Refinement Residual Phase Polynomial Degree
Degree of the polynomial used to estimate the phase ramp, which will be removed from the input unwrapped phase during the Re-flattening operation. In case this value is higher that the number of input Ground Control Points, it will be automatically decreased. The default values of 3 means that a phase ramp in range and azimuth direction plus a constant phase offset will be corrected. In case only the phase offset correction is needed, the polynomial degree will be set to 1.

Coregistration With DEM
This parameter can not be defined by the user.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Flattening

It brings to the flattening section of the Preferences 775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Coregistration

It brings to the coregistration section of the Preferences 770 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Refinement

It brings to the flattening section of the Preferences 775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Name of the output root. This file is optional.

_reflat_dint/fint
Re-flattened interferogram with the associated header files (.sml, .hdr).

_reflat_sint
Re-flattened synthetic phase with the associated header files (.sml, .hdr). This file is generated only if a "Refinement Method" 775 was selected.

_reflat_upha
Re-flattened unwrapped phase with the associated header files (.sml, .hdr).

_reflat_srdem
Digital Elevation Model, in slant range geometry, with the associated header files (.sml, .hdr). This file is generated only if a "Refinement Method" 775 was selected.

_reflat.txt
Text file with the orbital correction parameters resulting from the refinement.

_refinement.shp
Shape file containing those points retained (valid GCPs) form the input "Refinement GCP file". The following information is provided if the "Orbital 775" method is applied:

- Height value (in meters) from the input DEM in slant range - "ReadHeight".
- Absolute - "AbsHgtDiff" - and relative - "HeightDiff" - difference (in meters) between the real height (input DEM in slant range) and the height value derived from the corrected orbits.
- Standard deviation (in meters) of the input "Refinement GCP file" - "SigmaMt" - It is based on interferometric coherence and orbital configuration.
- Standard deviation (in radians) of the input "Refinement GCP file" - "SigmaRad" - It is based on the interferometric coherence.

The following information is provided if the "Polynomial Refinement 775" method is applied.

- Unwrapped phase value (in radians) - "ReadPhase".
- Absolute - "AbsPhDiff" - and relative - "PhaseDiff" - difference (in radians) between the real phase and its fitted value based on GCPs.

- Standard deviation (in meters) of the input "Refinement GCP file" - "SigmaMt" - It is based on interferometric coherence and orbital configuration.
- Standard deviation (in radians) of the input "Refinement GCP file" - "SigmaRad" - It is based on the interferometric coherence.

_refinement_geo.shp
Shape file containing the geocoded location of the valid GCPs used in the refinement process.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.6.3.9.5 5A - Phase to Height Conversion and Geocoding

Purpose

The absolute calibrated and unwrapped phase is re-combined with the synthetic phase and it is converted to height and geocoded into a map projection. This step is performed in a similar way as in the geocoding procedure (Basic module 142), by considering the Range-Doppler approach and the related geodetic and cartographic transforms. The fundamental difference with the geocoding step is that the Range-Doppler equations are applied simultaneously to the two antennae, making it possible to obtain not only the height of each pixel, but also its location (Easting, Northing) in a given cartographic and geodetic reference system.

As result of this step also the coherence image is geocoded.

Technical Note

The phase-to-height conversion is performed with a forward transformation. The calculated X, Y, Z Cartesian coordinates (and thereafter map coordinates) are transformed into the coordinates of the output DEM exclusively using a Nearest Neighbor approach.

Two files are generated in this step, beside the Digital Elevation Model and the geocoded coherence image, for a further use in the data mosaicing 712. They are:

- **Precision**, which is derived from parameters such as coherence, baseline and wavelength. It provides an estimate (i.e. standard deviation value) of the measurement precision. The higher this value the lower the measurement precision. The formula used for the precision calculation is:

$$\sqrt{\frac{1-\gamma^2}{2\gamma^2}}\ \frac{\lambda R \sin\vartheta}{4\pi B}$$

- **Resolution**, which represents the pixel resolution in ground range, that is:

$$\frac{\text{pixel spacing slant range}}{\sin\vartheta}$$

where γ is the interferometric coherence, λ is the wavelength, R is the slant range distance, ϑ is the local incidence angle.

- **Wavelet Number of Levels** The Number of Levels, which refers to the power of a base 2, determines what is kept of the unwrapped phase. As an example, considering input data with a pixel spacing of 25 m, a "Number of Levels" of 1 means that the information coarser than 50 m is removed and the information finer than 50 m is preserved; a "Number of Levels" of 2 means that the information coarser than 100 m is removed and the information finer than 100 m is preserved; a "Number of Levels" of 3 means that the information coarser than 200 m is removed and the information finer than 200 m is preserved. It is suggested to set this value as a function of the reference DEM (which is used for the interferogram flattening) resolution; as an example, if we process SAR data with 3 m resolution with an SRTM reference DEM (90 m resolution), we'll enter a number of levels of 5 or more.

- **Data Interpolation** is intended to assign a specific value to the dummy (NaN) pixels. The "Relax Interpolation" model is represented by a soft surface, which is adapted to the dummy surrounding area. The algorithm, which is based on the solution of the heat transfer equation (Poisson equation), uses known height values to reconstruct at the best the unknown topography; for this reason it is optimally suited to interpolate small zones, especially where abrupt morphological changes (i.e. steep slopes) are not present.

- Generate Shape format allows representing the DEM as a point cloud. This procedure is intended to preserve the actual pixel value without applying any interpolation, which is the case of the raster output. This format is the one to use as input for the Point Cloud DEM Fusion 687 and for the Point Gridding 751. It can happen that the .shp and the .dbf become very large when there are a lot of valid points.

Input Files

Coherence File
File name of the coherence (_cc). This file is mandatory.

Unwrapped Phase File
File name of the unwrapped phase (_reflat_upha). This file is mandatory.

Synthetic Phase File
File name of the synthetic phase (_reflat_sint). This file is mandatory.

Master File
File name of the master orbital data (_pwr.sml). This file is mandatory.

Slave File
File name of the slave orbital data (_pwr.sml). This file is mandatory.

DEM/Cartographic System

Output Projection
The following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Product Coherence Threshold
Pixels with coherence values smaller than this threshold will be set to dummy (NaN) in the final products.

Wavelet Number of Levels
Level setting for the wavelet calculation. It determines the level of detail to preserve.

Generate Shape format
By setting this flag the DEM is generated in vector (.shp) format.

X Dimension (m)
The grid size of the output data in Easting (X) must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Y Dimension (m)
The grid size of the output data in Northing (Y) must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Mean Window Size
The mean filtering of the output height image is carried out. The window filter size must be specified. If zero is entered, the mean filtering is not applied. This filter is applied after the execution of the interpolation steps. The mean filtering is performed only on the Digital Elevation Model output.

Interpolation Window Size
The dummy values in the output file are interpolated. The interpolated value is the average of the valid values in a window of the size specified. If zero is entered, the interpolation is not applied; it is suggested to avoid setting this value to zero (see Technical Note).

Relax Interpolation
By setting this flag the relax interpolation is carried out. This interpolation is applied only to the Digital Elevation Model output.

Dummy Removal
By setting this flag the output geocoded files will be automatically resized in order to remove the dummy area exceeding the frame border.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Geocoding

It brings to the geocoding section of the Preferences 766 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Name of the output root. It is mandatory.

_dem
Digital Elevation Model with the associated header files (.sml, .hdr).

_dem.shp
Digital Elevation Model in shape format and associated header files (.sml, .hdr).

_cc_geo
Geocoded coherence with the associated header files (.sml, .hdr).

_precision

Estimate of the data quality with the associated header files (.sml, .hdr). This file is used during the Digital Elevation Model mosaicing (Tools 712).

_resolution
Spatial resolution based on the local incidence angle with the associated header files (.sml, .hdr). This file is used during the Digital Elevation Model mosaicing (Tools 712).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Holecz F., J. Moreira, P. Pasquali, S. Voigt, E. Meier, D. Nuesch: "Height Model Generation, Automatic Geocoding and Mosaicing using Airborne AeS-1 InSAR Data". Proceedings of IGARSS'97 Symposium, 1997.

W. Göblirsch and P. Pasquali: "Algorithms for calculation of digital surface models from the unwrapped interferometric phase". Proceedings of IGARSS 1996, pp. 656–658.

1.6.3.9.6 5B - Phase to Displacement Conversion and Geocoding

Purpose

The absolute calibrated and unwrapped phase values are converted to displacement and directly geocoded into a map projection. This step is performed in a similar way as in the geocoding procedure (Basic module 142), by considering the Range-Doppler approach and the related geodetic and cartographic transforms. The fundamental difference with the geocoding step is that the Range-Doppler equations are applied simultaneously to the two antennae, making it possible to obtain not only the displacement of each pixel, but also its location (Easting, Northing) in a given cartographic and geodetic reference system.

As result of this step also the coherence image is geocoded.

Technical Note

Each 2π cycle (interferometric fringe) of differential phase corresponds to half wavelength of displacement along the Slant Range direction (SAR viewing direction). It is possible to specify any vector (i.e direction and inclination) where the measured slant range displacement - component of the deformation in the satellite viewing direction - will be projected. Hence this vector represents the re-projection of the slant range deformation component onto a direction on the ground which is known a-priori and specified by the user (i.e. "vertical" in case of subsidence; "slope" in case of landslides; "custom" in any other case).

The output map shows displacement magnitude in meters:

- Slant Range Displacement - Positive sign if the movement corresponds to a decrease of the sensor-to-target slant range distance (slave respect to master acquisition).
- Displacement Custom Direction - Positive sign corresponds to movement in the user defined direction (slave respect to master acquisition).

Displacement Custom Direction
Direction and inclination of the displacement vector can be specified. As an example an "azimuth angle" of 45° means that the displacement is oriented North 45° East and the movement is expected Northeastward; while an "azimuth angle" of 225° means that the displacement is always oriented North 45° East, but the movement is expected Southwestward. Positive inclination angles indicate upward movement; negative inclination angles indicate downward movement.

Precision
This output product, which is derived from parameters such as coherence and wavelength, provides an estimate (i.e. standard deviation value) of the measurement precision. The higher this value the lower the measurement precision. The formula used for the precision calculation is:

$$\sqrt{\frac{1-\gamma^2}{2\gamma^2}}\ \frac{\lambda}{4\pi}$$

where γ is the interferometric coherence.

It is important to outline that the Refinement and Re-flattening 308 step must have been performed previously.

Input Files

Coherence file
File name of the coherence (_cc). This file is optional.

Unwrapped Phase file
File name of the reflattened unwrapped phase (_upha). This file is mandatory.

DEM/Cartographic System

Digital Elevation Model file
Name of the Digital Elevation Model file. This should be referred to the ellipsoid. This file is optional. In case it is omitted, the ellipsoidal height and the relevant cartographic reference system, must be entered.

Output Projection
In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Product Coherence Threshold
Pixels with coherence values smaller than this threshold will be set to dummy (NaN) in the final products.

Vertical Displacement
By setting this flag the map showing the displacement values projected on the vertical direction is generated among the output products.

Slope Displacement
By setting this flag the map showing the displacement values projected along the maximum slope is generated among the output products.

Displacement Custom Direction
By setting this flag any vector can be specified, in terms of azimuth (**Azimuth Angle**, measured in degrees from the North - clockwise direction) and inclination (**Inclination Angle**, measured in degrees from the horizontal plane). The map showing the displacement values projected on the specified direction is generated among the output products.

X Dimension (m)
The grid size of the output data in Easting (X) must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Y Dimension (m)
The grid size of the output data in Northing (Y) must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Interpolation Window Size
By setting this flag the dummy values in the output file are interpolated. The interpolated value is the average of the valid values in a window of the size selected.

Dummy Removal
By setting this flag the output geocoded files will be automatically resized in order to remove the dummy area exceeding the frame border.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Geocoding

It brings to the geocoding section of the Preferences 766 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Displacement Projection

Generate Line Of Sight
by setting this flag the displacement in line of sight as measured by the satellite in generated.

Vertical Displacement
By setting this flag the map showing the displacement values projected on the vertical direction is generated among the output products.

Slope Displacement
By setting this flag the map showing the displacement values projected along the maximum slope is generated among the output products.

Generate East
By setting this flag the map showing the displacement values projected on the East-West direction is generated among the output products.

Generate North
By setting this flag the map showing the displacement values projected on the North-South direction is generated among the output products.

Displacement Custom Direction
By setting this flag any vector can be specified, in terms of azimuth (**Azimuth Angle**, measured in degrees from the North - clockwise direction) and inclination (**Inclination Angle**, measured in degrees from the horizontal plane). The map showing the displacement values projected on the specified direction is generated among the output products.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Name of the output root. It is mandatory.

_dem
Input Digital Elevation Model resampled onto the specified cartographic system and grid size, with the associated header files (.sml, .hdr). Its areal extent is the same as the output SAR products.

_cc_geo
Geocoded coherence with the associated header files (.sml, .hdr).

_ADF
Maximum slope direction values, with the associated header files (.sml, .hdr).

_IDF
Maximum slope inclination values, with the associated header files (.sml, .hdr).

_SD
Displacement values along the maximum slope direction, with the associated header files (.sml, .hdr).

_UD
Displacement values in the direction specified as azimuth and inclination degrees (i.e. custom direction), with the associated header files (.sml, .hdr).

_VD
Vertical displacement values, with the associated header files (.sml, .hdr).

_disp
Slant Range (satellite view direction) displacement values, with the associated header files (.sml, .hdr).

_precision
Estimate of the data quality with the associated header files (.sml, .hdr). This file is generated only if the coherence file is entered as input.

_ALOS
Azimuth Line of Sight with the associated header files (.sml, .hdr). Positive angles are measured clockwise from the North; negative angles are measured counterclockwise from the North.

_ILOS
Incidence angle of the Line of Sight with the associated header files (.sml, .hdr). The angle is measured between the Line Of Sight and the vertical on the ellipsoid (flat earth).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.6.3.10 Dual Pair Differential Interferometry

Purpose

This functionality is an extension of the 3-pass and the 4-pass differential interferometry approaches. The products (in slant range and geocoded geometries) are represented by displacement map (in slant range direction) and height measurements.

Technical Note

The different steps implemented here are executed using the default processing approach (consult the reference guide specific to each processing step for more details); in particular:

- The Interferogram Generation is performed without using input Digital Elevation Model for the coregistration process.

- The Interferogram Flattening is performed using an input reference Digital Elevation Model or the ellipsoidal model. In case of inaccuracy in the satellite orbits or in the Digital Elevation Model geolocation, a Ground Control Point (i.e. "Geometry GCP file") is required to correct the SAR data (i.e. master acquisition of the interferometric pair) with respect to the reference Digital Elevation Model. If two different master images are used (4-pass approach), the GCP file 747 must be created using the "Master 1" as "Reference file"; note that the pixel used as GCP must be imaged by both "Master 1" and "Master 2" acquisitions. The GCP is not needed if the manual 722 or the automatic 719 correction procedure has been previously executed on the Master(s) acquisitions.

SAR data must be acquired by the same sensor with the same acquisition geometry (i.e. same incidence angle).

The output products consist of:

- Displacement velocity (if the "Linear Model" flag is checked) measured in mm/year.
- Displacement (if the "Linear Model" flag is not checked) measured in millimeters.
- Precise surface elevation measurement. This is obtained by summing the residual heights (_height), which are derived from the interferometric technique, to the input Digital Elevation model. The unit of measure is meters.
- Interferometric coherence images.
- Flattened and filtered interferograms.
- Unwrapped phase images.

The displacement values are reported with:

- Positive sign if the movement corresponds to a decrease of the sensor-to-target slant range distance.
- Negative sign if the movement corresponds to an increase of the sensor-to-target slant range distance.

All intermediate processing results and parameters are stored in the "*Root Name*_dual_work_dir" folder, which is created in the output directory. This folder can be removed only whether no more processing iterations have to be executed for a specific input data set.

Depending on the input files, a 3-pass or a 4-pass approach is implemented:

- When the "Input Master 2 file" is not inputted, the **3-pass approach** is implemented and the "Input Master 1 file" will be the master for both the "Input Slave 1 file" and the "Input Slave 2 file".

- When the "Input Master 2 file" is inputted, the **4-pass approach** is implemented and the "Input Master 1 file" will be the master for the "Input Slave 1 file", while the "Input Master 2 file" will be the master for the "Input Slave 2 file". It is worthwhile to note the the "Resampling" method, which is set among the input parameters, is used for the coregistration of the 2nd pair onto the 1st.

When the "**Linear Model**" flag is checked, which means that a linear displacement can be assumed, the displacement velocity (mm/year) as well as the height estimate is computed from the two interferometric pairs.

When the "**Step Model**" flag is checked, the same (or very similar) displacement is expected in the two interferometric pairs. This model is typically used to generate the displacement map related to abrupt deformations (e.g. earthquakes), when two "post-displacement" acquisitions are available. The displacement figures are provided in millimeters.

When the "**No Model**" flag is checked, the "Input Master 1/Input Slave 1" pair is supposed not to be affected by displacement, which is actually measured (in millimeters) from the "Input Master 1/Input Slave 2" pair (3-pass) or from the "Input Master 2/Input Slave 2" pair (4-pass).
The "Input Master 1/Input Slave 1" pair is used in this case for the height estimate; thus this is supposed to be a "good quality" InSAR pair for DEM generation.

The **Linear Model** solves the following equation system:

$$Phase1 = (H_{res}*K_1) + (V*T_1*4\pi/\lambda)$$

$$Phase2 = (H_{res}*K_2) + (V*T_2*4\pi/\lambda)$$

The **Step Model** solves the following equation system:

$$Phase1 = H_{res}*K_1 + (D*4\pi/\lambda)$$

$$Phase2 = (H_{res}*K_2) + (D*4\pi/\lambda)$$

The **No-Model** solves the following equation system:

$$Phase1 = H_{res}*K_1$$

$$Phase2 = (H_{res}*K_2) + (D*4\pi/\lambda)$$

where H_{res} is the is the residual height (_height, derived from the interferometric technique); V is the displacement velocity (mm/year); D is the displacement (millimeters); K_1 and K_2 are height-to-phase conversion factors; T_1 is the 1st pair acquisition time distance; T_2 is the 2nd pair acquisition time distance.

The process is typically executed in two consecutive iterations:

1. The flag "From SLC to Phase Unwrapping" is checked, while the "Generate Slant Range Products" and "Generate Geocoded Products" are not checked. Only the coherence images, flattened/filtered interferograms and unwrapped phase images are generated (in slant range geometry). The "Geometry GCP file", if entered, is used here for the interferogram flattening process.
2. The "Orbital GCP file" is entered (this is mandatory), the flag "From SLC to Phase Unwrapping" is

unchecked, while the "Generate Slant Range Products" and "Generate Geocoded Products" are checked. All products (respectively in slant range projection and geocoded) are generated. The application of a linear or not-linear ("Step Model" or "No Model") model can be performed by running two times this 2nd iteration.

The Ground Control Points in the "Orbital GCP file", are selected with the same criteria and for the same purpose of the Ground Control Points used in the Refinement and Re-flattening 308 step. Note that the criteria for the GCPs selection must be fulfilled for both interferometric pairs.

However the possibility to execute all processing (iteration 1 + iteration 2) in one step can be considered in case the "Orbital GCP file" is available.

Input Files

Input Master File 1
File name of the first pair master data (_slc). This file is mandatory.

Input Master File 2
File name of the second pair master data (_slc). This file is optional.

Input Slave File 1
File name of the first pair slave data (_slc). This file is mandatory.

Input Slave File 2
File name of the second pair slave data (_slc). This file is mandatory.

Refinement GCP file
Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File) or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the "Tools>Generate Ground Control Point 747" for details). This file is mandatory.

Optional Files

Geometry GCP file
Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File) or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the "Tools>Generate Ground Control Point 747" for details). This file is optional. It serves to correct the Master image/s with respect to the Digital Elevation Model (refer to the Technical Note for more details).

DEM/Cartographic System

Digital Elevation Model file
Name of the Digital Elevation Model file. This should be referred to the ellipsoid. This file is optional. In case it is omitted, the ellipsoidal height and the relevant cartographic reference system, must be entered.

Output Projection

In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System** 6:

State

Definition of the country or general projection systems.

Projection

Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid

Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere

Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone

Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters

Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height

In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters

The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Range Looks

Number of looks in range.

Azimuth Looks

Number of looks in azimuth.

Grid Size for Suggested Looks

The grid size, in meters, used to tune range and azimuth looks. If the other parameters are manually set, the grid size will not imply a change in their values.

Product Coherence Threshold
Pixels with coherence values smaller than this threshold will be set to dummy (NaN) in the final - i.e. geocoded - products generation.

From SLC to Phase Unwrapping
By setting this flag, the processing is executed until the phase unwrapping (1st iteration in the technical note).

Generate Slant Range Products
By setting this flag, the slant range output products are generated (2nd iteration in the technical note).

Generate Geocoded Products
By setting this flag, the geocoded output products are generated (2nd iteration in the technical note).

Model Type
The choice is given between the following models:

- *Linear*, the displacement velocity (mm/year) is calculated;
- *Step*, the displacement magnitude (in millimeters) is calculated;
- *No Model*, the displacement magnitude (in millimeters) is calculated.

Refer to the Technical Note for further informations.

Refinement method
The choice is given between the following refinement methods:

- *Automatic Refinement;*
- *Polynomial Refinement;*
- *Orbital Refinement.*

Refer to the flattening section of the Preferences 775 for further information about these methods.

Refinement Residual Phase Polynomial Degree
Degree of the polynomial used to estimate the phase ramp, which will be removed from the input unwrapped phase during the Re-flattening operation. In case this value is higher that the number of input Ground Control Points, it will be automatically decreased. The default values of 3 means that a phase ramp in range and azimuth direction plus a constant phase offset will be corrected. In case only the phase offset correction is needed, the polynomial degree will be set to 1.

Coregistration With DEM
By setting this flag, the output will be coregistered with the Digital Elevation Model.

Unwrapping Method Type

The choice is given between the following unwrapping methods:

- *Region Growing*, the Region Growing unwrapping method is used;
- *Minimum Cost Flow*, the Minimum Cost Flow (square grid) unwrapping method is used;
- *Delaunay MCF*, the Minimum Cost Flow (triangular grid) unwrapping method is used.

Unwrapping Decomposition Level
The number of multilooking and undersampling iterations can be specified (refer to the Technical Note).

Unwrapping Coherence Threshold
Pixels with coherence values smaller than this threshold are not unwrapped.

Filtering method
The choice is given between the following filtering methods according to the default values of the filtering section of the Preferences 783 parameters:

- *Adaptive window;*
- *Boxcar window;*
- *Goldstein.*

Refer to the Preferences 783 description for further information about these methods.

Coherence from Fint
By setting this flag, the coherence is computed using the filtered interferogram (_fint) instead of the unfiltered one (_dint).

X Dimension (m)
The grid size in Easting (X) of the output geocoded data must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Y Dimension (m)
The grid size in Northing (Y) of the output geocoded data must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Mean Window Size

The mean filtering, of the interferometric height output products - i.e. geocoded -, is carried out. The window filter size must be specified. If zero is entered, the mean filtering is not applied.

Interpolation Window Size
The dummy values, in the interferometric height and displacement output products - i.e. geocoded -, are interpolated. The interpolated value is the average of the valid values in a window of the size specified. If zero is entered, the interpolation is not applied

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Geocoding

It brings to the geocoding section of the Preferences 766 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Interferogram

It brings to the interferometry section of the Preferences 779 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Flattening

It brings to the flattening section of the Preferences 775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Filtering

It brings to the adaptive filter section of the Preferences 783 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Phase Unwrapping

It brings to the phase unwrapping parameters section of the Preferences 779 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Coregistration

It brings to the coregistration section of the Preferences 770 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Refinement

It brings to the flattening section of the Preferences [775] parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences [759] parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Name of the output root. This file is mandatory.

_cc
Slant range coherence with the associated header files (.sml, .hdr).

_disp
Slant range displacement map with the associated header files (.sml, .hdr).

_fint
Slant range flattened/filtered interferogram with the associated header files (.sml, .hdr).

_height
Slant range residual elevation with the associated header files (.sml, .hdr).

_srdem
Precise Digital Elevation Model (input DEM + InSAR residual height), in slant range geometry, with the associated header files (.sml, .hdr).

_upha
Unwrapped phase with the associated header files (.sml, .hdr).

_vel
Slant range displacement velocity map with the associated header files (.sml, .hdr).

_dem
Precise Digital Elevation Model (input DEM + InSAR residual height), with the associated header files (.sml, .hdr).

_disp_geo
Geocoded displacement map with the associated header files (.sml, .hdr).

_vel_geo
Geocoded displacement velocity map with the associated header files (.sml, .hdr).

In order to distinguish the input SAR pair where each output product comes from, a prefix containing the master-slave acquisition dates (i.e. yyyymmdd) will be added to the file extensions here above.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

Looks
The most appropriate range and azimuth multi-looking factors are calculated.

References

Consult the reference guide specific to each processing step.

1.6.3.11 Amplitude Tracking

Section Content

1.6.3.11.1 1 - Amplitude Tracking

Purpose

This functionality is intended to estimate the displacement by means of the amplitude (intensity) data.

Technical Note

This estimate of the shift is performed by means of a coregistration process using the coherence first and, where the coherence is below the "SNR Threshold", the amplitude cross correlation (refer to the relevant Technical Note 293 for details). The values of the output cross correlation vary between 0 (worst conditions) and 1 (best conditions), same as the coherence product. Note however that the coherence estimate requires a higher computational time that the amplitude estimate, all the while being more phase noise sensitive.

The relationship between the Signal to Noise Ratio (SNR) value and the coherence (γ) value is:

$$SNR = \gamma^2/1-\gamma^2$$

The shift is calculated with steps (in terms of number of pixels) defined by the "Azimuth Looks" and "Range Looks" factors. We suggest using factors which are five times bigger than the default ones used in the multilooking 119 process.

The coregistration shift estimate is optimized by means of the input Digital Elevation Model.

A flattening process is executed to remove the systematic effects due to the topography. It is executed by transforming the input Digital Elevation Model into the master slant range image geometry. In case of precise orbits and accurately geocoded reference Digital Elevation Model, this process is run in a fully automatic way. However, in case of inaccuracy in the satellite orbits or in the Digital Elevation Model geolocation, a Ground Control Point (GCP file) is required to correct the master acquisition of the SAR pair with respect to the reference Digital Elevation Model. In this case the shift calculated in the coregistration process is combined with the Ground Control Point shift in order to correct the slave data according to the master data.

It is important to note that:

- In case the "Input Master file" has already been corrected with the manual 722 or the automatic 719 procedure the "GCP file" is not needed.

- In case the "Input Master file" is correct (i.e. the nominally geocoded image fits with the DEM), while the orbital parameters of the "Input Slave file" are not accurate (i.e. the nominally geocoded image does not fit with the DEM), the "GCP file" is not needed but the flag "Automatic Slave Orbit Correction", in the Preferences>Flattening775, must be checked.

The shift between master and slave data is calculated in pixel units and it is measured in the satellite viewing geometry: considering the pixel position of the slave respect to the master acquisition, positive values correspond to an increase of the sensor-to-target distance, respectively in the satellite viewing (_dr output file) and in the satellite flight (_da output file) directions. In order to transform these values from pixel to meters, they must be multiplied by the pixel sampling.

It is possible to geocode the displacement by means of the Phase to Displacement320 functionality. This process must be performed separately for the two displacement components (i.e. _dr and _da). In particular the across track component (_dr) can be re-projected into any user-defined direction.

Input Files

Input Master File
File name of the master data (_slc). This file is mandatory.

Input Slave File
File name of the slave data (_slc). This file is mandatory.

Optional Files

Geometry GCP file
Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File) or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the "Tools>Generate Ground Control Point747" for details). This file is optional.

Coregistration file
A previously created vector file (either .xml or), with the points used for the manual coregistration (.xml), is automatically loaded. These points represent the center of the coregistration windows. This file is optional.

Shift Parameter file
Name of the file with the shift parameters used for the coregistration (_par). This file is an optional output.

DEM/Cartographic System

Digital Elevation Model file
Name of the Digital Elevation Model file. This should be referred to the ellipsoid. This file is optional.

Output Projection

In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System** 6:

State

Definition of the country or general projection systems.

Projection

Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid

Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere

Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone

Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters

Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height

In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters

The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Range Looks

Number of looks used to average the shift estimate in range direction.

Azimuth Looks

Number of looks used to average the shift estimate in azimuth direction.

Grid Size for Suggested Looks

The grid size, in meters, used to tune range and azimuth looks. If the other parameters are manually set, the grid size will not imply a change in their values.

Amplitude

By setting this flag, the amplitude will be computed. The following parameters can also be set:

- **CC Range Window Size**
  Range dimension, in pixels, of the windows where the cross correlation based shift is estimated.

- **CC Azimuth Window Size**
  Azimuth dimension, in pixels, of the windows where the cross correlation based shift is estimated.

- **CC Oversampling**
  The cross-correlation based estimate is applied on over sampled data. The higher this value the longer the processing time and the accuracy. Values higher then 16 are typically not required.

- **Cross Correlation Threshold**
  If the correlation value is below this threshold, then the window is not used for the shift estimate.

Coherence
By setting this flag, the coherence will be computed. The following parameters can also be set:

- **COH Range Window Size**
  Range dimension, in pixels, of the windows where the coherence based shift is estimated.

- **COH Azimuth Window Size**
  Azimuth dimension, in pixels, of the windows where the coherence based shift is estimated.

- **COH Oversampling**
  The pixel over sampling factor, for a more accurate coherence based estimate, can be entered. The higher this value the longer the processing time and the accuracy.

- **COH SNR Threshold**
  The coherence based estimate is performed only whether the Signal-to-Noise Ratio is greater than this value.

Coregistration with DEM
This parameter can not be set by the user and is always executed.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Flattening

It brings to the flattening section of the Preferences 775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Coregistration

It brings to the coregistration section of the Preferences 770 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Name of the output root. This file is mandatory.

_dr
Shift measured in range direction with the associated header files (.sml, .hdr).

_da
Shift measured in azimuth direction with the associated header files (.sml, .hdr).

_rg_sint
Synthetic shift in range with the associated header files (.sml, .hdr).

_az_sint
Synthetic shift in azimuth with the associated header files (.sml, .hdr).

_coh
Coherence image with the associated header files (.sml, .hdr).

_cc
Cross correlation image with the associated header files (.sml, .hdr).

_srdem
Digital Elevation Model in slant range geometry (.sml, .hdr).

_par
ASCII file containing the coregistration shift parameters in range and azimuth. This file is generated only if the shift parameters are calculated.

_pwr
Multi-looked master and slave image with the associated header files (.sml, .hdr).

_orb.sml
Xml file containing the scene orbital parameters.

_orbit_off.shp
Shape file with the points used to estimate the orbit based shift. This file contains the following information:

- Pixel position in range direction (Range), in Single Look pixel units.
- Pixel position in azimuth direction (Azimuth), in Single Look pixel units.
- Shift measured in range direction (Dr), in Single Look pixel units.
- Shift measured in azimuth direction (Da), in Single Look pixel units.
- Calculated polynomial shift, to apply in range direction (Drfit), in Single Look pixel units.
- Calculated polynomial shift, to apply in azimuth direction (Dafit), in Single Look pixel units.

The file, which is generated only when the shift parameters are calculated, is multilooked (i.e. Azimuth and Range looks) as specified in the Input Parameters.

_winCC_off.shp
Shape file with the points used to estimate the cross correlation based shift from the Intensity data. In addition to the information provided by the "_orbit_off.shp" file, this file contains also the cross-correlation value (CC), which is dimensionless and it can vary from 0 to 1.

The file, which is generated only when the shift parameters are calculated, is multilooked (i.e. Azimuth and Range looks) as specified in the Input Parameters.

_winCoh_off.shp
Shape file with the points used to estimate the coherence based shift from the complex data (fine shift estimate). In addition to the information provided by the "_orbit_off.shp", this file contains also the the following information:

- Signal to Noise Ratio (SNR), which is a linear dimensionless value.
- Coherence value. It is dimensionless and it can vary from 0 to 1.

The file, which is generated only when the shift parameters are calculated, is multilooked (i.e. Azimuth and Range looks) as specified in the Input Parameters.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.6.3.11.2 2 - Shift Refinement and Re-Flattening

Purpose

This step is crucial for a correct transformation of the shifts information into displacement values. It allows to remove possible shift ramps.

The execution of this step is mandatory for Displacement Mapping 347 in range and azimuth direction.

To execute this step a Ground Control Point file 747 must be previously created.

Technical Note

Depending on the specific processing parameter setting (Preferences>Flattening>Refinement and Re-flattening/Refinement Method 775), the polynomials and the correction factors are calculated and written in the header file of the shift images (_dr/_da.sml>interferometric_processing section) - as well as on a popup window when the process is not executed in batch mode - at the process completion; these correction factors/polynomials are:

- **RPPPhasePolyDegree** - Degree of the polynomial used to estimate the phase ramp - It is generated if the "Polynomial Refinement 775" method is applied.
- **RPPPhasePoly** - The polynomial used to estimate the phase ramp - It is generated if the "Polynomial Refinement 775" method is applied.
- **RPPRMSE** - Root mean square error calculated as the difference between the height value of the Ground Control Points and the corresponding value in the interferometric phase (in meters) - It is generated if the "Polynomial Refinement 775" method is applied.

The popup window additionally provides, for each input Ground Control Point, the following values:

- Mean difference between SRDEM - slant range input DEM - and SAR DEM (in meters);
- Mean difference between Shift and calculated Shift Ramp (in pixels);
- Standard Deviation between SRDEM and SAR DEM (meters).

Very large "RPPRMSE" **-** root mean square errors - (in the order of hundreds or thousands) eventually bring to wrong results.

Ground Control Points located on null/dummy value pixels (NaN) are discarded.
The correction parameters are calculated depending on the specific "Refinement Setting 775" and are applied to rebuild the following input files:

- Shift (_dr, _da).
- Synthetic Shift (_rg_sint, _az_sint).

The points ("Refinement Ground Control Point file") used to calculate the correction parameters (Refinement Setting), shall be selected on the input shift files (_dr, _da) in order to avoid "moving areas". The Ground Control Points must be well distributed throughout the entire scene.

An indication about the Ground Control Points quality can be obtained by inspecting the "_refinement.shp" (see "Output" product description below).
Areas with good coherence should be preferred for the Ground Control Points location. In any case the importance of each GCP is weighted by the program on the basis of its coherence value.

If errors exist in the shift images, they must be corrected before running this step. Otherwise wrongly estimated areas have to be discarded for the Ground Control Points location.

Input Files

Coherence file
Name of the coherence image (_cc). This file is mandatory.

Input Range Shift File
Name of the Shift file in range direction (_dr). This file is mandatory.

Input Azimuth Shift File
Name of the Shift file in azimuth direction (_da). This file is mandatory.

Input Master File
File name of the multi-looked master Intensity data (_pwr). This file is mandatory.

Input Slave File
File name of the multi-looked coregistered slave Intensity data (_pwr). This file is mandatory.

Range Synthetic Shift File
Name of the synthetic shift file in range direction (_rg_sint). This file is mandatory.

Azimuth Synthetic Shift File
Name of the synthetic shift file in azimuth direction (_az_sint). This file is mandatory.

Slant Range Digital Elevation Model file
Name of the Digital Elevation Model in slant range geometry (_srdem).

Refinement GCP file
Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File), or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the "Tools>Generate Ground Control Point 747" for details). This file is mandatory.

DEM/Cartographic System

Digital Elevation Model file
Name of the Digital Elevation Model file (geocoded reference DEM). This file is mandatory if it had been used as input for the flattened interferogram generation. If the Digital Elevation Model is omitted, an ellipsoidal height including the cartographic reference system must be set.

Output Projection
In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Refinement method
The choice is given between the following refinement methods:

- *Automatic Refinement;*
- *Polynomial Refinement;*
- *Orbital Refinement.* (Not available yet)

Refer to the flattening section of the Preferences 775 for further information about these methods.

Refinement Residual Phase Polynomial Degree
Degree of the polynomial used to estimate the phase ramp, which will be removed from the input unwrapped phase during the Re-flattening operation. In case this value is higher that the number of input Ground Control Points, it will be automatically decreased. The default values of 3 means that a phase ramp in range and azimuth direction plus a constant phase offset will be corrected. In case only the phase offset correction is needed, the polynomial degree will be set to 1.

Coregistration With DEM
This parameter can not be defined by the user.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and

stored for further processing sessions.

Parameters - Flattening

It brings to the flattening section of the Preferences 775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Coregistration

It brings to the coregistration section of the Preferences 770 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Refinement

It brings to the flattening section of the Preferences 775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Name of the output root. This file is optional.

_reflat_dr
Re-flattened interferogram in range with the associated header files (.sml, .hdr).

_reflat_da
Re-flattened interferogram in azimuth with the associated header files (.sml, .hdr).

_reflat_rg_sint
Re-flattened synthetic phase in range with the associated header files (.sml, .hdr).

_reflat_az_sint
Re-flattened synthetic phase in azimuth with the associated header files (.sml, .hdr).

_reflat_srdem
Digital Elevation Model, in slant range geometry, with the associated header files (.sml, .hdr). This file is generated only if a "Refinement Method" 775 was selected.

_reflat.txt
Text file with the orbital correction parameters resulting from the refinement.

_refinement.shp
Shape file containing those points retained (valid GCPs) form the input "Refinement GCP file".
The following information is provided if the "Polynomial Refinement" method is applied. 775

- Unwrapped phase value (in radians) - "ReadPhase".
- Absolute - "AbsPhDiff" - and relative - "PhaseDiff" - difference (in radians) between the real phase and its fitted value based on GCPs.
- Standard deviation (in meters) of the input "Refinement GCP file" - "SigmaMt" - It is based on interferometric coherence and orbital configuration.
- Standard deviation (in radians) of the input "Refinement GCP file" - "SigmaRad" - It is based on the interferometric coherence.

_refinement_geo.shp
Shape file containing the geocoded location of the valid GCPs used in the refinement process.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format section. 21

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser button allows to load the batch processing list. 802

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.6.3.11.3 3 - Shift to Displacement Conversion and Geocoding

Purpose

The absolute refined shift (_dr, _da) values are converted to displacement and directly geocoded into a map projection. This step is performed in a similar way as in the geocoding procedure (Basic module 142), by considering the Range-Doppler approach and the related geodetic and cartographic transforms. The fundamental difference with the geocoding step is that the Range-Doppler equations are applied simultaneously to the two antennae, making it possible to obtain not only the displacement of each pixel, but also its location (Easting, Northing) in a given cartographic and geodetic reference system.

As result of this step also the coherence image is geocoded.

Technical Note

Each pixel shift corresponds a to a single look pixel size displacement along both the Slant Range direction (SAR viewing direction) and the satellite flying direction (SAR azimuth direction). It is possible to specify any vector (i.e direction and inclination) where the measured slant range displacement (from _dr) - component of the deformation in the satellite viewing direction - will be projected. Hence this vector represents the re-projection of the slant range deformation component onto a direction on the ground which is known a-priori and specified by the user (i.e. "vertical" in case of subsidence; "slope" in case of landslides; "custom" in any other case).

The output map shows displacement magnitude in meters:

- Slant Range Displacement - Positive sign if the movement corresponds to a decrease of the sensor-to-target slant range distance (slave respect to master acquisition);
- Azimuth displacement - Positive sign if the movement increases along the satellite flying direction;
- Displacement Custom Direction - Positive sign corresponds to movement in the user defined direction (slave respect to master acquisition). It can be applied only to the Range shift component.

Displacement Custom Direction
Direction and inclination of the displacement vector can be specified. As an example an "azimuth angle" of 45° means that the displacement is oriented North 45° East and the movement is expected Northeastward; while an "azimuth angle" of 225° means that the displacement is always oriented North 45° East, but the movement is expected Southwestward. Positive inclination angles indicate upward movement; negative inclination angles indicate downward movement.

Precision
This output product, which is derived from parameters such as coherence and wavelength, provides an estimate (i.e. standard deviation value) of the measurement precision. The higher this value the lower

the measurement precision. The formula used for the precision calculation is:

$$\sqrt{\frac{1-\gamma^2}{2\gamma^2}}\;\frac{\lambda}{4\pi}$$

where γ is the interferometric coherence.

It is important to outline that the Refinement and Re-flattening 308 step must have been performed previously.

Input Files

Coherence file
Name of the coherence image (_cc). This file is mandatory.

Input Range Shift File
Name of the Shift file in range direction (_dr). This file is mandatory.

Input Azimuth Shift File
Name of the Shift file in azimuth direction (_da). This file is mandatory.

DEM/Cartographic System

Digital Elevation Model file
Name of the Digital Elevation Model file. This should be referred to the ellipsoid. This file is optional. In case it is omitted, the ellipsoidal height and the relevant cartographic reference system, must be entered.

Output Projection
In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Product Coherence Threshold
Pixels with coherence values smaller than this threshold will be set to dummy (NaN) in the final products.

Vertical Displacement
By setting this flag the map showing the displacement values projected on the vertical direction is generated among the output products.

Slope Displacement
By setting this flag the map showing the displacement values projected along the maximum slope is generated among the output products.

Displacement Custom Direction
By setting this flag any vector can be specified, in terms of azimuth (**Azimuth Angle**, measured in degrees from the North - clockwise direction) and inclination (**Inclination Angle**, measured in degrees from the horizontal plane). The map showing the displacement values projected on the specified direction is generated among the output products.

X Dimension (m)

The grid size of the output data in Easting (X) must be defined; the default unit of measure is meters. Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Y Dimension (m)

The grid size of the output data in Northing (Y) must be defined; the default unit of measure is meters. Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Interpolation Window Size

By setting this flag the dummy values in the output file are interpolated. The interpolated value is the average of the valid values in a window of the size selected.

Dummy Removal

By setting this flag the output geocoded files will be automatically resized in order to remove the dummy area exceeding the frame border.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Geocoding

It brings to the geocoding section of the Preferences 766 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Displacement Projection

Generate Line Of Sight

by setting this flag the displacement in line of sight and satellite flying direction as measured by the satellite in generated.

Vertical Displacement

By setting this flag the map showing the displacement values projected on the vertical direction is generated among the output products.

Slope Displacement

By setting this flag the map showing the displacement values projected along the maximum slope is generated among the output products.

Generate East

By setting this flag the map showing the displacement values projected on the East-West direction is generated among the output products.

Generate North

By setting this flag the map showing the displacement values projected on the North-South direction is generated among the output products.

Displacement Custom Direction

By setting this flag any vector can be specified, in terms of azimuth (**Azimuth Angle**, measured in degrees from the North - clockwise direction) and inclination (**Inclination Angle**, measured in degrees from the horizontal plane). The map showing the displacement values projected on the specified direction is generated among the output products.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name

Name of the output root. It is mandatory.

_dem

Input Digital Elevation Model resampled onto the specified cartographic system and grid size, with the associated header files (.sml, .hdr). Its areal extent is the same as the output SAR products.

_dr_disp_cc_geo

Geocoded coherence in range with the associated header files (.sml, .hdr).

_da_disp_cc_geo

Geocoded coherence in azimuth with the associated header files (.sml, .hdr).

_ADF

Maximum slope direction values, with the associated header files (.sml, .hdr).

_IDF

Maximum slope inclination values, with the associated header files (.sml, .hdr).

_SD

Displacement values along the maximum slope direction, with the associated header files (.sml, .hdr).

_UD
Displacement values in the direction specified as azimuth and inclination degrees (i.e. custom direction), with the associated header files (.sml, .hdr).

_VD
Vertical displacement values, with the associated header files (.sml, .hdr).

_dr_disp
Slant Range (satellite view direction) displacement values, with the associated header files (.sml, .hdr).

_da_disp
Azimuth (satellite flying direction) displacement values, with the associated header files (.sml, .hdr).

_dr_precision
Estimate of the data quality of the Range Shift with the associated header files (.sml, .hdr). This file is generated only if the coherence file is entered as input.

_da_precision
Estimate of the data quality of the Azimuth Shift with the associated header files (.sml, .hdr). This file is generated only if the coherence file is entered as input.

_dr_disp_ALOS
Azimuth Line of Sight with the associated header files (.sml, .hdr). Positive angles are measured clockwise from the North; negative angles are measured counterclockwise from the North.

_da_disp_ALOS
Satellite flying direction with the associated header files (.sml, .hdr). Positive angles are measured clockwise from the North; negative angles are measured counterclockwise from the North.

_dr_disp_ILOS
Incidence angle of the Line of Sight with the associated header files (.sml, .hdr). The angle is measured between the Line Of Sight and the vertical on the ellipsoid (flat earth).

_da_disp_ILOS
Incidence angle for the Satellite flying direction with the associated header files (.sml, .hdr). The angle is measured between the Flying Direction and the vertical on the ellipsoid (flat earth).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch

The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close

The window will be closed.

Help

Specific help document section.

Specific Function(s)

None.

References

None.

1.6.3.12 Stereo-Radargrammetry

Section Content

1.6.3.12.1 1 - Stereo Matching Process

Purpose

This functionality is intended to estimate the elevation by means of the amplitude (intensity) data in a stereo-matching workframe.

Technical Note

As for photogrammetry, also radargrammetry exploits a stereo acquisition configuration to estimate a precise topographic height. In the process, the use of Single Look Complex (_slc) data is favored. The software retrieves a shift in pixel, along the range direction, that is proportional to the topographic height. The first step of this tool is to consider the known topography by coregistering the slave acquisition over the master acquisition. The residual mismatch (in range direction) will correspond to the residual topography with respect to the reference DEM. The matching algorithm is performed in a pyramidal way, by estimating an initial coarse shift on the multilooked acquisitions and refining it iteration by iteration to obtain a finer estimate.

The separation angle between the two acquisition should be between 15 to 25-30 degree. The higher the separation angle, the higher the sensitivity to the topography, while presenting the matching algorithm with a harder task. The radargrammetry tool can provide good results with high resolution sensors, and mostly in natural areas.

This estimate of the shift is performed by means of a coregistration process using the amplitude cross correlation (refer to the relevant Technical Note 293 for details). The values of the output cross correlation vary between 0 (worst conditions) and 1 (best conditions), same as the coherence product.

The relationship between the Signal to Noise Ratio (SNR) value and the coherence (γ) value is:

$$SNR = \gamma^2/1-\gamma^2$$

The shift is calculated with steps (in terms of number of pixels) defined by the "Azimuth Looks" and "Range Looks" factors. We suggest using factors which are five times bigger than the default ones used in the multilooking 119 process.

The coregistration shift estimate is optimized by means of the input Digital Elevation Model.

A flattening process is executed to remove the systematic effects due to the topography. It is executed by transforming the input Digital Elevation Model into the master slant range image geometry. In case of precise orbits and accurately geocoded reference Digital Elevation Model, this process is run in a fully automatic way. However, in case of inaccuracy in the satellite orbits or in the Digital Elevation Model geolocation, a Ground Control Point (GCP file) is required to correct the master acquisition of the SAR pair with respect to the reference Digital Elevation Model. In this case the shift calculated in the coregistration process is combined with the Ground Control Point shift in order to correct the slave data according to the master data.

It is important to note that:

- In case the "Input Master file" has already been corrected with the the manual 722 or the automatic 719 procedure the "GCP file" is not needed.
- In case the "Input Master file" is correct (i.e. the nominally geocoded image fits with the DEM), while the orbital parameters of the "Input Slave file" are not accurate (i.e. the nominally geocoded image does not fit with the DEM), the "GCP file" is not needed but the flag "Automatic Slave Orbit Correction", in the Preferences>Flattening 775, must be checked.

The shift between master and slave data is calculated in pixel units and it is measured in the satellite viewing geometry.

Input Files

Input Master File
File name of the master data (_slc). This file is mandatory.

Input Slave File
File name of the slave data (_slc). This file is mandatory.

Optional Files

Geometry GCP file
Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File) or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the "Tools>Generate Ground Control Point 747" for details). This file is optional.

Shift Parameter file
Name of the file with the shift parameters used for the coregistration (_par). This file is an output.

DEM/Cartographic System

Digital Elevation Model file
Name of the Digital Elevation Model file. This should be referred to the ellipsoid. This file is optional.

Output Projection
In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Range Looks
Number of looks used to average the shift estimate in range direction.

Azimuth Looks
Number of looks used to average the shift estimate in azimuth direction.

Grid Size for Suggested Looks
The grid size, in meters, used to tune range and azimuth looks. If the other parameters are manually set, the grid size will not imply a change in their values.

CC Range Window Size
Range dimension, in pixels, of the windows where the cross correlation based shift is estimated.

CC Azimuth Window Size
Azimuth dimension, in pixels, of the windows where the cross correlation based shift is estimated.

CC Oversampling
The cross-correlation based estimate is applied on over sampled data. The higher this value the longer the processing time and the accuracy. Values higher then 16 are typically not required.

Cross Correlation Threshold
If the correlation value is below this threshold, then the window is not used for the shift estimate.

Max Residual Topography (m)
Maximum residual height difference (in meters) with respect to the input DEM considered in the matching process.

Coregistration with DEM
By setting this flag, the input Digital Elevation Model is used in the coregistration process.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Flattening

It brings to the flattening section of the Preferences 775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Coregistration

It brings to the coregistration section of the Preferences 770 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Name of the output root. This file is mandatory.

_dr
Shift measured in range direction with the associated header files (.sml, .hdr).

_rg_sint
Synthetic shift in range with the associated header files (.sml, .hdr).

_az_sint
Synthetic shift in azimuth with the associated header files (.sml, .hdr).

_cc
Cross correlation image with the associated header files (.sml, .hdr).

_srdem

Digital Elevation Model in slant range geometry (.sml, .hdr).

_par
ASCII file containing the coregistration shift parameters in range and azimuth. This file is generated only if the shift parameters are calculated.

_pwr
Multi-looked master and slave image with the associated header files (.sml, .hdr).

_orb.sml
Xml file containing the scene orbital parameters.

_orbit_off.shp
Shape file with the points used to estimate the orbit based shift. This file contains the following information:

- Pixel position in range direction (Range), in Single Look pixel units.
- Pixel position in azimuth direction (Azimuth), in Single Look pixel units.
- Shift measured in range direction (Dr), in Single Look pixel units.
- Shift measured in azimuth direction (Da), in Single Look pixel units.
- Calculated polynomial shift, to apply in range direction (Drfit), in Single Look pixel units.
- Calculated polynomial shift, to apply in azimuth direction (Dafit), in Single Look pixel units.

The file, which is generated only when the shift parameters are calculated, is multilooked (i.e. Azimuth and Range looks) as specified in the Input Parameters.

_winCC_off.shp
Shape file with the points used to estimate the cross correlation based shift from the Intensity data. In addition to the information provided by the "_orbit_off.shp" file, this file contains also the cross-correlation value (CC), which is dimensionless and it can vary from 0 to 1.

The file, which is generated only when the shift parameters are calculated, is multilooked (i.e. Azimuth and Range looks) as specified in the Input Parameters.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.6.3.12.2 2- Shift Refinement and Re-flattening

Purpose

This step is crucial for a correct transformation of the range shift information into topographic height values. It allows to remove possible shift ramps.

The execution of this step is mandatory for Height Conversion 364.

To execute this step a Ground Control Point file 747 must be previously created.

Technical Note

Depending on the specific processing parameter setting (Preferences>Flattening>Refinement and Re-flattening/Refinement Method 775), the polynomials and the correction factors are calculated and written in the header file of the shift images (_dr.sml>interferometric_processing section) - as well as on a popup window when the process is not executed in batch mode - at the process completion; these correction factors/polynomials are:

- **RPPPhasePolyDegree** - Degree of the polynomial used to estimate the phase ramp - It is generated if the "Polynomial Refinement 775" method is applied.
- **RPPPhasePoly** - The polynomial used to estimate the phase ramp - It is generated if the "Polynomial Refinement 775" method is applied.

- **RPPRMSE** - Root mean square error calculated as the difference between the height value of the Ground Control Points and the corresponding value in the interferometric phase (in meters) - It is generated if the "Polynomial Refinement" method is applied.

The popup window additionally provides, for each input Ground Control Point, the following values:

- Mean difference between SRDEM - slant range input DEM - and SAR DEM (in meters);
- Mean difference between Shift and calculated Shift Ramp (in pixels);
- Standard Deviation between SRDEM and SAR DEM (meters).

Very large "RPPRMSE" **-** root mean square errors - (in the order of hundreds or thousands) eventually bring to wrong results.

Ground Control Points located on null/dummy value pixels (NaN) are discarded.
The correction parameters are calculated depending on the specific "Refinement Setting" and are applied to rebuild the following input files:

- Shift (_dr).
- Synthetic Shift (_rg_sint).

The points ("Refinement Ground Control Point file") used to calculate the correction parameters (Refinement Setting), shall be selected on the input shift files (_dr) in order to avoid residual topography. The Ground Control Points must be well distributed throughout the entire scene.

An indication about the Ground Control Points quality can be obtained by inspecting the "_refinement.shp" (see "Output" product description below).
Areas with good coherence should be preferred for the Ground Control Points location. In any case the importance of each GCP is weighted by the program on the basis of its coherence value.

If errors exist in the shift images, they must be corrected before running this step. Otherwise wrongly estimated areas have to be discarded for the Ground Control Points location.

Input Files

Coherence file
Name of the coherence image (_cc). This file is mandatory.

Input Master File
File name of the multi-looked master Intensity data (_pwr). This file is mandatory.

Input Slave File
File name of the multi-looked coregistered slave Intensity data (_pwr). This file is mandatory.

Input Range Shift File
Name of the Shift file in range direction (_ra). This file is mandatory.

Range Synthetic Shift File
Name of the synthetic shift file in range direction (_rg_sint). This file is mandatory.

Slant Range Digital Elevation Model file
Name of the Digital Elevation Model in slant range geometry (_srdem).

Refinement GCP file
Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File), or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the "Tools>Generate Ground Control Point 747" for details). This file is mandatory.

DEM/Cartographic System

Digital Elevation Model file
Name of the Digital Elevation Model file (geocoded reference DEM). This file is mandatory if it had been used as input for the flattened interferogram generation. If the Digital Elevation Model is omitted, an ellipsoidal height including the cartographic reference system must be set.

Output Projection
In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be

provided. Default Reference Height is 0.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Refinement method
The choice is given between the following refinement methods:

- *Automatic Refinement;*
- *Polynomial Refinement;*
- *Orbital Refinement.* (Not available yet)

Refer to the flattening section of the Preferences 775 for further information about these methods.

Refinement Residual Phase Polynomial Degree
Degree of the polynomial used to estimate the phase ramp, which will be removed from the input unwrapped phase during the Re-flattening operation. In case this value is higher that the number of input Ground Control Points, it will be automatically decreased. The default values of 3 means that a phase ramp in range and azimuth direction plus a constant phase offset will be corrected. In case only the phase offset correction is needed, the polynomial degree will be set to 1.

Coregistration With DEM
This parameter can not be defined by the user.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Flattening

It brings to the flattening section of the Preferences 775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Coregistration

It brings to the coregistration section of the Preferences 770 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Refinement

It brings to the flattening section of the Preferences775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Name of the output root. This file is optional.

_reflat_dr
Re-flattened interferogram in range with the associated header files (.sml, .hdr).

_reflat_rg_sint
Re-flattened synthetic phase in range with the associated header files (.sml, .hdr).

_reflat_srdem
Digital Elevation Model, in slant range geometry, with the associated header files (.sml, .hdr). This file is generated only if a "Refinement Method"775 was selected.

_reflat.txt
Text file with the orbital correction parameters resulting from the refinement.

_refinement.shp
Shape file containing those points retained (valid GCPs) form the input "Refinement GCP file".
The following information is provided if the "Polynomial Refinement775" method is applied.

- Unwrapped phase value (in radians) - "ReadPhase".
- Absolute - "AbsPhDiff" - and relative - "PhaseDiff" - difference (in radians) between the real phase and its fitted value based on GCPs.
- Standard deviation (in meters) of the input "Refinement GCP file" - "SigmaMt" - It is based on interferometric coherence and orbital configuration.
- Standard deviation (in radians) of the input "Refinement GCP file" - "SigmaRad" - It is based on the interferometric coherence.

_refinement_geo.shp
Shape file containing the geocoded location of the valid GCPs used in the refinement process.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.6.3.12.3 3 - Shift to Height Conversion and Geocoding

Purpose

The absolute calibrated shift is re-combined with the synthetic shift and it is converted to height and geocoded into a map projection. This step is performed in a similar way as in the geocoding procedure (Basic module 142), by considering the Range-Doppler approach and the related geodetic and cartographic transforms. The fundamental difference with the geocoding step is that the Range-Doppler equations are applied simultaneously to the two antennae, making it possible to obtain not only the height of each pixel, but also its location (Easting, Northing) in a given cartographic and geodetic reference system.

As result of this step also the coherence image is geocoded.

Technical Note

The shift-to-height conversion is performed with a forward transformation. The calculated X, Y, Z Cartesian coordinates (and thereafter map coordinates) are transformed into the coordinates of the output DEM exclusively using a Nearest Neighbor approach.

Two files are generated in this step, beside the Digital Elevation Model and the geocoded coherence image, for a further use in the data mosaicing 712. They are:

- **Precision**, which is derived from parameters such as coherence, baseline and wavelength. It provides an estimate (i.e. standard deviation value) of the measurement precision. The higher this value the lower the measurement precision. The formula used for the precision calculation is:

$$\sqrt{\frac{1-\gamma^2}{2\gamma^2}}\;\frac{\lambda R \sin\vartheta}{4\pi B}$$

- **Resolution**, which represents the pixel resolution in ground range, that is:

$$\frac{\text{pixel spacing slant range}}{\sin\vartheta}$$

where γ is the interferometric coherence, λ is the wavelength, R is the slant range distance, ϑ is the local incidence angle.

- **Wavelet Number of Levels** The Number of Levels, which refers to the power of a base 2, determines what is kept of the unwrapped phase. As an example, considering input data with a pixel spacing of 25 m, a "Number of Levels" of 1 means that the information coarser than 50 m is removed and the information finer than 50 m is preserved; a "Number of Levels" of 2 means that the information coarser than 100 m is removed and the information finer than 100 m is preserved; a "Number of Levels" of 3 means that the information coarser than 200 m is removed and the information finer than 200 m is preserved. It is suggested to set this value as a function of the reference DEM (which is used for the interferogram flattening) resolution; as an example, if we process SAR data with 3 m resolution with an SRTM reference DEM (90 m resolution), we'll enter a number of levels of 5 or more.

- **Data Interpolation** is intended to assign a specific value to the dummy (NaN) pixels. The "Relax Interpolation" model is represented by a soft surface, which is adapted to the dummy surrounding area. The algorithm, which is based on the solution of the heat transfer equation (Poisson equation), uses known height values to reconstruct at the best the unknown topography; for this reason it is optimally suited to interpolate small zones, especially where abrupt morphological changes (i.e. steep slopes) are not present.

- Generate Shape format allows representing the DEM as a point cloud. This procedure is intended to preserve the actual pixel value without applying any interpolation, which is the case of the raster output. This format is the one to use as input for the Point Cloud DEM Fusion 687 and for the Point Gridding 751. It can happen that the .shp and the .dbf become very large when there are a lot of valid points.

Input Files

Coherence file
Name of the coherence image (_cc). This file is mandatory.

Input Range Shift File
Name of the Shift file in range direction (_dr). This file is mandatory.

Range Synthetic Shift File
Name of the synthetic shift file in range direction (_rg_sint). This file is mandatory.

Master File
File name of the multi-looked master Intensity data (_pwr). This file is mandatory.

Slave File
File name of the multi-looked coregistered slave Intensity data (_pwr). This file is mandatory.

Output Root Name
Name of the output root. This file is optional

DEM/Cartographic System

Output Projection
The following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone

Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters

Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Cartographic Parameters

The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Product Coherence Threshold

Pixels with coherence values smaller than this threshold will be set to dummy (NaN) in the final products.

Wavelet Number of Levels

Level setting for the wavelet calculation. It determines the level of detail to preserve.

Generate Shape format

By setting this flag the DEM is generated in vector (.shp) format.

X Dimension (m)

The grid size of the output data in Easting (X) must be defined; the default unit of measure is meters. Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Y Dimension (m)

The grid size of the output data in Northing (Y) must be defined; the default unit of measure is meters. Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Mean Window Size

The mean filtering of the output height image is carried out. The window filter size must be specified. If zero is entered, the mean filtering is not applied. This filter is applied after the execution of the interpolation steps. The mean filtering is performed only on the Digital Elevation Model output.

Interpolation Window Size

The dummy values in the output file are interpolated. The interpolated value is the average of the valid values in a window of the size specified. If zero is entered, the interpolation is not applied; it is suggested to avoid setting this value to zero (see Technical Note).

Relax Interpolation
By setting this flag the relax interpolation is carried out. This interpolation is applied only to the Digital Elevation Model output.

Dummy Removal
By setting this flag the output geocoded files will be automatically resized in order to remove the dummy area exceeding the frame border.

Parameters - Global

It brings to the general section of the Preferences759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Geocoding

It brings to the geocoding section of the Preferences766 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Name of the output root. It is mandatory.

_dem
Digital Elevation Model with the associated header files (.sml, .hdr).

_dem.shp
Digital Elevation Model in shape format and associated header files (.sml, .hdr).

_cc_geo
Geocoded coherence with the associated header files (.sml, .hdr).

_precision
Estimate of the data quality with the associated header files (.sml, .hdr). This file is used during the Digital Elevation Model mosaicing (Tools712).

_resolution

Spatial resolution based on the local incidence angle with the associated header files (.sml, .hdr). This file is used during the Digital Elevation Model mosaicing (Tools 712).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Holecz F., J. Moreira, P. Pasquali, S. Voigt, E. Meier, D. Nuesch: "Height Model Generation, Automatic Geocoding and Mosaicing using Airborne AeS-1 InSAR Data". Proceedings of IGARSS'97 Symposium, 1997.

W. Göblirsch and P. Pasquali: "Algorithms for calculation of digital surface models from the unwrapped interferometric phase". Proceedings of IGARSS 1996, pp. 656–658.

1.6.3.13 MAI Processing

Section Content

MAI Phase to Displacement Conversion and Geocoding 384

1.6.3.13.1 MAI Interferometric Process

Purpose

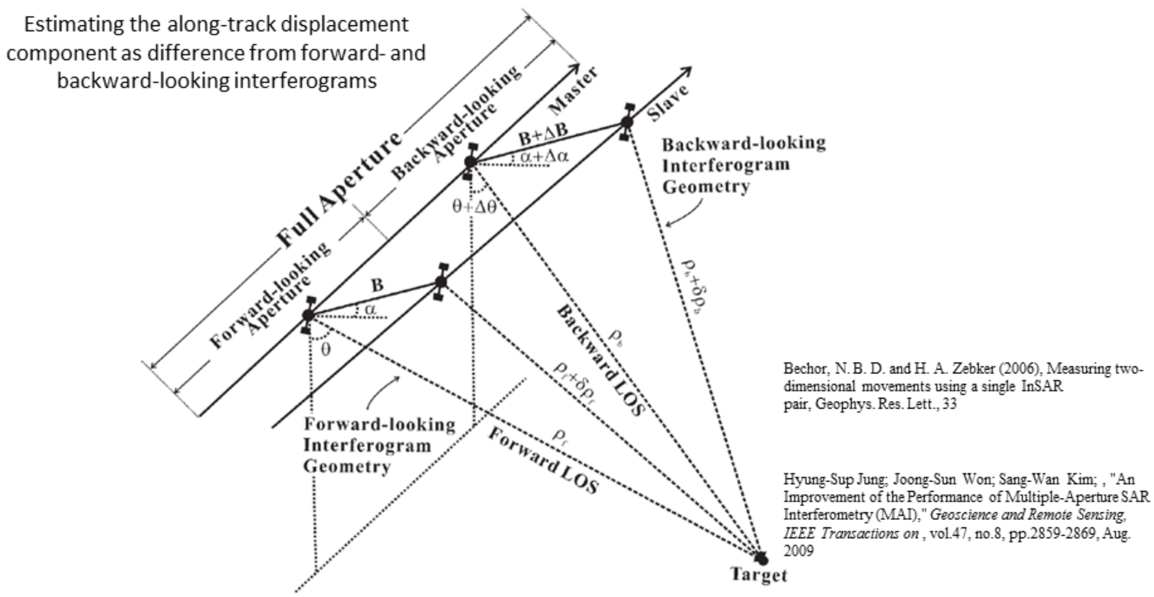
This functionality enables to execute, in a single iteration, the following processing sequence:

- Interferogram Generation and Flattening 293.
- Adaptive Filter and Coherence Generation 300.
- Phase Unwrapping 305.

It is important to point out that, in case ENVISAT-ERS pairs are processed, the "Coregistration with DEM" flag must be checked.

Technical Note

Details specific to each step implemented here are described in the relevant section of the reference guide. We recommend to read it carefully.



MAI (Multi Aperture Interferometry)
It activates the decomposition of the original doppler bandwidth, in the master and slave data, into smaller portions of the full spectrum. The result of this process is the generation of an additional differential interferogram (_mai_fint), which represents the displacement observed in azimuth direction.

The input "factor" is aimed at defining how many *pieces* the original (full) doppler spectrum must be subdivided in: the higher the "factor" the more the *pieces*, which means noisier split interferograms (due to the limited doppler bandwidth exploited) but higher sensitivity to the azimuth displacement. It must be noted that in any case the sensitivity to the displacement is much coarser than in range direction. The larger the MAI factor, the higher the separation between the sub-apertures, hence the displacement sensitivity along the azimuth direction (satellite flight direction) while the band spectrum becomes smaller along with the SNR.

This functionality has been currently tested on ENVISAT ASAR, ALOS PALSAR and ERS data; the program can fail in case other sensors are used. The program requires data pairs characterized by a small doppler difference; large doppler variations can cause program failures.

Input Files

Input Master file

File name of the master data (_slc). This file is mandatory.

Input Slave file
File name of the slave data (_slc). This file is mandatory.

Optional Files

Geometry GCP file
Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File) or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the "Tools>Generate Ground Control Point747" for details). This file is optional.

DEM/Cartographic System

Digital Elevation Model file
Name of the Digital Elevation Model file. This should be referred to the ellipsoid. This file is optional. In case it is omitted, the ellipsoidal height and the relevant cartographic reference system, must be entered. This file is used for the Interferogram Flattening.

Output Projection
In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System**6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be

provided. Default Reference Height is 0.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Range Looks
Number of looks in range.

Azimuth Looks
Number of looks in azimuth.

Grid Size for Suggested Looks
The grid size, in meters, used to tune range and azimuth looks. If the other parameters are manually set, the grid size will not imply a change in their values.

Generate Flattening Interferogram
By setting this flag, the Flattened interferogram is generated. If the MAI factor is set to values different than 1 the original doppler bandwith will be decomposed, resulting in outputs corresponding to both the lowermost and uppermost portion of the doppler spectrum.

Generate Filtering and Coherence
By setting this flag, the Filtered interferogram is generated. This file is generated only if the Adaptive Filter flag is selected. If the MAI factor is set to values different than 1 the original doppler bandwith will be decomposed, resulting in FINT outputs corresponding to both the lowermost and uppermost portion of the doppler spectrum.

Generate Unwrapping
By setting this flag, the Unwrapped phase is generated.

Coregistration with DEM
By setting this flag, the input Digital Elevation Model is used in the coregistration process.

Unwrapping Method Type
The choice is given between the following unwrapping methods:

- *Region Growing*, the Region Growing unwrapping method is used;
- *Minimum Cost Flow*, the Minimum Cost Flow (square grid) unwrapping method is used;
- *Delaunay MCF*, the Minimum Cost Flow (triangular grid) unwrapping method is used.

Refer to Phase Unwrapping 305 for further information.

Unwrapping Decomposition Level
The number of multilooking and undersampling iterations can be specified. Refer to Phase Unwrapping 305 for further information.

Unwrapping Coherence Threshold
Pixels with coherence values smaller than this threshold are not unwrapped.

Filtering Method
The choice is given to execute the "Interferogram Filter and Coherence Generation" using the following filtering methods according to the default values of the filtering section of the Preferences 783 parameters:

- *Adaptive window;*
- *Boxcar window;*
- *Goldstein window.*

Refer to Adaptive Filter and Coherence Generation 300 for further information.

Coherence from Fint
By setting this flag, the coherence is computed using the filtered interferogram (_fint) instead of the unfiltered one (_dint).

MAI Factor
Enter the number of pieces the original (full) doppler spectrum must be subdivided in.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Interferogram

It brings to the interferometry section of the Preferences 779 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Flattening

It brings to the flattening section of the Preferences 775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Filtering

It brings to the adaptive filter section of the Preferences 783 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Phase Unwrapping

It brings to the phase unwrapping parameters section of the Preferences 779 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Coregistration

It brings to the coregistration section of the Preferences 770 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Name of the output root. This file is mandatory.

_int
Interferogram with the associated header files (.sml, .hdr).

_par
ASCII file containing the coregistration shift parameters in range and azimuth.

_pwr
Multi-looked master (_master) and slave (_slave) image with the associated header files (.sml, .hdr).

_orb.sml
Xml file containing the scene orbital parameters.

_orbit_off.shp
Shape file with the points used to estimate the orbit - and DEM in case the "Coregistration with DEM" flag is checked - based shift. This file contains the following information:

- Pixel position in range direction (Range), in original pixel units.

- Pixel position in azimuth direction (Azimuth), in original pixel units.
- Shift measured in range direction (Dr), in original pixel units.
- Shift measured in azimuth direction (Da), in original pixel units.
- Calculated polynomial fitted shift in range direction (Drfit), in original pixel units.
- Calculated polynomial fitted shift in azimuth direction (Dafit), in original pixel units.

The file is multilooked (i.e. Azimuth and Range looks) as specified in the Input Parameters.

_winCC_off.shp
Shape file with the points used to estimate the cross correlation based shift from the Intensity data. In addition to the information provided by the "_orbit_off.shp" file, which are updated on the basis of the cross correlation estimate, this file contains also the following information (provided that the "Coregistration with DEM" flag is checked):
- Residual shift in range direction (DrResidual), in original pixel units. This is the difference with respect to the previously measured (orbit_off.shp) shift.
- Residual shift in azimuth direction (DaResidual), in original pixel units. This is the difference with respect to the previously measured (orbit_off.shp) shift.
- Calculated polynomial fitted residual shift in range direction (DrFitRes), in original pixel units. This is the difference with respect to the previously fitted (orbit_off.shp) shift.
- Calculated polynomial fitted residual shift in azimuth direction (DaFitRes), in original pixel units. This is the difference with respect to the previously fitted (orbit_off.shp) shift.

_winCoh_off.shp - It is generated only when Single Look Complex data are used as input
Shape file with the points used to estimate the coherence based shift. The information provided in the "_winCC_off.shp" are updated by means the coherence based estimate. This file contains also the following additional information:
- Signal to Noise Ratio (SNR), which is a linear dimensionless value.
- Coherence value. It is dimensionless and it can vary from 0 to 1.

The file is generated using the multilooking factors (i.e. Azimuth and Range looks) specified in the Input Parameters.

_dint
Flattened interferogram with the associated header files (.sml, .hdr).

_sint
Synthetic phase with the associated header files (.sml, .hdr).

_srdem
Digital Elevation Model, in slant range geometry, with the associated header files (.sml, .hdr).

_fint
Filtered interferogram with the associated header files (.sml, .hdr). This file is generated only if the Adaptive Filter flag is selected.

_mai_fint
Filtered interferogram, corresponding to the difference between lowermost (_part2_fint) and uppermost (_part1_fint) portions of the doppler spectrum, with the associated header files (.sml, .hdr). This file is generated only if the MAI functionality is activated (refer to the "Technical Note").

_cc
Estimated coherence in range direction with the associated header files (.sml, .hdr). This file is generated only if the Coherence Generation flag is selected.

_mai_cc
Estimated coherence in azimuth direction with the associated header files (.sml, .hdr). This file is generated only if the Coherence Generation flag is selected.

_upha
Unwrapped phase in range direction with the associated header files (.sml, .hdr).

_mai_upha
Unwrapped phase in azimuth direction with the associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

Looks
The most appropriate range and azimuth multi-looking factors are calculated.

References

Consult the reference guide specific to each processing step.

1.6.3.13.2 MAI Refinement and Re-flattening

Purpose

This step is crucial for a correct transformation of the unwrapped phase and the Multi Aperture Interferometry (MAI) unwrapped phase information into displacement values. It allows both to refine the orbits (i.e. correcting possible inaccuracies) and to calculate the phase offset (i.e. getting the absolute phase values), or remove possible phase ramps. The MAI unwrapped phase reflattening will be performed by phase ramps removal only.

The execution of this step is mandatory for Displacement Mapping 320 in range and azimuth direction.

To execute this step a Ground Control Point file 747 must be previously created.

Technical Note

Depending on the specific processing parameter setting (Preferences>Flattening>Refinement and Re-flattening/Refinement Method 775), the polynomials and the correction factors are calculated and written in the header file of the unwrapped phase image (_upha/MAI_upha.sml>interferometric_processing section) - as well as on a popup window when the process is not executed in batch mode - at the process completion; these correction factors/polynomials are:

- **ORShiftOrbitInX** - Orbital shift in X direction (in meters) - It is generated if the "Orbital 775" method is applied.
- **ORShiftOrbitInY** - Orbital shift in Y direction (in meters) - It is generated if the "Orbital 775" method is applied.
- **ORShiftOrbitInZ** - Orbital shift in Z direction (in meters) - It is generated if the "Orbital 775" method is applied.
- **ORAzShiftOrbitInX** - Dependency of the shift in X direction, from the azimuth position (in meters per pixel) - It is generated if the "Orbital 775" method is applied.
- **ORAzShiftOrbitInY** - Dependency of the shift in Y direction, from the azimuth position (in meters per pixel) - It is generated if the "Orbital 775" method is applied.
- **ORAzShiftOrbitInZ** - Dependency of the shift in Z direction, from the azimuth position (in meters per pixel) - It is generated if the "Orbital 775" method is applied.
- **ORPhaseOffset** - Absolute phase offset (in radians) - It is generated if the "Orbital 775" method is applied.
- **ORRMSError** - Root mean square error calculated as the difference between the height value of the Ground Control Points and the corresponding value in the interferometric phase (in meters) - It is generated if the "Orbital 775" method is applied.
- **PhaseError** - A-priori achievable root mean square error, calculated as average on the input

GCPs (height in meters) - It is generated if the "Default" method flag is checked.
- **RPPPhasePolyDegree** - Degree of the polynomial used to estimate the phase ramp - It is generated if the "Polynomial Refinement 775" method is applied.
- **RPPPhasePoly** - The polynomial used to estimate the phase ramp - It is generated if the "Polynomial Refinement 775" method is applied.
- **RPPRMSE** - Root mean square error calculated as the difference between the height value of the Ground Control Points and the corresponding value in the interferometric phase (in meters) - It is generated if the "Polynomial Refinement 775" method is applied.

The popup window additionally provides, for each input Ground Control Point, the following values:

- Mean difference between SRDEM - slant range input DEM - and SAR DEM (in meters).
- Mean difference between Unwrapped Phase and calculated Phase Ramp (in radians)
- Standard Deviation between SRDEM and SAR DEM (meters).

Very large "ORRMSError" or "RPPRMSE" **-** root mean square errors - (in the order of hundreds or thousands) eventually bring to wrong results. Care must be paid also when very small "ORRMSError" values (less than 1) are reported; as a rule of thumb errors from some units to some tens are a good preliminary indication that the Ground Control Points have been properly located.
Large "ORRMSError" values can be reported when processing pairs with very small baseline (i.e. less than about 10 meters).

Ground Control Points located on null/dummy value pixels (NaN) are discarded.
The correction parameters are calculated depending on the specific "Refinement Setting 775" and they are applied to rebuild the following input files:

- Unwrapped Phase (_upha).
- MAI unwrapped Phase (_MAI_upha).
- Flattened Interferogram (_dint or _fint).
- MAI flattened Interferogram (_mai_fint).
- Synthetic Phase (_sint).

The points ("Refinement Ground Control Point file") used to calculate the correction parameters (Refinement Setting), shall be selected on the input flattened interferogram (_dint, _fint) in order to avoid areas where topographic fringes remained "unflattened" and "moving areas". The Ground Control Points must be well distributed throughout the entire scene.

An indication about the Ground Control Points quality can be obtained by inspecting the "_refinement.shp" (see "Output" product description below).

If the Interferogram Flattening has been performed using a reference Digital Elevation Model, it is not necessary to specify the co-ordinates of each Ground Control Point; in this case the cartographic co-ordinates (easting, northing and height on the reference DEM) of each GCP are written in the log file 825 at the end of this processing step.
Areas with good coherence should be preferred for the Ground Control Points location. In any case the importance of each GCP is weighted by the program on the basis of its coherence value.

If errors exist in the unwrapped phase image, they must be corrected before running this step. Otherwise wrongly unwrapped areas (disconnected phase "islands") have to be discarded for the Ground Control Points location.

Input Files

MAI Coherence file
Name of the MAI coherence image (_mai_cc). This file is mandatory.

Coherence file
Name of the coherence image (_cc). This file is mandatory.

Input Master File
File name of the multi-looked master Intensity data (_pwr). This file is mandatory.

Input Slave File
File name of the multi-looked coregistered slave Intensity data (_pwr). This file is mandatory.

MAI Unwrapped Phase file
Name of the MAI unwrapped phase (_mai_upha). This file is mandatory.

Unwrapped Phase file
Name of the unwrapped phase (_upha). This file is mandatory.

Synthetic Phase file
Name of the synthetic phase (_sint). This file is mandatory.

Slant Range Digital Elevation Model file
Name of the Digital Elevation Model in slant range geometry (_srdem).

Refinement GCP file
Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File), or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the "Tools>Generate Ground Control Point 747" for details). This file is mandatory if a "Refinement Method" 775 is selected.

Optional Files

MAI Interferogram file
Name of the MAI flattened phase (_mai_fint). This file is optional.

Interferogram file
Name of the flattened phase (_fint). This file is optional.

DEM/Cartographic System

Digital Elevation Model file

Name of the Digital Elevation Model file (geocoded reference DEM). This file is mandatory if it had been used as input for the flattened interferogram generation. If the Digital Elevation Model is omitted, an ellipsoidal height including the cartographic reference system must be set.

Output Projection

In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the Cartographic System 6:

State

Definition of the country or general projection systems.

Projection

Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid

Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere

Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone

Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters

Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height

In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters

The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Refinement method

The choice is given between the following refinement methods:

- *Automatic Refinement;*
- *Polynomial Refinement;*
- *Orbital Refinement.*

Refer to the flattening section of the Preferences 775 for further information about these methods.

Refinement Residual Phase Polynomial Degree
Degree of the polynomial used to estimate the phase ramp, which will be removed from the input unwrapped phase during the Re-flattening operation. In case this value is higher that the number of input Ground Control Points, it will be automatically decreased. The default values of 3 means that a phase ramp in range and azimuth direction plus a constant phase offset will be corrected. In case only the phase offset correction is needed, the polynomial degree will be set to 1.

Coregistration With DEM
This parameter can not be defined by the user.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Flattening

It brings to the flattening section of the Preferences 775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Coregistration

It brings to the coregistration section of the Preferences 770 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Refinement

It brings to the flattening section of the Preferences 775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Name of the output root. This file is optional.

_reflat_dint/fint
Re-flattened interferogram with the associated header files (.sml, .hdr).

_reflat_mai_fint
Re-flattened interferogram with the associated header files (.sml, .hdr).

_reflat_sint
Re-flattened synthetic phase with the associated header files (.sml, .hdr). This file is generated only if a "Refinement Method" 775 was selected.

_reflat_upha
Re-flattened unwrapped phase with the associated header files (.sml, .hdr).

_reflat_mai_upha
Re-flattened unwrapped phase with the associated header files (.sml, .hdr).

_reflat_srdem
Digital Elevation Model, in slant range geometry, with the associated header files (.sml, .hdr). This file is generated only if a "Refinement Method" 775 was selected.

_reflat.txt
Text file with the orbital correction parameters resulting from the refinement.

_refinement.shp
Shape file containing those points retained (valid GCPs) form the input "Refinement GCP file". The following information is provided if the "Orbital 775" method is applied:
- Height value (in meters) from the input DEM in slant range - "ReadHeight".
- Absolute - "AbsHgtDiff" - and relative - "HeightDiff" - difference (in meters) between the real height (input DEM in slant range) and the height value derived from the corrected orbits.
- Standard deviation (in meters) of the input "Refinement GCP file" - "SigmaMt" - It is based on interferometric coherence and orbital configuration.
- Standard deviation (in radians) of the input "Refinement GCP file" - "SigmaRad" - It is based on the interferometric coherence.

The following information is provided if the "Residual Phase 775" method is applied.
- Unwrapped phase value (in radians) - "ReadPhase".
- Absolute - "AbsPhDiff" - and relative - "PhaseDiff" - difference (in radians) between the real phase and its fitted value based on GCPs.

- Standard deviation (in meters) of the input "Refinement GCP file" - "SigmaMt" - It is based on interferometric coherence and orbital configuration.
- Standard deviation (in radians) of the input "Refinement GCP file" - "SigmaRad" - It is based on the interferometric coherence.

_refinement_geo.shp
Shape file containing the geocoded location of the valid GCPs used in the refinement process.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.6.3.13.3 MAI Phase to Displacement Conversion and Geocoding

Purpose

The absolute refined phases (_upha, _mai_upha) values are converted to displacement and directly geocoded into a map projection. This step is performed in a similar way as in the geocoding procedure (Basic module 142), by considering the Range-Doppler approach and the related geodetic and cartographic transforms. The fundamental difference with the geocoding step is that the Range-Doppler equations are applied simultaneously to the two antennae, making it possible to obtain not only the displacement of each pixel, but also its location (Easting, Northing) in a given cartographic and geodetic reference system.

As result of this step also the coherence image is geocoded.

Technical Note

Each 2π cycle (interferometric fringe) of differential phase corresponds to half wavelength of displacement along the Slant Range direction (SAR viewing direction), while for the MAI, the phase is converted in displacement along the satellite flying direction by a factor depending on the antennae sub-aperture distance. It is possible to specify any vector (i.e direction and inclination) where the measured slant range displacement (from _upha) - component of the deformation in the satellite viewing direction - will be projected. Hence this vector represents the re-projection of the slant range deformation component onto a direction on the ground which is known a-priori and specified by the user (i.e. "vertical" in case of subsidence; "slope" in case of landslides; "custom" in any other case).

The output map shows displacement magnitude in meters:

- Slant Range Displacement - Positive sign if the movement corresponds to a decrease of the sensor-to-target slant range distance (slave respect to master acquisition);
- Azimuth displacement - Positive sign if the movement increases along the satellite flying direction;
- Displacement Custom Direction - Positive sign corresponds to movement in the user defined direction (slave respect to master acquisition). It can be applied only to the standard interferometric phase component.

Displacement Custom Direction
Direction and inclination of the displacement vector can be specified. As an example an "azimuth angle" of 45° means that the displacement is oriented North 45° East and the movement is expected Northeastward; while an "azimuth angle" of 225° means that the displacement is always oriented North 45° East, but the movement is expected Southwestward. Positive inclination angles indicate upward movement; negative inclination angles indicate downward movement.

Precision
This output product, which is derived from parameters such as coherence and wavelength, provides an estimate (i.e. standard deviation value) of the measurement precision. The higher this value the lower the measurement precision. The formula used for the precision calculation is:

$$\sqrt{\frac{1-\gamma^2}{2\gamma^2}}\ \frac{\lambda}{4\pi}$$

where γ is the interferometric coherence.

It is important to outline that the Refinement and Re-flattening 308 step must have been performed previously

Input Files

MAI Coherence File
File name of the coherence (_mai_cc). This file is mandatory.

Coherence File
File name of the coherence (_cc). This file is mandatory.

MAI Unwrapped Phase file
File name of the reflattened unwrapped phase (_mai_upha). This file is mandatory.

Unwrapped Phase file
File name of the reflattened unwrapped phase (_upha). This file is mandatory.

DEM/Cartographic System

Digital Elevation Model file
Name of the Digital Elevation Model file. This should be referred to the ellipsoid. This file is optional. In case it is omitted, the ellipsoidal height and the relevant cartographic reference system, must be entered.

Output Projection
In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters

Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Cartographic Parameters

The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Product Coherence Threshold

Pixels with coherence values smaller than this threshold will be set to dummy (NaN) in the final products.

Vertical Displacement

By setting this flag the map showing the displacement values projected on the vertical direction is generated among the output products.

Slope Displacement

By setting this flag the map showing the displacement values projected along the maximum slope is generated among the output products.

Displacement Custom Direction

By setting this flag any vector can be specified, in terms of azimuth (**Azimuth Angle**, measured in degrees from the North - clockwise direction) and inclination (**Inclination Angle**, measured in degrees from the horizontal plane). The map showing the displacement values projected on the specified direction is generated among the output products.

X Dimension (m)

The grid size of the output data in Easting (X) must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Y Dimension (m)

The grid size of the output data in Northing (Y) must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Interpolation Window Size

By setting this flag the dummy values in the output file are interpolated. The interpolated value is the average of the valid values in a window of the size selected.

Dummy Removal
By setting this flag the output geocoded files will be automatically resized in order to remove the dummy area exceeding the frame border.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Geocoding

It brings to the geocoding section of the Preferences 766 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Displacement Projection

Generate Line Of Sight
by setting this flag the displacement in line of sight and satellite flying direction as measured by the satellite in generated.

Vertical Displacement
By setting this flag the map showing the displacement values projected on the vertical direction is generated among the output products.

Slope Displacement
By setting this flag the map showing the displacement values projected along the maximum slope is generated among the output products.

Generate East
By setting this flag the map showing the displacement values projected on the East-West direction is generated among the output products.

Generate North
By setting this flag the map showing the displacement values projected on the North-South direction is generated among the output products.

Displacement Custom Direction
By setting this flag any vector can be specified, in terms of azimuth (**Azimuth Angle**, measured in degrees from the North - clockwise direction) and inclination (**Inclination Angle**, measured in degrees from the horizontal plane). The map showing the displacement values projected on the specified direction is generated among the output products.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Name of the output root. It is mandatory.

_dem
Input Digital Elevation Model resampled onto the specified cartographic system and grid size, with the associated header files (.sml, .hdr). Its areal extent is the same as the output SAR products.

_disp_cc_geo
Geocoded coherence in range direction with the associated header files (.sml, .hdr).

_mai_disp_cc_geo
Geocoded coherence in azimuth direction with the associated header files (.sml, .hdr).

_ADF
Maximum slope direction values, with the associated header files (.sml, .hdr).

_IDF
Maximum slope inclination values, with the associated header files (.sml, .hdr).

_SD
Displacement values along the maximum slope direction, with the associated header files (.sml, .hdr).

_UD
Displacement values in the direction specified as azimuth and inclination degrees (i.e. custom direction), with the associated header files (.sml, .hdr).

_VD
Vertical displacement values, with the associated header files (.sml, .hdr).

_disp
Slant Range (satellite view direction) displacement values, with the associated header files (.sml, .hdr).

_mai_disp
Azimuth (satellite flying direction) displacement values, with the associated header files (.sml, .hdr).

_disp_precision
Estimate of the data quality in range with the associated header files (.sml, .hdr). This file is generated

only if the coherence file is entered as input.

_mai_disp_precision
Estimate of the data quality in azimuth with the associated header files (.sml, .hdr). This file is generated only if the coherence file is entered as input.

_disp_ALOS
Azimuth Line of Sight with the associated header files (.sml, .hdr). Positive angles are measured clockwise from the North; negative angles are measured counterclockwise from the North.

mai disp_ALOS
Satellite flying direction with the associated header files (.sml, .hdr). Positive angles are measured clockwise from the North; negative angles are measured counterclockwise from the North.

_disp_ILOS
Incidence angle of the Line of Sight with the associated header files (.sml, .hdr). The angle is measured between the Line Of Sight and the vertical on the ellipsoid (flat earth).

_mai_disp_ILOS
Incidence angle for the Satellite flying direction with the associated header files (.sml, .hdr). The angle is measured between the Flying Direction and the vertical on the ellipsoid (flat earth).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.6.3.14 Displacement Modeling

Section Content

1.6.3.14.1 Overview

A Note on the Modeling module

The Modeling module is aimed at interpreting the geodetic data, primarily InSAR and GPS, through analytical models suitable for tectonic and volcanic sources.

Main functionalities of this module are:

- **Image Subsampling** 411: used to convert a raster image into a vector dataset of geodetic data to invert;
- **Non-Linear Inversion** 413: used to find all the source parameters by means of a non-linear inversion of geodetic data;
- **Linear Inversion** 417: used to find the source linear parameters by means of a linear inversion of

geodetic data;

- **Forward Modeling** 423: used to generate geocoded or slant range surface displacement maps due to tectonic or volcanic sources;
- **CFF Stress Transfer** 420: used to calculate the stress change induced between sources.

The Modeling module offers also a set of related tools:

- **Initialization from CMT** 445: used to initialize seismic sources for the inversion from the Global Centroid Moment Tensor catalog;
- **Moment Tensor calculation** 428: used to calculate the moment tensor from a tectonic source and draw its beach-ball mechanism;
- **Import USGS slip distribution** 426: used to create seismic sources from the seismological-based USGS slip distributions;
- **LOS Projection** 430: used to project into the Line-of-Sight the East/North/Up components of the displacement.

Two type of geodetic datasets are currently supported:

- InSAR dataset derived from the sampling of an unwrapped and geocoded displacement map 432;
- GPS dataset created off-line and stored in a shapefile format 433.

Two type of analytical sources can be currently handled:

- Shear and/or tensile dislocation for a rectangular source in a homogeneous and elastic half-space 434: this source has a double implementation: with a single and distributed dislocation;
- Point pressure source in a homogeneous and elastic half-space 441.

There is no restriction on the amount of geodetic datasets and geophysical sources that can combined together in a processing.

Most of the panels benefit from the use of the **XML Project File** 447, that is an ASCII file in XML format where the information about the input/output data, sources and processing options are stored to allow an easy recovery of the modeling session.

A tutorial 393 based on InSAR data for the 2003 Bam (Iran) earthquake can be used to explore the module functionalities.

IMPORTANT NOTE

At present, every processing can be carried out only with a projected cartographic system.

We strongly encourage the use of UTM-WGS84 projected data.

1.6.3.14.2 ModelingTutorial1

1. Introduction

This tutorial is aimed at making the user familiar with the main modeling functionalities, by means of a complete modeling session of a seismic event, the M_w 6.6 earthquake occurred near the city of Bam (Iran) on December 26th, 2003. The tutorial starts with the Image Subsampling 411 of a displacement map, then the coseismic displacement is modeled via Non-Linear Inversion 413 and Linear Inversion 417, to retrieve the position of the fault and its slip distribution. The latter is then used to calculate the CFF Stress Transfer 420 induced by the earthquake on the fault itself; finally, the retrieved model is used in a Forward Modeling 423 to generate the raster maps of predicted displacement, projected into the Line-Of-Sight.

Though this tutorial gets through the main modeling features, it does not involve all the technical and scientific modeling aspects. In most cases, only one of the possible processing configurations is presented: we strongly suggest the user to refer to the linked help pages for a complete description of all the available options.

We remark that modeling is, in general, a non-unique problem: different solutions can lead to comparable results, equally able to reproduce the observed data. Only the experience and an incisive data analysis can lead to realistic solutions.

Tips and **Notes** are provided to improve the modeling strategy and/or highlight further software functionalities.

2. The Bam event data

This tutorial is based on the displacement map generated with a pair of SAR images acquired by the Envisat satellite from the European Space Agency. This map has been obtained with an interferometric processing carried out with the SARscape interferometric module; the images have been acquired on

December 3rd, 2003 and February 11th, 2004 and have a spatial baseline of about 4 m. In this tutorial the displacement is modeled with a single fault with distributed slip.

Refer to the cited literature (Wang et al., 2004; Funning et al, 2005) for a review of the event.

REFER TO YOUR LOCAL DISTRIBUTOR TO GET THE DATA FOR THIS TUTORIAL.

To run the tutorial, you need the following files:

- **Bam_envisat_dsc_disp**: displacement map (m) obtained from a descending Envisat image pair;
- **Bam_envisat_dsc_ALOS**: map of the Line-Of-Sight azimuth angle (deg);
- **Bam_envisat_dsc_ILOS**: map of the Line-Of-Sight incident angle (deg);
- **Bam_SRTM_dem**: SRTM digital elevation model with 90 m resolution;
- **Bam_project_backup.xml**: XML Project File (see next paragraph);
- **Subsampling_areas.shp**: shapefile containing the areas to sample the displacement map.

All the images are in a UTM-WGS84, Zone 40 North, projection.

3. The XML Project File

The main modeling panels requires the setting of an XML Project File 447. This file allows to save the input configuration of any processing for a quick restore in any moment. Most of the processing outputs are stored in the XML Project File 447 as well, allowing an efficient project portability.

In this tutorial, an XML Project File 447 created from scratch and named **Bam_project.xml** will be used. Though a project file with all the sections already set is provided with the tutorial data (**Bam_project_backup.xml**), we suggest the use of a new one to get confident with its use.

4. Image subsampling

Since modeling is predomintaly carried out with vector data, Image Subsampling 411 is a mandatory task to create a vector dataset of values sampled from the InSAR displacement maps.This can be due in two ways: by sampling the image over regularly spaced points in manually defined areas (mesh from vector file 411) or with the Quadtree algorithm 411. In this tutorial we use the first approach, which needs the definition of the areas and their sampling resolution by means of a shapefile. This file is provided with the input data (**Subsampling_areas.shp**) where two areas with density 500 m and 2000 m, close and far from the fault, respectively, are already set (Fig. 1).

Tip You can define different subsampling areas and resolutions, by editing the shapefile or creating a new one (see mesh from vector file 411); in this way a different dataset to model is obtained and results may differ from this tutorial.

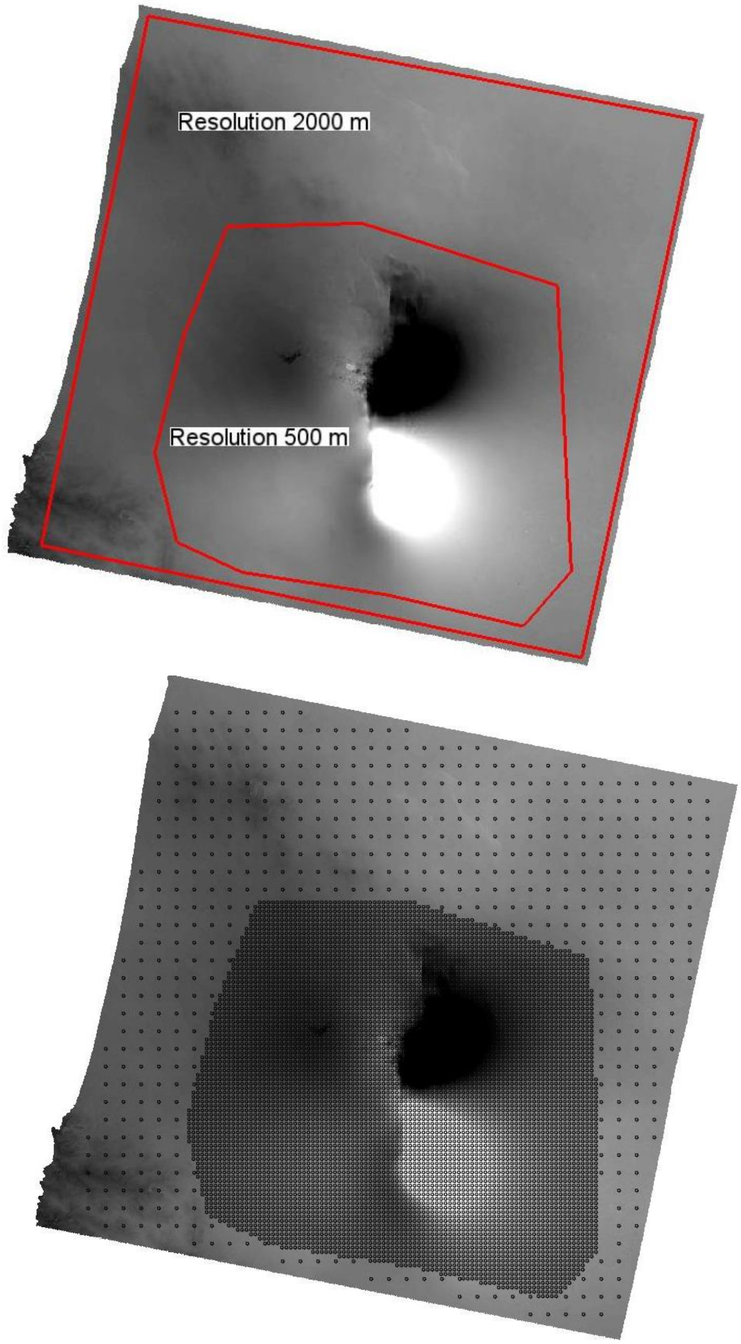


Figure 1. Sampling areas with resolution values (left) and resulting points (right)

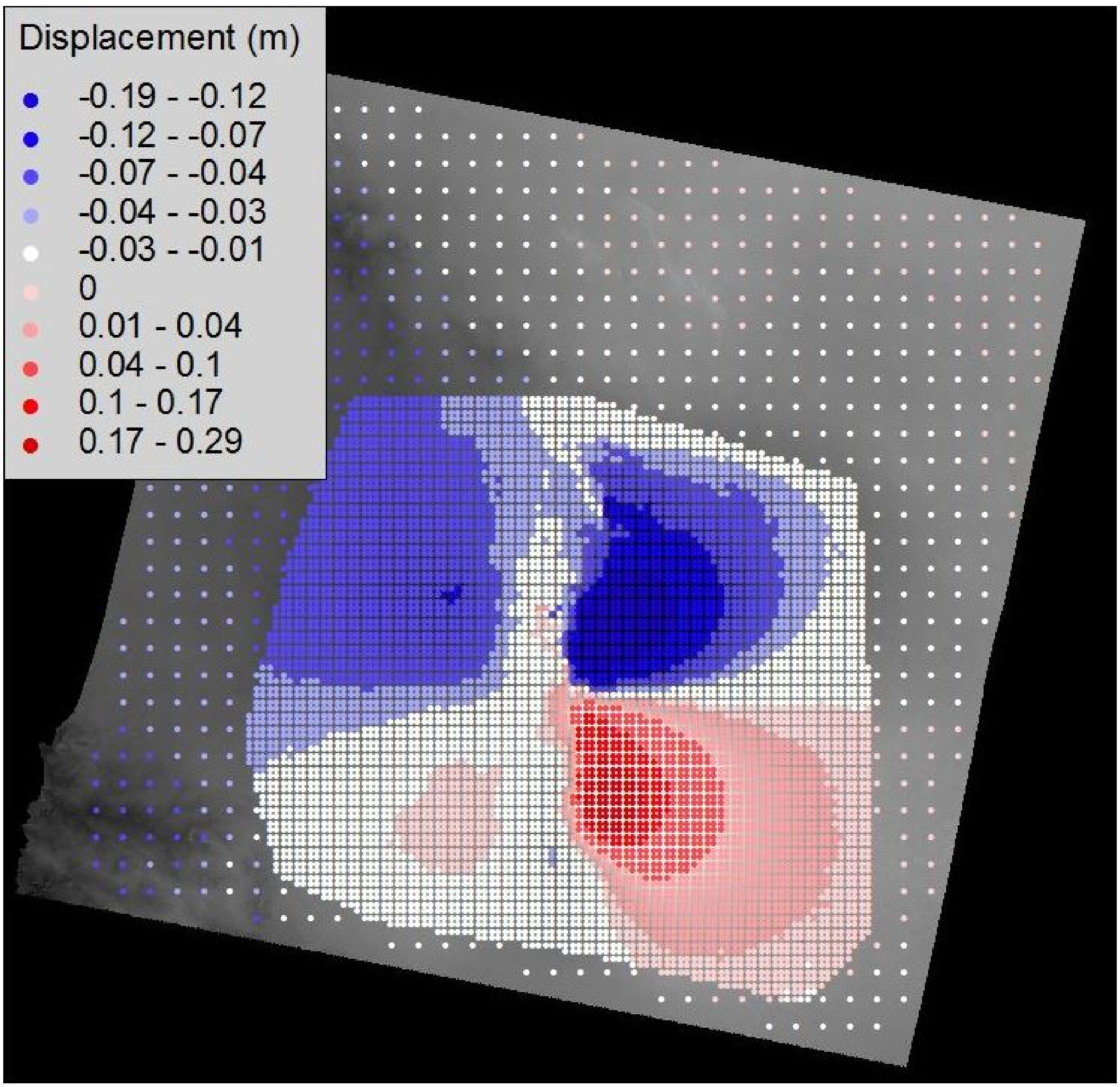
Once the file with the sampling areas is available:

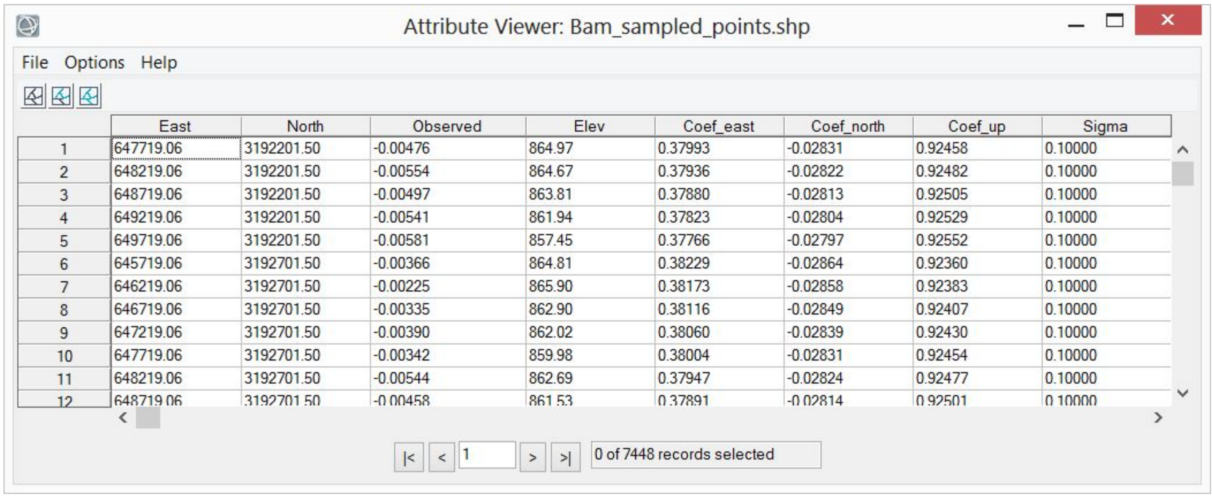
1. Open the Image Subsampling 411 panel;
2. Set the following files:
   - "Subsampling Image": **Bam_envisat_dsc_disp**
   - "Azimuth LOS image": **Bam_envisat_dsc_ALOS**

- "Incidence LOS image": **Bam_envisat_dsc_ILOS**
- "DEM": **Bam_SRTM_dem**

3. Set **Mesh from vector file** as "Subsampling method"
4. Set in "Vector File" the **Subsampling_areas.shp** file (or a newly created one)
5. Set in "Output Shapefile" the **Bam_sampled_points.shp** name
6. Click "Start" and wait for the "END" message.

By using the **Subsampling_areas.shp** as it is provided with the tutorial data, the **Bam_sampled_points.shp** will contain 7448 points (Fig. 2) with the related attributes. This shapefile of points represents, in the modeling tools, an InSAR dataset432.





	East	North	Observed	Elev	Coef_east	Coef_north	Coef_up	Sigma
1	647719.06	3192201.50	-0.00476	864.97	0.37993	-0.02831	0.92458	0.10000
2	648219.06	3192201.50	-0.00554	864.67	0.37936	-0.02822	0.92482	0.10000
3	648719.06	3192201.50	-0.00497	863.81	0.37880	-0.02813	0.92505	0.10000
4	649219.06	3192201.50	-0.00541	861.94	0.37823	-0.02804	0.92529	0.10000
5	649719.06	3192201.50	-0.00581	857.45	0.37766	-0.02797	0.92552	0.10000
6	645719.06	3192701.50	-0.00366	864.81	0.38229	-0.02864	0.92360	0.10000
7	646219.06	3192701.50	-0.00225	865.90	0.38173	-0.02858	0.92383	0.10000
8	646719.06	3192701.50	-0.00335	862.90	0.38116	-0.02849	0.92407	0.10000
9	647219.06	3192701.50	-0.00390	862.02	0.38060	-0.02839	0.92430	0.10000
10	647719.06	3192701.50	-0.00342	859.98	0.38004	-0.02831	0.92454	0.10000
11	648219.06	3192701.50	-0.00544	862.69	0.37947	-0.02824	0.92477	0.10000
12	648719.06	3192701.50	-0.00458	861.53	0.37891	-0.02814	0.92501	0.10000

Figure 2. Subsampled points and relative attributes

Note In addition to the known shapefile components (.shp, .dbf, .shx and .prj files) a further file is created (**Bam_sampled_points.shp.xml**) with ancillary information required by the inversion. This file is generated only when subsampling is carried out over a displacement map created with SARscape; in the other cases, its content must be manually set through the interface.

5. Non-Linear Inversion

With the Non-Linear Inversion 413 we want to reproduce the observed displacement by means of a geophysical source, assuming that nothing is known about the source and all its parameters must be inferred from the InSAR dataset just created. In this tutorial we model the data with a single fault (see Elastic Dislocation 434), but we invert also a further parameter, accounting for a possible offset that could affect the data; this is advisable when the reference point in the interferogram could have been set in a deforming area.

In the Non-Linear Inversion 413 the use of the XML Project File 447 is mandatory and must be set:

1. Open the "Non-Linear and Linear Inversion" panel;
2. Select the "Non-Linear" tab;
3. Set the "XML Project File" to **Bam_project.xml**.

Dataset setting

The InSAR dataset 432 created with the displacement map subsampling is added as follows:

1. Click on the "Add..." button in the "Dataset(s)" list and select the **Bam_sampled_points.shp**;
2. Open the Parameter setting panel through the "Edit..." button;
3. Flag the "Invert for orbital surface" (default option);
4. Set 0 as "Polynomial degree";
5. Click on "Commit".

By setting 0 as polynomial degree, you let the inversion to assess also a possible offset that may affect the data.

Source setting

In this tutorial we assume that all the source parameters are unknown; however, we must set, for each parameters, a range of allowed values between a minimum and a maximum. Since the Elastic Dislocation 434 source is characterized by an high number of parameters, we developed a specific tool to initialize the source based on the Global Centroid Moment Tensor on-line catalogue. This tool only needs the CMT event identifier, which can be preliminarily retrieved as follows:

1. Open the http://www.globalcmt.org/CMTsearch.html site;
2. Set the following parameterse:
    - Starting Date - Year: 2003
    - Starting Date - Month: 12
    - Starting Date - Day: 26
    - Ending Date - Number of days: 1
    - Moment magnitude range with 6 <= Mw <= 7
3. Click on "Done";
4. Two events should fit this constraints: we will use the identifier of the "SOUTHERN IRAN" event (**122603B**).

Once the CMT event identifier is known, you can initialize the source to invert:

1. In the Non-Linear Inversion 413 panel, click on the "New…" button from the "Source(s)" list;
2. Select Elastic dislocation (Okada) 434 from the pull down menu;
3. Click on the "Initialize from CMT solution…" button to open the Initialize Values from CMT Catalogue 445 panel;
4. Set the event identifier (**122603B**) in the "Insert the CMT identifier" field and click the "Search" button (it could take a while to get the result);
5. From the pull down menu select "Plane 1" then click "Commit";
6. Set "Bam_fault" as "Source name", then click "Commit" to return to the main panel;
7. Click on the "Start" button to run the inversion;
8. Click "Yes" to the "XML Project File updated" dialog box;
9. Wait until the "END" message (it could take few minutes);
10. Click "No" to the "Focal Mechanism" dialog box

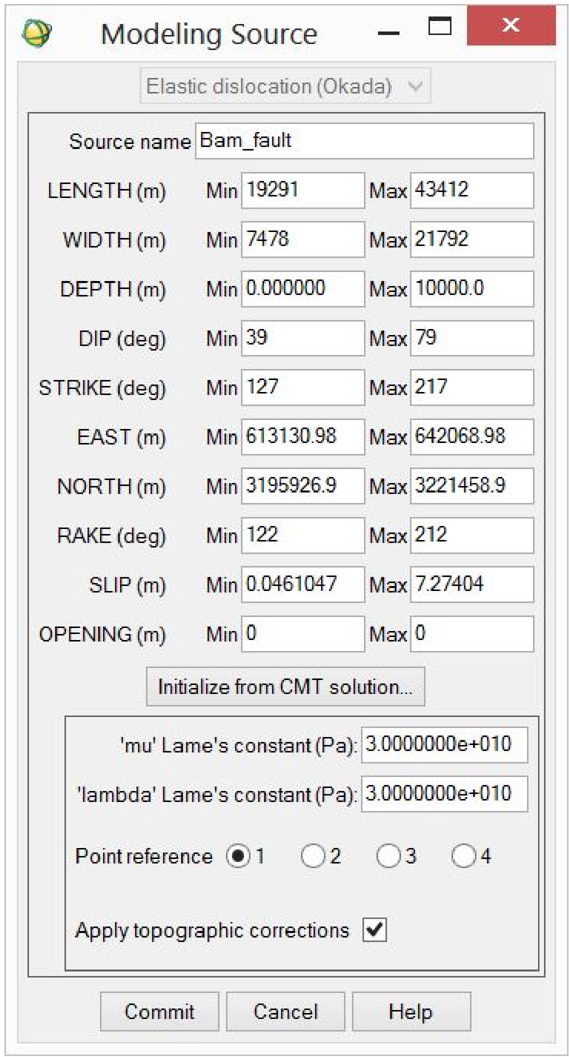


Figure 3. Source parameters automatically initialized with the CMT solution

Tip The CMT catalogue provides two alternative solutions, corresponding to two possible nodal planes: the real slipped plane and the auxiliary one, which is only a mathematical solution. In the case of Bam, the displacement pattern clearly shows that the fault plane is nearly North-South oriented, which corresponds to the "Plane 1" solution in the Initialize Values from CMT Catalogue 445 panel.

Note When the XML Project File 447 file is updated, the "NLInput" and "NLOptions" sections are created under the "ModelingRoot"-"NonLinearInversion" XML section. If they already exist from a previous processing, they are overwritten. In order to maintain the alignment between input parameters and output models, when the "NLInput" and "NLOptions" sections are updated, the "NLOutput" section, if existing from a previous processing, is canceled.

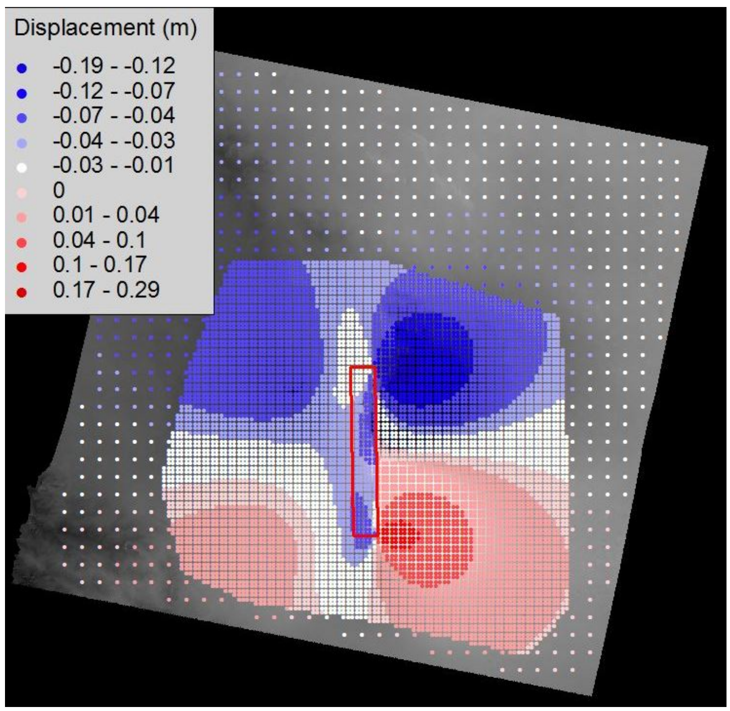
When the Non-Linear Inversion 413 ends, the **Bam_project.xml** file is updated with the results: inverted model parameters, InSAR data offset, RMS of the residuals between observed and modeled data, geodetic moment, moment magnitude, etc... All the information are written in the "ModelingRoot"-"NonLinearInversion"-"NLOutput" section.

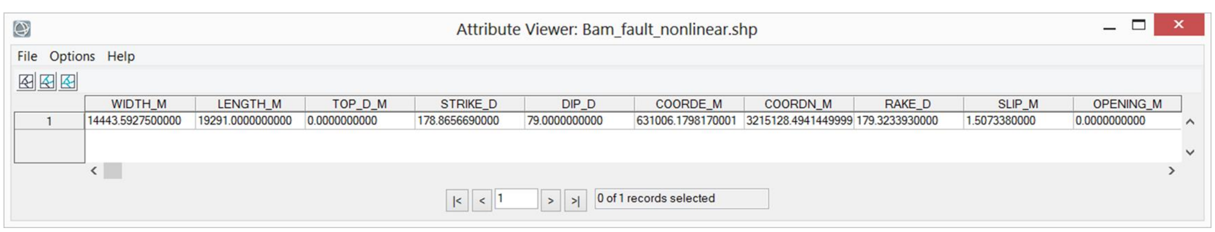
Note the Non-Linear Inversion 413 algorithm is based on multiple restarts: every starting configuration is randomly picked within the allowed ranges to avoid, as far as possible, to trap the cost function into local minima. This aleatory component can lead to different results with repeated runs.

Tip We strongly suggest to run the Non-Linear inversion several times and inspect every time the inferred source, in order to understand the reliability and the stability of a result.

Here we show the result obtained with the source initialized as in Fig. 3. If the flags "Generate output shapefile" in the Inversion_Settings 792 (accessible through the "Inversion settings…" button in the inversion panel) are set, the following files have also been created:

- **Bam_fault_nonlinear.shp**, with the best fit source and its parameters as attributes;
- **Bam_sampled_points_nonlinear.shp**, containing the observed and modeled data (see the output attributes after the inversion for the InSAR dataset 432).





Attribute Viewer: Bam_fault_nonlinear.shp

File Options Help

	WIDTH_M	LENGTH_M	TOP_D_M	STRIKE_D	DIP_D	COORDE_M	COORDN_M	RAKE_D	SLIP_M	OPENING_M
1	14443.5927500000	19291.0000000000	0.0000000000	178.8656690000	79.0000000000	631006.1798170001	3215128.4941449999	179.3233930000	1.5073380000	0.0000000000

0 of 1 records selected

From the XML Project File	
Overall residual RMS	0.028 m
Geodetic Moment	$1.26 \cdot 10^{19}$ N·m
Moment Magnitude	6.7
Data offset	0.014 m

Figure 4. Modeled points, fault parameters and other general parameters after the Non-Linear Inversion 413 automatically initialized with the CMT values.

The results of Fig. 4 show that the source automatic initialization with CMT values has already led to reasonable results. However further improvements of the Non-Linear Inversion 413 are still possible.

Tip When a parameter reaches the upper or the lower limit of the allowed range after the inversion, the range should be modified to let the algorithm explore other possible values. A good result is achieved when all the parameters fall within the specified range without assuming any limit value.

Tip When a parameter is already known, you can fix it by setting the minimum and maximum to the known value.

In Fig. 4 the "Dip" reached the upper limit (79°), and this indicates that higher values could be preferred. In fact, the "Strike" and "Dip" ranges only allow to explore westward dipping faults, while the deformation pattern suggests an eastward dipping plane (see Fig. 1). Therefore we run again the Non-Linear Inversion 413 with modified "Strike" and "Dip" ranges, as shown in Fig. 5 (see the Elastic Dislocation 434 source for "Strike" and "Dip" angle conventions). To set the new ranges click on the "Edit..." button under on the "Source(s)" list.

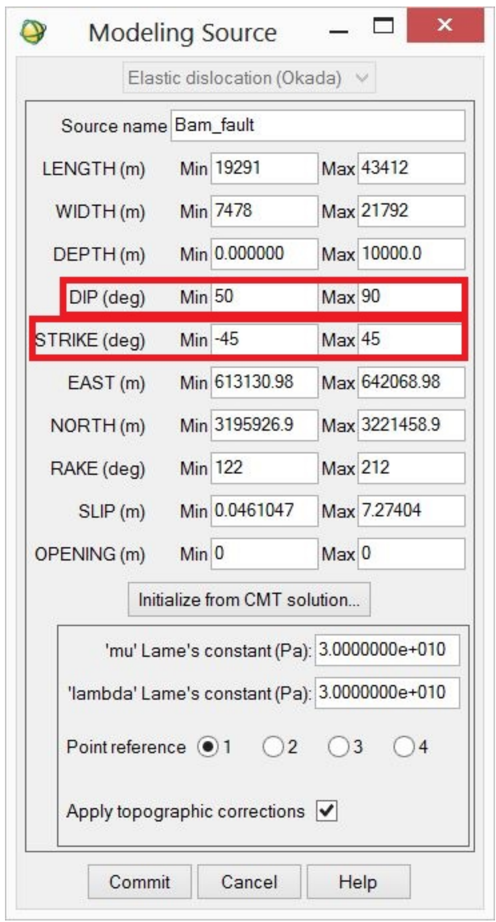
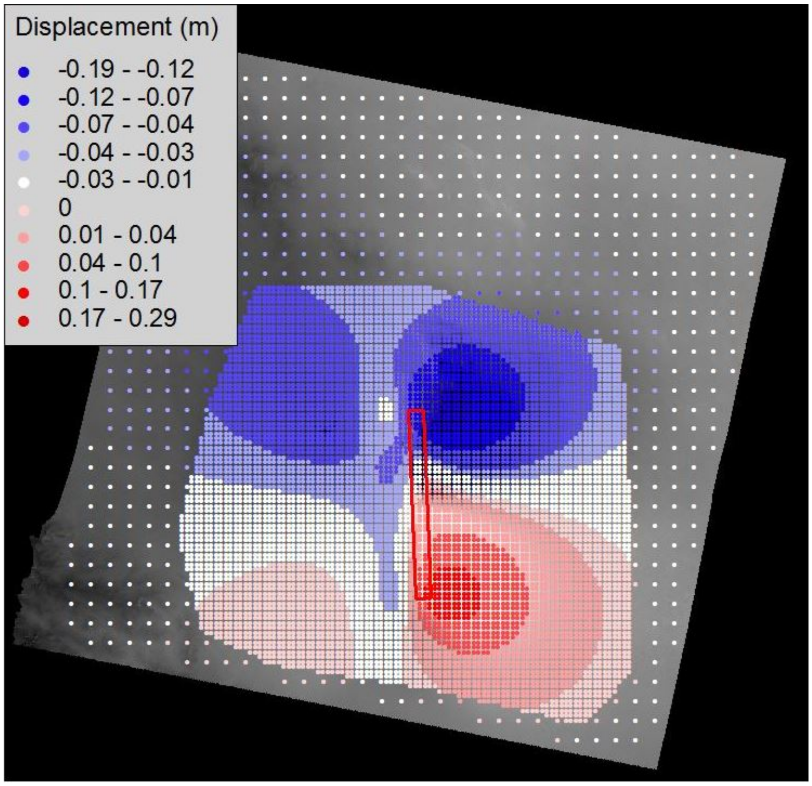
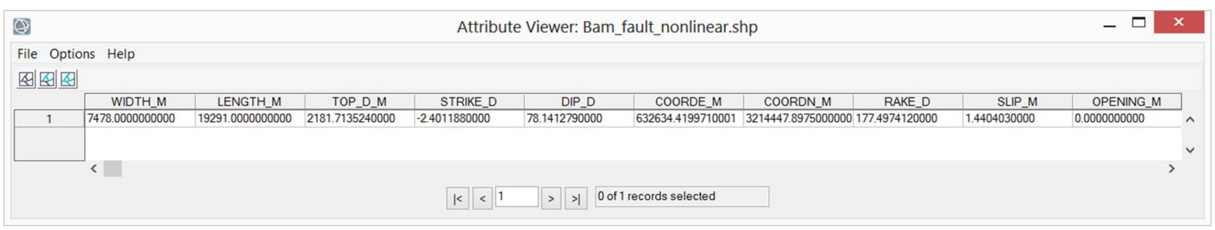


Figure 5. Modified ranges (in red) for the second inversion with a eastward dipping source

After editing the ranges, run again the Non-Linear Inversion 413 and check that all the parameters now fall within the ranges. You can also navigate through the "NLOutput" section of the **Bam_project.xml** file to verify that the RMS of the residuals is slightly lower than before, showing that this second solution better reproduces the observed data.





	WIDTH_M	LENGTH_M	TOP_D_M	STRIKE_D	DIP_D	COORDE_M	COORDN_M	RAKE_D	SLIP_M	OPENING_M
1	7478.0000000000	19291.0000000000	2181.7135240000	-2.4011880000	78.1412790000	632634.4199710001	3214447.8975000000	177.4974120000	1.4404030000	0.0000000000

From the XML Project File	
Overall residual RMS	0.026 m
Geodetic Moment	0.62 $\cdot 10^{19}$ N·m
Moment Magnitude	6.5
Data offset	0.017 m

Figure 6. Modeled points, fault parameters and other general parameters after the Non-Linear Inversion 413 with revised ranges for "Strike" and "Dip".

Note Different solutions can fit almost equally the observed data, as visible by comparing the RMS of the residuals between observed and modeled data of Fig. 4 and Fig. 6. The RMS is nearly the same, in spite of the different sources. Only external information and the experience help in understanding whether a solution is reliable or not.

6. Linear inversion

With the Non-Linear Inversion 413 a mean source with a mean and unique slip value of 1.44 m has been inferred (Fig. 6). With the Linear Inversion 417 we retrieve a more realistic slip distribution over the fault plane by means of a Elastic dislocation 434 model. Before the inversion parameter setting, the XML Project File 447 must be specified:

1. Open the "Non-Linear and Linear Inversion" panel;
2. Select the "Linear" tab;
3. Set the "XML Project File" to **Bam_project.xml**.

Note In this tutorial, we collect all the tasks in the same XML Project File 447. However, tasks are independent and can be stored separately in different project files.

Dataset setting

The InSAR dataset 432 to invert is loaded as in the Non-Linear Inversion 413 (just make sure you switched to the "Linear Inversion" tab in the panel):

1. Click on the "Add..." button in the "Dataset(s)" list and select the **Bam_sampled_points.shp**;
2. Open the Parameter setting panel through the "Edit..." button;
3. Flag the "Invert for orbital surface" (default option);
4. Set 0 as "Polynomial degree";
5. Click on "Commit".

Source setting

The starting point of the Linear Inversion 417, in this tutorial, is the source calculated through the Non-Linear Inversion 413: instead of creating a new source from scratch with the "New..." button, we load the Non-Linear Inversion 413 results. This can be done in two ways: loading the **Bam_fault_nonlinear.shp** (created after the inversion) through the "Add from file..." button or retrieving the plane parameters with the "Load from XML..." button, which allow to explore the content of any XML Project File 447.

Note The "Add from XML..." button allows to access any XML Project File 447, to inspect and retrieve any stored source (input/output of Non-Linear Inversion 413, Linear Inversion 417, CFF Stress Transfer 420, Forward Modeling 423). Here, we access the same **Bam_project.xml** file to get the output of the Non-Linear Inversion 413.

To extract the source from the XML Project File: 447

1. Click on the "Load from XML..." button under the "Source(s)" list;
2. Select the **Bam_project.xml** file;
3. In the XML section, select "Non-Linear Inversion - Output";
4. Select, from the "Bam_fault [Elastic dislocastion (Okada)]" item;

5. Click “Commit”.

Tip Since the slip retrieved through Non-Linear Inversion413 is a mean value of the real one, it is always convenient to extend the fault dimensions to include the whole slipped area, letting the slip to vanish at the fault limits (Fig. 7).

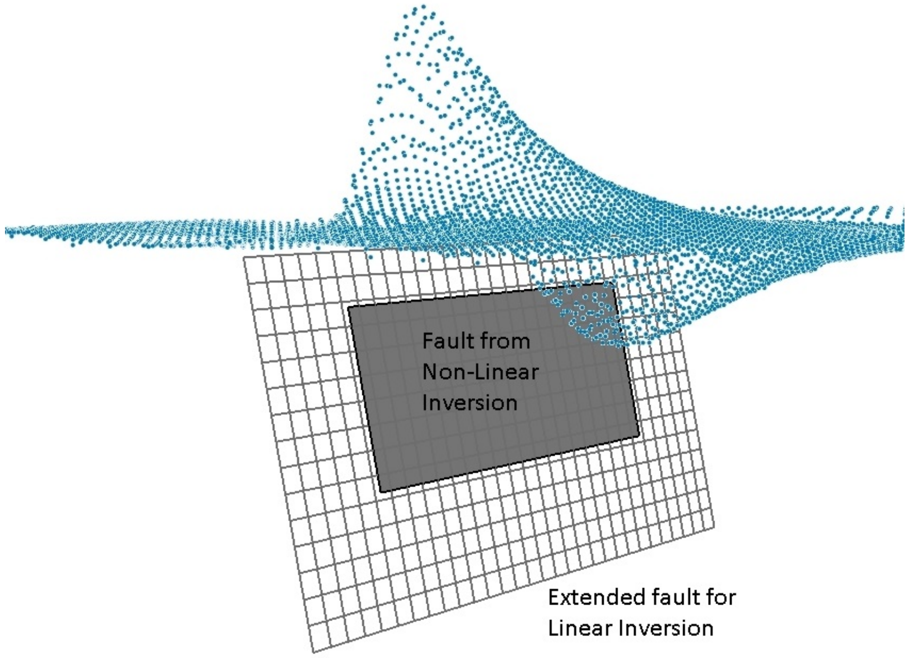


Figure 7. Fault from Non-Linear Inversion (gray rectangle) extended and subdivided into 30x15 patches; blue points represent the observed displacement in the Line-Of-Sight.

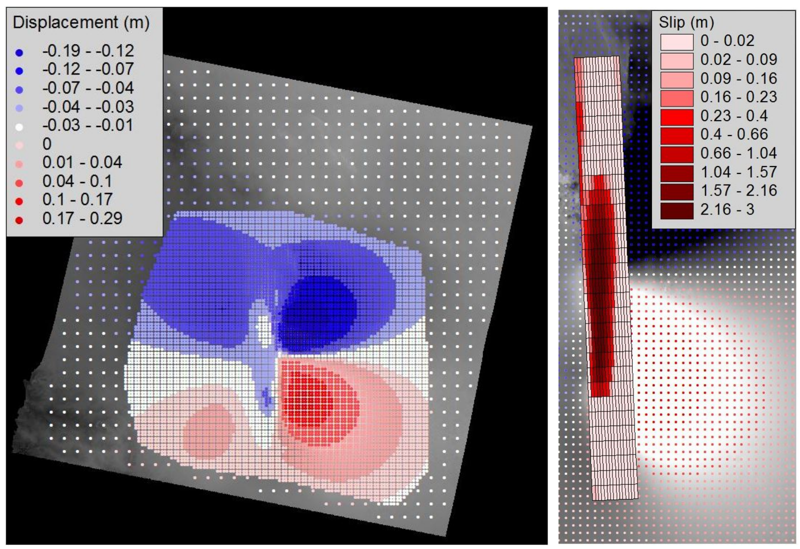
The source retrieved from the Non-Linear Inversion413 is added to the “Source(s)” list with the flag “*** CHECK PARAMETERS ***”, notifying that more information must be provided before running the inversion. To complete the source setup and change the source dimension:

1. Select the source in the “Source(s)” list and click the “Edit…” button;
2. Change the “Point reference” to 4;
3. Set the “Length (m)” field to “30000.”;
4. Set the “Width (m)” field to “15000.”;
5. Set the “Depth (m)” field to “0.”;
6. Set “Fixed rake” as Inversion Type;
7. Set the “PATCHES ALONG STRIKE” field to “30” and “PATCHES ALONG DIP” field to “15”;
8. Set the “Damping value” to 0.05
9. Only for ENVI 5.0 or higher, click the “Draw Source in ENVI 5.x” button to see the source in the ENVI view (a reference layer must be already present);
10. Click the “Commit” button;
11. Click on "Start" to run the inversion;

12. Answer “No” to the “Focal Mechanism” dialog box after the inversion ends.

Note By switching the Point Reference to 4 (see the Point Reference 437 in the Elastic dislocation source), the source length, width and depth can be changed without affecting the East and North coordinates, that are referred to the unchanged fault trace.

In the Linear Inversion we extended the initial fault to a 30x15 km source, subdivided into patches of 1 km. After clicking on the “Start” button, the **Bam_project.xml** file is updated: the ”LinInput” and ”LinOptions” sections in “ModelingRoot”-”LinearInversion” are immediately created (or updated), while the "LinOutput" section is added at the processing end. The results of the Linear Inversion 417 are shown in Fig. 8.



From the XML Project File	
Overall residual RMS	0.012 m
Geodetic Moment	$0.53 \cdot 10^{19}$ N·m
Moment Magnitude	6.4
Data offset	0.017 m

Figure 8. Modeled points, slip distribution and other parameters after Linear Inversion 417

Tip The slip distribution strongly depends on the Damping Value: a low damping leads to scattered slip values while high values to an over-smoothed solution. The best value can be obtained only with a *trial-and-error* approach. Unless you want a complete damping vs. RMS curve, we suggest a *divide-and-conquer* algorithm: start from a low value, then move to a high value, then test a value in between, and so on… checking at every step the result. This is quite fast, if the output shapefile is loaded into a GIS: since the output shapefile, at every step, is overwritten, you just need to refresh the view to check the result for every new damping value.

If the flags “Generate output shapfile” in the Inversion Settings 792 (accessible through the “Inversion settings…” button in the inversion panel) are set, the following files have been created:

- **Bam_fault_linear.shp**: containing the best fit source and its parameters;

- **Bam_sampled_points_linear.shp**: containing the observed and modeled data (see the output attributes after the inversion for the InSAR dataset 432)

7. Moment Tensor and "beach ball" calculation

The Calculate and Draw Focal Mechanism 420 panel can be used to calculate the seismic moment, to moment tensor and to draw the beach ball of the focal mechanism. This can be accomplished with a new source created from scratch or loading an existing source from a shapefile or an XML Project File 447. In this tutorial, we load the results of the Linear Inversion 417 from the **Bam_project.xml** file:

1. Open the Calculate and Draw Focal Mechanism 420 panel;
2. Click on the "Add from XML..." button;
3. Select the **Bam_project.xml** file;
4. Form the "XML section" pull down menu, select "Linear Inversion – Output";
5. Select in the source list the "Bam_fault [Fault patches(Okada)]" item and click "Commit";
6. In the main panel, select the source just loaded and click "Start" (Fig. 9).

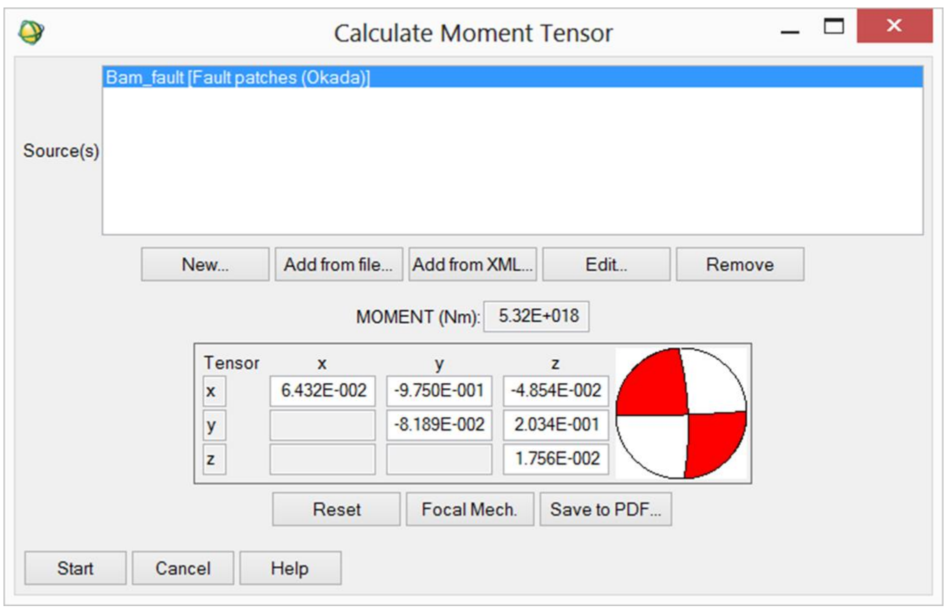


Figure 9. Moment tensor and focal mechanism for the modeled source of the Bam earthquake

Tip You can test, for instance, the effect of changing the shear modulus μ just editing the source through the "Edit..." button and setting a different value in the "'mu' Lame's constant" field.

8. CFF Stress Transfer

This tool can be used to calculate the stress change induced by one or more sources onto other sources acting as receivers. In the case of Bam, where only one source is involved, we calculate the stress change induced by the fault on the slipped plane itself.

Tip The self-induced stress change can be used, for instance, to check whether the aftershock distribution is coherent with the highest loaded areas.

This task requires the setting of the XML Project File 447:

1. Open the CFF Stress Transfer 420 panel;
2. Set the "XML Project File" to **Bam_project.xml**.

The input and receiver sources are retrieved, as in previous tasks, from the **Bam_project.xml** file itself:

1. Click on the "Add from XML..." button under the "INPUT SOURCE(S)" list;
2. Select the **Bam_project.xml** file;
3. From the "XML section" pull down menu, select "Linear Inversion – Output";
4. Select in the source list the Bam fault item and click "Commit";
5. Click on the "Add from XML..." button under the "RECEIVER SOURCE(S)" list;
6. Repeat the steps from 2 to 4;
7. Set the flag "Automatically create output Shapefiles";
8. Click on the "Start" button in the main panel and wait for the "END" message.

After the processing, the output source, i.e. the receiver with the CFF values, can be loaded into a GIS, as in Fig. 10.

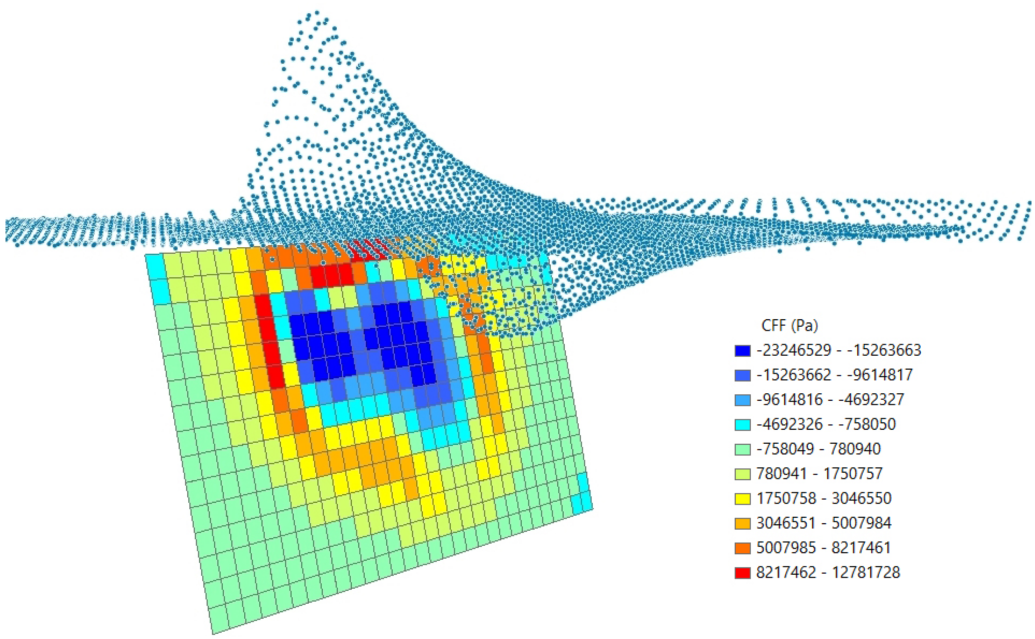


Figure 10. Stress change induced by the slip of Fig. 8, over the Bam fault itself.

9. Forward Modeling

In this step, we use the source obtained via Linear Inversion 417 to calculate the surface displacement in the East, North and Up directions. Forward Modeling 423 can be carried out over a set of points, stored in a shapefile, or creating three raster files containing the East, North and Up components. In this tutorial we create a raster output, using the **Bam_envisat_dsc_disp** (the original displacement map from the interferometric processing) as reference to set the output extent and resolution. The latter is reduced from 25 m to 250 m to speed up the processing.

Tip For big earthquakes, the USGS website makes available a slip distribution obtained through the inversion of seismic waveforms. The tool Import USGS Slip Distribution 426 can be used to generate the source in a shapefile form; the source can be then loaded with the "Add from file..." button in the Forward Modeling 423 source list to generate the surface displacement maps.

This task requires the setting of the XML Project File 447:

1. Open the Forward Modeling 423 panel;
2. Set the “XML Project File” to **Bam_project.xml**.

Note We remark that with in this release, any modeling processing must be carried out in a projected cartographic system; in the case of Bam, data are in the UTM-WGS84, Zone 40 North, projection.

To create the raster maps of the surface displacement:

1. Click on the “Add from XML…” button under the “INPUT SOURCE(S)” list;
2. Select the **Bam_project.xml** file;
3. From the “XML section” pull down menu, select “Linear Inversion – Output”;
4. Select in the source list the “Bam_fault [Fault patches(Okada)]” item and click “Commit”;
5. In the “Forward Model Output” pull down menu, select “Raster”;
6. Click on “Get from image…” and select the **Bam_envisat_dsc_disp** file;
7. Change, if necessary, the “Output File” name and the path automatically created;
8. Check on the “Set raster info…” button;
9. Change to 250 the “Cell size”;
10. Click on the “Cartographic System” button and set the following parameters:
    - “State”: UTM-GLOBAL
    - “Hemisphere”: NORTH
    - “Projection”: UTM
    - “Zone”: 40
    - “Ellipsoid”: WGS84
11. Click on “Commit” to close the “Set cartographic system” panel;
12. Click on “Commit” to close the “Raster Parameters”;
13. Click on “Start” and wait for the “END” message.

Unless you changed the output name, automatically generated, the processing will create the following files (Fig. 11):

- **Bam_envisat_dsc_disp_forward_east**: with the displacement East component;

- **Bam_envisat_dsc_disp_forward_north**: with the displacement North component;
- **Bam_envisat_dsc_disp_forward_up**: with the displacement Up component.

After Forward_Modeling 423, the **Bam_project.xml** file is automatically updated with the section “ModelingRoot”-“ForwardModeling”. You can navigate through the XML tags to inspect its content.

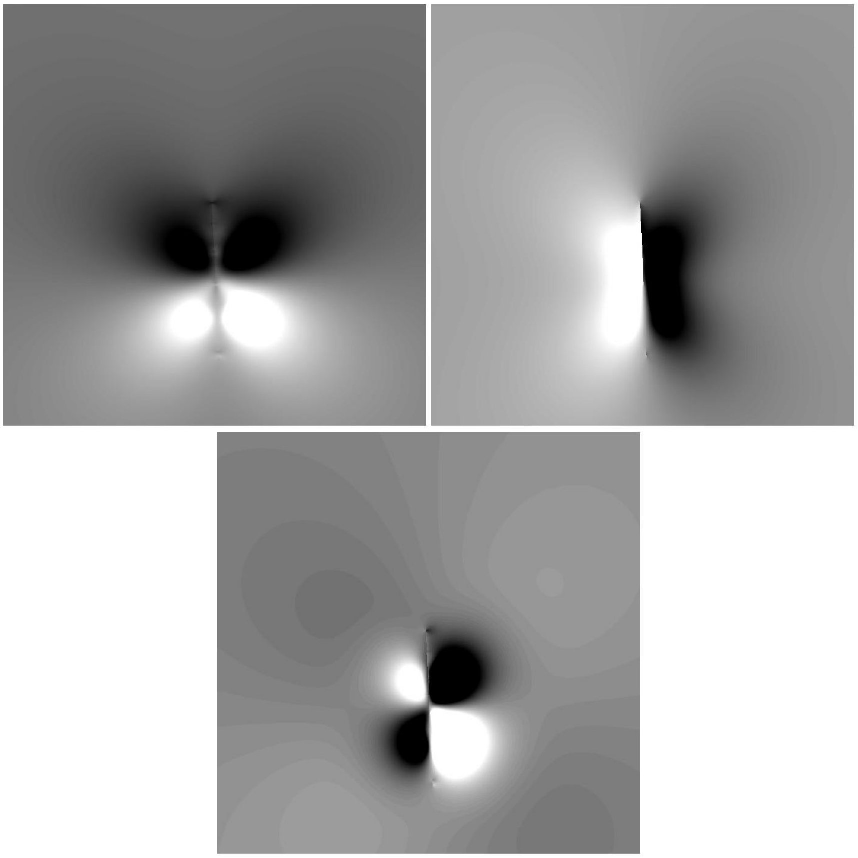


Figure 11. East, North and Up components of the displacement generated by the slip distribution retrieved via Linear Inversion.

Note The displacement measurement unit is always coherent with the input source: if the slip is provided in meters, the output displacement will be in meters.

10. Projection into the Line-Of-Sight

In the last step, the three maps resulting from Forward_Modeling 423 are combined together and projected into the direction of a specific Line-Of-Sight. This panel just needs the three raster maps and the ALOS (Azimuth Line-Of-Sight) and the ILOS (Incidence Line-Of-Sight) images.

Note The group of the East/North/Up displacement maps and the ALOS/ILOS pair have in general different extents and resolutions; extent and resolution of the output raster can be independently set according to any of the two groups.

Tip When several LOSs are available (perhaps Ascending and Descending) Forward_Modeling 423 can be done just once to create the East/North/Up displacement maps; then they can be projected into as many LOSs as available.

To run the LOS projection:

1. Open the Project raster to LOS 430 panel;
2. Set the following files:
   - "East component": **Bam_envisat_dsc_disp_forward_east**
   - "North component": **Bam_envisat_dsc_disp_forward_north**
   - "Up component": **Bam_envisat_dsc_disp_forward_up**
   - "Azimuth LOS image": **Bam_envisat_dsc_ALOS**
   - "Incidence LOS image": **Bam_envisat_dsc_ILOS**
3. Set the "Output image" to **Bam_envisat_dsc_disp_forward_los**;
4. Set the "Raster extent" to "Same as the ALOS/ILOS components";
5. Set the "Raster resolution" to "Same as the ALOS/ILOS components";
6. Click on the "Start" button and wait for the "END" message.

After that, you can compare the Forward Modeling results projected into the LOS with the original displacement map, as in Fig. 12.

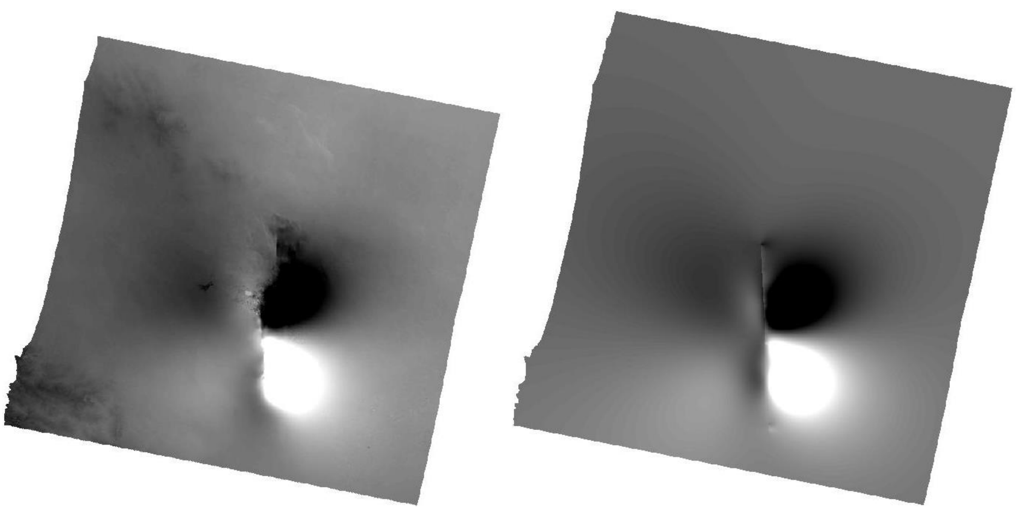


Figure 12. Comparison between the observed (left) and the modelled (right) displacement maps in the Line-Of-Sight

Note To make a fair comparison between the observed and modeled displacement maps, it must be taken into account that in the inversion an orbital surface could have been assessed.

In this case, we calculated in the Linear Inversion 417 an offset of 0.017 m (see Fig. 8); this value must be added to the modeled displacement of Fig. 12 (right) to obtain the complete modeled displacement.

11. References

Funning, G.J., B. Parsons, T.J. Wright, J.A. Jackson and Fielding, E. J. (2005), Surface displacements and source parameters of the 2003 Bam (Iran) earthquake from Envisat advanced synthetic aperture radar imagery, *J. Geophys. Res.*, 110, B09406, doi:10.1029/2004JB003338.

Wang, R., Xia, Y., Grosser, H., Wetzel, H.-U., Kaufmann, H. and Zschau, J. (2004), The 2003 Bam (SE Iran) earthquake: precise source parameters from satellite radar interferometr, *Geophy. J. Int.*, 159: 917–922. doi: 10.1111/j.1365-246X.2004.02476.x

1.6.3.14.3 Image Subsamping

Purpose

This tool is intended to sample a raster image to create a shapefile of points to be used as input to any inversion.

Technical Note

Though this panel can be used to simply create a shapefile of points with values sampled from a raster image, it is primarily intended to create an InSAR dataset 432 to be used in the Non-Linear Inversion 413, Linear Inversion 417 and Forward Modeling 423.

Since InSAR displacement maps typically contain millions of valid pixels, downsampling is often required to reduce the computational load and time required by the inversion. Two ways are provided to sample raster images:

- **Mesh from vector file** - It is used to get a mesh of points sampled on user-defined areas; for every area a different sampling interval can be specified. Sampling areas can be defined through an ESRI Shapefile (.shp) of polygons or an Envi Vector File (.evf). Every polygon identifies a sampling area; **an associated .dbf file with a "resolution" numeric field must be present, containing the sampling interval (in meters) of each area**. The absence of the field "resolution" issues an error message. If polygons with different sampling density overlap, the highest density is adopted for the overlapping area.
  In alternative, the vector file can be also of Point type (or PointZ, PointM, Multipoint, etc.); in this case, the image is sampled at the point position and the resolution is not required.
- **Quadtree** - This method, originally proposed by Jónnson et al. [2002] is based on an iterative algorithm to subdivide the input image into a number of smaller squares. The image dimension is initially increased to reach a number of rows and columns equal to 2^n . At the first iteration (1st level) it is subdivided into 4 parts; then, at every subdivision (2nd level, 3rd level, etc.), every square is subdivided into 4 parts. The algorithm keeps the image subdivision until a convergence is reached. Three parameters must be set:
  RMS tolerance - Threshold below which a square doesn't need further subdivision; the algorithm

stops when all the squares have an RMS value below this value; to increases the final number of elements, the "RMS tolerance" must be lower.

Maximum number of levels - The algorithm stops when the maximum level of subdivision is reached

Starting level - Number of starting subdivisions to be done *a priori*, i.e. without a check of the RMS values of the subdivisions; after that, the subdivision is carried out only for those squares with RMS above the tolerance set.

The Quadtree algorithm stops either when the RMS of each square gets below the "RMS Tolerance" or when the "Maximum number of levels" is reached.

The "Azimuth Line Of Sight" (_ALOS), "Incidence Line Of Sight" (_ILOS) and "Digital Elevation Model" files are mandatory to obtain a complete InSAR dataset432 shapefile to use for the inversion. ALOS and ILOS images are generated at the end of an interferometric processing. If the _ALOS and _ILOS images are supplied and the DEM is not, the InSAR dataset432 is generated with all the attributes, with the "Elevation" set to 0 for every point.

A complete tutorial involving this module can be found **here**393.

Input Parameters

Subsampling Image

Image to subsample; this file is mandatory.

Azimuth Line Of Sight image

_ALOS images file; this file is required to generate an InSAR dataset432 shapefile.

Incidence Line Of Sight image

_ILOS image file; this file is required to generate an InSAR dataset432 shapefile.

Digital Elevation Model

Name of the input DEM file; if missing, values are set to 0.

Mesh from vector file

Sampling Areas

Vector file with sampling areas (see Technical Note). This file is mandatory for the Mesh from vector file411 method.

Quadtree

RMS tolerance

RMS threshold below which a square is not further subdivided (see Technical Note).

Maximum number of levels
Maximum level of subdivision before the algorithm stops.

Starting Level
Number of *a priori* subdivision levels.

Output Files

Output shapefile
Shapefile of points created with the selected method to be used as input for the inversion.

General Functions

Start
Start of the processing.

Cancel
The window will be closed.

Help
Specific help document section.

References

Jónsson, S., Zebker, H.A., Segall, P. & Amelung, F., 2002. Fault slip distribution of the 1999 Mw7.2 HectorMine earthquake, California, estimated from satellite radar and GPS measurements, *Bull. seism. Soc. Am.*, **92,** 1377–1389.

1.6.3.14.4 Non-Linear Inversion

Purpose

This panel is intended to run the Non-Linear inversion of geodetic data.
See the Modeling Tutorial 1 393 for an example of its use.

Technical Note

The inversion processing is used to find the source parameters for the available models such to minimize

a Cost Function based on the difference between observed and predicted geodetic data, i.e. the "best fit" solution. In the Non-Linear inversion, all the source parameters can be inferred from geodetic data. A typical use of Non-Linear inversion is the retrieval of the fault parameters for an earthquake (source dimension, location, depth, mechanism, etc.) or to those related to a magma chamber activity (source position, depth, volume variation, etc.).
The Non-Linear inversion is based on the Levemberg-Marquardt [Marquardt, 1963] minimization algorithm, implemented with multiple restarts to reasonably guarantee the convergence of the Cost Function to the global minimum; further details on the inversion algorithm can be found in the cited reference.
For this inversion, all the model parameters can be set free to vary between a minimum and maximum values, defined by the user; when the minimum and maximum values are set equal, the parameter is considered fixed with that value. Only for earthquake modeling, if the event is contained in the Global CMT catalog, parameter ranges can be automatically set thorough the Initialize Values from CMT Catalogue 445 panel. The processing time is problem dependent: amount and quality of geodetic data, number of free parameters and width of allowed values can strongly increase the time required to find the best-fit solution. After the inversion, the Calculate and Draw Focal Mechanism 428 panel is automatically invoked to inspect the moment tensor, the focal mechanism and the geodetic moment of the solution.
There is no limit to the number and type of datasets and models involved in the inversion.

The **INPUT Dataset** folder allows to add the geodetic dataset(s) to invert; see the InSAR dataset 432 and GPS dataset 433 links to know how to get them in the proper format. After a dataset is added to the list, some parameters can be set through the "Set..." button. When the "**CHECK PARAMETERS**" string is appended to the dataset name, the setting of missing parameters is mandatory.

The **INPUT Sources** folder allows to create, recover and setup the sources used to model the geodetic data. Two sources are available: Elastic dislocation 434 source, used to model the surface displacement induced by a uniform dislocation for a rectangular source in an elastic and homogeneous half-space [Okada, 1985]; Point pressure 441 source, used to model the surface displacement induced by an expanding or compressing point-source [Mogi, 1958]. The "Edit..." button must be used to properly set the source(s).

The **Options** folder allows to set some extra processing parameter.

After the processing, **OUTPUT Datasets** and **OUTPUT Sources** folders are added to the panel, with information on the modeled data and sources.

In this panel the use of the XML Project File 447 **is mandatory**

INPUT Datasets

Add...
Add a geodetic (InSAR or GPS) dataset to invert.

Set...
Set the dataset properties with the Dataset Parameter Setting 444 panel.

Remove
Remove a dataset from the dataset list.

INPUT Sources

New...
Create and add a new source.

Add From XML...
Retrieve a source from an already existing XML Project File 447.

Edit...
Modify the source parameters.

Remove
Remove a source from the list.

Options

Number of tests for global minimum
Number of iterations ending with the same Cost Function value such that this value is considered as global minimum. Default value is 3.

Cost function Tolerance
Within the same iteration, the Cost Function is considered stable when two consecutive iterations are below this value. The default value is 0.0001.

Maximum Levemberg-Marquardt iterations
Maximum number of algorithm restarts; it is a convergence criterion used to terminate the inversion when geodetic data have poor quality and the global minimum of the Cost Function is blurred among local minima. The default value of 300 is a generic high number.

Calculate standard deviation and trade-offs
Not available in the current version.

Automatically create output shapefiles
If set, a shapefile for every modeled sources is saved to the disk.

OUTPUT Datasets

This folder is only visible after the inversion ends. It reports the *rms* between observed and modeled data

for every modeled dataset.
NOTE: to maintain a coherence between input and output, this folder is automatically removed whenever an input parameter is changed.

OUTPUT Sources

This folder is only visible after the inversion ends. It contains the best-fit sources.
NOTE: to maintain a coherence between input and output, this folder is automatically removed whenever an input parameter is changed.

Save to file
It allows to permanently save the modeled source as a shapefile.

View...
It allows to inspect the modeled source parameters.

XML Project File section

Set...
Set the XML Project File 447 for this panel.

Load XML
Load the XML Project File 447 content into the panel.

Update XML
Update the XML Project File 447 content from the panel.

Output Files

_nonlinear
Shapefile with the modeled displacement (.shp, .dbf, .shx).

[*source_name*]
Shapefile with the modeled source (.shp, .dbf, .shx). It is created only when the "Automatically create output shapefiles" flag is set.

General Functions

Start
Start of the processing.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Cancel

The window will be closed.

Help
Specific help document section.

References

Marquardt, D. (1963), An algorithm for least-squares estimation of nonlinear parameters, SIAM J. Appl. Math., 11, 431 – 441, doi:10.1137/
0111030.

Mogi, K. (1958), Relations between eruptions of various volcanoes and the deformation of the ground surface around them, Bull. Earth Res. Inst., 36, 99–134.

Okada, Y. (1985), Surface deformation due to shear and tensile faults in a half-space, Bull. Seismol. Soc. Am., 75, 1135–1154.

1.6.3.14.5 Linear Inversion

Purpose

This panel is intended to run the Linear inversion of geodetic data.
See the Modeling Tutorial 1 393 for an example of its use.

Technical Note

The inversion processing is used to find the source parameters that have a linear relation with the surface displacement; the "best-fit" solution is found with a least squares minimization between observed and modeled geodetic data. Non-linear parameters are assumed to be already known; if not, non-linear parameters can be retrieved via Non-Linear Inversion 413. A typical use of the linear inversion is the retrieval of the dislocation distribution over a subsurface discontinuity, as the slip occurred on a fault plane with an earthquake, or the crack opening induced by magma intrusion. After the inversion end, the Calculate and Draw Focal Mechanism 428 panel can be automatically invoked to see the inversion results, in the case of tectonic modeling. A priori damping conditions and positivity/negativity constraints, whether required by the specific problem, can be also set to improve the solution reliability.
There is no limit to the number and type of datasets and models involved in the inversion.

The **INPUT Dataset** folder allows to add the geodetic dataset(s) to invert; see the InSAR dataset 432 and GPS dataset 433 links to know how to get them in the proper format. After a dataset is added to the list, some parameters can be set through the "Set..." button. When the "**CHECK PARAMETERS**" string is appended to the dataset name, the setting of missing parameters is mandatory.

The **INPUT Sources** folder allows to create, recover and setup the sources used to model the geodetic data. Two sources are available: Elastic dislocation 434 source, used to model the surface displacement induced by a dislocation over a source in an elastic and homogeneous half-space [Okada, 1985]; Point pressure 441 source, used to model the surface displacement induced by an expanding or compressing point-source [Mogi, 1958]. The "Edit..." button must be used to properly set the source(s).

The **Options** folder allows to set some extra processing parameter.

After the processing, **OUTPUT Datasets** and **OUTPUT Sources** folders are added to the panel, with information on the modeled data and sources.

In this panel the use of the XML Project File 447 **is mandatory**

INPUT Datasets

Add...
Add a geodetic (InSAR or GPS) dataset to invert.

Set...
Set the dataset properties with the Dataset Parameter Setting 444 panel.

Remove
Remove a dataset from the dataset list.

INPUT Sources

New...
Create and add a new source.

Add from file...
Add a source from an existing shapefile.

Add From XML...
Retrieve a source from an already existing XML Project File 447.

Edit...
Modify the source parameters.

Remove
Remove a source from the list.

Options

Automatically create output shapefiles
If set, a shapefile for every modeled sources is saved to the disk.

OUTPUT Datasets

This folder is only visible after the inversion ends. It reports the *rms* between observed and modeled data for every modeled dataset.
NOTE: to maintain a coherence between input and output, this folder is automatically removed whenever an input parameter is changed.

OUTPUT Sources

This folder is only visible after the inversion ends. It contains the best-fit sources.
NOTE: to maintain a coherence between input and output, this folder is automatically removed whenever an input parameter is changed.

Save to file
It allows to permanently save the modeled source as a shapefile.

View...
It allows to inspect the modeled source parameters.

XML Project File section

Set...
Set the XML Project File 447 for this panel.

Load XML
Load the XML Project File 447 content into the panel.

Update XML
Update the XML Project File 447 content from the panel.

Output Files

_linear
Shapefile with the modeled displacement (.shp, .dbf, .shx).

[*source_name*]
Shapefile with the modeled source (.shp, .dbf, .shx).

General Functions

Start
Start of the processing.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Cancel
The window will be closed.

Help
Specific help document section.

References

Mogi, K. (1958), Relations between eruptions of various volcanoes and the deformation of the ground surface around them, Bull. Earth Res. Inst., 36, 99–134.

Okada, Y. (1985), Surface deformation due to shear and tensile faults in a half-space, Bull. Seismol. Soc. Am., 75, 1135–1154.

1.6.3.14.6 CFF Stress Transfer

Purpose

This panels is used to calculate the stress transfer between sources, on the base of the Coulomb Failure Function.
See the Modeling Tutorial 1 393 for an example of its use

Technical Note

This panel allows to calculate the stress variation induced by the deformation due to an arbitrary number of geophysical sources; it can be calculated for an arbitrary number of receiver sources. Input source(s) and Receiver source(s) can be a whatever combination of Elastic dislocation 434 and Point pressure 441 sources. The calculation is based on the Coulomb Failure Function [Harris, 1998] and it can be performed with the simple friction coefficient (Classical Formulation), or with the additional Skempton's coefficient (Undrained Formulation), that can vary from 0 (dry soil, equivalent to the Classical formulation) to 1 (fully saturated soil), according to:

$$\Delta CFF = \Delta\tau + \mu \cdot (\Delta\sigma - \beta \cdot T/3)$$

where $\Delta\tau$ is the shear stress variation, μ is the friction coefficient, $\Delta\sigma$ is the normal stress change, β is the Skempton's coefficient and T is the stress tensor trace. Input and receiver sources are retrieved and stored in the XML Project File 447.

The **INPUT Sources** folder allows to create, recover and setup the sources used as input for the stress calculation. Two sources are available: Elastic dislocation 434 source, used to model the surface displacement induced by a dislocation over a source in an elastic and homogeneous half-space [Okada, 1985]; Point pressure 441 source, used to model the surface displacement induced by an expanding or compressing point-source [Mogi, 1958]. The "Edit..." button must be used to properly set the source(s).

The **Receiver Sources** folder allows to create, recover and setup the sources on which the stress change is calculated.

The **CFF Options** folder allows to set the algorithm to use for the calculation: classic formulation or undreained formulation, with their parameters.

Note: in this panel the use of the XML Project File 447 is mandatory.

INPUT Sources

New...
Create and add a new source.

Add from file...
Add a source from an existing shapefile.

Add From XML...
Retrieve a source from an already existing XML Project File 447.

Edit...
Modify the source parameters.

Remove
Remove a source from the list.

Receiver Sources

New...
Create and add a new source.

Add from file...
Add a source from an existing shapefile.

Add From XML...
Retrieve a source from an already existing XML Project File 447.

Edit...
Modify the source parameters.

Remove

Remove a source from the list.

CFF Options

Classical Formulation

Apparent Friction Coefficient

Sliding friction coefficient (see Technical Note).

Undrained Formulation

Friction Coefficient

Sliding friction coefficient (see Technical Note).

Skempton's Coefficient

Skempton's Coefficient (see Technical Note).

Output all tensor components

By setting this flag, the output source will contain within its attributes all the tensor components

Automatically create output Shapefiles

Generate the output shapefile for every receiver source

XML Project File section

Set...

Set the XML Project File 447 for this panel.

Load XML

Load the XML Project File 447 content into the panel.

Update XML

Update the XML Project File 447 content from the panel.

General Functions

Start

Start of the processing.

Cancel

The window will be closed.

Help

Specific help document section.

References

Harris, R. A. (1998), Introduction to special section: Stress trigger, stress shadows, and implication for seismic hazard, J. Geophys. Res., 103(B10), 24,347–24,358, doi:10.1029/98JB01576.

1.6.3.14.7 Forward Modeling

Purpose

This panel can be used to generate the surface displacement, either geocoded or in slant range, produced by any combination of geophysical sources.
See the Modeling Tutorial 1 393 for an example of its use.

Technical Note

Forward, or direct, modeling is used to generate the surface displacement due to any combination of geophysical sources; the predicted displacement can be produced in a vector or raster format and, in the last case, in a geocoded or slant range geometry.

The **Forward Options** folder allows to set the type of output; for a raster format, the user must specify the extent and the resolution of the displacement maps; this can be done in different ways:

- **Set raster info...** It allows to specify the raster parameters and the cartographic system through an interface.
- **Get from image...** It allows the selection of a reference image (SARscape or ENVI format) to get its extent and resolution; when SARscape slant range image is provided, the output is generated in the same geometry, with line-of-sight displacement in radians. In this case a DEM must be also provided. In the case of geocoded output, the East, North and Up component of the displacement can be projected together into a Line-of-Sight with the Project Raster to LOS 430 panel.

In the case of output in **vector format**, a reference shapefile of points must be supplied and the forward calculation is performed on every point. It can be a generic shapefile of points, an InSAR dataset 432 or a GPS dataset 433, and the results are different according to the file supplied. See the InSAR dataset 432 and GPS dataset 433 help pages to see which fields are added to the shapefile after the processing.

The **INPUT Sources** folder allows to create, recover and setup the sources used to create the surface displacement map. Two sources are available: Elastic dislocation 434 source, used to model the surface displacement induced by a dislocation over a source in an elastic and homogeneous half-space [Okada, 1985]; Point pressure 441 source, used to model the surface displacement induced by an expanding or compressing point-source [Mogi, 1958]. The "Edit..." button must be used to properly set the source(s). Use the "Edit..." button when a source name has the "**CHECK PARAMETERS**" recommendation appended.

After the processing the **OUTPUT Sources** folder is added, with the CFF results and the possibility of saving them to disk as shapefile.

In this panel the use of the XML Project File 447 **is mandatory**

INPUT Sources

New...
Create and add a new source.

Add from file...
Add a source from an existing shapefile.

Add From XML...
Retrieve a source from an already existing XML Project File 447.

Edit...
Modify the source parameters.

Remove
Remove a source from the list.

Forward Options

Forward Model Output

Raster
Set the output in raster format.

DEM
A DEM file required only when a SARscape slant range file is set as reference raster

Set raster info...
Allow to set the output resolution, extent and Cartographic System 6.

Reference raster...
Allow to get the raster parameters from an existing image, either geocoded or slant range with a SARscape format.

Output Unit
The measurement unit of the output raster image: **m, cm, mm** for geocoded images; **Phase, Complex** for slant range images.

Output File
Name of the output file root. According to the output type, a different suffix is appended

Vector
Set the output in vector (shapefile of points) format.

Shapefile
Allow to select a shapefile of points (see the Technical Note 423).

Output Unit
The measurement unit of the output data: **m, cm, mm**

XML Project File section

Set...
Set the XML Project File 447 for this panel.

Load XML
Load the XML Project File 447 content into the panel.

Update XML
Update the XML Project File 447 content from the panel.

Output(s)

_forward_east
For geocoded raster output, the east component of the displacement (.shp, .dbf, .shx).

_forward_north
For geocoded raster output, the north component of the displacement (.shp, .dbf, .shx).

_forward_up
For geocoded raster output, the vertical component of the displacement (.shp, .dbf, .shx).

_forward
For vector output, the point vector shapefile with the modeled points stored as attributes (.shp, .dbf, .shx)

_sint
Line-of-sight, slant range raster file with Phase as output unit

_dint
Line-of-sight, slant range raster file with Complex as output unit

General Functions

Start
Start of the processing.

Store Batch

The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Cancel
The window will be closed.

Help
Specific help document section.

1.6.3.14.8 Modeling Tools

Section Content

1.6.3.14.8.1 Import USGS Slip Distribution

Purpose

It is intended to create a shapefile with the geometry and the slip distribution provided by USGS for the most important earthquakes.

Technical Note

The USGS earthquake website provides, soon after the major earthquakes, a distribution of the fault dislocation, based on the inversion of seismic waves. This panel allows to create an Elastic Dislocation 434 source from the USGS website. This slip distribution is available only for the significant earthquakes; when available for a given event, it can be found under the "Scientific & Technical Information" tab, following the "Finite Fault Model" and then the “SUBFAULT FORMAT” links, at the page bottom. In the panel, the "USGS source" field can contain either the webpage URL or the path of the text file, after the download.

Here below there are some examples:

1. **December 26, 2004, M 9.1 (Sumatra):**

- Event page
- Fault model

2. **February 27, 2010, M 8.8 (Chile):**
   - Event page
   - Fault model

3. **February 27, 2010, M 8.8 (Chile):**
   - Event page
   - Fault model

The Fault Patches model, stored in a shapefile, can be used in the Linear Inverion, Forward modeling 423 and CFF stress transfer 420 panels.

Note: as the modeling can be performed only with projected cartographic systems, the shape file with the USGS slip distribution is automatically created in the UTM - WGS84 projection, adopting the zone that best fits the involved area.

Parameters

USGS source
Webpage URL or text file with the USGS slip distribution.

Output shapefile
Shapefile containing the Elastic Dislocation 434 source, in UTM-WGS84 co-ordinates (.dbf, .shx, .prj).

General Functions

Start
Start of the processing.

Cancel
The window will be closed.

Help
Specific help document section.

1.6.3.14.8.2 Calculate and Draw Focal Mechanism

Purpose

This panel is used to calculate the moment tensor and draw the focal mechanism of a list of geophysical sources.
See the Modeling Tutorial 1 393 for an example of its use

Technical Note

This panel can be used to calculate the moment tensor of any source (Elastic Dislocation 434, Point Pressure 441), or source combination, and generate the related "beach ball" diagram, exportable as PDF file. This panel is automatically displayed after running a Non-Linear Inversion 413 or a Linear Inversion 417. The beach ball diagram can be created in three ways:

- by adding sources to the source list interface, then clicking on "Start" (the "Direct draw" option must be unchecked);
- by directly writing the Strike, Dip and Rake angles, then clicking on "Start" (the "Direct draw" option must be checked);
- by directly writing the tensor elements T_{xx}, T_{yy}, T_{zz}, T_{xy}, T_{xz} and T_{yz}, then clicking the "Focal Mech." button; X, Y and Z axes correspond to the East, North and Up directions, respectively;

Since the source list can contain sources of any type, the moment tensor is calculated accounting for all the shear and tensile components, as the opening of an Elastic Dislocation 434 or the volume change of a Point Pressure 441 source). To exclude from this calculation the tensile components, the "Use only shear components" option must be checked.
The "Seismic Moment" and the "Magnitude" are calculated only with the shear components, regardless whether the "Use only shear components" option is checked or not. When only tensile sources are present, the "Seismic Moment" and "Magnitude" values are set as not available. The same occurs when the moment tensor and the beach ball are calculated with the "Direct draw" option through the Strike, Dip and Rake angles.

The **INPUT Sources** folder allows to create, recover and setup the sources for which the tensor and the focal mechanism is calculated. Two sources are available: Elastic dislocation 434 source, used to model the surface displacement induced by a dislocation over a source in an elastic and homogeneous half-space [Okada, 1985]; Point pressure 441 source, used to model the surface displacement induced by an expanding or compressing point-source [Mogi, 1958]. The "Edit..." button must be used to properly set the source(s).

INPUT Sources

New...
Create and add a new source.

Add from file...

Add a source from an existing shapefile.

Add From XML...
Retrieve a source from an already existing XML Project File 447.

Edit...
Modify the source parameters.

Remove
Remove a source from the list.

Tensor and Focal Mechanism

Use only shear components
Exclude the volume change components from the moment tensor calculation (see the Technical Note)

Direct draw
Allow to enter the *Strike*, *Dip* and *Rake* angles to calculate the moment tensor and draw the beach ball

Tensor
Enter in the cells the tensor components T_{xx}, T_{yy}, T_{zz}, T_{xy}, T_{xz} and T_{yz} components.

Reset
Cancel the Moment Tensor components.

Focal Mechanism
Draw the beach ball diagram from the Tensor components.

Save to PDF...
Save the beach ball diagram to a PDF file.

General Functions

Start
Start of the processing.

Cancel
The window will be closed.

Help
Specific help document section.

1.6.3.14.8.3 Project Raster to LOS

Purpose

This panel is used to project the three displacement components (East, North and Vertical) into the Line-of-Sight.

Technical Note

After Forward Modeling[423], the three images with the East, North and Up components can be combined to calculate the displacement in the Line-of-Sight. This is carried out by supplying the _ALOS and _ILOS raster images produced with the interferometric processing[250]. Extent and resolution of the output raster can be set through pull down menus; two alternatives are provided: equal to that of the East/North/Up images or equal to that of the ALOS/ILOS images.

A complete tutorial involving this module can be found **here**[393].

Input Files

East component
Image with the East component of the displacement. This file is mandatory.

North component
Image with the North component of the displacement. This file is mandatory.

Up component
Image with the Up component of the displacement. This file is mandatory.

Azimuth LOS image
ALOS images from an interferometric processing[250].

Incidence LOS image
ILOS images from an interferometric processing[250].

Parameters - Principal Parameters

Raster extent
Extent of the output image.

Raster resolution

Resolution of the output image.

Output Files

Output image
Image with the displacement projected into the Line-of-Sight.

General Functions

Start
Start of the processing.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Cancel
The window will be closed.

Help
Specific help document section.

References

None.

1.6.3.14.9 Geodetic Datasets

Section Content

1.6.3.14.9.1 InSAR dataset

InSAR dataset

Within the modeling tools, we use the term **InSAR dataset** to indicate a dataset of points stored in a shapefile (of the type Point or PointZ), with the following attributes:

- **East** - A numeric field with the east UTM coordinates, in meters, of the InSAR point;
- **North** - A numeric field with the north UTM coordinates, in meters, of the InSAR point;
- **Elev** - A numeric field with the elevation above the sea level, in meters; though this field is mandatory, values can be set to 0 if not known;
- **Observed** - A numeric field with the displacement sampled from the raster image; it has the same measurement unit of the raster image;
- **Coef_east** - A numeric field with the East coefficient of the Line-Of-Sight;
- **Coef_north** - A numeric field with the North coefficient of the Line-Of-Sight;
- **Coef_up** -A numeric field with the Up coefficient of the Line-Of-Sight;
- **Sigma** - A numeric field with the standard deviation of the InSAR points, in meters.

An InSAR dataset can be obtained through the Image Subsampling 411 panel, by supplying the results of an interferometric processing 250, or can be manually created, adding all the required attributes. When a shapefile is formatted according to the above attributes, it is automatically recognized as "InSAR dataset" by the software. However, according to the performed tasks, other attributes can be present.

The cosine directors of the Line-Of-Sight can be used to combine the displacement in East, North and Up direction into the ground-satellite direction, through a linear combination:

$$Displ_{LOS} = Displ_{EAST} \times Coef\_east + Displ_{NORTH} \times Coef\_north + Displ_{UP} \times Coef\_up$$

where $Displ_{LOS}$, $Displ_{EAST}$, $Displ_{NORTH}$ and $Displ_{UP}$ are the displacement in the Line-Of-Sight, East, North and Up directions that can be obtained with Forward Modeling 423.

Further fields can be present in the InSAR dataset, according to the processing step.

After **Non-Linear Inversion** 413 and **Linear Inversion** 417:

- N x **[*source_name*]** - Displacement, or velocity, due to the source [*source_name*] in the source list set for the inversion; this field is replicated for every source in the source list;
- **Orbital** - Displacement, or velocity, due to the reference point (constant offset) and orbital components (linear or quadratic surface);
- **Modeled** - Overall modeled displacement, or velocity, in the LOS direction, due to all the contributions (sources and orbital surface);
- **Modeled_ea** - Displacement, or velocity, in the east direction;
- **Modeled_no** - Displacement, or velocity, in the north direction;
- **Modeled_up** - Displacement, or velocity, in the up direction;
- **Residual** - Difference between the Observed and the Modeled fields.

The measurement unit of the fields is coherent with the input data, i.e. is the same of **East_obs**, **North_obs**, etc...

Note that there is no limit to the number of sources set in the inversion; therefore an equal number of fields will be present in the output shapefile. On the contrary, only one field **Orbital** is present, since it refers to the specific InSAR dataset.

The original input shapefile is never changed: during the processing a copy with the suffix "*_nonlinear*", and "*_linear*", for the Non-Linear and Linear inversions respectively, is created with all the original shapefile fields and the new ones added.

After **Forward Modeling** 423:

- N x **[*source_name*]** - Displacement, or velocity, due to the source [*source_name*] in the Forward Modeling source list; this field is replicated for every source in the source list;
- **Residual** - Difference between the Observed and the Modeled fields;
- **Modeled** - Overall modeled displacement, or velocity, in the LOS direction, due to all the contributions (sources and orbital surface);
- **Forward_ea** - Displacement, or velocity, in the east direction;
- **Forward_no** - Displacement, or velocity, in the north direction;
- **Forward_up** - Displacement, or velocity, in the up direction;

The measurement unit of the displacement is coherent with the source model, i.e. is in meters (meters/year in the case of velocity).
The original input shapefile is never changed: during the processing a copy with the suffix "*_forward*" is created with all the original shapefile fields and the new ones added.
Note: Forward Modeling can also carried out over a generic shapefile of points; in this case only the **Modeled_ea**, **Modeled_no** and **Modeled_up** fields will be created.

1.6.3.14.9.2 GPS dataset

GPS dataset

The GPS dataset must be stored in a shapefile of the type Point (or PointZ) and the associated .dbf file must contain the following fields

- **East** - A numeric field with the east UTM coordinates, in meters, of the GPS point;
- **North** - A numeric field with the north UTM coordinates, in meters, of the GPS point;
- **Elev** - A numeric field with the elevation above the sea level, in meters; though this field is mandatory, values can be set to 0 if not known;
- **East_obs** - East component of the observed displacement, or velocity, in meters, centimeters or millimeters (/year, in the case of velocity);
- **Sigma_e** - Standard deviation of the measurement in East direction;
- **North_obs** - North component of the observed displacement, or velocity, in meters, centimeters or millimeters (/year, in the case of velocity);
- **Sigma_n** - Standard deviation of the measurement in North direction;
- **Up_obs** - Vertical component of the observed displacement, or velocity, in meters, centimeters or millimeters (/year, in the case of velocity);
- **Sigma_u** - Standard deviation of the measurement in Up direction;

The measurement unit for displacements (or velocity) and their standard deviations must be coherent among them, i.e. all in meters, or millimiters, etc.

Further fields are added to the GPS dataset, according to the performed processing:

After **Non-Linear Inversion** 413 and **Linear Inversion** 417:

- **Modeled_ea** - Displacement, or velocity, in the east direction.
- **Modeled_no** - Displacement, or velocity, in the north direction.

- **Modeled_up** - Displacement, or velocity, in the up direction.

The measurement unit of these fields is coherent with the input data, i.e. is the same of **East_obs**, **North_obs**, etc...
The original input shapefile is never changed: during the processing a copy with the suffix "*_nonlinear*", and "*_linear*", for the Non-Linear and Linear inversions respectively, is created with all the original shapefile fields and the new ones added.

After **Forward Modeling** 423:
- **Modeled_ea** - Displacement, or velocity, in the east direction.
- **Modeled_no** - Displacement, or velocity, in the north direction.
- **Modeled_up** - Displacement, or velocity, in the up direction.

The measurement unit of the displacement is coherent with the source model, i.e. is in meters (meters/year in the case of velocity).
The original input shapefile is never changed: during the processing a copy with the suffix "*_forward*" is created with all the original shapefile fields and the new ones added.

1.6.3.14.10 Geophysical Sources

Section Content

1.6.3.14.10.1 Elastic dislocation (Okada)

Purpose

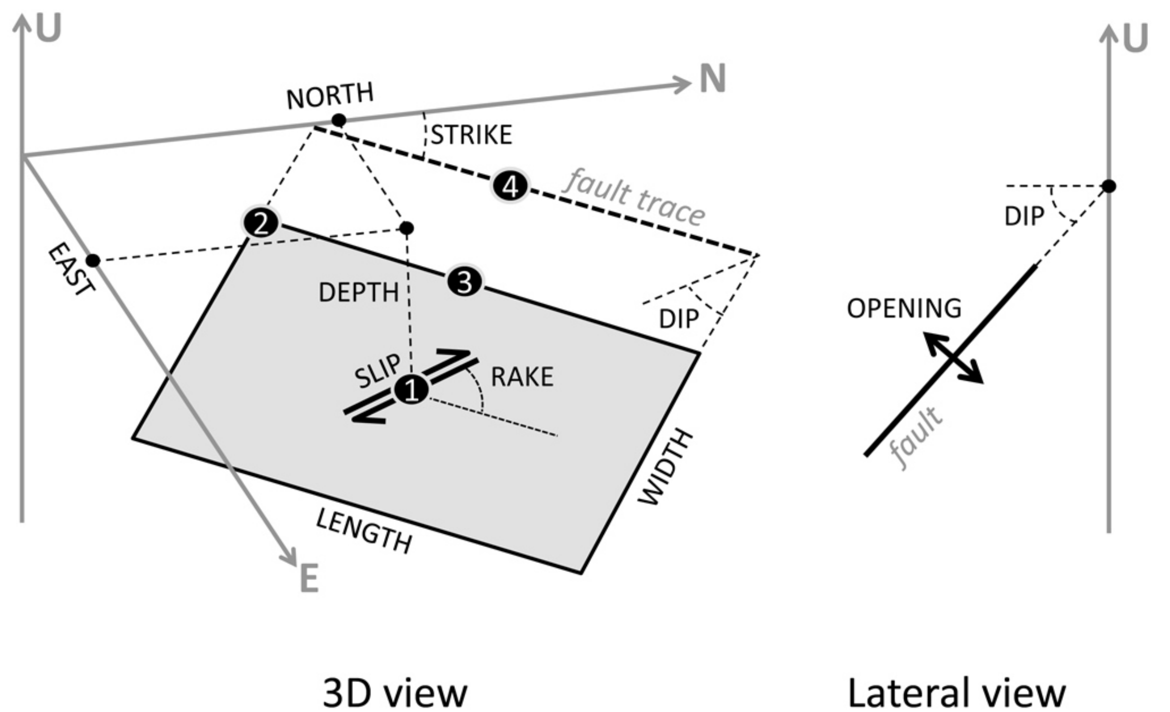
This panel is intended to set the parameters for the Elastic dislocation source, according to the formulation of Okada [1985].

Technical note

This analytical source is used to predict the surface displacement induced by a rectangular dislocation in homogeneous and elastic half-space [Okada 1985]. It is adopted in the modeling of earthquakes, sills, dike intrusions, etc. Model parameters required to describe its geometry and kinematic are shown in Fig. 1.
The Okada source is implemented in two forms:
- **single source with uniform slip/opening**, as shown in Fig. 1;
- **planar array of sources, with distributed slip/opening**, as shown in Fig. 2.
The distributed source is generally obtained by dividing a uniform slip sources into a number of elements (patches) along the strike and dip directions. Typically, within an inversion process, a Non-Linear Inversion 413 is used to obtain all the parameters of the uniform slip source; the resulting source is then

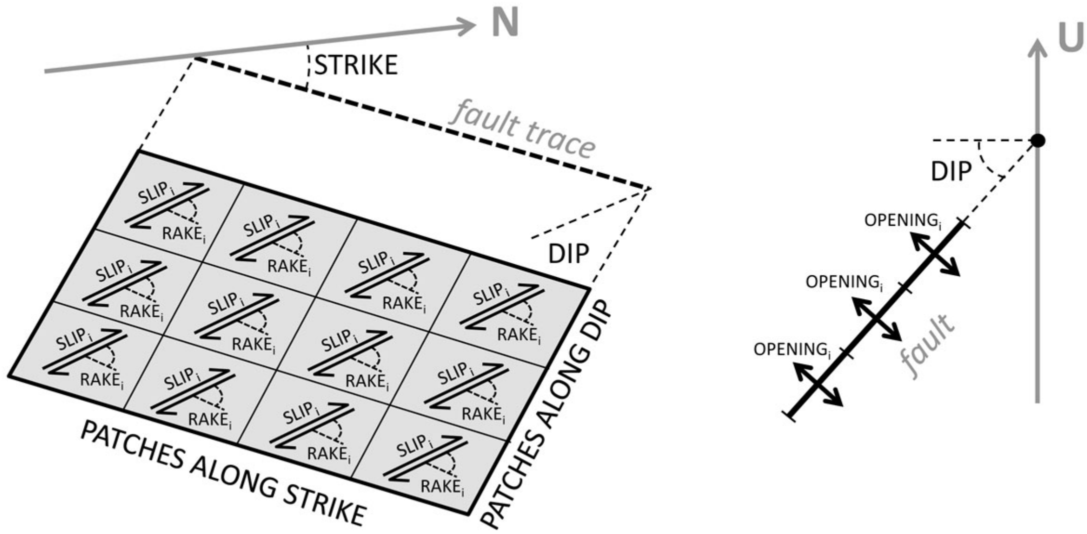
subdivided into elements, whose slip/opening values are retrieved by Linear Inversion 417. This allows to simulate a more realistic source model, as described in the Modeling Tutorial 1 393.

The source setup panel has a different appearance, according to the processing phase (Non-Linear Inversion 413, Linear Inversion 417, Forward Modeling 423, CFF Stress Transfer 420, Calculate and Draw Focal Mechanism) 428. Moreover, only for the Non-Linear Inversion 413, the user must not set a single value for parameters of Fig. 1, but a range (minimum/maximum) of allowed values to search for the best-fit solution.



Elastic dislocation source

Figure 1. Source parameters of the Elastic dislocation (Okada)

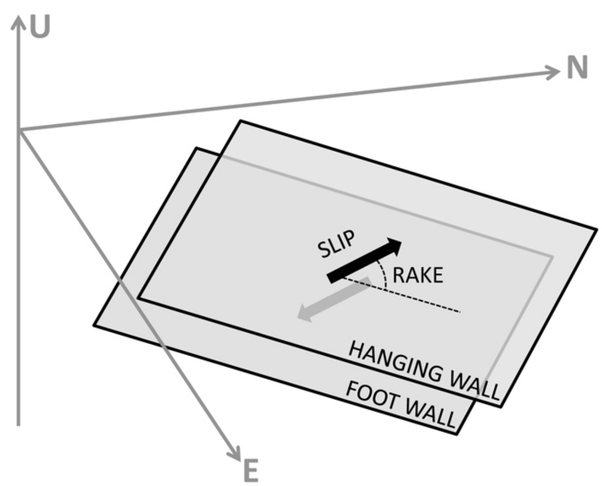


Distributed elastic dislocation source

Figure 2. Source parameters for a distributed Elastic Dislocation (Okada)

About the Strike, Dip angle convention. The Strike angle is counted clockwise from the North to the trace direction; of the two possible trace directions, it is considered the one such that the source is dipping at right, as in Fig.1. The Dip angle has values ranging from 0° (horizontal source) to 90° (vertical source) and values out of this range are considered wrong: sources dipping at left (dip > 90°) must be instead represented as dipping at right with the opposite strike direction. For example, a source with Strike 30° and Dip 100° must be represented with Strike 210° (30°+π) and Dip 80°.

About the Rake convention. The Rake describes the shear direction, considering the displacement of the overlaying surface relative to the underlying surface; in Tectonics, the hanging wall with respect to the footwall. The Rake angle varies from -180° to 180° and is calculated as shown Fig. 3. According to the seismological terminology, the earthquake mechanism is left-lateral for rake 0°, thrust or inverse for rake 90°, direct or normal for rake -90° and right lateral for rake 180° or -180°. Rake values are "wrapped": negative values or greater than 360 are converted to 0-360 (for example: 200° is equal to -160°).



Rake angle convention

Figure 3. Convention on the Rake angle

About the reference point. Four alternative ways are provided to describe the source position and depth (see Fig. 4):

1 - East and North coordinates of the source center, vertically projected on the surface; depth, in meter, is calculated between source upper edge and the surface (positive downward);

2 - East and North are referred to the source upper-left corner; depth is the same as 1;

3 - East and North are referred to the center of the source upper edge; depth is the same as 1;

4 - East and North are referred to the source (fault) trace center; depth is the upper edge distance from the trace. This notation can not be used when Dip = 0.

Though these alternatives are absolutely equivalent, sometimes it is more convenient to adopt one in particular. For example, some earthquakes are generated by a fault with a known trace, either from literature or because the rupture reached the surface; in this situation, the notation 4 is particularly convenient, because dip and depth are independent.

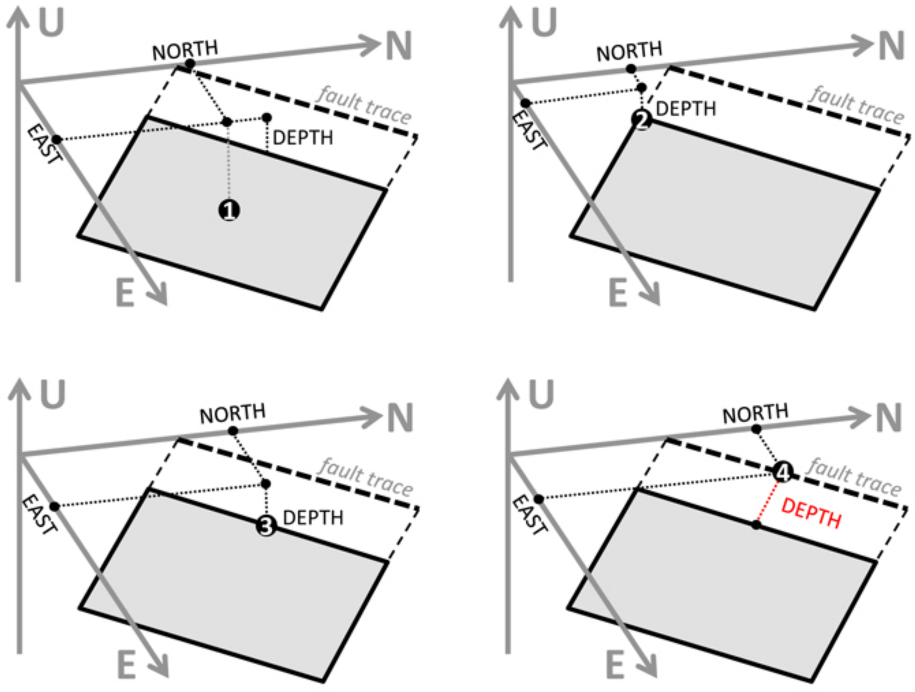


Figure 4. Reference point used to define the source position and depth

About topographic corrections. Analytical equations provide the displacement at the surface of the elastic half-space, considered as zero-level. For areas with strong topography, the depth from the flat half-space can significantly differs from that of the real surface. A strategy adopted to account for this difference is to sum the source depth and the point elevation above the zero level in the displacement calculation (Fig. 5). This can be done when the topographic elevation is available for the modeling dataset (see the Image Subsampling 411 tool) by setting the "Compensate for Topography" flag.

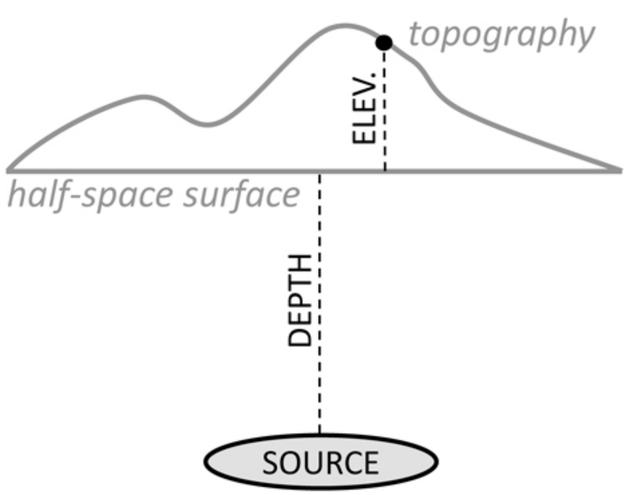


Figure 5. Source depth and point elevation composition in modeling

Input Parameter(s)

Length
Source length, in meters.

Width
Source width, in meters.

Depth
Source depth, positive downward, in meters; read the Technical Note 434 to see how it is calculated according to the Reference Point (Fig. 4) .

Dip
Angle between the source and the surface, in degrees (see the Technical Note 437 and Fig. 1).

Strike
Angle between the source trace and the North, in degrees (see the Technical Note 437 and Fig. 1).

East, North
Coordinates of the source reference point (see the Technical Note 437 and Fig. 4). UTM-WGS84 coordinates are strongly suggested.

Rake:
Dislocation angle, in degrees (see the Technical Note 437 and Fig. 3).

Slip:
shear dislocation over the plane, in meters.

Opening:
Tensile dislocation perpendicular to the source, in meters, describing a source opening or closure.

Patches along strike
Number of subdivisions along strike.

Patches along dip
Number of subdivisions along dip.

Invert for

> **Variable slip- fixed rake**
> Only the slip values, with a fixed direction, are retrieved by inversion.
>
> **Variable slip - Variable rake**
> Slip values and rake directions are both retrieved by inversion.
>
> **Variable Opening/Closure**
> Only the opening (or closure) values are retrieved by inversion.
>
> **Fixed source - No inversion**
> The source is completely known (no parameters are retrieved by inversion), but it must be accounted for in the modeled data.

Inversion algorithm

Only for Linear Inversion, it can be:

Uncostrained least square
positive and negative values are allowed

Non-negative least square
only positive values are allowed

Non-Positive least square
only negative values are allowed

Damping value
Intensity of the smoothing for slip or opening distributions.

Seismic moment
Value of the source seismic moment (not used in the inversion)

'mu' and 'lambda' Lame's constant
Lame's constant of the elastic medium, in Pascal (see Preferences 795).

Reference Point
Point used to define the source position (see the Technical Note 437 and Fig. 4):

1. Fault center - Vertical top edge
2. Upper left corner - Vertical top edge
3. Top edge center - Vertical top edge
4. Fault trace center - Along dip top edge

Compensate for topography
The processing is carried out accounting for the local topography (see the Technical Note 438 and Fig. 5).

Specific Function(s)

Draw Source in ENVI 5.x
Draw the source in the ENVI 5.x view.

Initialize from CMT solution
Open the panel to Initialize from CMT solution 445 the source parameters.

General Functions

Commit
End the source parameter editing.

Cancel
The window will be closed.

Help
Specific help document section.

References

Okada, Y. (1985), Surface deformation due to shear and tensile faults in a half-space, Bull. Seismol. Soc. Am., 75, 1135–1154.

1.6.3.14.10.2 Point pressure (Mogi)

Purpose

This panel is intended to set the parameters for the elastic Point Pressure source, according to the formulation of Mogi [1958]

Technical Note

The Point Pressure source is a simple model used to predict the surface displacement induced by the pressure variation in a point buried in an elastic half-space. Despite its simplicity, it is largely used to model the deformations induced by the magma chamber activity or those caused by fluid or gas injection or extraction. The point-source approximation can be reasonable, provided that the real source dimension is enough smaller than its depth (Fig. 1).

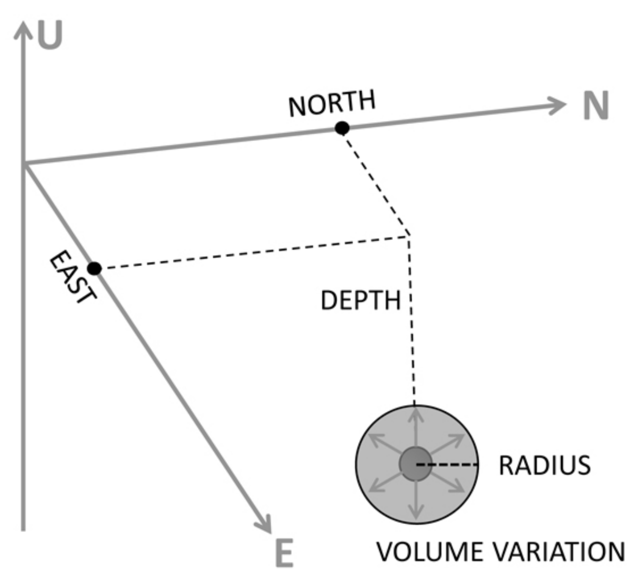


Figure 1. Mogi source

Given the relationship between the pressure change and the volume change, we adopt the volume notation which is more intuitive and coherent with the Elastic dislocation 434 source. As for the other

sources, the Point Pressure parameters to set differ according to the specific processing: Non-Linear Inversion 413, Linear Inversion 417, Forward Modeling 423, CFF Stress Transfer 420 or Calculate and Draw Focal Mechanism 428.
Unlike the other panels, in the Non-Linear Inversion 413 the user must set a range value (minimum/ maximum) for the source parameters shown in Fig. 1. When the maximum and minimum value are equal, that parameter is considered fixed and not inverted.

About topographic corrections. The analytical model allows to calculate the displacement at the surface of the elastic half-space. This condition is acceptable when the source depth is considerably higher than the elevation above the sea level of a point where the displacement is calculated. However, it could happen that the topography for a given area is comparable with the source depth; in this case the point vertical distance from the source is significantly higher than the source depth. The strategy adopted to account for this elevation is to sum the source depth and the point elevation when calculating the point displacement (Fig. 2) [Lungarini et al., 2005]. When creating the InSAR dataset through the Image Subsampling tool, it is possible to add the elevation for every point to allow the use of the "Apply Topographic Corrections" option.

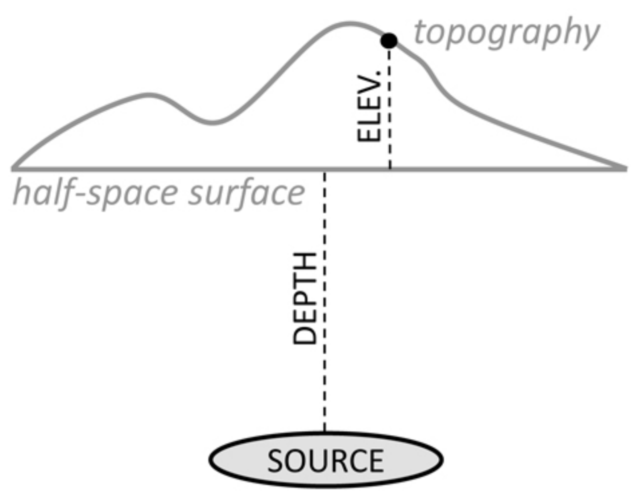


Figure 2. Source depth and point elevation composition in modeling

Input Parameter(s)

Volume variation
Source volume variation, expressed in meters^3.

Depth
Source depth, positive downward, in meters.

East, North
coordinates of the point source, in a projected cartographic system (UTM-WGS84 is suggested)

Inversion Type
Variable Volume

The volume variation is is retrieved by inversion
Fixed Source
No parameters are retrieved by inversion, and the source contribution to the displacement is considered as it is (it can be used only if other sources to invert are present).

'mu' Lame's constant, **'lambda' Lame's constant**
Lame's constant of the elastic medium (see Preferences 795).

Apply topographic corrections
Setting the flag, the processing is carried out with topographic corrections (see the Technical Note 442 and Fig. 2).

Specific Function(s)

Draw Source in ENVI 5.x
Draw the source in the ENVI 5.x view.

General Functions

Commit
End the source parameter editing.

Cancel
The window will be closed.

Help
Specific help document section.

References

Lungarini, L., Troise, C., Meo, M. and G. De Natale (2005) Finite element modelling of topographic effects on elastic ground deformation at Mt. Etna, J. Volc. Geo. Res., 144,, 257-271, doi: 10.1016/j.jvolgeores.2004.11.031

Mogi, K. (1958), Relations between eruptions of various volcanoes and the deformation of the ground surface around them, Bull. Earth Res. Inst., 36, 99–134.

1.6.3.14.11 Common Tools

Section Content

1.6.3.14.11.1 Dataset Parameter Setting

Purpose

This panel is intended to set the ancillary parameter of a geodetic dataset before the inversion.

Technical Note

Through this panel it is possible to set few parameters that are required for the Non-Linear Inversion 413 and the Linear Inversion 417. The panel appearance is different according to the geodetic dataset being edited. For a GPS dataset 433 only the weight to be applied in the inversion and the measurement unit must be set. For an InSAR dataset 432, in addiction, it must be specified also the SAR sensor name and the parameters that allow the inversion algorithms to assess also a surface due to the orbit inaccuracy. Further parameters can be set to characterize the spatial correlation properties of the dataset. The autocorrelation function is described in the Preferences 792 panel for modeling.

About the weighting factor. The dataset weight is important only when more than one dataset is being inverted; in this case, the absolute value of the weight is not important, but only the ratio between them. If two datasets are inverted and the second is more reliable, setting 0.5 for the first and 1 for the second is the same of setting 1 and 2, respectively. This value can be useful when many dataset are available and the user wants to test the effects of excluding one of them; instead of removing it, its weight can be set to 0.

Input Parameter(s)

Weigth
Weight of the dataset in the inversion (see the Technical Note 444).

Measure unit
Measurement unit of the displacement data.

Sensor name (only for InSAR datasets)
Sensor (satellite) that acquired the SAR images used in the interferometric processing.

Orbital surface (only for InSAR dataset)

Set offset range
Allow to specify a range of allowed values for the data offset.

Calculate polynomial surface

Allow to set the degree of the polynomial surface to be assessed in the inversion.

Uncertainty Parameters (only for InSAR dataset)

Data variance
Data variance of the InSAR dataset, in square meters.

Data covariance at zero distance
Data covariance calculated at zero distance, in square meters.

Decreasing factor
Parameter describing the spatial decay of the InSAR data correlation.

General Functions

Commit
End the dataset editing.

Cancel
The window will be closed.

Help
Specific help document section.

Specific Function(s)

Get From Defaults
Retrieve the uncertainty parameter values from the Preferences 792.

References

None.

1.6.3.14.11.2 Initialize Values from CMT Catalogue

Purpose

This panel is intended to initialize a source from the Global CMT Catalog.

Technical Note

Since the number of parameters to set for the inversion or other procedures involving the geophysical sources is generally high, this panel allows to initialize them on the base of the event parameters coming from the Global Centroid Moment Tensor Catalog. To exploit this functionality it is just necessary to know the CMT code related to an event; this code can be found through the search page of the Global CMT Catalog; when the code is inserted into the "Insert the CMT identifier" field, the software retrieves all the event information and populate the source parameter with the proposed values. Proposed values are directly taken from the event parameters or derived according to the Wells and Coppersmith [1994] relationships.
When this panel is invoked from the setting of a source in the Non-Linear Inversion, the upper and lower limits of the allowed values for every parameter is also proposed, according to the parameter standard deviation derived with the Wells and Coppersmith rules.
We remark that these parameters are based on statistical laws, therefore they can differ from the real ones or those actually found by inversion.

The following are examples of CMT indentifiers:
200904060132A - Mw 6.3 L'Aquila, central Italy, earthquake (06/04/2009).
201103110546A - Mw 9.1 Great Japan earthquake (11/03/2011).
201102212351A - Mw 6.1 Christchurch, New Zealand, earthquake (21/02/2011).

Since the CMT catalogue provides the double solution corresponding to the alternative focal planes, the user must known which one is the real and which is the auxiliary one. This choice, only affecting the Strike, Dip and Rake angles (see the Elastic Dislocation 434), can be done through a pull-down menu. Once the "Commit" button is pressed, the Elastic Dislocation panel is filled with the CMT-derived parameters.

A complete tutorial involving this module can be found **here** 393.

Input Parameter(s)

CMT identifier
Event code retrieved from the CMT catalog (see the Technical Note).

General Functions

Commit
Set the parameters in the Elastic Dislocation panel.

Cancel
The window will be closed.

Help

Specific help document section.

Specific Function(s)

Focal Plane
Allow to select between the two possible focal planes.

References

None.

1.6.3.14.11.3 XML Modeling Project file

Purpose

Aim of the XML Project file is to store all the information about input/output data and source and the processing options.

The XML Project File

The XML Project File is an ASCII file in XML format used to store the input configuration and output results of Non-Linear Inversion 413, Linear Inversion, Forward Modeling and CFF calculation.
In the XML project file, everything can be saved to and restored from in order to easily retrieve the starting configuration, rerun procedures or inspect the results. By concentrating all the information in a single file, the XML project is intended to minimize the risk of errors when repeating a processing, as well to easily share the results or the starting parameters with other users.
Only geodetic data, which are usually formed by thousands of points, are not stored in the XML file, which only contains the full path name: when restoring a modeling session from the XML project file, a warning message is issued if the file has been moved.
The XML file is arranged as a tree, starting from a general root tag, subdivided into four brunches corresponding to the abovementioned procedures (Figure 1).

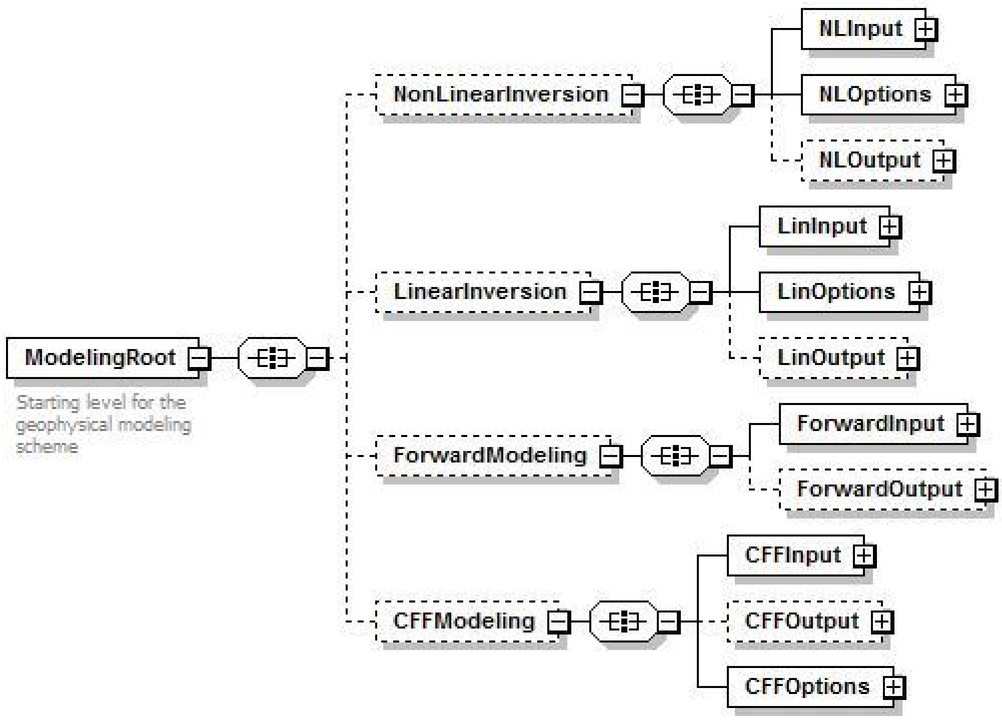


Figure 1 – First two levels of the XML project file

The XML Modeling Project file should not be manually modified, therefore its structure is not documented. A manual editing would result in unpredictable errors and/or wrong results. However, since expert users might find the text editing faster than using of graphic interfaces, tags in the XML file have been created with self-explaining names. In this case, the use of an XML editor to preserve the syntax integrity is strongly suggested.
The four main sections of the XML Project File support the Non-Linear Inversion 413, Linear Inversion 417, Forward Modeling 423 and CFF Stress Transfer 420 panels. Setting the XML Project File for these panels is mandatory. A section is created only when the "Update XML" button is pressed in the related panel; after that, any further update overwrites the section content. To maintain a coherence between the input and the output of an inversion, either non-linear or linear, when a new input configuration is updated in the XML Project File, the already existing output section is canceled, even if the processing is not run.

About the source retrieval. A further use of the XML Project File is in the possibility of inspecting its content in order to retrieve any of the sources that are stored in the existing sections. This can be done from every interface for the source handling with the "Add from XML..." button. This allow to inspect the content of every XML Project File, not necessarily the one set for that specific processing, through a simple interface, where the user can select one of the following sections:

- **Non-Linear Inversion - Output**, containing all the sources generated after the Non-Linear Inversion 413;
- **Linear Inversion - Input**, containing all the sources set as input for the Linear Inversion 417;
- **Linear Inversion - Output**, containing all the sources generated after the Linear Inversion 417;
- **Forward Modeling**, containing all the sources set to run the Forward Modeling 423;
- **CFF Calculation - Input**, containing all the sources set as input for the CFF Stress Transfer 420;

- **CFF Calculation - Output**, containing all the sources set as receiver in the CFF Stress Transfer 420;
- **All Sections**, that allow to see all the sources contained in the whole XML Project File.

Since the parameters to set depend on the specific processing, sources retrieved from the XML Project File might require a further editing; this is indicated with the "***CHECK PARAMETERS***" recommendation.

Specific Function(s)

XML section

Select the XML Project File section to see the sources therein (see the Technical Note 448).

General Functions

Commit

Add the selected source(s) to the processing panel.

Cancel

The window will be closed.

Help

Specific help document section

1.6.3.15 Interferometric Tools

Purpose

This chapter provides information relevant to the interferometric tools, which are suitable for the processing of products generated in the following SARscape modules:

- Interferometry.
- ScanSAR Interferometry.
- PolInSAR.

Section Content

1.6.3.15.1 Frequently Asked Questions

Q. - When it makes sense to use the **Sample Selection** tool?

A. - It is typically used when you have a temporal series (two images or more acquired with same viewing geometry) and you are interested only on a small portion of the full frame; it is then possible to define the area of interest in one scene/acquisition (this must be the first in the input list) and get the other images of the series automatically cut on the same area. The process of estimating the relative shift of each input image, with respect to the first of the list, is exactly the same used for the Coregistration 121; the only difference being that here only the shift parameters are estimated and the images are not resampled/coregistered.

This tool is usually adopted for preparing a sample data set to input into a DInSAR, Persistent Scatterers or SBAS processing; nevertheless it is also useful to prepare a temporal series which have to be processed in the Basic module for amplitude related application.

Q. - What is the method adopted for the **Phase Editing** and when should I perform this step?

A. - First of all it must be outlined that the phase editing can be performed only under the "ENVI Classic" interface. It is based on the following procedure:

1. The original unwrapped phase (_upha) is copied and the editing is executed on the duplicated file (in order to always keep the original product).
2. The "phase jumps" are identified visually as well as checking the pixel value variation (i.e. phase variation in radians) using "ENVI View Tools" such as the "Profiles>Arbitrary Profile(Transect)" or the "Cursor Location/Value".
3. Each "phase island" is contoured with an ENVI vector file (.evf).
4. A Manual or semi-automatic estimate of the number of 2π cycles, which have to be added (or subtracted) to each "phase island", is computed.
5. The phase correction is performed.

It is recommended not to perform the contouring and correction of more "phase islands" at the same time.

The term "phase jumps" indicates discontinuities in the unwrapped phase.These can be due to unwrapping error, which are typically induced by low coherence. However it must be noted that there can be "phase jumps", due for instance to steep topography, which have not to be corrected.

The term "phase island" indicates an area which is bordered by a "phase jump". Due to this the island is higher (or lower) of a certain number of 2π cycles with respect to the surrounding area.

It must be noted that an attempt of reducing (or completely avoid) the presence of "phase jumps" in the unwrapped phase can be done by:
- Change the unwrapping coherence threshold 305 (usually reducing it).
- Use a different unwrapping method 305.

1.6.3.15.2 Baseline Estimation

Purpose

This functionality enables to obtain information about the baseline values and other orbital parameters related to the input pair. The extracted parameters have to be intended as approximate measurements aimed at a preliminary data characterisation and interferometric quality assessment. The baseline value itself is not used in any part of the Interferometric processing chain.

An IDL graph, which shows the theoretical relationship between the coherence value and the height measurement standard deviation, pops up at process completion (the graph is not shown if the process is executed in batch mode).

Technical Note

The generation of an interferogram is only possible when the ground reflectivity acquired with at least two antennae overlap. When the perpendicular component of the baseline (B_n) increases beyond a limit known as the critical baseline, no phase information is preserved, coherence is lost, and interferometry is not possible. The critical normal baseline $B_{n,cr}$, can be calculated as:

$$B_{n,cr} = \frac{\lambda R \tan(\theta)}{2 R_r}$$

where λ is the wavelength, R is the range distance, R_r is the pixel spacing in range, and θ is the incidence angle. Note that the critical baseline can be significantly reduced by the topography.

The sensibility to detect height variations is inversely proportional to the "2π ambiguity height": the bigger the ambiguity height the worse the capability to detect small elevation changes. The 2π ambiguity height *AH* can be calculated as:

$$AH = \frac{\lambda R \sin(\theta)}{4\pi B_n}$$

The sensibility to detect displacements depends on the observation wavelength with the following relationship:

$$AD = \frac{\lambda}{2}$$

In case of Single Look Complex inputs, the output files are multi-looked with the default 779 azimuth and range multi-looking factors.

Input Files

Input Master file
File name of the master data (_pwr for ScanSAR products; _slc or _pwr for all the others). This file is mandatory.

Input Slave file
File name of the slave data (_pwr for ScanSAR products; _slc or _pwr for all the others). This file is mandatory.

Parameters - Principal parameters

None.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

The following information is provided in a pop-up screen:

- **Normal baseline**	Perpendicular baseline (m) between master and slave orbit.
- **Critical baseline**	Maximum theoretical baseline (m) suitable for interferometric processing.
- **2π ambiguity height**	Height difference corresponding to an interferometric fringe (2π cycle). The larger is this figure the coarser is the capability to detect small height changes.
- **2π ambiguity displacement**	Displacement corresponding to an interferometric fringe (2π cycle). The larger is this figure the coarser is the capability to detect small displacements.
- **Range shift**	Shift (pixel), which will be applied in range direction during the master-slave coarse coregistration.
- **Azimuth shift**	Shift (pixel), which will be applied in azimuth direction during the master-slave coarse coregistration.
- **Doppler centroid difference**	Difference (Hz) between master and slave Doppler centroids. In case the Doppler centroid difference is higher than the Pulse Repetition Frequency (value marked as "critical"), than the SAR pair is not suitable for interferometric processing.

Estimated Baseline file

Filename of the optional output file. This file includes the multilooked baseline and height of the ambiguity values for each pixel. This file is optional.

Root Name

Normal estimated baseline and associated header files (.sml, .hdr).

_dop_diff

Doppler Centroid difference and associated header files (.sml, .hdr).

_eb

Normal baseline values and associated header files (.sml, .hdr).

_H

Horizontal component of the normal baseline values and associated header files (.sml, .hdr). It is related to the across-track orbital errors.

_V

Vertical component of the normal baseline values and associated header files (.sml, .hdr). It is related to the radial component of the state vectors.

_R

Slant range distance and associated header files (.sml, .hdr).

_amb

Estimated ambiguity height and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

F. Holecz, P. Pasquali, J. Moreira, E. Meier, D. Nüesch: "Automatic Generation and Quality Assessment of Digital Surface Models generated from AeS-1 InSAR data". Proceedings of European Conference on Synthetic Aperture Radar, Friedrichshafen, Gemany, May 1998.

D. Small, P. Pasquali, S. Fuglistaler: "A Comparison of Phase to Height Conversion Methods for SAR Interferometry".

Wolfgang Goblirsch, P. Pasquali: "Algorithms for Calculation of Digital Surface Models from the Unwrapped Interferometric Phase". Proceedings of International Geoscience and Remote Sensing Symposium (IGARSS'96). Lincoln, Nebraskq USA. May 27-31.1996.

1.6.3.15.3 Multi Baseline Calculation

Purpose

This functionality enables to obtain information about both the baseline values and the doppler centroid difference and the acquisition time distance in a multi-temporal SAR acquisitions series. The values for all possible interferometric pair combinations are calculated.

The extracted values have to be intended as approximate measurements aimed at a preliminary data characterisation and interferometric quality assessment. The baseline value itself is not used in any part of the Interferometric processing chain.

Technical Note

The generation of an interferogram is only possible when the ground reflectivity acquired with at least two antennae overlap. When the perpendicular component of the baseline (B_n) increases beyond a limit known as the critical baseline, no phase information is preserved, coherence is lost, and interferometry is not possible. The critical normal baseline $B_{n,cr}$, can be calculated as:

$$B_{n,cr} = \frac{\lambda R \tan(\theta)}{2 R_r}$$

where λ is the wavelength, R is the range distance, R_r is the pixel spacing in range, and θ is the incidence angle. Note that the critical baseline can be significantly reduced by the topography.

Input Files

Input File List
List of data files (_pwr for ScanSAR products; _slc or _pwr for all the others). This file list is mandatory.

Output Files

Output Root Name
Name of the output root. This file is mandatory.

The normal baseline values, as well as the acquisition time distance (in days) and the doppler centroid difference, are provided on a pop-up screen.

.xls, .txt
The information provided on screen are stored in two different formats.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser[802] button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

F. Holecz, P. Pasquali, J. Moreira, E. Meier, D. Nüesch: "Automatic Generation and Quality Assessment of Digital Surface Models generated from AeS-1 InSAR data". Proceedings of European Conference on Synthetic Aperture Radar, Friedrichshafen, Gemany, May 1998.

D. Small, P. Pasquali, S. Fuglistaler: "A Comparison of Phase to Height Conversion Methods for SAR Interferometry".

Wolfgang Goblirsch, P. Pasquali: "Algorithms for Calculation of Digital Surface Models from the Unwrapped Interferometric Phase". Proceedings of International Geoscience and Remote Sensing Symposium (IGARSS'96). Lincoln, Nebraskq USA. May 27-31.1996.

1.6.3.15.4 Atmospheric Phase Delay Correction

Purpose

Water vapour data contained in ENVISAT MERIS, OSCAR (Online Services for Correcting Atmosphere in Radar, © Jet Propulsion Laboratory, California Institute of Technology. http://oscar.jpl.nasa.gov/) or ECMWF (© European Centre for Medium-Range Weather Forecasts. http://www.ecmwf.int/) data are used to correct atmospheric disturbances in interferometric pairs. MERIS standard products must be previously imported[48] and work only with ENVISAT ASAR products. It is important to point out that the MERIS master and slave data must have been acquired simultaneously to the ASAR corresponding acquisitions. In the OSCAR and ECMWF case, the parameter files must be downloaded from the internet, it is compulsory to provide an internet connection.

Technical Note

The layers of master and slave data, containing the water vapor related parameters, are used to compute the phase delay of the corresponding acquisitions. The calculated phase delay difference is subtracted to the input flattened (and possibly filtered) interferogram.

It must be noted that cloud covered data should not be used for this purpose. Isolated cloudy pixels are masked out by means of an available mask provided with the input data, in the MERIS case the mask is generated starting from the input layers of "Cloud Mask", "Reflectance" and "Pressure" (all provided with the original standard product).

- **Data Interpolation** is intended to assign a specific value to the dummy/masked (NaN) pixels, which typically correspond to the clouds. The "Relax Interpolation" model is represented by a soft surface, which is adapted to the dummy surrounding area. The algorithm, which is based on the solution of the heat transfer equation (Poisson equation), uses known water vapor values to reconstruct at the best the masked areas. It must be noted that isolated dummy pixels are better interpolated using an "Interpolation Window", which can be associated with the "Relax Interpolation".

- **Mean Filter** is used in order to smooth small atmospheric changes (e.g. isolated clouds).

Input Files

Interferogram file
File name of the previously generated interferogram (_dint or _fint). This file is mandatory.

Slant Range Digital Elevation Model file
Name of the Digital Elevation Model in slant range geometry (_srdem). This file is mandatory.

Optional Files

Optional Master MERIS File
File name of the master MERIS data (_list.txt). This file is mandatory only when the MERIS sensor type is used.

Optional Slave MERIS File
File name of the slave MERIS data (_list.txt). This file is mandatory only when the MERIS sensor type is used.

Parameters - Principal Parameters

Resampling

Interpolation Window Size

The dummy values are interpolated with a value that is the average of the valid values in a window of the size specified. If zero is entered, the interpolation is not applied; it is suggested to avoid setting this value to zero (see Technical Note).

Relax Interpolation
By setting this flag the relax interpolation is carried out (see Technical Note).

Mean Window Size
The mean filtering is carried out. The window filter size must be specified. If zero is entered, the mean filtering is not applied. This filter is applied after the execution of the interpolation steps.

Sensor Type
The choice is given between the following sensors:

- MERIS

- OSCAR

- ECMWF

Enhanced Cloud Mask (only available for MERIS sensor Type)

MERIS Reflectance
The reflectance input data are used for the original "Cloud Mask" enhancement.

MERIS Cloud Mask
This is the original input "Cloud Mask".

MERIS Pressure Difference
The pressure input data are used for the original "Cloud Mask" enhancement.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Name of the output root. This file is mandatory.

_corr_dint/fint
Corrected interferogram with the associated header files (.sml, .hdr).

_corr_mask
MERIS masked master and slave data, in the original image geometry, with the associated header files (.sml, .hdr).

_corr_atm
Atmospheric phase delay, in slant range SAR master image geometry, with the associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Z. Li, E.J. Fielding, P. Cross, and J.-P. Muller, "Interferometric synthetic aperture radar atmospheric correction: MEdium Resolution Imaging Spectrometer and Advanced Synthetic Aperture Radar integration", Geophysical Research Letters, 33: L06816, 2006.

R. Jolivet, R. Grandin, C. Lasserre, M. P. Doin, G. Peltzer, "Systematic InSAR tropospheric phase delay corrections from global meteorological reanalysis data", Geophysical Research Letters, Vol. 38, No. 17., 2011.

1.6.3.15.5 Complex Data Multilooking

Purpose

Multiple looks complex data can be generated by averaging over range and/or azimuth resolution cells.

Technical Note

Unlike the Basic module multilooking 119 functionality, which generate the average from the detected intensity, this functionality perform the complex data average enabling to keep the complex (multilooked) product in output.

Input Files

Input file
Input file name of the Complex (_slc, _int, _dint, _fint) data. This file is mandatory.

Parameters - Principal Parameters

Azimuth looks
Number of looks in azimuth.

Range looks
Number of looks in range.

Grid Size for Suggested Looks
The grid size, in meters, used to tune range and azimuth looks. If the other parameters are manually set, the grid size will not imply a change in their values.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file
Output file name of the multi-looked data. This file is mandatory.

_ml
Multi-looked data and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.6.3.15.6 Interferometric Data Coregistration

Purpose

This functionality is intended for coregistering all interferometric products coming from two different pairs.

Technical Note

The master data belonging to the two InSAR pairs must be provided in input: the one entered as "Input Slave File" will be resampled to fit the geometry of the "Input Reference File". Reference and Slave must be of the same data type (i.e. SLC).

Details about the coregistration process are provided in the relevant Technical Note 121.

All complex data types (e.g. _int, _fint, etc.) are resampled using the "Sinc" interpolator, whatever resampling method has been specified.

Input Files

Input Reference file
File name of the master data (_pwr for ScanSAR products; _slc or _pwr for all the others) of the InSAR pair to use as reference. It is suggested to enter here the SLC product. This file is mandatory.

Input Slave file
File name of the master data (_pwr for ScanSAR products; _slc or _pwr for all the others) of the InSAR pair to use as slave. It is suggested to enter here the SLC product. This file is mandatory.

Input File List
File name of all the interferometric products to be coregistered (these must belong to the "slave" pair). This file list is mandatory. In case SLC data are in this list, they will not be coregistered.

Optional Files

Coregistration file
A previously created file containing points representing the center of the coregistration windows used for the manual coregistration. The file can be either a *.xml file or a point shape file (.shp). This file is optional.

Output Files

Output File List
File name of the coregistered interferometric products. This file list is mandatory.

_rsp
Coregistered interferometric products ("slave" file list) with the associated header files (.sml, .hdr).

_par
ASCII file containing the coregistration shift parameters in range and azimuth.

_orbit_off.shp
Shape file with the points used to estimate the orbit based shift. This file contains the following information:

- Pixel position in range direction (Range), in original pixel units.
- Pixel position in azimuth direction (Azimuth), in original pixel units.
- Shift measured in range direction (Dr), in original pixel units.
- Shift measured in azimuth direction (Da), in original pixel units.
- Calculated polynomial fitted shift in range direction (Drfit), in original pixel units.
- Calculated polynomial fitted shift in azimuth direction (Dafit), in original pixel units

_winCC_off.shp
Shape file with the points used to estimate the cross correlation based shift from the Intensity data. The information provided by the "_orbit_off.shp" file are updated on the basis of the cross correlation estimate.

_winCoh_off.shp
Shape file with the points used to estimate the coherence based shift. The information provided in the "_winCC_off.shp" are updated by means the coherence based estimate. This file contains also the following additional information:

- Signal to Noise Ratio (SNR), which is a linear dimensionless value.
- Coherence value. It is dimensionless and it can vary from 0 to 1.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.6.3.15.7 Interferogram Difference

Purpose

The differential phase is generated from the difference of two input interferograms; it is suggested to previously flatten and filter the input data.

This functionality can be exploited also for flattening an interferogram by means of a previously generated synthetic phase.

Technical Note

The input files must be coregistered.

It must be noted that, using this functionality for the interferogram flattening, the spectral shift filter is not adapted to the local slope variations.

Input Files

Interferogram File
File name of the interferogram (_int, _dint, _fint). This file is mandatory.

Reference Interferogram File
File name of the synthetic phase (_sint, _int, _dint, _fint). This file is mandatory.

Output Files

Output File
File name of the output differential interferogram. This file is mandatory.

_dint
Differential interferogram with the associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.6.3.15.8 DEM - Ellipsoidal Flattening

Purpose

The constant phase (due to the acquisition geometry) and the phase expected for a flat Earth or for a known topography (in case a Digital Elevation Model is inputted) are separated from the residual - differential - phase.

This functionality can be used also to generate the synthetic phase only from orbital data, system and processing parameters and the Digital Elevation Model (alternatively the ellipsoidal height).

Technical Note

The interferogram is split in two components:

- Low frequency phase, which is related to the reference Digital Elevation Model topography (or ellipsoidal height) and to the constant phase (phase variation intrinsic to the InSAR system geometry). This is the synthetic phase (_sint).
- High frequency phase, which is related to the temporal phase variations between master and slave (e.g. land changes or atmospheric variations) and to the difference with respect to the reference Digital Elevation Model topography (or ellipsoidal height). This is the differential/ residual phase or flattened interferogram (_dint).

If a reference Digital Elevation Model is entered as input the flattening process is executed by removing the available topography. The better the reference Digital Elevation Model accuracy/resolution the better the result in terms of topography removal.

If a reference Digital Elevation Model is not entered as input, then a Reference Height must be provided. In this case the flattening process is executed assuming a ellipsoidal model with constant height.

The DEM flattening is executed by transforming the input Digital Elevation Model into the master slant range image geometry. In case of precise orbits and accurately geocoded reference Digital Elevation Model, this process is run in a fully automatic way. However, in case of inaccuracy in the satellite orbits or in the Digital Elevation Model geolocation, a Ground Control Point is required to correct the SAR data (i.e. master acquisition of the interferometric pair) with respect to the reference Digital Elevation Model. In this case the shift calculated in the coregistration process is combined with the Ground Control Point shift in order to correct the slave data according to the master data.1

It is important to note that:

- In case the "Master input file" has already been corrected with the the manual 722 or the automatic 719 procedure the GCP is not needed.
- In case the "Master input file" is correct (i.e. the nominally geocoded image fits with the DEM), while the orbital parameters of the "Slave input file" are not accurate (i.e. the nominally geocoded image does not fit with the DEM), the GCP is not needed but the flag "Automatic Slave Orbit Correction", in the Preferences>Flattening 775, must be checked.

In case the orbits are not accurate, the differential interferogram (_dint) can contain some residual phase (i.e. residual orbital fringes). These fringes can be removed by setting the "REMOVE RESIDUAL PHASE" flag in the Preferences>Flattening 775, before running the flattening process.

When this functionality is used to make only the synthetic phase, the master and slave input files must be those coming from the interferogram generation process.

Input Files

Interferogram File
File name of the previously generated interferogram (_int). This file is mandatory if the "Compute Synthetic Phase Only" flag is unchecked.

Input Master File
File name of the master Intensity data (_pwr). This file is mandatory.

Input Slave File
File name of the slave coregistered Intensity data (_pwr). This file is mandatory.

Optional Files

Geometry GCP File
Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File) or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the "Tools>Generate Ground Control Point747" for details). This file is optional.

DEM/Cartographic System

Digital Elevation Model file
Name of the Digital Elevation Model file. This should be referred to the ellipsoid. This file is optional. In case it is omitted, the ellipsoidal height and the relevant cartographic reference system, must be entered.

Output Projection
In case that the Digital Elevation Model is not used, t6he following parameters are compulsory to define the **Cartographic System**6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Compute Synthetic Phase Only
By setting this flag only the synthetic phase is generated.

Coregistration with DEM
By setting this flag the data will be coregistered with the optional input Digital Elevation Model.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Coregistration

It brings to the coregistration section of the Preferences 770 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Flattening

It brings to the flattening section of the Preferences 775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Name of the output root. This file is mandatory.

_dint
Flattened interferogram with the associated header files (.sml, .hdr).

orig_
Original phase, before the Residual Phase Frequency Removal, with the associated header files (.sml, .hdr). This file is generated only when the Preferences>Flattening>Remove Residual Phase Frequency 775 flag is checked.

_sint
Synthetic phase with the associated header files (.sml, .hdr).

_srdem
Digital Elevation Model, in slant range geometry, with the associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

A. Monti Guarnieri, C. Cafforio, P. Guccione, D. Nüesch, D. Small, E. Meier, P. Pasquali, M. Zink, Y. L. Desnos: "Multi-mode ENVISAT ASAR Interferometry: Techniques and Preliminary Results". Proceedings of EUSAR Conference 2002.

1.6.3.15.9 Phase Editing

Purpose

This functionality must be operated under ENVI Classic.

1.6.3.15.10 Remove Residual Phase Frequency

Purpose

The residual phase frequency is estimated on the wrapped phase (interferogram), removed from it and added to the synthetic phase (_sint).

The objective it is to simplify the "Phase Unwrapping" step.

Technical Note

The difference with respect to the Residual Phase Frequency removal, which is possible by setting the relevant Preferences 775, is that this is more flexible/tunable as more parameters can be set.

The "Ground Control Point file" can be optionally entered for the residual phase calculation. It has the same meaning of the "Orbital GCP file" used in the Refinement and Re-Flattening 308 process. If it is used, the Ground Control Points must be well distributed throughout the entire scene and they have not to be located on areas where topographic fringes remained "unflattened".

It must be noted that, only whether the input and output file names are the same or the "Output Root Name" is missing, the original synthetic (_sint) and differential (_dint) interferograms, which are modified as result of phase removal, are saved with the prefix "original_".

Azimuth Window Size
The window size must be larger than the orbital fringe dimension (in pixels) in order to have an optimal performance. If the window is too big, with respect to the image size, the program will automatically reduce it.

Range Window Size

The window size must be larger than the orbital fringe dimension (in pixels) in order to have an optimal performance. If the window is too big, with respect to the image size, the program will automatically reduce it.

Polynomial Degree

The number of coefficients (from 1 to 10) used for the residual phase removal. It makes sense to have this value set at least to 2, since a dominant dependency in range is expected.

$$\varphi = K_1 + K_2X + K_3Y + K_4X^2 + K_5XY + K_6Y^2 + K_7X^3 + K_8X^2Y + K_9XY^2 + K_{10}Y^3$$

Low Pass Filter m

Window size (meters) for the Low Pass atmospheric removal, in range and azimuth direction, which is used for the removal process. If set to zero, the Low Pass removal is not applied. Suggested values are more than 15000 meters, only in case of small spatial size displacement pattern.

Input Files

Interferogram File

File name of the differential interferogram (_dint, _fint). This file is mandatory.

Coherence File

File name of the coherence image (_cc). This file is mandatory.

Optional Files

Geometry GCP File

Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File) or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the "Tools>Generate Ground Control Point 747" for details). This file is optional.

Parameters - Principal Parameters

Azimuth Window Size

Window Size in azimuth direction – better using power of 2 values – which is used to estimate the local fringe frequency.

Range Window Size

Window Size in range direction – better using power of 2 values – which is used to estimate the local fringe frequency.

Azimuth Window Number

Number of windows, in azimuth direction, which are used for the removal process. If set to zero, the polynomial removal is not applied.

Range Window Number

Number of windows, in range direction, which are used for the removal process. If set to zero, the polynomial removal is not applied.

Polynomial Degree
The number of coefficients (from 1 to 10) used for the residual phase removal. Refer to the flattening section of the Flattening Preferences 775 for further informations.

Low Pass Filter m
Window size in meter for the Low Pass Filter. If set to zero, the Low Pass removal is not applied.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Flattening

It brings to the flattening section of the Preferences 775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Name of the output root. This file is mandatory.

_dint
Flattened corrected interferogram with the associated header files (.sml, .hdr). This file is generated only if the input is an unfiltered interferogram (_dint).

_fint
Flattened and filtered corrected interferogram with the associated header files (.sml, .hdr). This file is generated only if the input is a flattened-filtered interferogram (_fint).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.7 Interferometric Stacking

Section Content

1.7.1 Overview

A Note on the Interferometric Stacking module

This module is intended for the generation of Displacement Maps and Digital Elevation Models (DEMs) from multitemporal interferometric SAR data series.

Two different processing approaches are foreseen:

1. **PS** (Persistent Scatterers) - It is intended for the analysis of point targets. The resulting product is relevant to the measurements of linear displacements and the derivation of precise heights of local scatterers, which are typically characterized by high coherence. The number of input images is crucial for the pixel coherence estimate, which determines the identification of suitable PSs. The use of an insufficient number of acquisitions will produce a high coherence estimate throughout the entire scene, which would result in a PS number overestimation. The application of this technique can be considered reliable when 20 or more acquisitions, which are characterized by a regular temporal separation, are available. This approach should exclusively be used in urban areas, or in general, where scatterers remain stable in radiometric and interferometric phase terms. Depending upon the scatterer stability (time coherence), the displacement measurement accuracy can reach the precision of millimeters, while the maximum detectable displacement velocity depends on both the minimum time distance between consecutive acquisitions and the SAR wavelength. Finally concerning the height estimates, this technique provides a better accuracy than the SBAS approach; the difference between the two methodologies is particularly evident in layover areas (e.g. skyscrapers in urban zones) where the SBAS, due to both the interferogram filtering and the phase unwrapping processes (none of the two is performed in the PS processing), tends to smooth the elevations.

2. **SBAS** (Small Baseline Subset) - It is intended for the analysis of distributed targets. The resulting products resemble those coming from a conventional DInSAR processing; the key difference is that SBAS enables the analysis of large time-series, while the classical DInSAR is limited to the 2-, 3- and 4-acquisitions (refer also to the Dual Pair Differential Interferometry 325). With respect to the PS, the SBAS technique is less sensitive to the number of acquisitions; this is because the SBAS exploits the spatially distributed coherence, instead of estimating the coherence exclusively on local scatterers (PS characteristic). It remains anyhow that, also with the SBAS technique, the availability of more acquisitions allow to achieve a better product quality; in this case the improvement is mostly related to the better estimate (and removal) of the atmospheric phase component. Concerning the displacement assessment, while the PS is limited to linear models, the SBAS can cope with linear, quadratic and cubic models (i.e. when the displacement velocity and/or acceleration change over the time). Moreover the SBAS technique can also be exploited only for the terrain elevation estimate and, in such case, the “no model” option is adopted. In terms of maximum measurable displacement, there are not relationships with the temporal distance between consecutive acquisitions, whilst there are limitations with respect to the displacement spatial variability; this is due to the phase unwrapping intrinsic constraints. We can finally state that, in several cases, the SBAS approach is

more robust than the PS, as the former takes advantage of the higher redundancy (i.e. number of connections of each acquisition), which eventually allows to generate many more interferograms.

The following basic requirements have to be fulfilled in the input data series:

- All data must be acquired by the same sensor.
- All data must be acquired with the same viewing geometry.
- In case of multi-polarization acquisitions, the same polarization must be selected for all data. It must be noted that it is possible to enter, in the same input temporal series, both single polarization and multi-polarization acquisitions; for instance, in case of ALOS PALSAR data, we can make a series using the HH channels of Fine Beam Single (FBS) and the HH channels of Fine Beam Dual (FBD). When the SBAS processing is performed, we suggest to select an FBD acquisition as Super Master file 510.

Note that:

- SAR data must be imported (see Basic module 32).
- In case of SAR RAW products, the data must be imported and focussed (refer to Focusing module 215).
- Default setting for selected parameters can be specified in the Preferences panel.
- The PS vs SBAS Comparison document, provides details relevant to a practical case where different sensors have been exploited.
- The SAR Tutorial, which includes basic knowledge on SAR theory and data processing, complements the online help.
- Data geocoded to GEO-GLOBAL cartographic reference system can be automatically displayed into the Google Earth environment by double clicking on the output .kml file.
- Co-ordinate decimal values must be entered using the dot (e.g. 29.30) and not the comma (e.g. 29,30) character.

References

P. Pasquali, P. Riccardi, A. Cantone, M. Defilippi, F. Ogushi & S. Gagliano, "Quantitative comparison of methods and sensors for monitoring land subsidence phenomena based on satellite SAR interferometric stacking", Proceedings of GRSG Annual General Meeting 201, Including the 2011 Oil and Gas industry workshop, 7th –9th December 2011, ESA ESRIN, Frascati, Italy

1.7.2 Frequently Asked Questions

Q. - Is it correct to say that using this module we can process the data using their **Full Resolution**?

A. - All modules enables to exploit the product full spatial resolution. What is estimated with higher precision in the Persistent Scatterers module, with respect to the Interferometry module, is the displacement (i.e. differential phase) of those targets which behave as stable scatterers.

Q. - Does the processing chain applies any procedure specifically intended to make closer the **Doppler Centroids** of the acquisitions belonging to the same input temporal series?

A. - The interferometric processing takes properly care of the data Doppler Centroids either during the design of the interpolation filters or when the common azimuth bandwidth filter is performed (as it is for example done in range direction for the baseline de-correlation/spectral shift filtering). These filtering steps can be activated by setting the relevant flag in the Preferences 779. Specifically, the common Doppler bandwidth (i.e. Doppler Filter) and the Spectral Shift Filter are never performed (Preferences flags always off) within the PS module 490 due to the nature of the algorithm and the type of targets that are considered, which are actually point targets; for these objects there is not spectral shift, baseline decorrelation or decorrelation of the Doppler bands, thus none of the filters in range and azimuth direction is necessary, moreover the activation of these filters cause the loss of much information for real point targets and it eliminates the advantage of exploiting large baselines for obtaining a very precise estimate of the PS height.
On the other hand the SBAS module 519, which focuses on distributed targets where common Doppler bandwidth and spectral shift filtering are meaningful, normally activates these filters.

Q. - Did you ever do any **Comparison** between results obtained with the **PS** and the **SBAS** methods?

A. - Yes we actually did this comparison in an area affected by subsidence in Japan, where we had also collected field data; the results obtained with the two methodologies are in general very much comparable and in agreement with the field data (refer to the PS vs SBAS Comparison document for more details).
However some differences can be noted with respect to the following points:

- PS (Persistent Scatterers) - it is sometime better to detect displacement patterns of local targets.
- SBAS (Small Baseline Subset) - the displacement map is more homogeneous and it allows to characterise the real displacement in those areas where the trend is not linear.

However it must be said that this example refers to a relatively "easy case" for the application of the PS technique, due to three main reasons:

1. We had a quite high number of acquisitions (34 images).
2. In most of the cases the subsidence is a phenomenon, which can be well described by a linear model especially when the observations are regularly distributed over the time.
3. A notable number of coherent scatterers was present in the area.

In other cases, when one of the three points above is missing or weak, the SBAS is definitely more robust and reliable than the PS.

Q. - What is the displacement measurement accuracy that we can expect with the **Persistent Scatterers Approach**?

A. - Given a number of images and a displacement rate which is compatible with the PS requirements, the achievable accuracy is:

- Less than 1 cm per year in terms of displacement velocity.

❖ In the order of the centimeter as relative position of the PS, on each date in the input temporal series with respect to a reference date.
Note that this reference date, which is assumed as "zero displacement" acquisition, is not necessarily the input entered (manually or automatically) as "Reference file" in the processing panel, but it can be (possibly) fixed as the oldest image in the input file list by checking the appropriate flag in the relevant Preferences 787.

Q. - When the **PS Density** is lower than around 100 PS/sqkm the result accuracy becomes questionable. What is the approach suggested in these cases?

A. - Eventually the most important problem to deal with, when the PS density is low, it is the proper atmospheric disturbances estimation and removal. This is why the PS approach is especially suitable in urban areas, but it often provides wrong results in rural areas and urban outskirts. In these cases the approach we suggest is to apply the SBAS technic.

Q. - I've an interferometric temporal stack of **19 Images** acquired on a slightly urbanized **Rural Area**. What is the processing approach that you suggest?

A. - Actually, being the input acquisitions below the minimum suggested number and being them not acquired in an area where we can expect plenty of persistent scatterers, the best results can be achieved by adopting the SBAS approach. However an attempt using the PS approach can be performed after having reduced the default PS Density 787, which is normally set considering urban-like areas.

Q. - It is mentioned, in the online documentation, that some of the algorithms implemented in the **Interferometry Module** are also exploited in some of the routines executed during the Interferometric Stacking processing. Are there specific Interferometry Module functions that I have to run during the Interferometric Stacking processing?

A. - The Interferometry Module routines, which are required during the Interferometric Stacking processing, are automatically called by the program; the generation of the PS/SBAS specific outputs does not require to execute any functionality which is not in this specific module.

Q. - What is the meaning of the **Baseline Threshold**, which can be set among the other Preferences 787 ?

A. - The default threshold (500 meters) corresponds to 5 times the critical baseline (i.e. same meaning of the critical baseline calculated by the Baseline Estimation 451 functionality). Actually the baseline related constraints in the interferometric processing are applicable when analysing distributed targets (Interferometry module and Interferometric Stacking/SBAS method). Vice versa, when the analysed objects are represented by local/point targets (Interferometric Stacking/Persistent Scatterers method) the critical baseline has not to be considered a limitation anymore.

Q. - Are there specific criteria to change the **Product Coherence Threshold** value in the Persistent Scatterers processing?

A. - After a first processing iteration with the default setting, it is possible to decrease (in case few PS are found) or increase (in case too many, possibly "noisy pixels", PS are found) the threshold value. The second processing iteration can be executed only for the generation of the final geocoded products, by de-selecting the "Generate Slant Range Products" flag and checking the "Generate Geocoded Products" flag; in this way the first and longest processing part, which does not change when the coherence threshold value is modified, can be skipped.

Q. - What are the criteria to follow for a good **Selection of the Reference Acquisition** and which are the information concerned with the **Estimate Precision** function in the Persistent Scatterers processing?

A. - The Reference file is automatically selected by the program as the image that minimizes the average baseline of the stack, that means the image
that has an ideal temporal and spatial position respect to the other ones. This helps in performing the data coregistration and all processing steps easier, as well as trying to provide a higher coherence (smaller baselines are less sensitive to volume de-correlation). It is better to avoid, for the Reference image selection, those data which are known to be affected by strong atmospheric variations.

The "Estimate Precision" function allows getting a preliminary knowledge of the expected measurement accuracy, which is valid for the whole acquisition stack and for all PSs. The precision factors, which are estimated prior the PS processing execution, are computed with an approach similar to that used for estimating the DOP (Dilution Of Precision) factor for GPS systems; the geometry of the stack is considered, estimating the baselines and the corresponding 2π height ambiguities and using the default PS Density 787.
Later on, once the PS process is ended, the real accuracy of each PS is provided on the basis of the pixel coherence and the actual local PS density.

Q. - Is there a way to know which acquisitions have been discarded due to **Data Coregistration Failure**?

A. - In case of coregistration failures, the "coreg_discard.txt" file is generated in the output folder; it is a list of the acquisitions which have been discarded for coregistration related problems.

Q. - Are there key elements the operator should check, at completion of a **PS Analysis**, to make sure that the **Results Are Reliable**?

A. - One check may be relevant to the co-registration process: the "coreg_discard.txt" file contains a list of the files which have not been coregistered. Another check may be related to the proper removal of the atmospheric fluctuation effects: as a rule of thumb an increase of the multitemporal coherence, from the "_cc_first" products (before the atmospheric effects removal) to the "_cc" product (after the atmospheric effects removal), means that the atmospheric correction has been successfully carried out.
>
> Comparing both coherence files you can better decide how set the filter parameters (low pass, in meters and high pass, in days) to avoid loss of coherence and consequently to better estimate the displacement values..

Q. - What the acronym **SBAS** stands for?

A. - It stands for "small-baseline subset"; the technique has been originally introduced by Berardino, Fornaro, Lanari and Sansosti (refer to the reference bibliography).

Q. - What are the criteria to change the **Min and Max** spatial (i.e. normal) and temporal **Baseline** values in the **SBAS Connection Graph**?

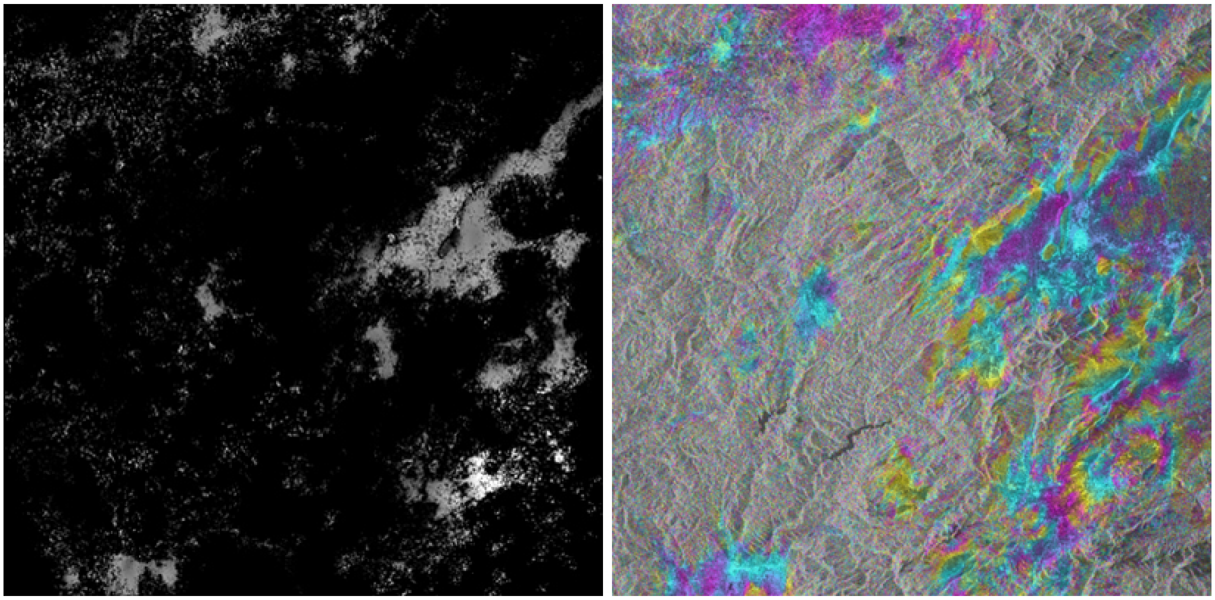
A. - The criteria to define the minimum and maximum normal baseline mostly depend on the type of product (i.e. Displacement Map or Digital Elevation Model) one wants to obtain from the SBAS processing. If you are looking for a Displacement Map, the typical choice it is to get a fully connected graph; vice versa, if the objective is to generate a Digital Elevation Model, also disconnected pairs can give a contribution to improve the final product accuracy.
On the basis of what above, if you select the option "Allow Disconnected Blocks" (DEM generation purposes) the min and max normal baselines can be used to discard pairs with very small values (e.g. less than 20% of the critical baseline), which are quite useless for accurately measure height variation.
on the other side one can also prefer (either for DEM or Displacement mapping) to avoid using pairs with very large normal baseline, which are often characterised by low coherence; in such case the max limit can be set for instance to 50% of the critical baseline. This same concept can be applied for the definition of the maximum temporal baseline value, considered that the coherence decreases proportionally to the temporal distance; of course a factor which dramatically influences the temporal decorrelation is the land cover type (e.g. vegetation, soil moisture, snow cover, etc.).
A processing option to consider it is to leave these thresholds as much as possible "open" and, after the Interferogram Generation 519 step, analyse the products in order to discard bad pairs by editing the Connection Graph 551.

Q. - How can I properly set the **Size** of the **Atmosphere Low Pass** and **High Pass** filters in the SBAS Inversion 535?

A. - A smaller window size will make the filter stronger. The smoothing introduced by the filter can be assessed by comparing the temporal signature of the "disp_first" (products without atmospheric removal) and the final displacement products. This allows understanding if the atmospheric filter smoothing removed also important displacement patterns. It can happen that the atmospheric patterns are actually small (for instance over mountainous areas) and thus also the filter size must be set accordingly; this can be assessed by observing the interferograms, before running the "SBAS Inversion" process. However, if also the displacement patterns have a small size (i.e. same or smaller than the atmosphere), we discourage to excessively reduce the window size, to avoid removing the displacement as atmosphere.

Q. - How does the program handle datasets characterized by **Scattered Areas of Low Coherence**?

A. - The example below shows a typical case of scattered coherence areas. The area of interest, where subsidence phenomena have been reported, is in the lower right corner.



This area is well represented and the coherence is good, but the surrounding low coherence zones are can affect the SBAS inversion process and eventually the measurement accuracy. However, if there are enough interferograms (theoretically at least five per acquisition) the program is able to "reconstruct" the missing information by means of the 3-dimensions unwrapping approach.

Q. - What is the **Unwrapping Approach** adopted for the interferogram series?

A. - Actually the unwrapping execution depends on the Interferometric Stacking approach which is adopted:

- in the Persistent Scatterers 482, based on the original publication of Ferretti et al., the unwrapping is not performed for the estimation of the displacement rate and height corrections, since a pixel-wise spectral analysis approach in the time-baseline plane is exploited; this approach has the advantage of avoiding the need of unwrapping by working on the complex data only.
- in the SBAS Inversion 529, it is possible to choose between two main methods: Region Growing or Minimum Cost Flow, this last one either with a square or with an irregular triangulated - Delaunay - grid (Preferences>Interferometry 779). In case the Delaunay method is adopted, a 2- or 3-dimensions unwrapping (the third dimension being represented by the time) can be selected. At this regards it must be noted that the 3-dimensions approach provides superior results when there are disconnected areas (typically due to low coherence), as it exploits the high coherence interferograms (third dimension) to estimate how to create new connections in "scattered" (low coherence) interferograms; the disadvantage of this method is that it is much more costly in terms of processing time. The unwrapping, in the SBAS processing chain, is carried out two times: once before a first estimate of average displacement rate and height correction and once more afterwards to refine the first results.

Q. - Are there specific indications or rules to optimally set the **Decomposition Levels**?

A. - There are not specific rules since the optimal setting of this parameter depends strongly on the scene coherence and also on the unwrapping method adopted. In most of the cases, especially when the

Delaunay method is adopted, the use of 1 decomposition is a good and robust setting. Sometimes good results are obtained by increasing the decomposition level from 1 (in the 1A - Interferometric Workflow 519 step) to 2 (in the First Inversion 529 step).

Q. - After the SBAS inversion, some of the **Unwrapped Interferograms** are still affected by **Directional Slopes**. Is this due to a problem during the Refinement and Re-Flattening step? What is the best way to address such issues?

A. - The first thing to do it is to visualize and verify the unwrapped data (_upha_list_meta), after the Interferometric Workflow 519 step, in order to understand where the GCPs must be located for the next Refinement and Re-Flattening 525. The worst pairs (i.e. very low or scattered coherence, which typically causes a bad unwrapping) shall be removed by means of the appropriate tool 551; if possible before the Refinement and Re-Flattening, otherwise after the First Inversion 529 step.
After the execution of the Refinement and Re-Flattening, in order to ensure that the GCPs have been properly selected (in terms of position, distribution and quantity), another visual analysis is needed to verify that major residual phase ramps are not in; if they are still present, a higher number of GCPs (20 or more) is probably required.
Once the re-flattened data have been checked, the First Inversion step can performed, which generates a new set of the unwrapped data (these are stored in the "_sbas_inversion_dir" folder). After this step, the remaining "bad pairs" can be removed before executing the second and final inversion 535.
Note that the program is implemented in a way that, even when some small residual ramps remain (of course the less the better...), the inversion process is not notably affected.

Q. - Is there an easy way to create the **Orbital GCP File**?

A. - The most important criteria for the GCPs selection, as well as the main parameters adopted by the program when the "Orbital GCP file" is used, are described in the relevant FAQ 252 of the Interferometry module guide. What has to be added in the case of the Interferometric Stacking, it is that the same set of points must be used to "reflatten" the entire stack of phase images which have been created after the coregistration onto the "Super Master file". Being quite difficult (if not impossible...) to find the best point configuration for all pairs at once, the suggested approach it is to try a point distribution which is good for the majority of the pairs (for this purpose it becomes useful to visualize the stack of images by means of the meta file generated automatically by the program); in several cases the use of the Preferences>Flattening>Refinement and Re-flattening>Refinement Method>Residual Phase 775, which allows the use of the less precise but most robust phase correction approach, shall be adopted. It must be also taken into account that some points, which are inside the imaged area for some pairs, can fall outside in others and thus it can be required to enter more points; in other cases, for instance when the original orbits are all very much accurate and there is not any visual evidence of residual phase ramps, it can be sufficient to simply remove a phase offset (constant value) by choosing a Preferences>Flattening>Refinement and Re-flattening>Refinement Method>Residual Phase Poly Degree 775 equal to 1.

In any case, also relying on very precise orbits, the use of the "Orbital GCP file" is mandatory as the reflattening process must be always executed in order to correct the phase offset (i.e. constant phase removal).

Q. - What is the best way to analyse the **SBAS results**?

A. - The output products are grouped in meta files in order to make easier the simultaneous multi-temporal analysis. The meta files can be interpreted using either the raster data analyzer 745 or, after a conversion from raster to shape 547, the vector data analyzer 746.

1.7.3 Persistent Scatterers

Section Content

1.7.3.1 Overview

A Note on the Persistent Scatterers functionality

It is conceived for the generation of products aimed at monitoring the temporal evolution of surface deformations.
The technique, extending SAR Interferometry to the analysis of large sets of multi-temporal acquisitions, enables to improve the measurement accuracy from few centimetres (classical Interferometry approach) to few millimetres (Persistent Scatterers approach). In addition to that, limitations typical of SAR Interferometry (i.e. atmospheric distortions or temporal de-correlation) are dramatically reduced.

The use of large temporal series enables to improve the identification and further removal of atmospheric related effects (artifacts) by means of a dedicated space-time filtering operation. A minimum number of three acquisitions is required to be able to run the processing, but more (at least twenty) are suggested to get reliable results especially in case of low coherence conditions.

ScanSAR data cannot be processed with this module.

The output products are stored in step-specific folders, which the program creates during the processing execution. These folders are automatically created inside the root output directory named using, as prefix, the "Output Root Name" and "_PS_processing" as suffix, which is entered in the first processing step 484.
All intermediate files generated from each step are stored inside the _PS_processing/work sub folder. In order to avoid processing failures it is recommended not to move any file from its original repository folder.

The "Auxiliary file" (marked by the name auxiliary.sml) is saved in the root output directory and it is updated during the execution of the different processing step. It is the input used, from the Area of Interest Definition 487 step onwards, throughout the whole processing chain; it is important to note that the first input to enter, in any processing panel, is the "Auxiliary file". This file contains information to understand which steps have been executed, and what are the products generated.
The "work_parameters.sml" is saved in the work sub folder and contains information about the processing parameters setting.

It is important to know that constant displacements, which affect all the area in the observed "Geographical Region", are not detected.

The following processing sequence is generally adopted:

1) Connection Graph
All images are connected to create a network of master and slaves pairs, which are linked each other only whether the baseline values are within the input thresholds. All data will be coregistered onto a master acquisition, which can be automatically identified by the program or manually selected by the user.

Area of Interest Definition
This is an optional step, which has to be executed in case an area of interest (i.e. a region smaller than the input scene whole coverage) has to be extracted and processed.

2) Interferometric Workflow
The flattened interferograms (and related SAR intensity images), together with the intensity images are generated.

3) PS First Inversion
The first displacement (date by date value), velocity and height (correction values) related products are generated without removing any phase component due to the atmosphere;

4) PS Second Inversion
The atmospheric corrections, related to spatial and temporal variations, are performed in this step; then this component is estimated and finally subtracted from the interferogram files in order to generate the final displacements.

5) Geocoding

All PS related products (e.g. displacement velocities, residual heights, displacement time series, kml and shape files, etc.) are projected onto the cartographic system of the input "DEM file".
It is possible to get two kind of output formats: Raster and Shape.
Regarding the raster format, the displacement measurements can be re-projected onto a vertical and slop direction.

Note that:

- SAR data must be imported (see Basic module32).
- SAR RAW products must be imported and focussed (refer to Focusing module).
- Default setting for selected parameters can be specified in the Preferences panel.
- TheSAR Tutorial, which includes basic knowledge on SAR theory and data processing, complements the online help.
- Data geocoded to GEO-GLOBAL cartographic reference system can be automatically displayed into the Google Earth environment by double clicking on the output .kml file.
- Co-ordinate decimal values must be entered using the dot (e.g. 29.30) and not the comma (e.g. 29,30) character.

References

A. Ferretti, C. Prati and F. Rocca: "Nonlinear subsidence rate estimation using permanent scatterers in differential SAR interferometry". Geoscience and Remote Sensing, IEEE Transactions on, vol. 38, no. 5, Part 1, Sept. 2000, pp. 2202 - 2212.

A. Ferretti, C. Prati and F. Rocca: "Permanent scatterers in SAR interferometry". Geoscience and Remote Sensing, IEEE Transactions on, vol. 39, no. 1, Jan. 2001, pp. 8 - 20.

A. Hooper, H. Zebker, P. Segall, and B. Kampes: "A new method for measuring deformation on volcanoes and other non-urban areas using InSAR persistent scatterers". Geophysical Research Letters, vol. 31, December 2004.

1.7.3.2 1 - Connection Graph

Purpose

This functionality defines the SAR pair combination (Master and Slaves) and connection network, which is used for the generation of the multiple differential interferograms519. This step is mandatory. Unlike the SBAS tool, this network cannot be edited551.

Technical Note

The network links created in this step are only those connecting pairs that are within the spatial baseline values specified in the relevant "Preferences", (refer to the Preferences>Persistent Scatterers>Baseline Threshold (%) 787 setting). Those acquisitions which remain disconnected, due to baseline values exceeding the specified thresholds, are discarded from the further PS analysis.

At the end of the processing an IDL graph is shown, where all connection are represented as well as the selected Master. Each acquisition is represented by a diamond associated to an ID number, which is reported also in both the "CG_report.txt" file. The colour of the diamond symbol is as follows: i) Discarded acquisitions due to user specific constraints in red colour; ii) Valid acquisitions in green colour; iii) Master acquisition in yellow colour.

The following graphs are generated:

- **Time-Position plot**, which provides the normal distance from the Master (y axis) and the input acquisition dates (x axis).
- **Time-Baseline plot**, which provides the normal baseline (y axis) and the input acquisition dates (x axis).

They can be reloaded at any processing step by means of the relevant tool 553.

The multilooking factors of the output Master image (suffix, "_pwr") are automatically calculated by taking into account the Cartographic Grid Size, which is set in the relevant SARscape Preferences panel.

Auxiliary file
It contains information to understand which steps have been executed and what are the products generated.

Input Files

Input file list
Input files (_slc) to be used. This file list is mandatory.

Optional Files

Input Master file
Name of the the acquisition to use as processing reference data. This acquisition must be contained in the "Input File list" as well. If this file is not entered the program identify it in order to have the maximum number of connected acquisitions. This file is optional.

Output Files

Output Root Name
Name of the output root. This file is mandatory. It is used as root name throughout the entire PS processing chain.

connection_graph
Directory containing the following products:

- Multilooked Master intensity image (_pwr) and associated header files (.sml, .hdr).
- Report file (Reference_selection.txt) showing various input selection parameters such as: selected master, baseline and precision values, and thresholds, etc.
- The "plot" sub folder is used to store the files (CG_baseline.txt and CG_position.txt) used for the visualization of the graphs and interfacing with ENVI.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

auxiliary.sml
Text file with process related information (products, parameters, etc.)

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.7.3.3 Area of Interest Definition

Purpose

A spatial subset of the data can be performed by manually specifying the area of interest either with its corner co-ordinates or using a vector file.
By enetring a shape file, the coorner coordinates This step is optional.

Technical Note

In case the processing has to be executed on a portion of the input data, the data resize must be executed using this tool. Once the Auxiliary file 483 (which was generated in the "Connection Graph" step) is entered as input, the "Reference file" (multilooked master image) is automatically loaded in ENVI in order to draw the subset polygon or identify the pixel co-ordinates for the subset.

The subset co-ordinates must be referred to the multilooked "Master file", which is automatically opened once the "Auxiliary file" is entered as input.

If the sample coordinates are referred to any supported cartographic reference, a backward geocoding is automatically executed by the program in order to estimate the row/column position of the corners of the area to be extracted in the SAR geometry of the master image (Master file).
In order to avoid loading failures it is recommended not to move any file from its original repository folder.

Input Files

Auxiliary file
Reference file generated as output of the "Connection Graph" step. This file is mandatory.

Optional Files

Vector File
A vector file (.shp) can be entered to specify the area to be processed. In case the area is irregular, the circumscribed rectangular area is considered.
This file is optional.

DEM/Cartographic System

Digital Elevation Model file
Digital Elevation Model file name. This file is optional.

Output Projection

In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Geographical Region
By setting this flag the area to be processed is specified in cartographic co-ordinates or georeferenced vector file (referred to the input DEM or Cartographic system); otherwise file co-ordinates (i.e. slant range geometry) must be entered. The selected region is referred to the master data. Co-ordinate decimal values must be entered using the dot (e.g. 29.30) and not the comma (e.g. 29,30) character.

- **West/First column**
  The Westernmost cartographic co-ordinate or the first column file co-ordinate.

- **East/Last column**
  The Easternmost cartographic co-ordinate or the last column file co-ordinate.

- **North/First row**
  The Northernmost cartographic co-ordinate or the first row file co-ordinate.

- **South/Last row**
  The Southernmost cartographic co-ordinate or the last row file co-ordinate.

Rebuild All
By setting this flag the whole process is started from scratch.

It is advisable to leave this flag unchecked in case of process interruption, so that the products already generated have not to be computed and stored again.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Coregistration

It brings to the coregistration section of the Preferences 770 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

aoi_definition
Directory containing the following products:
- Subset of all the SLC inputs (prefix AOI_) and associated header files (.sml, .hdr).
- The Master file is identified with "AOI_master" extension.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch

processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.7.3.4 2 - Interferometric Process

Purpose

This functionality enables to execute, in an automatic way, the following processing sequence:

- Coregistration 121.
- Interferogram Generation and Flattening 293.

This step is mandatory.

Technical Note

The different steps implemented here are executed using the default processing approach (consult the reference guide specific to each processing step for more details); in particular:

- During the coregistration step, all sampled images are coregistered onto the resampled " Master file" . This involves an oversampling of a factor 4, in range direction (refer to the Preferences>Persistent Scatterers>Range Looks setting 788), which is executed to avoid aliasing of fast fringes in case of large baseline values. Differently from the standard InSAR processing, since the PS approach is looking at point targets, the spectral shift and the common Doppler bandwidth filters are not executed.The interferograms are then generated for each slave (i.e. "Input File List") using always the same master image (i.e. "Reference file").
- The Interferogram Flattening is performed using an input reference Digital Elevation Model or the ellipsoidal model if the DEM is not inputted; the "Geometry GCP file", if entered, is used to correct

the master image (i.e. Super Master acquisition of the interferometric stack) onto the Digital Elevation Model. The better the reference Digital Elevation Model accuracy/resolution the better the result in terms of topography removal. It is important to note that, in case the Super Master image has already been corrected with the the manual 722 or the automatic 719 procedure the GCP is not needed.

The data multilooking factors are relevant to the Master image. In case the input SAR series contains data with different pixel sampling (e.g. ALOS PALSAR FBS and FBD acquisitions), the program automatically changes the multilooking factors of each interferometric pair depending on its master acquisition mode.

Due to the large number of output products, the following three meta files are generated. They enable to load at once all relevant output products:

- **slant_dint_meta**, which refers to all flattened interferograms.
- **slant_pwr_meta**, which refers to all slant range power images.

In order to avoid loading failures it is recommended not to move any file from its original repository folder.

Input Files

Auxiliary file

Reference file generated as output of the "Connection Graph" step and possibly updated 551 afterwards. This file is mandatory.

Optional Files

Geometry GCP file

Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File) or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the "Tools>Generate Ground Control Point 747" for details). This file is optional. If an area of interest 487 has been previously specified, then the GCP must be located within that area. This file is optional.

DEM/Cartographic System

Digital Elevation Model file

Name of the Digital Elevation Model file. This should be referred to the ellipsoid. This file is optional. In case it is omitted, the ellipsoidal height and the relevant cartographic reference system, must be entered.

Output Projection

In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Generate Dint Multilooked for Quick View
By setting this flag the differential interferograms, with the multilooking factors specified below, are also generated as processing outputs.

Range looks for Quik View
Number of looks in range direction.

Azimuth looks for Quick View
Number of looks in azimuth direction.

Rebuild All
By setting this flag the whole process is started from scratch.

It is advisable to leave this flag unchecked in case of process interruption, so that the products already generated have not to be computed and stored again.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Interferogram

It brings to the interferometry section of the Preferences 779 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Flattening

It brings to the flattening section of the Preferences 775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Coregistration

It brings to the coregistration section of the Preferences 770 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

interferogram_stacking
Directory containing the following products:
- Meta files allowing to load the specific processing results (_meta).
- **mean**, SAR Intensity average image and associated header files (.sml, .hdr).
- **mu_sigma**, amplitude dispersion index.It is computed as the ration (SAR intensity average/ Standard Deviation).

In order to distinguish the input SAR pair where each output product comes from (as well as to identify it in the connection network), a prefix containing the master-slave acquisition dates (i.e. yyyymmdd) and the master-slave relationships will be added.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None

1.7.3.5 3 - Inversion: First Step

Purpose

This functionality implements the first model inversion to derive the residual height and the displacement velocity. They are used to flatten the complex interferograms.This step is mandatory.
The approach is based on the identification of a certain number of “coherent radar signal reflectors” (Persistent Scatterers). The processing is then focused on the analysis of the phase history of these reliable single targets (each one represented by an image pixel), as opposed to the conventional approaches that process the input scene as a whole. A Persistent Scatterer is subject to two main constraints: it has to be stable (fluctuations lower than a millimeter) and it has to be properly oriented in order to be detectable from the SAR antenna.

It is important to know that:

- Constant displacements, which affect all Persistent Scatterers in the observed "Geographical Region", are not detected.
- The system is designed to estimate displacements characterized by a linear trend, which means that displacement rate variations over time are not properly represented.

Good PS candidates - like roofs, poles, bridges - are typically found in urban settlements, or other man-made structures such as green-houses, dams, metallic and concrete features (e.g. well fields surrounding structures, pipelines and dwells). Beside these artificial features, also natural targets such as well exposed outcropping rock formations are potential PS.
The temporal distribution of the acquisitions shall also be adequate compared with the expected dynamics of the displacements under analysis.
The unique feature of the PS technique is to take advantage of the dense distribution of scatterers to remove most of the fluctuation of the signal propagation delay, which is mostly due to variations in the troposphere; this approach is essentially the same used for a differential GPS.

Technical Note

After the interferograms generation, an offset phase is removed from all interferograms.
One or more pixels (Reference Points) are automatically selected by the program for the calculation of the phase offset to remove.
The number of the 'Reference Points' depends on the size of the Area of Interest. As default, just one 'Reference Point' is selected for Areas within **5 sqkm**, (refer to the Preferences>Persistent Scatterers>Area for Single Reference Point).
At this point, the algorithm can follows two kind of directions:

- Areas of analysis with size within the value specified by the 'Area for Single Reference Point' parameter are processed using just one 'Reference point' for the entire Area.
- A second approach is carried out when larger Area has to be analyzed. Then the entire area is splitted into more sub-areas taking into account the overlap percentage too, each one with size corresponded to the input parameter. Every sub areas is processed in independent way. Finally, a mosaicing operation is carried out to merge all sub - areas and getting the the whole result.

From this stage all the re-flattened interferograms, together with the phase-height pair-by-pair proportionality factors (_k_factor files, which are stored in the "work/work_interferogram_stacking"), are used to estimate the residual height and the displacement related information (i.e. velocity), which are known as low pass components. These components are removed from the re-flattened interferograms before the atmosphere estimation process takes place.

Unlike the SBAS tool, just one model is implemented:

- **Linear Model**, to estimate residual height and displacement velocity.

The model can be synthesized as follows:

$$Disp = V*(t-t_0)$$

where *Disp* is the displacement at time *t*; *V* is the displacement velocity.

Input Files

Auxiliary file
Reference file generated as output of the "Connection Graph" step and possibly updated 551 afterwards. This file is mandatory.

Parameters - Principal Parameters

Displacement Sampling (mm/year)
This corresponds to the sampling frequency (in mm/sec) which is used to estimate the displacement velocity.

Min Displacement Velocity (mm/year)
This corresponds to the value expected (in mm/year) as the minimum displacement velocity.

Max Displacement Velocity (mm/year)
This corresponds to the value expected (in mm/year) as the maximum displacement velocity.

Residual Height Sampling (m)
This corresponds to the sampling frequency (in meters) which is used to estimate the residual height.

Min Residual Height (m)
These correspond to the minimum (negative value) residual height, with respect to the reference Digital Elevation Model.

Max Residual Height (m)
These correspond to the maximum (positive value) residual height, with respect to the reference Digital Elevation Model.

Area For Single Reference Point (sqkm)
It refers to the maximum size for one 'Reference Point'.

Overlap for SubArea (%)
It refers to the overlap between the sub areas.

Rebuild All
By setting this flag the whole SBAS Inversion process is started from scratch.

It is advisable to leave this flag unchecked in case of process interruption, so that the products already generated have not to be computed and stored again.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

ps_first_inversion
Directory containing the following products:

- **Height_first**, corresponding to the correction (in meters) with respect to the input Digital Elevation Model.

- **Velocity_first**, corresponding to the mean displacement velocity (in mm/year). This product is not generated when the "No Displacement Model" is selected.

- **cc_first**, corresponding to the multitemporal coherence. It shows how much the displacement trend fits with the selected model.

The displacement values are reported with:

- Positive sign if the movement corresponds to a decrease of the sensor-to-target slant range distance.
- Negative sign if the movement corresponds to an increase of the sensor-to-target slant range distance.

After the 'Reference Points' selection two shape files are generated:

- **Ref_GCP**, which refers to the GCPs selected on the image, in slant range geometry.
- **Ref_GCP_geo**, which refers to the GCPs selected on the image, in geographic coordinates. It is stored inside the Geocoding folder, (geocoding).
- **SubAreas**, which refers to the sub-areas (slant range geometry) computed according to the

atmospheric parameters, (refer to the Preferences>Persistent Scatterers>Area for Single Reference Point and 'Area Overlap for SubAreas).

- **SubAreas_geo,** which refers to the sub-areas (Cartographic coordinates) computed according to the atmospheric parameters, (refer to the Preferences>Persistent Scatterers>Area for Single Reference Point and 'Area Overlap for SubAreas). It is stored inside the Geocoding folder, (geocoding).

In order to avoid loading failures it is recommended not to move any file from its original repository folder.

- Meta files allowing to load the specific processing results (_meta).
- The "slant_range_dir" subfolder, which contains all processing results, in slant geometry, which are loaded by means of the meta files.
- The "work_dir" subfolder is used to store intermediate processing results.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

P. Berardino, G. Fornaro, R. Lanari, E. Sansosti: "A new algorithm for surface deformation monitoring based on Small Baseline differential SAR Interferometry". IEEE Aerospace and Electronic, Vol. 40, No. 11, November 2002.

1.7.3.6 4 - Inversion: Second Step

Purpose

This is the final inversion, which uses the first linear model products coming from the previous step 494 to estimate the atmospheric phase components.
The second model inversion is implemented to derive the date by date displacements, after removing the atmospheric phase components and eventually fit the final displacement velocity model. This step is mandatory.

Technical Note

The re-flattened interferograms are used to estimate the displacement related information (i.e. velocity, residual heights and date specific displacements).

Unlike the SBAS tool, just one model is implemented:

- **Linear Model**, to estimate height and displacement velocity.

The model can be synthesized as follows:

$$Disp = K + V*(t-t_0)$$

where *Disp* is the displacement at time *t*; *K* is the constant term of order zero, which is used only for the final fitting process; *V* is the displacement velocity;

Once the date by date displacement measurements (known as high pass components) are carried out, the program performs the estimate of the atmospheric effects.
First, the linear model previously estimated is subtracted date by date, from the interferograms measurements (_dint files).Then the atmospheric correction is performed by the following two filtering procedures:

- **Atmosphere Low Pass**, this accounts for the spatial distribution of the atmospheric variations. It is implemented by using a square window: large windows are more suitable to correct large scale variations, while small windows are better to correct isolated artifacts due to localized variations. The smaller is the window size, stronger will be the filter effect.

- **Atmosphere Hi Pass**, this accounts for the temporal distribution of the atmospheric variations. It is implemented by using a temporal window: large windows are more suitable to correct effects with low temporal variability, while small windows are better to correct frequent atmospheric variations. The bigger is the window size, stronger will be the filter effect.

The displacement values are reported with:

- Positive sign if the movement corresponds to a decrease of the sensor-to-target slant range distance.
- Negative sign if the movement corresponds to an increase of the sensor-to-target slant range distance.

It is worthwhile to mention that the re-flattening, which is performed on the displacement products, does not foresee the orbital refinement; it means than only a ramp (using minimum three GCPs) or a constant term (using minimum one GCP) can be removed..

A graphic, showing the extracted displacement information, can be created using the General Tools>Raster analyzer745.

Input Files

Auxiliary file
Reference file generated as output of the "Connection Graph" step and possibly updated551 afterwards. This file is mandatory.

Parameters - Principal Parameters

Atmosphere Low Pass Size
Enter the window size, in meters, to apply the spatial distribution related filter (refer to the Technical Note).

Atmosphere High Pass Size
Enter the window size, in days, to apply the temporal distribution related filter (refer to the Technical Note).

Rebuild All
By setting this flag the second step of the SBAS Inversion process is started from scratch.

It is advisable to leave this flag unchecked in case of process interruption, so that the products already generated have not to be computed and stored again.

Parameters - Global

It brings to the general section of the Preferences759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

second_inversion
Directory containing the following products:

- **Height**, corresponding to the correction (in meters) with respect to the input Digital Elevation Model, after atmospheric correction.
- **precision_height**, corresponding to the estimate in meters of the residual height measurement average precision (refer to the Phase to Height conversion 314 for more details).
- **Velocity**, corresponding to the mean displacement velocity (in mm/year, after atmospheric correction.
- **precision_vel**, corresponding to the estimate in millimeter/year of the velocity measurement average precision (refer to the Phase to Displacement conversion 320 for more details).
- **cc**, corresponding to the multitemporal coherence. It shows how much the displacement trend fits with the selected model.

Meta files allowing to load the specific processing results (_meta).

- **slant_atm_meta**, which refers to date by date atmospheric related components in slant range geometry. This meta file can be found in the working folder.
- **slant_dint_reflat_meta**, which refers to the date by date flattened interferograms, measured in slant range geometry, after the atmospheric correction.
- **slant_disp_meta**, which refers to the date by date displacements, measured in slant range geometry, after the atmospheric correction.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch

processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

P. Berardino, G. Fornaro, R. Lanari, E. Sansosti: "A new algorithm for surface deformation monitoring based on Small Baseline differential SAR Interferometry". IEEE Aerospace and Electronic, Vol. 40, No. 11, November 2002.

1.7.3.7 5 - Geocoding

Purpose

The PS products are geocoded and the displacements can be displayed in two kind of format: Shape and/ or Raster according to the flag selected from the parameters.
In order to obtain reliable displacement measurements, one or more Ground Control Points (e.g. coming from GPS or other ground measurements) - "**Displacement GCP file**" - can be entered as input to the processing. This information is used to optimize the displacement trend assessment. In case only 1 GCP is selected, the correction will consist of a mean velocity constant offset, which does not have any spatial variation; if more GCPs are selected, the correction will consist of the best fitting calculated from all GCPs. The Ground Control Points must be provided in cartographic co-ordinates.

Technical Note

Refer to the Interferometry module 320 for details.

The output results consist of geocoded products, which correspond to the outputs of both the step 1 494 and the step 2 499. These are:

- **Ref_GCP_geo**, shape file corresponding to the Reference Points of the highest MuSigma values (i.e. those used for the phase offset removal) automatically selected during the step 1.
- **SubAreas_geo**, shape file corresponding to the sub areas estimated according to the "Area For

Single Reference Point" parameter, ().

- **mean_geo,** SAR Intensity average image and associated header files (.sml, .hdr).
- Meta files (_meta), useful to load at once the displacement velocity, the residual height, the coherence images and the date-by-date displacements (the latter only when the "Geocoded Raster Products" flag is checked.
- Meta files (_meta), with the displacement projected along the maximum slope direction (_SD) and on the vertical plane (_VD).
- "work" subfolder, where intermediate processing results are stored.
- PS map and related information (PS_thrCohe_Id.shp and .kml), where thrCohe is the coherence threshold and Id is the shape index.
- Maximum slope direction values (_ADF), with the associated header files (.sml, .hdr).
- Maximum slope inclination values (_IDF), with the associated header files (.sml, .hdr).
- Azimuth Line of Sight (_ALOS) with the associated header files (.sml, .hdr). Positive angles are measured clockwise from the North; negative angles are measured counterclockwise from the North.
- Incidence angle of the Line of Sight (_ILOS) with the associated header files (.sml, .hdr). The angle is measured between the Line Of Sight and the vertical on the ellipsoid (flat earth).

general products which are:

- **_geo_vel+height_meta**, which refers to the height and displacement velocity measurements in the output cartographic projection.

- **_geo_otherinfo_meta**, which refers to the power mean, the multitemporal coherence, the height measurement precision and the corrected height measurements in the output cartographic projection.

- **_geo_disp_first_meta**, which refers to the date by date displacements, measured in the output cartographic projection, without atmospheric correction.

- **_geo_disp_meta**, which refers to the date by date displacements, after the atmospheric correction, in the output cartographic projection.

Pixels with a Precision (respectively "Height Precision Threshold" for the height related products and "Velocity Precision Threshold" for the displacement related products) higher than the specified thresholds, are masked out.

It is possible to move the entire SBAS_processing folder in another disk location without causing any problem in the further steps.

It is worthwhile to mention that the re-flattening is performed on the displacement products.

A graphic, showing the extracted displacement information, can be created using the General Tools>Raster analyzer 745.

Input Files

Auxiliary file
Reference file generated as output of the "Connection Graph" step and possibly updated 551 afterwards. This file is mandatory.

Optional Files

Displacement GCP file
Shape or .xml file related to the GCPs used to assest the final result.

DEM/Cartographic System

Digital Elevation Model file
Name of the Digital Elevation Model file. This should be referred to the ellipsoid. This file is optional. In case it is omitted, the ellipsoidal height and the relevant cartographic reference system, must be entered.

Output Projection
In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters

The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Upper Limit KML Scaling

The maximum expected displacement rate (integer value of the velocity in mm/year) is set.

Lower Limit KML Scaling

The minimum expected displacement rate (integer value of the velocity in mm/year) is set.

Make Geocoded Raster

By setting this flag the slant range products are geocoded onto the Digital Elevation Model cartographic reference system and the ultimate PS products are generated in raster format.
The raster product can be projected along both the maximum slope direction (_SD) and on the vertical plane (_VD).

Make Geocoded Shape

By setting this flag the slant range products are geocoded onto the Digital Elevation Model cartographic reference system and the ultimate PS products are generated in vector format.

Product Coherence Threshold

Pixels with coherence values smaller than this threshold cannot be kept as Persistent Scatterers.

Rebuild All

By setting this flag the whole geocoding process is started from scratch.

It is advisable to leave this flag unchecked in case of process interruption, so that the products already generated have not to be computed and stored again.

Vertical Displacement

By setting this flag the displacements and velocity products are projected on the vertical direction.

Slope Displacement

By setting this flag the displacements and velocity products are projected along the maximum slope.

Displacement Custom Direction

By setting this flag any vector can be specified, in terms of azimuth (**Azimuth Angle**, measured in degrees from the North - clockwise direction) and inclination (**Inclination Angle**, measured in degrees from the horizontal plane). The map showing the displacement values projected on the specified direction is generated among the output products.

X Dimension (m)
The grid size of the output data in Easting (X) must be defined; the default unit of measure is meters. Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Y Dimension (m)
The grid size of the output data in Northing (Y) must be defined; the default unit of measure is meters. Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Geocoding

It brings to the geocoding section of the Preferences 766 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Displacement Projection

Stand by.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

geocoding
Directory containing the following products:
- Meta files allowing to load the specific processing results (_meta).
- The "geocoded_dir" subfolder, which contains all processing results, in cartographic co-ordinates, which are loaded by means of the meta files.

_ADF
Maximum slope direction values, with the associated header files (.sml, .hdr).

_IDF
Maximum slope inclination values, with the associated header files (.sml, .hdr).

_SD
Displacement values along the maximum slope direction, with the associated header files (.sml, .hdr).

_VD
Vertical displacement values, with the associated header files (.sml, .hdr).

_ALOS
Azimuth Line of Sight with the associated header files (.sml, .hdr). Positive angles are measured clockwise from the North; negative angles are measured counterclockwise from the North.

_ILOS
Incidence angle of the Line of Sight with the associated header files (.sml, .hdr). The angle is measured between the Line Of Sight and the vertical on the ellipsoid (flat earth).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.7.4 SBAS

Section Content

1.7.4.1 Overview

A Note on the SBAS functionality

It is conceived for the generation of products aimed at monitoring the temporal evolution of surface deformations.
In case the input temporal series has to be used for digital elevation modelling (not land displacement), the program can be specifically tuned for producing an output Digital Elevation Model from multiple InSAR pairs, discarding completely the generation of surface deformation related products.

The approach used for Land displacement mapping is based on the combination of interferograms coming from data pairs characterized by small spatial (normal) and temporal baseline.
The approach used for Digital elevation modelling 529 is based on the combination of interferograms coming from data pairs characterized by a user defined baseline interval.

The use of large temporal series enables to improve the identification and further removal of atmospheric related effects (artifacts) by means of a dedicated space-time filtering operation. A minimum number of three acquisitions is required, but more (at least twenty) are suggested to get reliable results especially in case of low coherence conditions. It must be noted that the atmospheric removal process is not performed when the program is operated for Digital elevation modelling (i.e. discarding surface deformation related products).

ScanSAR data cannot be processed with this module.

The output products are stored in step-specific folders, which the program creates during the processing execution. These folders are automatically named using, as prefix, the "Output Root Name", which is entered in the first processing step 510. In order to avoid processing failures it is recommended not to move any file from its original repository folder.

The "Auxiliary file" (marked by the extension _ausiliary.sml) is saved in the output root directory and it is updated during the execution of the different processing step. It is the input used, from the Area of Interest Definition 516 step onwards, throughout the whole processing chain; it is important to note that the first input to enter, in any processing panel, is the "Auxiliary file". This file contains information to understand which steps have been executed, what are the products generated and the processing parameters setting.

It is important to know that constant displacements, which affect all the area in the observed "Geographical Region", are not detected.

The following processing sequence is generally adopted:

Connection Graph

All images are connected to create a network of master and slaves pairs, which are linked each other only whether the baseline values are within the input thresholds. All data are coregistered onto a super master acquisition, which can be automatically identified by the program or manually selected by the user.

Area of Interest Definition

This is an optional step, which has to be executed in case an area of interest (i.e. a region smaller than the input scene whole coverage) has to be extracted and processed.

Interferometric Workflow

The flattened and filtered interferograms (and related coherence images), together with the corresponding unwrapped phases (overwritten to the original ones after the orbital refinement and re-flattening) are generated.

Refinement and Re-flattening

The orbital refinement and the phase re-flattening process is performed for all pairs at once. Due to this, the criteria for the GCPs selection must be fulfilled for all possible interferometric pairs.

SBAS Inversion

The displacement (date by date value, velocity, acceleration and acceleration variation) and height (correction values and new DEM) related products are generated on the basis of the selected input model. The atmospheric corrections, related to spatial and temporal variations, are also performed in this step.

Geocoding

All processing results are projected onto the selected cartographic system; the displacement measurements can be re-projected onto a user-defined direction. Data must necessarily be geocoded if the Raster to Shape Conversion has to be performed afterwards.

Raster to Shape Conversion

The raster outputs generated in the previous step are converted into shape and kml files.

Note that:

- SAR data must be imported (see Basic module 32).
- SAR RAW products must be imported and focussed (refer to Focusing module).
- Default setting for selected parameters can be specified in the Preferences panel.
- The SAR Tutorial, which includes basic knowledge on SAR theory and data processing, complements the online help.
- Data geocoded to GEO-GLOBAL cartographic reference system can be automatically displayed into the Google Earth environment by double clicking on the output .kml file.
- Co-ordinate decimal values must be entered using the dot (e.g. 29.30) and not the comma (e.g. 29,30) character.

References

P. Berardino, G. Fornaro, R. Lanari, E. Sansosti: "A new algorithm for surface deformation monitoring based on Small Baseline differential SAR Interferometry". IEEE Aerospace and Electronic, Vol. 40, No. 11, November 2002.

1.7.4.2 1 - Connection Graph

Purpose

This functionality defines the SAR pair combination and connection network, which is used for the generation of the multiple differential interferograms 519. This step is mandatory. It is important to remember that this network can be edited 551 at any step, from the Interferometric Workflow 519 to the SBAS Inversion 535

Technical Note

The network links created in this step are only those connecting pairs that are within the temporal and spatial baseline values specified in the relevant "Input Parameters". Those acquisitions which remain disconnected, due to baseline values exceeding the specified thresholds, are discarded from the further SBAS analysis.

At the end of the processing an IDL graph is shown, where all connection are represented as well as the selected Super Master. Each acquisition is represented by a diamond associated to an ID number, which is reported also in both the "CG_report.txt" file and the Edit Connection Graph>Master/Slave lists 551 panel and the intermediate products file names. The colour of the diamond symbol is as follows: i) Discarded acquisitions due to user specific constraints in red colour; ii) Valid acquisitions in green colour; iii) Super Master acquisition in yellow colour.

The following graphs are generated:

- **Time-Position plot**, which provides the normal distance from the Super Master (y axis) and the input acquisition dates (x axis).
- **Time-Baseline plot**, which provides the normal baseline (y axis) and the input acquisition dates (x axis).
- **Time-Position Delaunay 3D plot**, which provides the normal distance from the Super Master (y axis) and the input acquisition dates (x axis). This is generated only when the "Delaunay 3D" flag has been checked. The connections here are a subset of the full redundant connection graph (i.e. "Time-Position Plot")

They can be reloaded and edited at any processing step by means of the relevant tool 553.

The multilooking factors of the output Super Master image (prefix "CG_super_master") are automatically calculated by taking into account the Cartographic Grid Size, which is set in the relevant SARscape Preferences 759 panel.

Min - Max Normal Baseline
Only those pairs whose baseline is between the "Min Normal Baseline" and the "Max Normal Baseline" are considered. The Min and Max Normal Baseline values are expressed here as percentage of the critical baseline value.

Only Forward Pair
The results of the processing, in terms of displacement/height measurements, does not change if this flag is checked or not. What changes is that, selecting this flag, the number of master images typically increases as well as the processing time. This option can be selected in case the objective is to analyse the output products, such as the interferograms, in chronological sequence.

Redundancy
This setting enables to define how many connections, which link each acquisition to other ones for making InSAR pairs (acceptable on the basis of the specified baseline thresholds), are kept. As a rule of thumb 5 connections per acquisition can be considered as a good redundancy value. The statistics relevant to the redundancy values are reported in the output "CG_report.txt".

Allow Disconnected Blocks
The program normally discards those images (or isolated groups of connected acquisitions), which are not linked to the main tree. This default setting, which is activated when the flag is unchecked, is typically preferred when the program is executed for the detection of land displacements.
Nevertheless the program can also be operated by allowing the presence of isolated groups of images

(i.e. made of two or more connected acquisitions). This setting, which is activated when the flag is checked, allows the generation of more interferograms; this is typically preferred for the height estimates. Note that the height estimate (or DEM generation) is performed by selecting the "No Displacement Model" flag in the SBAS Inversion 529 step. Nevertheless this setting can be used also for the displacement measurements in order to have an interpolated estimate in the temporal gaps in between isolated blocks; due to the fact that the temporal gaps are filled with interpolated values, their reliability have to be carefully assessed.

Delaunay 3D
This approach is especially intended to improve the quality of the unwrapping for those datasets, which are characterised by scattered areas of low coherence.

The program generates a triangular connection network in the time baseline domain, which is suitable for the 3 dimensional unwrapping. By checking this flag the following options are disabled:

- Redundancy Low
- Only Forward Pairs
- Allow Disconnected Blocks

The only acquisitions used are those which can be triangulated with a Delaunay consistent network, the others will be discarded.

An important consideration, which is relevant to the use of the coherence in the 3D unwrapping, is the following: a pixel is unwrapped if its coherence value is higher than the "Unwrapping Coherence Threshold" in at least 75% of the pairs exploited by the 3D connections. This constraint provides robustness and reliability to the unwrapped products and it also allows to notably reduce the processing time by increasing the "Unwrapping Coherence Threshold" (note that the 3D unwrapping is much more demanding than the normal 2D approach in terms processing time). As a general rule, the "Unwrapping Coherence Threshold" should be set to 0.3÷0.4 when the 3D unwrapping is performed.

Auxiliary file
It contains information to understand which steps have been executed, what are the products generated and the processing parameters setting. Experienced users can eventually edit this file to modify the parameters relevant to each SBAS processing step.

Input Files

Input file list
Input files (_slc) to be used. This file list is mandatory.

Optional Files

Super Master file
Name of the the acquisition to use as processing reference data. This acquisition must be contained in

the "Input File list" as well. If this file is not entered the program identify it in order to have the maximum number of connected acquisitions. This file is optional.

Parameters - Principal Parameters

Min Normal Baseline (%)
This threshold corresponds to the minimum percentage of the critical baseline value, which is considered acceptable in the generation of the possible data connections.

Max Normal Baseline (%)
This threshold corresponds to the maximum percentage of the critical baseline value, which is considered acceptable in the generation of the possible data connections.

Min Temporal Baseline
This threshold corresponds to the minimum temporal distance, which is considered acceptable in the generation of the possible data connections. This value is expressed in days.

Max Temporal Baseline
This threshold corresponds to the maximum temporal distance, which is considered acceptable in the generation of the possible data connections. This value is expressed in days.

Allow Disconnected Blocks
By setting this flag the program does not discard any group of images (refer to the Technical Note).

Delaunay 3D
By setting this flag a triangular connection network in the time baseline domain is generated, which is suitable for the 3 dimensional unwrapping (Refer to the Technical Note).

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

Min Normal Baseline (%)
This threshold corresponds to the minimum percentage of the critical baseline value, which is considered acceptable in the generation of the possible data connections.

Max Normal Baseline (%)
This threshold corresponds to the maximum percentage of the critical baseline value, which is considered acceptable in the generation of the possible data connections.

Min Temporal Baseline

This threshold corresponds to the minimum temporal distance, which is considered acceptable in the generation of the possible data connections. This value is expressed in days.

Max Temporal Baseline

This threshold corresponds to the maximum temporal distance, which is considered acceptable in the generation of the possible data connections. This value is expressed in days.

Degree of Redundancy

The following options are foreseen:

High
All possible connections are kept.

Low
The minimum number of connections is kept, while redundant ones are removed on the basis of the "Criteria" described below.

Criteria

The following selection criteria are foreseen for the removal of redundant connections:

Min Normal Baseline
The number of connections is minimized by keeping only those having the smallest spatial baseline.

Max Normal Baseline
The number of connections is minimized by keeping only those having the largest spatial baseline.

Min Temporal Baseline
The number of connections is minimized by keeping only those having the smallest temporal baseline.

Only Forward Pair

Selecting this options, those pairs where the master is acquired before the slave are inverted (i.e. the original slave image becomes a new master).

Allow Disconnected Blocks

By setting this flag the program does not discard any group of images (refer to the Technical Note).

Delaunay 3D

By setting this flag a triangular connection network in the time baseline domain is generated, which is suitable for the 3 dimensional unwrapping (Refer to the Technical Note).

Grid Size for Suggested Looks

The grid size, in meters, used to tune range and azimuth looks. If the other parameters are manually set, the grid size will not imply a change in their values.

Output Files

Output Root Name
Name of the output root. This file is mandatory. It is used as root name throughout the entire SBAS processing chain.

_connection_graph_dir
Directory containing the following products:
- Multilooked Super Master intensity image (_pwr) and associated header files (.sml, .hdr).
- Report file (CG_report.txt) showing various input selection parameters such as: selected super master, number of masters, baseline and doppler values, adopted selection criteria and thresholds, etc. In case the Connection Graph is edited 551 afterwards, the original report is updated and the old one/s is/are saved in the "work_dir" subfolder.
- The "work_dir" subfolder is used to store intermediate processing results as well as files used for the visualization and interfacing with ENVI.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

_auxiliary.sml
Text file with process related information (products, parameters, etc.)

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.7.4.3 Area of Interest Definition

Purpose

A spatial subset of the data can be performed by manually specifying the area of interest either with its corner co-ordinates or using a vector file. This step is optional.

Technical Note

In case the processing has to be executed on a portion of the input data, the data resize must be executed using this tool. Once the Auxiliary file 509 (which was generated in the "Connection Graph" step) is entered as input, the "Reference file" (multilooked super-master image) is automatically loaded in ENVI in order to draw the subset polygon or identify the pixel co-ordinates for the subset.

The subset co-ordinates must be referred to the multilooked "Super Master file", which is automatically opened once the "Auxiliary file" is entered as input.

In order to avoid loading failures it is recommended not to move any file from its original repository folder.

Input Files

Auxiliary File
Reference file generated as output of the "Connection Graph" step. This file is mandatory.

Optional Files

AOI Box File
A vector file (.shp) can be entered to specify the area to be processed. In case the area is irregular, the circumscribed rectangular area is considered.
This file is optional.

DEM/Cartographic System

Digital Elevation Model file
Digital Elevation Model file name. This file is optional.

Output Projection
In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the Cartographic System 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Rebuild All
By setting this flag the whole process is started from scratch.

It is advisable to leave this flag unchecked in case of process interruption, so that the products already generated have not to be computed and stored again.

Geographical Region
By setting this flag the area to be processed is specified in cartographic co-ordinates or georeferenced vector file (referred to the input DEM or Cartographic system); otherwise file co-ordinates (i.e. slant range geometry) must be entered. The selected region is referred to the master data. Co-ordinate decimal values must be entered using the dot (e.g. 29.30) and not the comma (e.g. 29,30) character.

- **West/First column**
  The Westernmost cartographic co-ordinate or the first column file co-ordinate.

- **East/Last column**
  The Easternmost cartographic co-ordinate or the last column file co-ordinate.

- **North/First row**
  The Northernmost cartographic co-ordinate or the first row file co-ordinate.

- **South/Last row**
  The Southernmost cartographic co-ordinate or the last row file co-ordinate.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Coregistration

It brings to the coregistration section of the Preferences 770 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Cut

See the Principal Parameters section for the parameters description.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

_aoi_definition_dir
Directory containing the following products:
- Subset of all the SLC inputs (prefix AOI_) and associated header files (.sml, .hdr).
- The "power_dir" subfolder, which is used to store all subsets (prefix AOI_) of the multilooked input intensity images (_pwr) and associated header files (.sml, .hdr).

_connection_graph_dir
This folder had been created in a previous processing step 510; it is used to store the following new product:
- Subset multilooked Super Master intensity image (_aoi_pwr) and associated header files

(.sml, .hdr).

- The report file (CG_report.txt), which had been generated in the previous processing step 510, is updated. The previous report file is saved in the "work_dir" subfolder.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.7.4.4 2 - Interferometric Process

Purpose

This functionality enables to execute, in an automatic way, the following processing sequence:

- Interferogram Generation and Flattening 293.
- Adaptive Filter and Coherence Generation 300.
- Phase Unwrapping 305.

This step is mandatory.

Technical Note

The different steps implemented here are executed using the default processing approach (consult the reference guide specific to each processing step for more details); in particular:

- The Interferogram Flattening is performed using an input reference Digital Elevation Model or the ellipsoidal model if the DEM is not inputted; the "Geometry GCP file", if entered, is used to correct the master image (i.e. Super Master acquisition of the interferometric stack) onto the Digital Elevation Model. The better the reference Digital Elevation Model accuracy/resolution the better the result in terms of topography removal. It is important to note that, in case the Super Master image has already been corrected with the the manual722 or the automatic719 procedure the GCP is not needed.
- When the Connection Graph510 has been executed with the "Delaunay 3D" option, the unwrapped products corresponding to the connections shown in the "Time-Position Delaunay 3D plot" are marked by the _del_upha extension.

The data multilooking factors are relevant to the Super Master image. In case the input SAR series contains data with different pixel sampling (e.g. ALOS PALSAR FBS and FBD acquisitions), the program automatically changes the multilooking factors of each interferometric pair depending on its master acquisition mode.

Due to the large number of output products, the following three meta files are generated. They enable to load at once all relevant output products:

- **_cc_list_meta**, which refers to all coherence images.
- **_fint_list_meta**, which refers to all flattened and filtered interferograms.
- **_upha_list_meta**, which refers to all unwrapped phases. Note that this same extension is used for the 2nd level unwrapped products, which are generated during the SBAS Inversion529 step.
- **_slant_pwr_meta**, which refers to all slant range power images.

In order to avoid loading failures it is recommended not to move any file from its original repository folder.

Input Files

Auxiliary file
Reference file generated as output of the "Connection Graph" step and possibly updated551 afterwards. This file is mandatory.

Optional Files

Geometry GCP file

Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File) or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the "Tools>Generate Ground Control Point 747" for details). This file is optional. If an area of interest 516 has been previously specified, then the GCP must be located within that area.

DEM/Cartographic System

Digital Elevation Model file

Name of the Digital Elevation Model file. This should be referred to the ellipsoid. This file is optional. In case it is omitted, the ellipsoidal height and the relevant cartographic reference system, must be entered.

Output Projection

In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System** 6:

State

Definition of the country or general projection systems.

Projection

Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid

Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere

Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone

Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters

Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height

In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters

The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Range Looks
Number of looks in range referred to the Super Master.

Azimuth Looks
Number of looks in azimuth referred to the Super Master.

Rebuild All
By setting this flag the whole process is started from scratch.

It is advisable to leave this flag unchecked in case of process interruption, so that the products already generated have not to be computed and stored again.

Unwrapping Method Type
The choice is given between the following unwrapping methods:

- *Region Growing*, the Region Growing unwrapping method is used;
- *Minimum Cost Flow*, the Minimum Cost Flow (square grid) unwrapping method is used;
- *Delaunay MCF*, the Minimum Cost Flow (triangular grid) unwrapping method is used.

Unwrapping 3D
By setting this flag, the 3D unwrapping method is used. This button is enabled only if the Delaunay 3D option 512 had been selected in the "Connection Graph" generation.

Unwrapping Decomposition Level
The number of multilooking and undersampling iterations can be specified (refer to the Phase Unwrapping 305).

Unwrapping Coherence Threshold
Pixels with coherence values smaller than this threshold are not unwrapped.

Filtering method
The choice is given between the following filtering methods according to the default values of the filtering section of the Preferences 783 parameters:

- *Adaptive window;*
- *Boxcar window;*
- *Goldstein.*

Parameters - Global

It brings to the general section of the Preferences759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Interferogram

It brings to the interferometry section of the Preferences779 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Flattening

It brings to the flattening section of the Preferences775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Filtering

It brings to the adaptive filter section of the Preferences783 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Phase Unwrapping

It brings to the phase unwrapping parameters section of the Preferences779 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Coregistration

It brings to the coregistration section of the Preferences770 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Geophysical Model

TBD

Parameters - Other Parameters

It brings to the general section of the Preferences759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

_interferogram_stacking_dir
Directory containing the following products:

- Meta files allowing to load the specific processing results (_meta).
- The "slant_range_dir" subfolder, which contains all processing results which are loaded by means of the meta files.
- The "work_dir" subfolder is used to store intermediate processing results.

In order to distinguish the input SAR pair where each output product comes from (as well as to identify it in the connection network), a prefix containing the master-slave acquisition dates (i.e. yyyymmdd) and the master-slave relationships will be added.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None

1.7.4.5 3 - Refinement and Re-Flattening

Purpose

This functionality enables to execute the orbital refinement and phase re-flattening process for all pairs at once. This step is mandatory.

Technical Note

The Interferogram Refinement and Re-flattening 308 is a mandatory step. A Ground Control Point file (i.e. "Orbital GCP file") must be previously generated; the points must be located onto the Super Master image geometry (typically the _fint or _upha files are the best products for the GCP location). It is suggested to use the "Residual Phase" option (Preferences>Flattening>Refinement and Re-flattening>Refinement Method 775) in order to make the system more robust.

The Ground Control Points in the "Orbital GCP file" are selected with the same criteria and for the same purpose of the Ground Control Points used in the Refinement and Re-flattening 308 step. Note that the criteria for the GCPs selection must be fulfilled for all possible interferometric pairs. As result of this processing step, the unwrapped phases (upha) and the flattened/filtered interferograms (_fint) are overwritten in the "slant_range_dir" subfolder; the original ones are stored in the output "work_dir" subfolder. The "_upha_list_meta" and the "_fint_list_meta", are both updated with the link the the re-flattened products.

From this step onwards, it is possible to move the entire SBAS_processing folder in another disk location without causing any problem in the further steps.

Due to the large number of output products, the following three meta files are generated. They enable to load at once all relevant output products:

- **_reflat_fint_list_meta**, which refers to all re-flattened and filtered interferograms.

- **_reflat_upha_list_meta**, which refers to all re-flattened unwrapped phases. Note that this same extension is used for the 2nd level unwrapped products, which are generated during the SBAS Inversion 529 step.

Input Files

Auxiliary file
Reference file generated as output of the "Connection Graph" step and possibly updated 551 afterwards. This file is mandatory.

Refinement GCP file
Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File) or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the

"Tools>Generate Ground Control Point 747" for details). If an area of interest 516 has been previously specified, then the GCP must be located within that area. This file is mandatory.

DEM/Cartographic System

Digital Elevation Model file
Name of the Digital Elevation Model file. This should be referred to the ellipsoid. This file is optional. In case it is omitted, the ellipsoidal height and the relevant cartographic reference system, must be entered.

Output Projection
In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Rebuild All
By setting this flag the whole process is started from scratch.

It is advisable to leave this flag unchecked in case of process interruption, so that the products already generated have not to be computed and stored again.

Refinement method

The choice is given between the following refinement methods:

- *Automatic Refinement;*
- *Polynomial Refinement;*
- *Orbital Refinement.*

Refer to the flattening section of the Preferences 775 for further information about these methods.

Refinement Residual Phase Polynomial Degree

Degree of the polynomial used to estimate the phase ramp, which will be removed from the input unwrapped phase during the Re-flattening operation. In case this value is higher that the number of input Ground Control Points, it will be automatically decreased. The default values of 3 means that a phase ramp in range and azimuth direction plus a constant phase offset will be corrected. In case only the phase offset correction is needed, the polynomial degree will be set to 1.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Flattening

It brings to the flattening section of the Preferences 775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Interferogram

It brings to the interferometry section of the Preferences 779 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Refinement

It brings to the flattening section of the Preferences 775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Coregistration

It brings to the coregistration section of the Preferences770 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

_interferogram_stacking_dir
Directory containing the following products:

- Meta files allowing to load the specific processing results (_meta).
- The "slant_range_dir" subfolder, which contains all processing results which are loaded by means of the meta files.
- The "work_dir" subfolder is used to store intermediate processing results.

In order to distinguish the input SAR pair where each output product comes from (as well as to identify it in the connection network), a prefix containing the master-slave acquisition dates (i.e. yyyymmdd) and the master-slave relationships will be added.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None

1.7.4.6 4 - Inversion: First Step

Purpose

This functionality implements the first model inversion to derive the residual height and the displacement velocity. They are used to flatten the complex interferograms, redo the phase unwrapping and refinement and generate better products to input in the following step 535. This step is mandatory.

Technical Note

The re-flattened interferograms, together with the phase-height pair-by-pair proportionality factors (_k_factor files, which are stored in the "_interferogram_stacking_dir/work_dir"), are used to estimate the residual height and the displacement related information (i.e. velocity, acceleration and acceleration variation), which are known as low pass components. These components are removed from the re-flattened interferograms before the unwrapping process takes place.

Four different models can be selected:

- **No Displacement Model**, to estimate the height only (Digital Elevation Model). Selecting this model all displacement related products are not generated. Moreover the atmospheric removal processes are not executed.
- **Linear Model**, to estimate height and displacement velocity.
- **Quadratic Model**, to estimate height, displacement velocity and acceleration.
- **Cubic Model**, to estimate height, displacement velocity, acceleration and acceleration variation.

The three models can be synthesized as follows:

$$Disp = K1*(t-t_0) + 1/2\ K2*(t-t_0)^2 + 1/6\ K3*(t-t_0)^3$$

where *Disp* is the displacement at time *t*; K1 is the linear term, corresponding to the instantaneous displacement velocity; K2 is the quadratic term, corresponding to the instantaneous displacement

acceleration; K3 is the cubic term, corresponding to the instantaneous displacement acceleration variation.
The software will provide also the average velocity, the average acceleration and the average acceleration variation.
The average velocity is computed as average over a certain interval of the modeled values: a definite integral, that at the end is equal to the value of the modeled displacement in the last time of the interval minus the value of the modeled displacement in the first time of the interval, normalized(divided) by the interval duration time. If the model choose by the user is first order, the average velocity correspond to the linear term K1.
The average acceleration and the average acceleration variation are computed in the same way.

The multi temporal coherence is estimated as the absolute, normalized, complex sum of all the flattened (by subtracting the modeled phase) interferograms. It measures how well the model fits the measures. Smaller is the average residuals in the flattened interferograms higher is the multi temporal coherence value till a maximum value of 1 (when the model perfectly fits the measures and no residues left).

When the Connection Graph510 has been executed with the "Delaunay 3D" option, the unwrapped products corresponding to the connections shown in the "Time-Position Delaunay 3D plot" are marked by the _del_upha extension.

It is possible to move the entire SBAS_processing folder in another disk location without causing any problem in the further steps.

Allow Disconnected Blocks

The difference with respect to the same option, which is available in the connection graph510 step, it is that here the connection can be lost due to the presence of null values related to a coherence value lower than either the unwrapping coherence threshold (in the Interferometric Process519 step) or the product coherence threshold (in this step).

Wavelet Number of Levels

The Number of Levels, which refers to the power of a base 2, determines what is kept of the residual topography estimated. As an example, considering input data with a pixel spacing of 25 m, a "Number of Levels" of 1 means that the information coarser than 50 m is removed and the information finer than 50 m is preserved; a "Number of Levels" of 2 means that the information coarser than 100 m is removed and the information finer than 100 m is preserved; a "Number of Levels" of 3 means that the information coarser than 200 m is removed and the information finer than 200 m is preserved. It is suggested to set this value as a function of the reference DEM (which is used for the interferogram flattening) resolution; as an example, if we process SAR data with 3 m resolution with an SRTM reference DEM (90 m resolution), we'll enter a number of levels of 5 or more.

Stop Before Unwrapping

This option gives the possibility to edit the connection graph by discarding the results of the second phase unwrapping, which are not good.

The output results consist of height related products which are:

_height, corresponding to the correction (in meters) with respect to the input Digital Elevation

Model.

- **_precision_height**, corresponding to the estimate in meters of the height measurement average precision (refer to the Phase to Height conversion 314 for more details).
- **_srdem**, corresponding to the corrected Digital Elevation Model in slant range geometry.

displacement related products which are:

- **_term1_frst_est**, corresponding to the first degree term of the inversion polynomial (in mm/year). This product is not generated when the "No Displacement Model" is selected.

- **_term2_frst_est**, corresponding to the second degree term of the inversion polynomial (in mm/year^2). This product is not generated when the "No Displacement Model" is selected.

- **_term3_frst_est**, corresponding to the third degree term of the inversion polynomial (in mm/year^3). This product is not generated when the "No Displacement Model" is selected.

- **_vel_frst_est**, corresponding to the average displacement velocity (in mm/year). This product is not generated when the "No Displacement Model" is selected.

- **_acc_frst_est**, corresponding to the average displacement acceleration (in mm/year^2). This product is not generated when the "No Displacement Model" is selected.

- **_delta_acc_frst_est**, corresponding to the average displacement acceleration variation (in mm/year^3). This product is not generated when the "No Displacement Model" is selected.
- **_precision_velocity**, corresponding to the estimate in millimeter/year of the velocity measurement average precision (refer to the Phase to Displacement conversion 320 for more details).

intensity related products:

- **_mean_pwr**, corresponding to the mean intensity (digital number) calculated using all master images.

general products which are:
- **_cc**, corresponding to the multitemporal coherence. It shows how much the displacement trend fits with the selected model.

- **_chisqr**, which is a measure of the fitting and inversion quality. The higher this value the worse the fitting and inversion quality.

- **_norm_L1**, corresponding to the cumulated summation of the date by date absolute value displacements (in millimeters).

The displacement values are reported with:
- Positive sign if the movement corresponds to a decrease of the sensor-to-target slant range

distance.

- Negative sign if the movement corresponds to an increase of the sensor-to-target slant range distance.

Due to the large number of output products, the following meta files are generated. They enable to load at once all relevant output products:

- **_slant_vel+height_first_meta**, which refers to the residual height and displacement velocity, without fitting process, in slant range geometry.
- **_slant_other_info_meta**, which refers to the power mean, the multitemporal coherence, the height measurement precision and the corrected height measurements in slant range geometry.

- **_fint_list_meta**, which refers to all re-flattened filtered interferograms. From these interferograms the estimated displacement model and the estimated residual topography has been removed. Note that this same extension is used for the 1st level unwrapped products, which are generated during the Interferometric Process 519 step.
- **_upha_list_meta**, which refers to all unwrapped phases. From these unwrapped phase the estimated residual topography has been removed. Note that this same extension is used for the 1st level unwrapped products, which are generated during the Interferometric Process 519 step.
- **_reflat_upha_list_meta**, which refers to all re-flattened unwrapped phases. From these unwrapped phase the estimated residual topography has been removed. Note that this same extension is used for the 1st level unwrapped products, which are generated during the Interferometric Process 519 step.

In order to avoid loading failures it is recommended not to move any file from its original repository folder.

Input Files

Auxiliary file

Reference file generated as output of the "Connection Graph" step and possibly updated 551 afterwards. This file is mandatory.

Parameters - Principal Parameters

Product Coherence Threshold

Pixels with coherence values smaller than this threshold will be set to dummy (NaN) in the final products.

Wavelet Number of Levels

Level setting for the wavelet calculation. It determines the level of detail to preserve in the residual topography estimated.

Allow Disconnected Blocks

By setting this flag the program does not discard any group of images (refer to the Technical Note in the Connection Graph 511).

Model Type
The choice is given between the following models:

- *Linear*, the displacement velocity (mm/year) is calculated;
- *Step*, the displacement magnitude (in millimeters) is calculated;
- *No Model*, the displacement magnitude (in millimeters) is calculated.

Refer to the Technical Note for further informations.

Stop Before Unwrapping
By setting this flag, the phase unwrapping (last step of the processing sequence) is not executed.

Rebuild All
By setting this flag the whole SBAS Inversion process is started from scratch.

It is advisable to leave this flag unchecked in case of process interruption, so that the products already generated have not to be computed and stored again.

Unwrapping Method Type
The choice is given between the following unwrapping methods:

- *Region Growing*, the Region Growing unwrapping method is used;
- *Minimum Cost Flow*, the Minimum Cost Flow (square grid) unwrapping method is used;
- *Delaunay MCF*, the Minimum Cost Flow (triangular grid) unwrapping method is used.

Unwrapping 3D
By setting this flag, the 3D unwrapping method is used. This button is enabled only if the Delaunay 3D option 512 had been selected in the "Connection Graph" generation.

Unwrapping Decomposition Level
The number of multilooking and undersampling iterations can be specified (refer to the Phase Unwrapping 305).

Unwrapping Coherence Threshold
Pixels with coherence values smaller than this threshold are not unwrapped.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Phase Unwrapping

It brings to the phase unwrapping parameters section of the Preferences 779 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

_sbas_inversion_dir
Directory containing the following products:

- Meta files allowing to load the specific processing results (_meta).
- The "slant_range_dir" subfolder, which contains all processing results, in slant geometry, which are loaded by means of the meta files.
- The "work_dir" subfolder is used to store intermediate processing results.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

P. Berardino, G. Fornaro, R. Lanari, E. Sansosti: "A new algorithm for surface deformation monitoring based on Small Baseline differential SAR Interferometry". IEEE Aerospace and Electronic, Vol. 40, No. 11, November 2002.

1.7.4.7 5 - Inversion: Second Step

Purpose

This is the final inversion, which uses the optimized unwrapped products coming from the previous step 529.

The second model inversion is implemented to derive the date by date displacements, which are filtered to remove the atmospheric phase components and eventually fit the final displacement velocity model. This step is mandatory.

Technical Note

The re-flattened interferograms are used to estimate the displacement related information (i.e. velocity, acceleration, acceleration variation and date specific displacements).

Four different models can be selected from the previous step:

- **No Displacement Model**, to estimate the height only (Digital Elevation Model). Selecting this model all displacement related products are not generated. Moreover the atmospheric removal processes are not executed.
- **Linear Model**, to estimate height and displacement velocity.
- **Quadratic Model**, to estimate height, displacement velocity and acceleration.
- **Cubic Model**, to estimate height, displacement velocity, acceleration and acceleration variation.

The three models can be synthesized as follows:

$$Disp = K0 + K1*(t-t_0) + 1/2\ K2*(t-t_0)^2 + 1/6\ K3*(t-t_0)^3$$

where *Disp* is the displacement at time *t*; K0 is the constant term, K1 is the linear term, corresponding to the instantaneous displacement velocity; K2 is the quadratic term, corresponding to the instantaneous displacement acceleration; K3 is the cubic term, corresponding to the instantaneous displacement

acceleration variation.
The software will provide also the average velocity, the average acceleration and the average acceleration variation.
The average velocity is computed as average over a certain interval of the modeled values: a definite integral, that at the end is equal to the value of the modeled displacement in the last time of the interval minus the value of the modeled displacement in the first time of the interval, normalized(divided) by the interval duration time. If the model choose by the user is first order, the average velocity correspond to the linear term K1.
The average acceleration and the average acceleration variation are computed in the same way.

The multi temporal coherence is estimated as the absolute, normalized, complex sum of all the flattened (by subtracting the modeled phase) interferograms. It measures how well the model fits the measures. Smaller is the average residuals in the flattened interferograms higher is the multi temporal coherence value till a maximum value of 1 (when the model perfectly fits the measures and no residues left).

Interpol. Disconnected Blocks
This setting is intended to estimate the displacement measurements also in those part of the temporal series where the information does not exists. This can happen for instance due to:

- null pixel values.
- disconnected blocks 511 in case they had been previously allowed.

It has to be considered that the estimated trend comes from the interpolation of the actual displacement measured before and after the temporal gap; for this reason its reliability has to be carefully assessed.

Once the date by date displacement measurements (known as high pass components) are carried out, the program performs the estimate of the atmospheric effects. These atmospheric components are finally subtracted, date by date, from the displacement measurements. The atmospheric correction is performed by the following two filtering procedures:

- **Atmosphere Low Pass**, this accounts for the spatial distribution of the atmospheric variations. It is implemented by using a square window: large windows are more suitable to correct large scale variations, while small windows are better to correct isolated artifacts due to localized variations. The smaller is the window size, stronger will be the filter effect.

- **Atmosphere Hi Pass**, this accounts for the temporal distribution of the atmospheric variations. It is implemented by using a temporal window: large windows are more suitable to correct effects with low temporal variability, while small windows are better to correct frequent atmospheric variations. The bigger is the window size, stronger will be the filter effect.

It is important to note that the No Displacement Model 529 does not foresee the displacement calculation as well as the atmospheric removal.

The output results consist of displacement related products which are:

- **_term0**, corresponding to the zero degree term of the inversion polynomial (in mm/year). This product is not generated when the "No Displacement Model" is selected.

- **_term1**, corresponding to the first degree term of the inversion polynomial (in mm/year). This product is not generated when the "No Displacement Model" is selected.
- **_term2**, corresponding to the second degree term of the inversion polynomial (in mm/year^2). This product is not generated when the "No Displacement Model" is selected.
- **_term3**, corresponding to the third degree term of the inversion polynomial (in mm/year^3). This product is not generated when the "No Displacement Model" is selected.
- **_vel**, corresponding to the average displacement velocity (in mm/year). This product is not generated when the "No Displacement Model" is selected.
- **_acc**, corresponding to the average displacement acceleration (in mm/year^2). This product is not generated when the "No Displacement Model" is selected.
- **_delta_acc**, corresponding to the average displacement acceleration variation (in mm/year^3). This product is not generated when the "No Displacement Model" is selected.
- **_precision_velocity**, corresponding to the estimate in millimeter/year of the velocity measurement average precision (refer to the Phase to Displacement conversion 320 for more details).
- **_disp_frst_est**, corresponding to the date specific displacement (in millimeters) measured with respect to the first acquisition date, to which a null displacement is assigned, without atmospheric correction
- **_disp**, corresponding to the date specific displacement (in millimeters) measured with respect to the first acquisition date, to which a null displacement is assigned, after the atmospheric correction

general products which are:

- **_cc**, corresponding to the multitemporal coherence. It shows how much the displacement trend fits with the selected model.
- **_chisqr**, which is a measure of the fitting and inversion quality. The higher this value the worse the fitting and inversion quality.
- **_norm_L1**, corresponding to the cumulated summation of the date by date absolute value displacements (in millimeters).

The displacement values are reported with:

- Positive sign if the movement corresponds to a decrease of the sensor-to-target slant range distance.
- Negative sign if the movement corresponds to an increase of the sensor-to-target slant range distance.

Due to the large number of output products, the following meta files are generated. They enable to load at once all relevant output products:

- **_slant_vel+height_meta**, which refers to the residual height and displacement velocity, after a fitting process based on the date by date displacements, in slant range geometry.
- **_slant_other_info_meta**, which refers to the power mean, the multitemporal coherence, the height measurement precision and the corrected height measurements in slant range geometry.
- **_slant_disp_first_meta**, which refers to the date by date displacements, measured in slant range geometry, without atmospheric correction.
- **_slant_disp_meta**, which refers to the date by date displacements, measured in slant range geometry, after the atmospheric correction.
- **_slant_atmosphere_meta**, which refers to date by date atmospheric related components in slant range geometry. This meta file can be found in the working folder.

It is possible to move the entire SBAS_processing folder in another disk location without causing any problem in the further steps.

It is worthwhile to mention that the re-flattening, which is performed on the displacement products, does not foresee the orbital refinement; it means than only a ramp (using minimum three GCPs) or a constant term (using minimum one GCP) can be removed..

A graphic, showing the extracted displacement information, can be created using the General Tools>Raster analyzer 745.

Input Files

Auxiliary file
Reference file generated as output of the "Connection Graph" step and possibly updated 551 afterwards. This file is mandatory.

Refinement GCP file
Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File) or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the "Tools>Generate Ground Control Point 747" for details). This file is mandatory and it can be the same "Orbital GCP file" used as input in the Refinement and Re-Flattening 525 step. It is used to remove only a constant phase or a phase ramp. This file is mandatory.

Parameters - Principal Parameters

Product Coherence Threshold
Pixels with coherence values smaller than this threshold will be set to dummy (NaN) in the final products.

Interpol. Disconnected Blocks
By setting this flag the temporal gaps, where the displacement measurement does not exist, are interpolated.

Atmosphere Low Pass Size
Enter the window size, in meters, to apply the spatial distribution related filter (refer to the Technical Note).

Atmosphere High Pass Size
Enter the window size, in days, to apply the temporal distribution related filter (refer to the Technical Note).

Rebuild All
By setting this flag the second step of the SBAS Inversion process is started from scratch.

It is advisable to leave this flag unchecked in case of process interruption, so that the products already generated have not to be computed and stored again.

Refinement method
The choice is given between the following refinement methods:

- *Automatic Refinement;*
- *Polynomial Refinement;*
- *Orbital Refinement.*

Refer to the flattening section of the Preferences 775 for further information about these methods.

Refinement Residual Phase Polynomial Degree
Degree of the polynomial used to estimate the phase ramp, which will be removed from the input unwrapped phase during the Re-flattening operation. In case this value is higher that the number of input Ground Control Points, it will be automatically decreased. The default values of 3 means that a phase ramp in range and azimuth direction plus a constant phase offset will be corrected. In case only the phase offset correction is needed, the polynomial degree will be set to 1.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Refinement

It brings to the flattening section of the Preferences 775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

Product Coherence Threshold
Pixels with coherence values smaller than this threshold will be set to dummy (NaN) in the final products.

Weighted Solution
By setting this flag the inversion is performed by weighting the interferograms with the coherence values, which are converted into phase standard deviation.

Atmosphere Low Pass Size
Enter the window size, in meters, to apply the spatial distribution related filter (refer to the Technical Note).

Atmosphere High Pass Size
Enter the window size, in days, to apply the temporal distribution related filter (refer to the Technical Note).

Rebuild All
By setting this flag the second step of the SBAS Inversion process is started from scratch.

It is advisable to leave this flag unchecked in case of process interruption, so that the products already generated have not to be computed and stored again.

Output Files

_sbas_inversion_dir
Directory containing the following products:

- Meta files allowing to load the specific processing results (_meta).
- The "slant_range_dir" subfolder, which contains all processing results, in slant geometry, which are loaded by means of the meta files.
- The "work_dir" subfolder is used to store intermediate processing results.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

P. Berardino, G. Fornaro, R. Lanari, E. Sansosti: "A new algorithm for surface deformation monitoring based on Small Baseline differential SAR Interferometry". IEEE Aerospace and Electronic, Vol. 40, No. 11, November 2002.

1.7.4.8 6 - Geocoding

Purpose

The SBAS products are geocoded and the displacements can be re-projected onto a user-defined direction. This step is mandatory if the conversion to shape 547 has to be carried out afterwards.

Technical Note

Refer to the Interferometry module 320 for details.

The output results consist of geocoded products, which correspond to the outputs of both the step 1 529 and the step 2 535. These are:

- **_term0_geo**, corresponding to the zero degree term of the inversion polynomial (in mm/year). This product is not generated when the "No Displacement Model" is selected.

- **_term1_geo**, corresponding to the first degree term of the inversion polynomial (in mm/year). This product is not generated when the "No Displacement Model" is selected.

- **_term2_geo**, corresponding to the second degree term of the inversion polynomial (in mm/year^2). This product is not generated when the "No Displacement Model" is selected.

- **_term3_geo**, corresponding to the third degree term of the inversion polynomial (in mm/year^3). This product is not generated when the "No Displacement Model" is selected.

- **_vel_geo**, corresponding to the mean displacement velocity (in mm/year). This product is not generated when the "No Displacement Model" is selected.

- **_acc_geo**, corresponding to the mean displacement acceleration (in mm/year^2). This product is not generated when the "No Displacement Model" is selected.

- **_delta_acc_geo**, corresponding to the mean displacement acceleration variation (in mm/year^3). This product is not generated when the "No Displacement Model" is selected.

- **_precision_velocity_geo**, corresponding to the estimate in millimeter/year of the velocity measurement average precision (refer to the Phase to Displacement conversion 320 for more details).

- **_disp_geo**, corresponding to the date specific displacement (in millimeters) measured with respect to the first acquisition date, to which a null displacement is assigned.

- **_disp_frst_geo**, corresponding to the date specific displacement (in millimeters) measured with respect to the first acquisition date, without atmospheric removal.

- **_height_geo**, corresponding to the correction (in meters) with respect to the input Digital Elevation Model.

- **_precision_height_geo**, corresponding to the estimate in meters of the height measurement average precision (refer to the Phase to Height conversion 314 for more details).

- **_dem**, corresponding to the corrected Digital Elevation Model.

general products which are:

- **_geo_vel+height_meta**, which refers to the height and displacement velocity measurements in the output cartographic projection.

- **_geo_otherinfo_meta**, which refers to the power mean, the multitemporal coherence, the height measurement precision and the corrected height measurements in the output cartographic projection.

- **_geo_disp_first_meta**, which refers to the date by date displacements, measured in the output cartographic projection, without atmospheric correction.

- **_geo_disp_meta**, which refers to the date by date displacements, after the atmospheric correction, in the output cartographic projection.

Pixels with a Precision (respectively "Height Precision Threshold" for the height related products and "Velocity Precision Threshold" for the displacement related products) higher than the specified thresholds, are masked out.

It is possible to move the entire SBAS_processing folder in another disk location without causing any problem in the further steps.

It is worthwhile to mention that the re-flattening is performed on the displacement products.

A graphic, showing the extracted displacement information, can be created using the General Tools>Raster analyzer 745.

Input Files

Auxiliary file
Reference file generated as output of the "Connection Graph" step and possibly updated 551 afterwards. This file is mandatory.

DEM/Cartographic System

Digital Elevation Model file
Name of the Digital Elevation Model file. This should be referred to the ellipsoid. This file is optional. In case it is omitted, the ellipsoidal height and the relevant cartographic reference system, must be entered.

Output Projection
In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Input Parameter(s)

Height Precision Threshold
Upper Threshold of the height measurement average precision (refer to the Phase to Height conversion 314 for more details). This must be provided in meters.

Velocity Precision Threshold
Upper Threshold of the velocity measurement average precision (refer to the Phase to Displacement conversion 320 for more details). This must be provided in millimeter/year.

Rebuild All
By setting this flag the whole geocoding process is started from scratch.

It is advisable to leave this flag unchecked in case of process interruption, so that the products already generated have not to be computed and stored again.

Vertical Displacement
By setting this flag the displacements and velocity products are projected on the vertical direction.

Slope Displacement
By setting this flag the displacements and velocity products are projected along the maximum slope.

Displacement Custom Direction
By setting this flag any vector can be specified, in terms of azimuth (**Azimuth Angle**, measured in degrees from the North - clockwise direction) and inclination (**Inclination Angle**, measured in degrees from the horizontal plane). The map showing the displacement values projected on the specified direction is generated among the output products.

X Dimension (m)
The grid size of the output data in Easting (X) must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Y Dimension (m)
The grid size of the output data in Northing (Y) must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Mean Window Size
The mean filtering of the output height image is carried out. The window filter size must be specified. If

zero is entered, the mean filtering is not applied. This filter is applied after the execution of the interpolation steps.

Interpolation Window Size
The dummy values in the output file are interpolated. The interpolated value is the average of the valid values in a window of the size specified. If zero is entered, the interpolation is not applied; it is suggested to avoid setting this value to zero (refer to the Phase Unwrapping 305).

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Geocoding

Relax Interpolation
By setting this flag the relax interpolation (refer to the Phase To Height Conversion and Geocoding 314) is carried out. This interpolation is applied only to the height related output products.

It brings to the geocoding section of the Preferences 766 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Displacement Projection

Stand by.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output(s)

_sbas_inversion_dir
Directory containing the following products:
- Meta files allowing to load the specific processing results (_meta).
- The "geocoded_dir" subfolder, which contains all processing results, in cartographic co-ordinates, which are loaded by means of the meta files.

_ADF
Maximum slope direction values, with the associated header files (.sml, .hdr).

_IDF
Maximum slope inclination values, with the associated header files (.sml, .hdr).

_SD
Displacement values along the maximum slope direction, with the associated header files (.sml, .hdr).

_UD
Displacement values in the direction specified as azimuth and inclination degrees (i.e. custom direction), with the associated header files (.sml, .hdr).

_VD
Vertical displacement values, with the associated header files (.sml, .hdr).

_ALOS
Azimuth Line of Sight with the associated header files (.sml, .hdr). Positive angles are measured clockwise from the North; negative angles are measured counterclockwise from the North.

_ILOS
Incidence angle of the Line of Sight with the associated header files (.sml, .hdr). The angle is measured between the Line Of Sight and the vertical on the ellipsoid (flat earth).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.7.4.9 Raster to Shape Conversion

Purpose

This functionality converts the SBAS geocoded 541 raster products, into shape and kml files. This step is optional.

Technical Note

The output products consist of both a vector file (shape format) and a kml file containing the following information:

- Displacement velocity measured in slant range direction (i.e. Line of Sight); this is related to the selected input model 529.
- Displacement measured on each date with respect to the oldest acquisition of the series.
- Total displacement integrated using the whole input temporal series (available only in the shape file).
- Coherence values. This is the multitemporal coherence 535 which is proportional to the displacement trend fitting with the selected model.
- Pixel cartographic co-ordinates and height based on the Digital Elevation Model value corrected using the interferometric measurement
- Height correction with respect to the input Digital Elevation Model.

Only those pixels with a coherence higher than the specified "Product Coherence Threshold" and a Precision (respectively "Height Precision Threshold" for the height related products and "Velocity Precision Threshold" for the displacement related products) lower than the specified thresholds, are converted.

It is possible to specify an area of interest, in cartographic co-ordinates ("Input Parameters>Area of Interest co-ordinates"), for the raster to shape transformation. The input area of interest must be entered (in form of vector file or corner co-ordinates) using the same reference system, which had been specified in the second step 535 of the SBAS Inversion.

Any meta file representing the displacement velocities, which are generated in the SBAS Inversion step, can be visualised using a SARscape default colour scaling. This is done by opening the specific displacement file through the "ENVI>Extensions>ENVI Classic Meta>Open Classic Metafile" and then loading the "_density_slice_" output.

The displacement values are reported with:

- Positive sign (and shown in red colour) if the movement corresponds to a decrease of the sensor-to-target slant range distance.
- Negative sign (and shown in blue colour) if the movement corresponds to a increase of the sensor-to-target slant range distance.

It is worthwhile to mention that:

- in case the number of points to represent in the output shape and/or kml file is very large.
- in case there are many acquisition dates (i.e. time series Input file list 510).

then the output shape/kml files can be too big for the visualisation of the Time Series related information, which is activated when the "Generate Shape/Kml Time Series" flags are checked. In this case these flags can be de-selected or the "Shape/Kml Max Nr of Points" can be reduced.

It is possible to move the entire SBAS_processing folder in another disk location without causing any problem in the further steps.

Input Files

Auxiliary file
Reference file generated as output of the "SBAS Inversion" step and possibly updated 551 afterwards. This file is mandatory.

Optional Files

Vector File
The Area Of Interest spatial region to be transformed can be entered as a vector Shape File (*.shp). This file is optional.

Parameters - Principal Parameters

Area Of Interest
If a vector file is not used (see Optional Files), specific cartographic co-ordinates can be entered as follows:

- **West**
  The Westernmost cartographic co-ordinate.

- **East**
  The Easternmost cartographic co-ordinate.

- **North**
  The Northernmost cartographic co-ordinate.

- **South**
  The Southernmost cartographic co-ordinate.

Product Coherence Threshold

Pixels with coherence values smaller than this threshold will be set to dummy (NaN) in the final products.

Shape Max Nr of Points
If values other than -1 are entered, the output shape file is split in several parts (each marked by a progressive numbering - _01; _02; etc.); each part of the shape contains a portion of the total number of points, which corresponds to the value entered. It is suggested not to exceed 100000 points in order to avoid visualization problems.

KML Max Nr of Points
If values other than -1 are entered, the output KML file is split in several parts (each marked by a progressive numbering - _01; _02; etc.); each part of the KML contains a portion of the total number of points, which corresponds to the value entered. It is suggested not to exceed 50000 points in order to avoid visualization problems.

Generate Shape
By setting this flag the output shape file/s are generated.

Generate Kml
By setting this flag the output kml file/s are generated.

Scaling Range
The maximum expected range of the displacement rate (integer value of the minimum - **Lower Limit KML Scaling** - and maximum - **Upper Limit KML Scaling** - velocities in mm/year) is set.

Generate Shape Time Series
By setting this flag the output shape file/s, with the displacement temporal evolution, are generated.

Generate Kml Time Series
By setting this flag the output kml file/s, with the displacement temporal evolution, are generated.

Output Files

.shp, **.kml**
The file name contains an indication of the input coherence threshold used.

By double clicking on the .kml file, the SBAS map will be visualized in Google Earth; locating the mouse on any point the relevant information will be provided. The following nomenclature is used to differentiate the different SBAS re-projected data 544:

_SD
Maximum slope direction
_UD
Direction specified by the user as azimuth and inclination degrees (i.e. custom direction).
_VD
Vertical direction.

_density_slice_
This is an ascii file with a legend representing, with different colours, the displacement velocity based on the input "scaling range"; this range is also written as file name suffix.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None

1.7.5 Stacking Tools

Section Content

1.7.5.1 SBAS Edit Connection Graph

Purpose

This functionality enables to modify the SAR pair combination and connection network which was generated in the Connection Graph 510 step.

Technical Note

The tool can be used either before or after the Interferometric Workflow 519 step; in the latter it is not possible both to change the "Super Master file" or to add new pairs. The following constraints must be respected:

- New pairs cannot be added if the Interferometric Workflow 519 and successive steps have been already executed.
- Neither single acquisitions nor image pairs can be removed if they are used in the connection network exploited by the Delaunay 3D 511. This removal can be done only after the first SBAS Inversion 529.
- Images or pairs cannot be removed if they are needed to link separate blocks and the option Allow Disconnected Blocks 510 had net been checked.

It must be noted that the connection graph editing can be carried out at any point of the processing chain after the Connection Graph 510 has been executed.

The "Remove Pair" and the "Remove Image" functions allow selecting a single master and single or multiple slaves.

Each time the report is edited the previous one is saved, in the "_connection_graph_dir\work_dir" subfolder, with a progressive number (the original being saved as "CG_report_1.txt"); this is to allow the possibility to restore any previous connection scenario.

Input Files

Auxiliary file
Reference file generated as output of the "Connection Graph" step. This file is mandatory.

Super Master file
Name of the acquisition selected as processing reference data. This file is automatically retrieved.

Parameters - Principal Parameters

Reload Report
By setting this flag the updated report is loaded.

Reload Connection Graph
By setting this flag the updated connection graph is loaded.

Output Files

None.

General Functions

Cancel
The window will be closed.

Help
Specific help document section.

Specific Function(s)

Add Pair
The pair selected in the "Master List" and "Slave List" is added to the original connection network. The process must be re-run from the step 2 519 or, alternatively, from the Area of Interest Definition 516 if it has been performed. The interferometric pairs processed in the previous iteration are not handled; only the new entries will be processed.

Remove Pair
The pair selected in the "Master List" and "Slave List" is removed from the original connection network.

Add Image
The input image list are added to the original connection network. The process must be re-run from the step 2 519 or, alternatively, from the Area of Interest Definition 516 if it has been performed. The interferometric pairs processed in the previous iteration are not handled; only the new entries will be processed.

Remove Image
The image selected in the "Master List" or "Slave List" is removed from the original connection network.

Undo
The previous connection network is restored.

References

None.

1.7.5.2 SBAS Plot Viewer

Purpose

This panel is to reload the previously generated Connection Graphs 510.

Technical Note

None.

Input Files

Auxiliary file
Reference file generated as output of the "Connection Graph" step. This file is mandatory.

Output Files

None.

General Functions

None.

Specific Function(s)

None.

References

None.

1.8 ScanSAR Interferometry Module

Section Content

1.8.1 Overview

A Note on the ScanSAR Interferometry module

This module supports the processing of:

- Interferometric SAR data (2-pass Interferometry, InSAR) for the generation of Digital Elevation Model (DEM) and related coherence.
- Differential Interferometric SAR data (n-pass Interferometry, DInSAR) for the generation of Land Displacement maps and related coherence.

Only the use of data pairs acquired by the ENVISAT ASAR sensor is supported. This module is specifically designed for processing Wide Swath (or ScanSAR) products, but it can also work combining ASAR Wide Swath with ASAR Stripmap products. In any case **the master image must always be a Wide Swath acquisition**.

A necessary condition to run the ScanSAR interferometric data processing is that the data synchronisation and the baseline are suitable. This can be checked using the ASAR WS Synchronisation 558 functionality.

It is worthwhile to note that the processing panels use the intensity image (_pwr) as input, for both master and slave ScanSAR datasets. The intensity images are intended as a link to the 5 SLC files (one for each of the 5 sub-swaths) an ASAR ScanSAR product is made of. The interferometric processing is eventually performed on each of the SLC swaths, which are combined together afterwards.

Several processing functions implemented in this module are adapted starting from those available in the Interferometry module and they maintain the same name. Specific technical details, which are not described hereafter, can be retrieved in the Interferometry module Reference Guide.

Assuming appropriate data pairs, the following processing sequences are proposed:

1. **Digital Elevation Model generation**, typically includes the following steps:

   – Synthetic Phase Generation.
   – Interferogram Generation.
   – Adaptive Filter and Coherence Generation.
   – Phase Unwrapping.
   – *Phase Editing* 470 *(if required)*.
   – Refinement and Re-flattening.
   – Phase to Height Conversion and Geocoding.

2. **Land Displacement Mapping**, typically includes the following steps:

   – Synthetic Phase Generation.
   – Interferogram Generation.
   – Adaptive Filter and Coherence Generation.
   – Phase Unwrapping.
   – *Phase Editing* 470 *(if required)*.
   – *Refinement and Re-flattening, if required.*
   – Phase to Displacement Conversion and Geocoding.

The following functions, included in this module, support any of the procedures above:

ASAR WS Synchronisation
Information related to baseline and burst synchronisation are provided. The use of this optional functionality is exclusively to assess the quality of the interferometric pair. Additional SAR pair related information can be gathered by executing the Baseline Estimation 451 functionality.

Synthetic Phase Generation
A multilooked synthetic phase is generated using orbital data, system and processing parameters and the Digital Elevation Model (alternatively the ellipsoidal height). The synthetic phase and the slant range projected Digital Elevation Model are also generated; note that these two files will be generated again, as coregistered products, in the Interferogram Generation 562 step.

Interferogram Generation
A multi-looked flattened interferogram - where the phase component related to the topography (or ellipsoid) and the constant phase due to the interferometric acquisition geometry have been subtracted using the previously generated synthetic phase - is created together with the following coregistered data:

– Master and Slave intensities.
– Synthetic phase.
– Slant range projected Digital Elevation Model.

These coregistered products have to be used as input to the further processing steps.

Adaptive Filter and Coherence Generation
The phase noise in the flattened interferogram is filtered and the corresponding coherence is generated.

Phase Unwrapping
The flattened, filtered interferogram is unwrapped in order to solve the 2π ambiguity.

Refinement and Re-flattening
Possible inaccuracies in the satellite orbits as well as the phase offset are corrected.

Phase to Height Conversion and Geocoding
The Digital Elevation Model is generated.

Phase to Displacement Conversion and Geocoding
The Land Displacement Map is generated.

Note that:

- SAR Single Look Complex (WSS) products must be imported (refer to Basic module 32).
- SAR RAW (WS0) products must be imported and focussed (refer to Focusing module).
- Master and Slave acquisitions must remain in the same order throughout the whole interferometric processing.
- Default setting for selected parameters can be specified in the Preferences panel.
- The SAR Tutorial, which includes basic knowledge on SAR theory and data processing, complements the online help.
- Data geocoded to GEO-GLOBAL cartographic reference system can be automatically displayed into the Google Earth environment by double clicking on the output .kml file.
- Co-ordinate decimal values must be entered using the dot (e.g. 29.30) and not the comma (e.g. 29,30) character.
- The module has been jointly developed by sarmap s.a. and Aresys (a spin off company of the Polytechnic University of Milan).

References

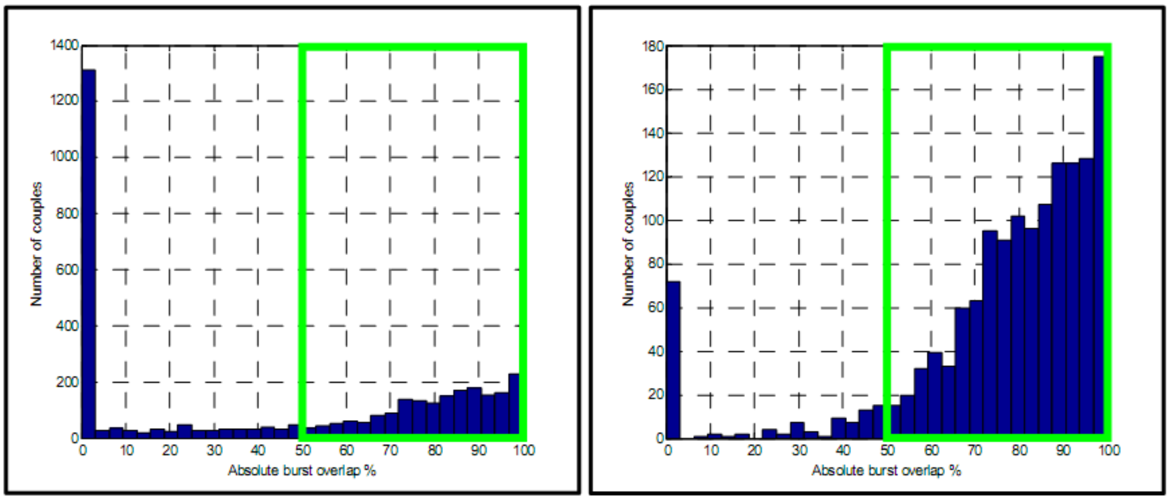
Monti Guarnieri A. and C. Prati: "ScanSAR focusing and interferometry". IEEE Transactions on Geoscience and Remote Sensing, Vol. 34, No. 4, July, 1996.

Monti Guarnieri A., P. Guccione, P. Pasquali, and Y.L. Desnos: "Multi-mode ENVISAT ASAR interferometry: Techniques and preliminary results". IEEE Proceedings on Radar, Sonar and Navigation, Vol. 150, No. 3, June, 2003.

1.8.2 Frequently Asked Questions

Q. - What is the amount of ENVISAT ScanSAR pairs, which are suitable in terms of **Burst Synchronization**, for interferometric purposes?

A. - The amount of ENVISAT ScanSAR interferometric pairs was very limited before ESA decided to perform a satellite planning optimization aimed at improving the burst synchronization (around October 2006). After that date the percentage of suitable pairs become much higher (refer to the graph below).



Before WS burst synch optimisation

After WS burst synch optimisation

Q. - Why do I get an error when the intensity image (_pwr) and the Single Look Complex (_slc) **Input Data** are stored in different folders?

A. - The processing panels use the intensity image in input, for both master and slave datasets. Each of these intensity images actually correspond to 5 SLC files (one for each of the 5 sub-swaths an ASAR ScanSAR acquisition is made of); during either the WSS data import 43 or the WS0 data focusing both the output root file name and the output location path of the SLC swaths (_slc) are - and they must remain - the same as the intensity image (_pwr).

Q. - Can I use this module to perform interferometric processing using **Wide Swath** data acquired by the **ALOS PALSAR** sensor?

A. - The interferometric technique is currently not applicable, in SARscape, to PALSAR Wide Swath data. Actually the azimuth sampling frequency (PRF) of this mode is almost never the same for different acquisitions on the same area. Different PRF implies that the data pair is not synchronised; consequently there is not possibility to generate ScanSAR interferograms. Starting from year 2009, the ALOS PALSAR acquisition configuration in ScanSAR mode have been changed in order to enable the Interferometric processing of PALSAR Wide Swath data, but the number of suitable interferometric pairs still remains very limited.

Q. - Can I use this module to perform interferometric processing using **ScanSAR** data acquired by the

COSMO-SkyMed satellites?

A. - The SLC products are available, but they have not been designed for interferometric exploitation.

Q. - Can I use this module to perform interferometric processing using **ScanSAR** data acquired by **TerraSAR-X**?

A. - These data are currently not supported for interferometric processing in SARscape.

Q. - In the **Combination Wide Swath - Stripmap** modes, is it possible to exploit all the Stripmap data acquired from IS1 to IS7 modes?

A. - The only Stripmap mode, which is not usable in combination with the WS, is the IS7. The other Stripmap modes are combined (automatically by the software) as follows:

- Stripmap IS1 and IS2 with Wide Swath SS1 portion (nearest range swath position).
- Stripmap IS3 with Wide Swath SS2 portion.
- Stripmap IS4 with Wide Swath SS3 portion.
- Stripmap IS5 with Wide Swath SS4 portion.
- Stripmap IS6 with Wide Swath SS5 portion (farthest range swath position).

Q. - How can I know if my **ScanSAR and Stripmap** data have the same viewing geometry (i.e. same incidence angle) in the overlapping area, so that I can process them in interferometric mode?

A. - The Local Incidence Angle 142 map can be generated for this purpose in order to check whether the two images had been acquired with the same viewing geometry.

Q. - Two **Synthetic Phase Data** are generated during the ScanSAR Interferometry processing chain. What is the one to use as input in the Interferometry module (e.g. Refinement and Re-flattening 308 step)?

A. - The two synthetic phase data are generated first in the Synthetic Phase Generation step (_sint) and afterward in the Interferogram Generation 562 step (_synt_sint). The one to use as input in the Interferometry module is the output of the Interferogram Generation 562 step.

Note that several relevant questions are answered in the Frequently Asked Questions 252 section of the Interferometry module.

1.8.3 Reference Guide

1.8.3.1 ASAR WS Synchronisation

Purpose

Baseline and burst synchronisation are key factors, which determine the suitability of ASAR Wide Swath data pairs for interferometric purposes. This functionality enables to check these parameters before actually running the interferometric processing chain. The extracted parameters have to be intended as approximate measurements aimed at a preliminary data characterisation and interferometric quality assessment. The baseline value itself is not used in any part of the Interferometric processing chain.

Technical Note

The input Data File List (master and slave data) can be represented by:

- Original products (i.e. standard ESA format not yet imported or focused with SARscape).
- Intensity images resulting from a previous data import (Basic module) or data focusing (Focusing module) process. In this case the Orbit File List is not required.

Any number of data files (and corresponding orbit files in case of not imported products) can be entered; the baseline and burst synchronisation values for all possible combinations (i.e. pairs) will be provided.

It must be noted that the same input list cannot contain original and imported data.

Baseline

The generation of an interferogram is only possible when the ground reflectivity acquired with at least two antennae overlap. When the perpendicular component of the baseline (B_n) increases beyond a limit known as the critical baseline, no phase information is preserved, coherence is lost, and interferometry is not possible. The critical normal baseline $B_{n,cr}$, can be calculated as:

$$B_{n,cr} = \frac{\lambda R \tan(\theta)}{2 R_r}$$

where λ is the wavelength, R is the range distance, R_r is the pixel spacing in range, and θ is the incidence angle. Note that the critical baseline can be significantly reduced by the topography.

Burst Synchronisation

ASAR Wide Swath data pair could be affected by burst synchronisation related problems, which make impossible to use them for interferometric product generation. Although ASAR Wide Swath mode was not designed to keep burst synchronisation between different acquisitions, there is a high percentage of synchronised Wide Swath data pairs. The European Space Agency provides a web based application to estimate the burst synchronisation percentage for a user selected set (based on satellite track number or area location) of ASAR Wide Swath mode products. The search can be eventually refined with specific time intervals. A similar result is provided, for specific data pairs (one or more than one), using this functionality.

Theoretically the interferometric processing can be attempted on all SAR pairs with minimum burst synchronisation percentage higher than zero. Of course the higher the percentage the larger the swath portion which is actually considered in the processing, thus a minimum burst synchronisation percentage of at least 50% is typically suggested.

DORIS

DORIS (Doppler Orbitography and Radiopositioning Integrated by Satellite) data provide precise orbital information for ENVISAT ASAR. Two versions of DORIS data are available:

- The VOR (Verified ORbits) are the most precise ones, but they are made available not earlier than one month after the actual satellite acquisition.
- The POR (Precise ORbits) are slightly less precise than the VOR, but they are made available together with the ASAR data.

Access to DORIS data is provided by the ESA Earth Observation Help Desk.

Input Files

Input File List
List of data files (_pwr in case of imported data). This file is mandatory.

Orbit File List
List of orbit files (DOR_VOR or DOR_POR) corresponding to the Data File List (the same input order must be respected). This list is not required only in case of imported data type (e.g. _pwr) but mandatory in case of N1 format data.

Output Files

Output Root Name
Name of the output root. If it is not provided the extracted parameters are written in the Log File 825.

Root Name
A suffix, to identify which input pair the information are related to, is added to the Output Root Name. The following information are provided in the output text files:

- Minimum Burst Synchronisation
  It corresponds to the synchronisation percentage value. Note that the synchronisation of the ASAR Wide Swath pair is proportional to the overlap between the same swath (1 to 5) of master and slave images. The algebraic sign (+/-) depends on the de-synchronisation direction. Zero value means that there is no synchronisation, between master and slave image, in at least one of the 5 swaths of which the entire ASAR Wide Swath acquisition is made of. In this case, the pair cannot be processed in interferometric mode. Otherwise, with synchronisation values other than zero, the interferometric processing can be attempted.

- Min Normal Baseline
  Estimated value (meter) of the normal baseline. The provided value is the smallest amid the 5 swaths.

- Max Normal Baseline
  Estimated value (meter) of the normal baseline. The provided value is the largest amid the 5 swaths.

The burst synchronisation and baseline value, specific for each swath of each pair, are provided in the log file at the process completion. They are named respectively "Overlap SubSwath" and "Baseline SubSwath".

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

B. Rosich, A. Monti-Guarnieri, D. D'Aria, I. Navas, B. Duesmann, C. Cafforio, P. Guccione, S. Vazzana, O. Barois, O. Colin, E. Mathot: "ASAR Wide Swath mode interferometry: optimisation of the scan pattern synchronisation".

Monti Guarnieri A. and C. Prati: "ScanSAR focusing and interferometry". IEEE Transactions on Geoscience and Remote Sensing, Vol. 34, No. 4, July, 1996.

Monti Guarnieri A., P. Guccione, P. Pasquali, and Y.L. Desnos: "Multi-mode ENVISAT ASAR interferometry: Techniques and preliminary results". IEEE Proceedings on Radar, Sonar and Navigation, Vol. 150, No. 3, June, 2003.

1.8.3.2 1 - Interferogram Generation

Purpose

A flattened interferogram can be generated from a ScanSAR pair or a from a ScanSAR-Stripmap pair.

Technical Note

Due to data separation into bursts, ScanSAR interferometry requires "ad-hoc" steps to consider overlap and different parameters between data sub-swaths. In particular timing and phase/magnitude compensation at the bounds of bursts and swaths have to be managed in order to avoid phase discontinuities or other undesired artifacts. These parameters are automatically taken into account during this processing step.

The multi-looked intensity data, which are generated either importing the WSS format or a Stripmap product (Basic module 43) or importing and focusing the WS0 format (Focusing module), are used as master/slave inputs.

It is important to note that, in case of a ScanSAR-Stripmap pair, it is mandatory to use the ScanSAR as master data. This input configuration requires that the ScanSAR and the Stripmap data have the same viewing geometry (i.e. same incidence angle) in the overlapping area. . **It is important to know that, unlike the multi-looked intensity images generated in the "Basic module>Multilooking", these master and slave intensities cannot be radiometrically calibrated 142 due to the spatial varying effect introduced by the spectral shift filter**.

Input Files

Input Master File
File name of the multi-looked Intensity Master data (_pwr). This file is mandatory.

Input Slave File
File name of the multi-looked Intensity Slave data (_pwr). This file is mandatory.

DEM/Cartographic System

Digital Elevation Model File
Name of the Digital Elevation Model file. This should be referred to the ellipsoid. This file is optional. In case it is omitted, the ellipsoidal height and the relevant cartographic reference system, must be entered.

Output Projection
In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Input Mode
The interferometric processing can be performed with the following option:

- WS-WS, if both master and slave are Wide Swath products.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Flattening

It brings to the flattening section of the Preferences 775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Coregistration

It brings to the coregistration section of the Preferences [770] parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences [759] parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Name of the output root. This file is mandatory.

_dint
Flattened interferogram and corresponding header file (.hdr, .sml).

_synt_sint
Synthetic phase and corresponding header file (.hdr, .sml).

_synt_srdem
Slant range projected Digital Elevation Model and corresponding header file (.hdr, .sml).

_mml_pwr
Multi-looked master Intensity and corresponding header file (.hdr, .sml).

_sml_pwr
Multi-looked slave Intensity and corresponding header file (.hdr, .sml).

_orb.sml
Xml file containing the scene orbital parameters.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format [21] section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser [802] button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Monti Guarnieri A. and C. Prati: "ScanSAR focusing and interferometry". IEEE Transactions on Geoscience and Remote Sensing, Vol. 34, No. 4, July, 1996.

Monti Guarnieri A., P. Guccione, P. Pasquali, and Y.L. Desnos: "Multi-mode ENVISAT ASAR interferometry: Techniques and preliminary results, IEEE Proceedings on Radar, Sonar and Navigation, Vol. 150, No. 3, June, 2003.

1.8.3.3 2 - Adaptive Filter and Coherence Generation

Purpose

The filtering of the flattened interferogram enables to generate an output product with reduced phase noise. The Interferometric Coherence (which is an indicator of the phase quality) and the master Intensity filtered image, are also generated.

Technical Note

It is possible to select on of the following three filtering methods:

Adaptive
The coherence values are used to set the filter window size; the mean Intensity difference among adjacent pixels is used to identify a stationary area, which defines the maximum dimension (in any case not bigger than the input parameter setting) and the shape of the filtering windows. The process is aimed at preserving even the smallest interferometric fringe patterns.

This filtering procedure is quite expensive in terms of computing time as well as for what concerns the identification of the threshold value to use as Similarity Mean Factor (similarity between the backscatter

values measured in the master and slave Intensity data). On the basis of this factor the areas of the image where the signal intensity is considered stationary are identified. The selection of the pixels to include within each "stationary area", is based on the value of the difference between the mean of the pixels in that area (M_{all}) and the value of the new pixel (M_{new}), which is potentially candidate (this difference is normalized for M_{all}). The new candidate pixels are identified using a region growing approach.
The formula of the Similarity Mean Factor, which is represented by a digital number in linear scale, can be written as:

$$(M_{all} - M_{new}) / M_{all}$$

It must be noted that several process iterations are typically required in order to set the optimal Similarity Mean Factor. This threshold value can be set from the Preferences>Adaptive Filter>Adaptive Interferogram Filtering>Similarity Mean Factor 783.

Boxcar
The local fringe frequency is used in order to optimize the band pass filter. The process is aimed at preserving even the smallest interferometric fringe patterns. The processing parameters, which are not directly visible in this processing interface, can be accessed and modified from the Preferences>Adaptive Filter>Boxcar Interferogram Filtering 783.

Goldstein
The variable bandwidth of the filter, derived directly from the power spectrum of the fringes, smoothes in a selective way the noise frequencies and the signal frequencies. In order to optimize the filter performance the "alpha" parameter, which characterizes the strength of the filter, is handled in an adaptive way on the basis of the local scene coherence: the lower the coherence the stronger the filter.

Several processing parameters, which are not directly visible in this processing interface, can be accessed and modified from the Preferences>Adaptive Filter>Goldstein Interferogram Filtering 783.

This filtering approach, which is an extension of the Goldstein method, significantly improves fringe visibility and reduces the noise introduced by temporal or baseline related decorrelation. In this implementation the alpha 783 parameter is depending on the coherence: incoherent areas are filtered more than coherent zones. This implies a signal loss minimization, while strongly reducing the level of noise. The use of the coherence generated from the filtered interferogram (option enabled by setting the flag "Coherence from Fint"), must be carefully considered since the phase smoothing, which is produced by the filter itself, causes an over estimation of the coherence (the stronger the filter the higher the coherence values). If the objective is either not to unwrap areas which appear coherent but are actually very noisy or to use of the coherence data for other purposes (i.e. land cover classification or other qualitative/quantitative applications), the coherence shall be generated from the unfiltered interferogram or using the boxcar filtering approach.

The interferometric correlation or **Coherence** (γ) is the ratio between coherent and incoherent summations:

$$\gamma = \frac{\left|\sum s_1(x) \cdot s_2(x)^*\right|}{\sqrt{\sum |s_1(x)|^2 \cdot \sum |s_2(x)|^2}}$$

The estimated coherence - which ranges between 0 and 1 - is function of:

- Systemic spatial de-correlation (i.e. the additive noise).
- Temporal de-correlation between master and slave acquisitions.

When working with single look data (i.e. azimuth and range multilooking factors are both set to 1), it could make sense to increase the "Coherence Window Size" (in azimuth and range) in order to increase the number of samples and eventually avoid coherence overestimate problems.

The coherence product has essentially a twofold purpose:

- To determine the quality of the measurement (i.e. interferometric phase). As a rule of thumb, InSAR pairs with low coherence should not be used to derive reliable phase related measurements.
- To extract thematic information relevant to the ground features properties and their temporal changes. This information is enhanced when coupled with the backscattering coefficient (σ^o) of the master and slave Intensity data.

As a general rule it can be assumed that the coherence decreases with increasing master-slave acquisition time distance.

The coherence image can be generated from the input unfiltered interferogram or from the filtered one (refer to the "Input Parameters>Coherence from Fint").

Input Files

Interferogram File
File name of the flattened interferogram (_dint). This file is mandatory.

Input Master File
File name of the multi-looked master Intensity data (_mml_pwr). This file is mandatory.

Input Slave File
File name of the multi-looked coregistered slave Intensity data (_sml_pwr). This file is mandatory.

Parameters - Principal Parameters

Coherence Generation
By setting this flag, the coherence is generated.

Adaptive Filter
By setting this flag, the input interferogram is filtered. This flag is disabled when the "Local Frequency Removal (Range and Azimuth)" is set to a value higher than zero; indeed in this case the _fint file should have already been generated.

Filtering method
The choice is given between the following filtering methods according to the default values of the filtering section of the Preferences 783 parameters:

- *Adaptive window;*
- *Boxcar window;*
- *Goldstein.*

Refer to the filtering Preferences 783 description for further information about these methods.

Coherence from Fint
By setting this flag, the coherence is computed using the filtered interferogram (_fint) instead of the unfiltered one (_dint).

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Filtering

It brings to the filtering section of the Preferences 783 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Name of the output root. This file is mandatory.

_fint

Filtered interferogram with the associated header files (.sml, .hdr). This file is generated only if the Adaptive Filter flag is selected.

_pwr_fil
Filtered Intensity - from master and slave combination - with the associated header files (.sml, .hdr). This file is generated only if the "Adaptive" filter is selected.

_cc
Estimated coherence with the associated header files (.sml, .hdr). This file is generated only if the Coherence Generation flag is selected.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

A. Monti Guarnieri, C. Cafforio, P. Guccione, D. Nüesch, D. Small, E. Meier, P. Pasquali, M. Zink, Y. L. Desnos: "Multi-mode ENVISAT ASAR Interferometry: Techniques and Preliminary Results". Proceedings of EUSAR Conference 2002.

Richard M. Goldstein, Charles L. Werner: "Radar Interferogram Filtering for Geophysical Applications". Geophys. Res. Lett., 25(21), 4035–4038.

Baran I., Stewart Mike P., Kampes Bert M., Perski Z., Lilly P.: "A Modification to the Goldstein Radar Interferogram Filter", IEEE Transactions on Geoscience and Remote Sensing, Vol. 41, No. 9, September

2003.

Ghulam A., Amer R., Ripperdan R.: "A filtering approach to improve deformation accuracy using large baseline, low coherence DInSAR phase images", Paper presented at IGARSS 2010.

1.8.3.4 3 - Phase Unwrapping

Purpose

The phase of the interferogram can only be modulo 2π; hence anytime the phase change becomes larger than 2π the phase starts again and the cycle repeats itself. Phase Unwrapping is the process that resolves this 2π ambiguity. Several algorithms (such as the branch-cuts, region growing, minimum cost flow, minimum least squares, multi-baseline, etc.) have been developed; in essence, none of these is perfect and different or combined approaches should be applied on a case by case basis to get optimal results.

Depending on specific data characteristics a further phase editing 470 could be required in order to correct errors in the unwrapped interferogram.

Technical Note

Two methods are implemented:

- **Region Growing** -> This is the default unwrapping algorithm. If this method is selected, it is suggested to avoid setting a high coherence threshold (good values are typically between 0.15 and 0.2) in order to leave enough freedom during the growing process; this shall limit the possibility to introduce erroneous phase jumps - "unwrapping islands" - in the output unwrapped phase image.
- **Minimum Cost Flow** -> This method should be adopted when the unwrapping process becomes difficult due to the presence of large areas of low coherence or other growing limiting factors; in such cases the Minimum Cost Flow algorithm enables to obtain better results than using the Region Growing method. This approach considers a square grid all over the image pixels. All pixels whose coherence is lower than the "Unwrapping Coherence Threshold" are masked out.
- **Delaunay MCF** (Minimum Cost Flow) -> It is the same approach of the previous method, with the only difference that the grid does not necessarily covers all image pixels, but only those above the "Unwrapping Coherence Threshold"; moreover it adopts the Delaunay triangular grid instead of square one. As result only the points with good coherence are unwrapped, without any influence from the low coherence pixels. The exploitation of the Delaunay triangulation is especially useful when there are several areas of low coherence (water bodies, densely vegetated areas, etc.) distributed throughout the image; in such case the others unwrapping approaches would eventually produce phase islands/jumps, while the Delaunay approach is able to minimize these jumps.

Decomposition Levels

The process is normally executed with the original pixel sampling (i.e. default setting -1). The use of the decomposition is intended to multilook and undersample the data in an iterative way: the interferogram is unwrapped at the lower resolution and then reconstructed back at the original resolution. The use of the decomposition can be of help to reduce unwrapping errors (e.g. in case of distributed low coherence areas) and it reduces the processing time and it limits the use of computer resources.

The user can specify the number of iterations (i.e. decompositions) to execute; each iteration corresponds to an undersampling factor of 3. We suggest to avoid setting this value higher than 3.

In case of very large displacements or very steep topography (fast phase/dense fringe distribution) the use of the decomposition can cause aliasing effects. In this case the decomposition process should be avoided by setting its value to -1.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Reigber A. and J. Moreira: "Phase Unwrapping by Fusion of Local and Global Methods". Proceedings of IGARSS'97 Symposium, 1997.

Costantini, M.: "A novel phase unwrapping method based on network programming". Geoscience and Remote Sensing, IEEE Transactions on, May 1998, 36(3), pp. 813 - 821.

1.8.3.5 4 - Refinement and Re-flattening

Purpose

This step is crucial for a correct transformation of the unwrapped phase information into height (or displacement) values. It allows both to refine the orbits (i.e. correcting possible inaccuracies) and to calculate the phase offset (i.e. getting the absolute phase values), or remove possible phase ramps.

The execution of this step is mandatory for Digital Elevation Model generation 578 as well as for Displacement Mapping 582.

To execute this step a Ground Control Point file 747 must be previously created.

Technical Note

When the "Re-flattening" flag is unchecked, the process consists of writing the correction factors in the header file of the unwrapped phase (_upha.sml); in this case new files are not generated in output. Depending on the specific processing parameter setting (Preferences>Flattening>Refinement and Re-flattening/Refinement Method 775), the polynomials and the correction factors are calculated and written in the header file of the unwrapped phase image (_upha.sml>interferometric_processing section) as well as on a popup window at the process completion; these correction factors/polynomials are:

- **ORShiftOrbitInX** - Orbital shift in X direction (in meters) - It is generated if the "Orbital 775" method is applied.
- **ORShiftOrbitInY** - Orbital shift in Y direction (in meters) - It is generated if the "Orbital 775" method is applied.
- **ORShiftOrbitInZ** - Orbital shift in Z direction (in meters) - It is generated if the "Orbital 775" method is applied.
- **ORAzShiftOrbitInX** - Dependency of the shift in X direction, from the azimuth position (in meters per pixel) - It is generated if the "Orbital 775" method is applied.
- **ORAzShiftOrbitInY** - Dependency of the shift in Y direction, from the azimuth position (in meters per pixel) - It is generated if the "Orbital 775" method is applied.
- **ORAzShiftOrbitInZ** - Dependency of the shift in Z direction, from the azimuth position (in meters per pixel) - It is generated if the "Orbital 775" method is applied.
- **ORPhaseOffset** - Absolute phase offset (in radians) - It is generated if the "Orbital 775" method is applied.
- **ORRMSError** - Root mean square error calculated as the difference between the height value of the Ground Control Points and the corresponding value in the interferometric phase (in meters) - It is generated if the "Orbital 775" method is applied.
- **PhaseError** - A-priori achievable root mean square error, calculated as average on the input GCPs (height in meters) - It is generated if the "Default" method flag is checked.
- **RPPPhasePolyDegree** - Degree of the polynomial used to estimate the phase ramp - It is generated if the "Residual Phase 775" method is applied.
- **RPPPhasePoly** - The polynomial used to estimate the phase ramp - It is generated if the "Residual Phase 775" method is applied.
- **RPPRMSE** - Root mean square error calculated as the difference between the height value of the Ground Control Points and the corresponding value in the interferometric phase (in meters) - It is generated if the "Residual Phase 775" method is applied.

Very large "ORRMSError" or "RPPRMSE" - root mean square errors - (in the order of hundreds or thousands) eventually bring to wrong Refinement and Re-flattening results. Care must be paid also when very small "ORRMSError" values (less than 1) are reported; as a rule of thumb errors from some units to some tens are a good preliminary indication that the Ground Control Points have been properly located.
Large "ORRMSError" values can be reported when processing pairs with very small baseline (i.e. less than about 10 meters).

Ground Control Points located on null/dummy value pixels (NaN) are discarded.

When the "Re-flattening" flag is checked, the correction parameters are calculated depending on the specific "Refinement Setting 775" and they are applied to rebuild the following input files:

- Unwrapped Phase (_upha).
- Flattened Interferogram (_dint or _fint).
- Synthetic Phase (_sint).

If the root name of the input files and the output root name are the same, or the "Output Root Name" is missing, the original synthetic (_sint) and flattened (_dint or _fint) phase, which are modified as result of re-flattening, are saved with the prefix "original_".

It is important to note that the "Re-flattening" flag must always be checked when the Displacement Mapping 320 has to be carried out afterwards; the "Re-flattening" flag can be deselected when the Digital Elevation Model generation 314 has to be carried out afterwards and the "Refinement Setting" adopts the "Orbital" method (Preferences>Flattening>Refinement and Re-flattening>Refinement Method 775).

The points ("Orbital Ground Control Point file") used to calculate the correction parameters (Refinement Setting), shall be selected on the input flattened interferogram (_dint, _fint) in order to avoid areas where topographic fringes remained "unflattened". The Ground Control Points must be well distributed throughout the entire scene.

An indication about the Ground Control Points quality can be obtained by inspecting the "_orbital_refinement.shp" or the "_phase_refinement.shp" (see "Output" product description below).

If the Interferogram flattening step has been executed using a reference Digital Elevation Model, it is not necessary to specify the co-ordinates of each Ground Control Point; in this case the cartographic co-ordinates (easting, northing and height on the reference DEM) of each GCP are written in the log file 825 at the end of this processing step.
Areas with good coherence should be preferred for the Ground Control Points location. In any case the importance of each GCP is weighted by the program on the basis of its coherence value.

If errors exist in the unwrapped phase image, they must be corrected before running this step. Otherwise wrongly unwrapped areas (disconnected phase "islands") have to be discarded for the Ground Control Points location.

Input Files

Coherence File
Name of the coherence image (_cc). This file is mandatory if a "Refinement Method" 775 is selected.

Input Master File
File name of the multi-looked master Intensity data (_mml_pwr). This file is mandatory.

Input Slave File
File name of the multi-looked coregistered slave Intensity data (_sml_pwr). This file is mandatory.

Unwrapped Phase File
Name of the unwrapped phase (_upha). This file is mandatory.

Synthetic Phase File
Name of the synthetic phase (_synt_sint). This file is mandatory.

Slant Range Digital Elevation Model File
Name of the Digital Elevation Model in slant range geometry (_srdem). This file is mandatory if a "Refinement Method" 775 is selected.

Refinement GCP File
Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File) or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the "Tools>Generate Ground Control Point 747" for details). This file is mandatory if a "Refinement Method" 775 is selected.

Optional Files

Interferogram File
Name of the flattened phase (_fint, _dint). This file is optional

DEM/Cartographic System

Digital Elevation Model File
Name of the Digital Elevation Model file (geocoded reference DEM). This file is mandatory if it had been used as input in the "Synthetic Phase Generation" step. If the Digital Elevation Model is omitted, an ellipsoidal height including the cartographic reference system must be set.

Output Projection
In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Refinement method
The choice is given between the following refinement methods:

- *Automatic Refinement;*
- *Polynomial Refinement;*
- *Orbital Refinement.*

Refer to the flattening section of the Preferences 775 for further information about these methods.

Refinement Residual Phase Polynomial Degree
Degree of the polynomial used to estimate the phase ramp, which will be removed from the input unwrapped phase during the Re-flattening operation. In case this value is higher that the number of input

Ground Control Points, it will be automatically decreased. The default values of 3 means that a phase ramp in range and azimuth direction plus a constant phase offset will be corrected. In case only the phase offset correction is needed, the polynomial degree will be set to 1.

Coregistration With DEM
This parameter can not be defined by the user.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Flattening

It brings to the flattening section of the Preferences 775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Coregistration

It brings to the coregistration section of the Preferences 770 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Refinement

It brings to the flattening section of the Preferences 775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Name of the output root. This file is optional.

_reflat_dint/fint
Re-flattened interferogram with the associated header files (.sml, .hdr).

_reflat_sint

Re-flattened synthetic phase with the associated header files (.sml, .hdr). This file is generated only if a "Refinement Method" 775 was selected.

_reflat_upha
Re-flattened unwrapped phase with the associated header files (.sml, .hdr).

_reflat_srdem
Digital Elevation Model, in slant range geometry, with the associated header files (.sml, .hdr). This file is generated only if a "Refinement Method" 775 was selected.

_orbital_refinement.shp
Shape file containing those points retained (valid GCPs) form the input "Orbital GCP file". This file is generated only if the "Orbital 775" method is applied. The following information are provided:

- Height value (in meters) from the input DEM in slant range - "ReadHeight".
- Absolute - "AbsHgtDiff" - and relative - "HeightDiff" - difference (in meters) between the real height (input DEM in slant range) and the height value derived from the corrected orbits.
- Standard deviation (in meters) of the input "Orbital GCP file" - "SigmaMt" - It is based on interferometric coherence and orbital configuration.
- Standard deviation (in radians) of the input "Orbital GCP file" - "SigmaRad" - It is based on the interferometric coherence.

_phase_refinement.shp
Shape file containing those points retained (valid GCPs) form the input "Orbital GCP file". This file is generated only if the "Residual Phase 775" method is applied. The following information are provided:

- Unwrapped phase value (in radians) - "ReadPhase".
- Absolute - "AbsPhDiff" - and relative - "PhaseDiff" - difference (in radians) between the real phase and its fitted value based on GCPs.
- Standard deviation (in meters) of the input "Orbital GCP file" - "SigmaMt" - It is based on interferometric coherence and orbital configuration.
- Standard deviation (in radians) of the input "Orbital GCP file" - "SigmaRad" - It is based on the interferometric coherence.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.8.3.6 5A - Phase to Height Conversion and Geocoding

Purpose

The absolute calibrated and unwrapped phase is re-combined with the synthetic phase and it is converted to height and geocoded into a map projection. This step is performed in a similar way as in the geocoding procedure (Basic module 142), by considering the Range-Doppler approach and the related geodetic and cartographic transforms. The fundamental difference with the geocoding step is that the Range-Doppler equations are applied simultaneously to the two antennae, making it possible to obtain not only the height of each pixel, but also its location (Easting, Northing) in a given cartographic and geodetic reference system.

As result of this step also the coherence image is geocoded.

Technical Note

Two files are generated in this step, beside the Digital Elevation Model and the geocoded coherence image, for a further use in the data mosaicing 712. They are:

- **Precision**, which is derived from parameters such as coherence, baseline and wavelength. It provides an estimate (i.e. standard deviation value) of the measurement precision. The higher this value the lower the measurement precision.

- **Resolution**, which represents the pixel resolution in ground range, that is:

pixel spacing slant range

sin(local incidence angle)

- **Wavelet Number of Levels** The Number of Levels, which refers to the power of a base 2, determines what is kept of the unwrapped phase. As an example, considering input data with a pixel spacing of 25 m, a "Number of Levels" of 1 means that the information coarser than 50 m is removed and the information finer than 50 m is preserved; a "Number of Levels" of 2 means that the information coarser than 100 m is removed and the information finer than 100 m is preserved; a "Number of Levels" of 3 means that the information coarser than 200 m is removed and the information finer than 200 m is preserved. It is suggested to set this value as a function of the reference DEM (which is used for the interferogram flattening) resolution; as an example, if we process SAR data with 3 m resolution with an SRTM reference DEM (90 m resolution), we'll enter a number of levels of 5 or more.

Input Files

Coherence File
File name of the coherence (_cc). This file is mandatory.

Unwrapped Phase File
File name of the unwrapped phase (_upha). This file is mandatory.

Synthetic Phase File
File name of the synthetic phase (_synt_sint). This file is mandatory.

Master File
File name of the master data (_pwr). This file is mandatory.

Slave File
File name of the slave data (_pwr). This file is mandatory.

DEM/Cartographic System

Output Projection
The following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Product Coherence Threshold
Pixels with coherence values smaller than this threshold will be set to dummy (NaN) in the final products.

Wavelet Number of Levels
Level setting for the wavelet calculation. It determines the level of detail to preserve.

Generate Shape format
By setting this flag the DEM is generated in vector (.shp) format.

X Dimension (m)
The grid size of the output data in Easting (X) must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Y Dimension (m)
The grid size of the output data in Northing (Y) must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Mean Window Size
The mean filtering of the output height image is carried out. The window filter size must be specified. If zero is entered, the mean filtering is not applied.

Interpolation Window Size
The dummy values in the output file are interpolated. The interpolated value is the average of the valid

values in a window of the size specified. If zero is entered, the interpolation is not applied.

Relax Interpolation
By setting this flag the relax interpolation is carried out. This interpolation is applied only to the Digital Elevation Model output.

Dummy Removal
By setting this flag the output geocoded files will be automatically resized in order to remove the dummy area exceeding the frame border.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Geocoding

It brings to the geocoding section of the Preferences 766 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Name of the output root. It is mandatory.

_dem
Digital Elevation Model with the associated header files (.sml, .hdr).

_cc_geo
Geocoded coherence with the associated header files (.sml, .hdr).

_precision
Estimate of the data quality with the associated header files (.sml, .hdr). This file is used during the Digital Elevation Model mosaicing (Tools 712).

_resolution
Spatial resolution based on the local incidence angle with the associated header files (.sml, .hdr). This file is used during the Digital Elevation Model mosaicing (Tools 712).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Holecz F., J. Moreira, P. Pasquali, S. Voigt, E. Meier, D. Nuesch: "Height Model Generation, Automatic Geocoding and Mosaicing using Airborne AeS-1 InSAR Data". Proceedings of IGARSS'97 Symposium, 1997.

1.8.3.7 5B - Phase to Displacement Conversion and Geocoding

Purpose

The absolute calibrated and unwrapped phase values are converted to displacement and directly geocoded into a map projection. This step is performed in a similar way as in the geocoding procedure (Basic module142), by considering the Range-Doppler approach and the related geodetic and cartographic transforms. The fundamental difference with the geocoding step is that the Range-Doppler equations are applied simultaneously to the two antennae, making it possible to obtain not only the displacement of each pixel, but also its location (Easting, Northing) in a given cartographic and geodetic reference system.

As result of this step also the coherence image is geocoded.

Technical Note

Each 2π cycle (interferometric fringe) of differential phase corresponds to half wavelength of displacement along the Slant Range direction (SAR viewing direction). It is possible to specify any vector (i.e direction and inclination) where the slant range displacement will be projected. This vector typically represents the deformation direction on the ground (i.e. "vertical" in case of subsidence; "slope" in case of landslides; "custom" in any other case).

The output map shows displacement magnitude in meters:

- Slant Range Displacement - Positive values correspond to movement towards the sensor.
- Displacement Custom Direction - Positive values correspond to movement in the user defined direction.

Displacement Custom Direction
Direction and inclination of the displacement vector can be specified. As an example an "azimuth angle" of 45° means that the displacement is oriented North 45° East and the movement is expected Northeastward; while an "azimuth angle" of 225° means that the displacement is always oriented North 45° East, but the movement is expected Southwestward. Positive inclination angles indicate upward movement; negative inclination angles indicate downward movement.

Precision
This output product, which is derived from parameters such as coherence and wavelength, provides an estimate (i.e. standard deviation value) of the measurement precision. The higher this value the lower the measurement precision.

It is important to outline that, if the Refinement and Re-flattening 572 step must have been performed previously.

Input Files

Coherence file
File name of the coherence (_cc). This file is optional.

Unwrapped Phase file
File name of the reflattened unwrapped phase (_upha). This file is mandatory.

DEM/Cartographic System

Digital Elevation Model file
Name of the Digital Elevation Model file. This should be referred to the ellipsoid. This file is optional. In

case it is omitted, the ellipsoidal height and the relevant cartographic reference system, must be entered.

Output Projection
In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Product Coherence Threshold
Pixels with coherence values smaller than this threshold will be set to dummy (NaN) in the final products.

Vertical Displacement
By setting this flag the map showing the displacement values projected on the vertical direction is generated among the output products.

Slope Displacement
By setting this flag the map showing the displacement values projected along the maximum slope is

generated among the output products.

Displacement Custom Direction
By setting this flag any vector can be specified, in terms of azimuth (**Azimuth Angle**, measured in degrees from the North - clockwise direction) and inclination (**Inclination Angle**, measured in degrees from the horizontal plane). The map showing the displacement values projected on the specified direction is generated among the output products.

X Dimension (m)
The grid size of the output data in Easting (X) must be defined; the default unit of measure is meters. Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Y Dimension (m)
The grid size of the output data in Northing (Y) must be defined; the default unit of measure is meters. Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Interpolation Window Size
By setting this flag the dummy values in the output file are interpolated. The interpolated value is the average of the valid values in a window of the size selected.

Dummy Removal
By setting this flag the output geocoded files will be automatically resized in order to remove the dummy area exceeding the frame border.

Parameters - Global

It brings to the general section of the Preferences759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Geocoding

It brings to the geocoding section of the Preferences766 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Displacement Projection

Stand by.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Name of the output root. It is mandatory.

_dem
Input Digital Elevation Model resampled onto the specified cartographic system and grid size, with the associated header files (.sml, .hdr). Its areal extent is the same as the output SAR products.

_cc_geo
Geocoded coherence with the associated header files (.sml, .hdr).

_ADF
Maximum slope direction values, with the associated header files (.sml, .hdr).

_IDF
Maximum slope inclination values, with the associated header files (.sml, .hdr).

_SD
Displacement values along the maximum slope direction, with the associated header files (.sml, .hdr).

_UD
Displacement values in the direction specified as azimuth and inclination degrees (i.e. custom direction), with the associated header files (.sml, .hdr).

_VD
Vertical displacement values, with the associated header files (.sml, .hdr).

_disp
Slant Range (satellite view direction) displacement values, with the associated header files (.sml, .hdr).

_precision
Estimate of the data quality with the associated header files (.sml, .hdr). This file is generated only if the coherence file is entered as input.

_ALOS
Azimuth Line of Sight with the associated header files (.sml, .hdr). Positive angles are measured clockwise from the North; negative angles are measured counterclockwise from the North.

_ILOS
Incidence angle of the Line of Sight with the associated header files (.sml, .hdr). The angle is measured between the Line Of Sight and the vertical on the ellipsoid (flat earth).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.8.3.8 ScanSAR Tools

Section Content

1.8.3.8.1 Remove Residual Phase Frequency

Purpose

The residual phase frequency is estimated on the wrapped phase (interferogram), removed from it and added to the synthetic phase (_sint).

The objective it is to simplify the "Phase Unwrapping" step.

Technical Note

The difference with respect to the Residual Phase Frequency removal, which is possible by setting the relevant Preferences 775, is that this is more flexible/tunable as more parameters can be set.

The "Ground Control Point file" can be optionally entered for the residual phase calculation. It has the same meaning of the "Orbital GCP file" used in the Refinement and Re-Flattening 308 process. If it is used, the Ground Control Points must be well distributed throughout the entire scene and they have not to be located on areas where topographic fringes remained "unflattened".

It must be noted that, only whether the input and output file names are the same or the "Output Root Name" is missing, the original synthetic (_sint) and differential (_dint) interferograms, which are modified as result of phase removal, are saved with the prefix "original_".

Azimuth Window Size
The window size must be larger than the orbital fringe dimension (in pixels) in order to have an optimal performance. If the window is too big, with respect to the image size, the program will automatically reduce it.

Range Window Size
The window size must be larger than the orbital fringe dimension (in pixels) in order to have an optimal performance. If the window is too big, with respect to the image size, the program will automatically reduce it.

Polynomial Degree
The number of coefficients (from 1 to 10) used for the residual phase removal. It makes sense to have this value set at least to 2, since a dominant dependency in range is expected.

$$\varphi = K_1 + K_2X + K_3Y + K_4X^2 + K_5XY + K_6Y^2 + K_7X^3 + K_8X^2Y + K_9XY^2 + K_{10}Y^3$$

Low Pass Filter m
Window size (meters) for the Low Pass atmospheric removal, in range and azimuth direction, which is used for the removal process. If set to zero, the Low Pass removal is not applied. Suggested values are more than 15000 meters, only in case of small spatial size displacement pattern.

Input Files

Interferogram File
File name of the differential interferogram (_dint, _fint). This file is mandatory.

Coherence File
File name of the coherence image (_cc). This file is mandatory.

Optional Files

Geometry GCP File
Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File) or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the "Tools>Generate Ground Control Point 747" for details). This file is optional.

Parameters - Principal Parameters

Azimuth Window Size
Window Size in azimuth direction – better using power of 2 values – which is used to estimate the local fringe frequency.

Range Window Size
Window Size in range direction – better using power of 2 values – which is used to estimate the local fringe frequency.

Azimuth Window Number
Number of windows, in azimuth direction, which are used for the removal process. If set to zero, the polynomial removal is not applied.

Range Window Number
Number of windows, in range direction, which are used for the removal process. If set to zero, the polynomial removal is not applied.

Polynomial Degree
The number of coefficients (from 1 to 10) used for the residual phase removal. Refer to the flattening section of the Flattening Preferences 775 for further informations.

Low Pass Filter m
Window size in meter for the Low Pass Filter. If set to zero, the Low Pass removal is not applied.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Flattening

It brings to the flattening section of the Preferences 775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Name of the output root. This file is mandatory.

_dint
Flattened corrected interferogram with the associated header files (.sml, .hdr). This file is generated only if the input is an unfiltered interferogram (_dint).

_fint
Flattened and filtered corrected interferogram with the associated header files (.sml, .hdr). This file is generated only if the input is a flattened-filtered interferogram (_fint).

_sint
Synthetic phase with the associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.9 Polarimetry and PolInSAR Module

Section Content

1.9.1 Overview

A Note on the SAR Polarimetry and Polarimetric Interferometry module

The proper utilisation of the processing functions, which are available within this module, requires a good knowledge of the Polarimetry and Polarimetric Interferometry principles and applications. Extensive information about these topics are provided by the ESA, Polarimetric SAR Interferometry tutorial.

The following functions are included in the **Polarimetry** section:

Polarimetric Calibration Matrix
It enables to obtain an accurate estimate of the target scattering matrix by using default or custom polarimetric calibration parameters.

Polarimetric Signature

It provides the real and theoretical estimate of the co-polarized and cross-polarized signatures of point-target-like objects (e.g. corner reflectors). The residual polarimetric calibration errors are also estimated.

Polarization Synthesis

Starting from a linearly-polarized dataset, it enables to create (i.e. synthesize) the scattering matrix for any arbitrary polarization orthogonal basis.

Polarimetric Decomposition

It provides coherent (i.e. Pauli decomposition) and incoherent (i.e. Entropy-Alpha-Anisotropy eigen-decomposition) methods for the scattering matrix decomposition. The first method is suitable for coherent local targets characterisation, while the second is intended for distributed target characterisation.

Polarimetric Classification

It consists of an unsupervised classification approach to discriminate different scattering behaviours on the basis of the Entropy Alpha Anisotropy decomposition result.

Polarimetric Features

It provides some possible combinations of co- and cross-polarized polarimetric Intensity data, which can be suitable for further interpretation or classification purposes.

The following functions are included in the **Polarimetric Interferometry** section:

SLC Coregistration

The polarimetric master and slave data sets are coregistered and over sampled in range direction.

Synthetic Phase Generation

The phase component, related to both the acquisition geometry (constant phase) and the flat Earth or the known topography (in case a Digital Elevation Model is used), is generated.

Coherence Optimisation

Interferograms and coherence data representative of the main scattering mechanisms are generated.

PPD / Interferogram Generation

Two types of products can be generated: i) the Polarimetric Phase Difference (PPD), which is generated from two different polarizations of the same acquisition; ii) the "classical" Interferogram, which is generated from the same polarization of two different coregistered acquisitions.

Synthetic Phase Flattening

The interferogram flattening can be executed using the synthetic phase generated from a different polarization of the same acquisition pair.

Polarimetric Coherence Generation

Coherence data relevant to the Polarimetric Phase Difference or to the single polarization interferogram are generated.

Note that:

- In case of SAR RAW products, the data must be imported and focussed (refer to Focusing module 215).
- Default setting for selected parameters can be specified in the Preferences panel.
- The SAR Tutorial, which includes basic knowledge on SAR theory and data processing, complements the online help.
- Co-ordinate decimal values must be entered using the dot (e.g. 29.30) and not the comma (e.g. 29,30) character.

References

ESA, Polarimetric SAR Interferometry tutorial

1.9.2 Frequently Asked Questions

Q. - What is the **Faraday Rotation**? Does SARscape take it into account??

A. - The Faraday Rotation, is an atmospheric effect which causes the polarization rotation of the scattering objects. SARscape does not foresee a specific functionality to correct these effects.
In case of ALOS PALSAR data generated by JAXA, these effect have been already compensated. A possible way to verify if a residual phase rotation is present in your data, it is to generate an interferogram between HV and VH, (for the mono-static sensors) polarizations: the average phase shall be different from 0 if a phase rotation exists.

Q. - Is it possible to first perform the **Geocoding** of the 4 SLC channels/polarizations and afterwards run the **Polarimetric Decomposition**?

A. - No, this is not possible since the decomposition process requires Single Look Complex data, while the result of the Geocoding 142 is an amplitude (possibly multi looked) image. The geocoding process must be then executed after the Polarimetric Decomposition has been carried out.

Q. - How can I interpret the results obtained from the **Polarimetric Decomposition**?

A. - Any coherent polarimetric decomposition algorithm (e.g. Pauli Decomposition 612) tries to interpret the SAR measured signal contained in a full polarimetric dataset as linear coherent (i.e. including the phase) combination of elementary scatterings of some defined type. Three independent input channels (since the HV and VH are, for monostatic systems, fully correlated and thus identical) can be considered as a weighted sum of three types of pre-defined elementary scattering types. The difference among the existing decomposition methods stands in the elementary scattering mechanisms which are used as base to describe our data. For instance, according to Pauli, each pixel is considered as possible combination of some odd-bounce (e.g. single - planar or triple – corner reflector), even-bounce (e.g. dual – double bounce) and even-45 degrees rotated / volume reflections. The goal of the decomposition algorithm is then to estimate for every pixel the weights of this combination.

Q. - Is the **Multitemporal** **Time Series De Grandi Filter** 135 suitable for filtering the Pauli Channels coming from different acquisition dates?

A. - Yes, this multitemporal filtering method can be adopted, given that the filter is executed by inputting homogeneous information (e.g. data with the same linear polarization or from the same component output of a decomposition, with same acquisition geometry, etc.). For instance you shall not mix in the same input list HH with VV polarizations or K_1 and K_2 decomposition channels.

Q. - The question concerns the **Interferogram Generation** and also the **Coherence Optimization** processes. Do I need to use different synthetic phase outputs: one calculated with the range and azimuth looks equal to 1 (Coherence Optimization step) and one with the range looks equal to 2 (PPD/ Interferogram Generation step)?

A. - For what concerns the Interferogram Generation 632 there are 3 mandatory inputs, which are the master and slave acquisitions (previously coregistered and thus overlooked 2 times in range) and the synthetic phase; this last file must have been previously generated using the coregistered master and slave data as inputs. Indeed, in order to have an output square pixel, it must be taken into account that the inputs (i.e. coregistered master and slave data) are oversampled in range direction, thus you have to multiply by 2 the range looks that you would normally adopt for those data. For instance, if you have PALSAR data that you normally multi-look with factors 7/1 (azimuth/range respectively), here you have to set the multi-look factors to 7/2. It is important to remember that the same factors (i.e. 7/2) have to be used both for the Synthetic Phase Generation 636 and in the Interferogram Generation. A final useful note is that the interferogram can be generated, probably with less efforts, by means of the Interferometry module!

For what concerns the Coherence Optimization 626 there are the same 3 mandatory inputs, generated in the same way as above, apart from the multi looking factors for the synthetic phase image; here indeed they must be set to 1/1 (azimuth/range). Afterwards, when the Coherence Optimisation process is executed, you must take into account the input data oversampling in range direction and consequently you must multiply by 2 the range looks that you would normally adopt for those data. The same example illustrated above for the PALSAR data, that you have to multi-look with factors 7/2 instead of 7/1, can be applied in this case. It must be finally noted that here the "Looks" button (for the automatic calculation of the multi looking factors) takes into account of the over sampling in the input data and, in the example above, it shall automatically set the values to 7/2.

Q. - How can I interpret the results obtained from the **Coherence Optimisation**?

A. - In terms of interpretation, the concept is similar to the "Polarimetric Decomposition" described above: we identify the most important scattering mechanisms (in this case we don't even say which ones) that are contained in each cell; the mechanisms showing the highest coherence are separated from those characterized by respectively intermediate and lowest coherence levels. If different mechanisms exist in a cell (e.g. for penetration through a vegetation pixel, where some reflection comes from the crown and some from the trunk), they could have a different location in height (as the crown, the trunk and the underlying terrain), which is revealed by the interferometric phase difference of the different scattering mechanisms. Among others, possible use of this information are: i) tree height estimate; ii) classification based on the number (1, 2 or 3) of significant mechanisms that are contained in each pixel.

Q. - Is it possible to correlate the tree height with the output of the **Coherence Optimisation**?

A. - The result of this processing step consists of three interferograms and corresponding coherence images, one for each of the (possibly significant) optimized polarization pairs (one master and one slave); the differential interferograms between the first and the second one (in terms of coherence) is proportional to the trees height. In reality the coherence is strongly related to the temporal decorrelation, which in case of PALSAR pairs is quite notable and this factor must be taken into account.

Q. - How can I use the **Polarimetric Phase Difference** (PPD) and what are the information that I gather?

A. - The first consideration to do it is that, in a polarimetric acquisition, the (complex) correlation between one co-polar (HH or VV) and one cross-polar (HV or VH) channel is close to zero, unless we are dealing with a very low frequency acquisitions (lower than L band). Hence the major interest is for estimating the PPD of pairs of co-polar channels (HH and VV); this relates with the number of bounces of the scattering (90 degrees for each bounce): water will have a different phase respect to buildings, while volumes of vegetation will have a almost totally random phase, depending on their thickness. In the end PPD, and the corresponding coherence, can be used to help in discriminating objects of different kind and/or shape.

1.9.3 Reference Guide Polarimetry

Section Content

Polarimetric Classification 619

1.9.3.1 Polarimetric Calibration Matrix

Purpose

Polarimetric calibration allows, in general, to minimize the impact of non ideal behaviours of a full-polarimetric SAR acquisition system, to obtain an estimate of the scattering matrix of the imaged objects as accurate as possible from their available measurement.

The calibration (or distortion) matrix is annotated within the header file (*PolarimetricCalibrationParameters* section) of the calibrated products.

In case of originally calibrated products (e.g. ALOS PALSAR data in JAXA format), this step has not to be executed unless a new - and more accurate - calibration matrix was available.

Technical Note

The terms of the matrixes that multiply the true target scattering matrix ***S***, that represent non ideal behaviours of the acquisition system, like imbalance and cross-talk, are usually estimated using reference targets of well-known polarimetric response, like dihedral or trihedral Corner Reflectors as well as natural distributed random targets like forests and water areas. The ***N*** noise terms are normally neglected during the calibration process. The purpose of this processing step is to perform the matrix products to obtain an estimate of the ***S*** matrix from the measured ***Z*** one, using either a user-provided calibration matrix or a default one, as typically available with the original product. It shall be noticed that such a calibration matrix may be expected as quite constant along the life of a spaceborne sensor (i.e. ALOS PALSAR) or subject to periodic updates, but not to be estimated for every single scene.

The relationship between the true and the measured scattering matrixes ***S*** and ***Z*** of a target are expressed by the following equation:

$$\begin{bmatrix} Z_{HH} & Z_{HV} \\ Z_{VH} & Z_{VV} \end{bmatrix} = Ae^{j\phi} \begin{bmatrix} 1 & \delta_3 \\ \delta_4 & f_2 \end{bmatrix} \begin{bmatrix} \cos\Omega & \sin\Omega \\ -\sin\Omega & \cos\Omega \end{bmatrix} \begin{bmatrix} S_{HH} & S_{HV} \\ S_{VH} & S_{VV} \end{bmatrix} \begin{bmatrix} \cos\Omega & \sin\Omega \\ -\sin\Omega & \cos\Omega \end{bmatrix} \begin{bmatrix} 1 & \delta_1 \\ \delta_2 & f_1 \end{bmatrix} + \begin{bmatrix} N_{HH} & N_{HV} \\ N_{VH} & N_{VV} \end{bmatrix}$$

Where:

S = Scattering matrix
$f_{1,2}$ = Channel amplitude imbalance
$\delta_{1,2}$ = Cross talk
N = Thermal noise
Ω = Faraday rotation
A = Absolute calibration

Input Files

Input HH File
Input file name of the uncalibrated HH data (_slc). This file is mandatory.

Input HV File
Input file name of the uncalibrated HV data (_slc). This file is mandatory.

Input VH File
Input file name of the uncalibrated VH data (_slc). This file is mandatory.

Input VV File
Input file name of the uncalibrated VV data (_slc). This file is mandatory.

Optional Files

Input Calibration Matrix
Calibration matrix set by the user (.sml). This optional file must be formatted as follows:


```
<?xml version="1.0" ?>
<HEADER_INFO xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.sarmap.ch/xml/SARscapeHeaderSchema
_version_1.0.xsd">
<PolarimetricCalibrationParameters>
<DT_Real>
<MatrixDouble NumberOfRows = "2" NumberOfColumns = "2">
<MatrixRowDouble ID = "0">
<ValueDouble ID = "0">1</ValueDouble>
<ValueDouble ID = "1">-0.028047</ValueDouble>
</MatrixRowDouble>
<MatrixRowDouble ID = "1">
<ValueDouble ID = "0">0.0316404</ValueDouble>
<ValueDouble ID = "1">0.9352351</ValueDouble>
</MatrixRowDouble>
</MatrixDouble>
</DT_Real>
<DT_Immaginary>
<MatrixDouble NumberOfRows = "2" NumberOfColumns = "2">
<MatrixRowDouble ID = "0">
<ValueDouble ID = "0">0</ValueDouble>
<ValueDouble ID = "1">-0.0029335</ValueDouble>
</MatrixRowDouble>
<MatrixRowDouble ID = "1">
<ValueDouble ID = "0">-0.0103815</ValueDouble>
<ValueDouble ID = "1">0.4073565</ValueDouble>
</MatrixRowDouble>
</MatrixDouble>
</DT_Immaginary>
<DR_Real>
<MatrixDouble NumberOfRows = "2" NumberOfColumns = "2">
<MatrixRowDouble ID = "0">
<ValueDouble ID = "0">1</ValueDouble>
<ValueDouble ID = "1">-0.0369903</ValueDouble>
</MatrixRowDouble>
```

```
<MatrixRowDouble ID = "1">
<ValueDouble ID = "0">0.0211591</ValueDouble>
<ValueDouble ID = "1">0.7249998</ValueDouble>
</MatrixRowDouble>
</MatrixDouble>
</DR_Real>
<DR_Immaginary>
<MatrixDouble NumberOfRows = "2" NumberOfColumns = "2">
<MatrixRowDouble ID = "0">
<ValueDouble ID = "0">0</ValueDouble>
<ValueDouble ID = "1">0.0008454</ValueDouble>
</MatrixRowDouble>
<MatrixRowDouble ID = "1">
<ValueDouble ID = "0">0.0056483</ValueDouble>
<ValueDouble ID = "1">0.0005536</ValueDouble>
</MatrixRowDouble>
</MatrixDouble>
</DR_Immaginary>
<ReceiverGainForLikePolatizedDB>24</ReceiverGainForLikePolatizedDB>
<ReceiverGainForCrossPolatizedDB>24</ReceiverGainForCrossPolatizedDB>
</PolarimetricCalibrationParameters>
</HEADER_INFO>
```


Parameters - Principal Parameters

Calibration Type

The selection of one of the following operations is mandatory:

- **Use Alos Palsar Calibration Matrix**
  It is intended to apply the calibration estimates - the same available in the standard JAXA SLC products - on SLC data generated with the Focusing module 219.

- **Revert Calibration**
  The calibration matrix is inverted, removing the effect of a previous calibration.
  As an example, SLC products provided by JAXA are calibrated with a reference matrix. If more accurate calibration estimates are available, the calibration process is inverted to perform a new (more accurate) one.

- **Use Input Calibration Matrix**
  The Parameter file containing the relevant calibration matrix (Input Matrix file) is used.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output HH File
Output file name of the calibrated HH data (_slc). This file is mandatory.

Output HV File
Output file name of the calibrated HV data (_slc). This file is mandatory.

Output VH File
Output file name of the calibrated VH data (_slc). This file is mandatory.

Output VV File
Output file name of the calibrated VV data (_slc). This file is mandatory.

_cal_slc
Calibrated scattering matrix (HH, HV, VH, VV) with the associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

ESA, Polarimetric SAR Interferometry tutorial

A. Freeman. "SAR calibration: an overview". IEEE Transactions on Geoscience and Remote Sensing, Vol. 30, No. 6, 1992.

S. Quegan. "A unified algorithm for phase and cross-talk calibration of polarimetric data-theory and observations". IEEE Transactions on Geoscience and Remote Sensing, Vol. 32, No. 1, 1994.

1.9.3.2 Polarimetric Signature

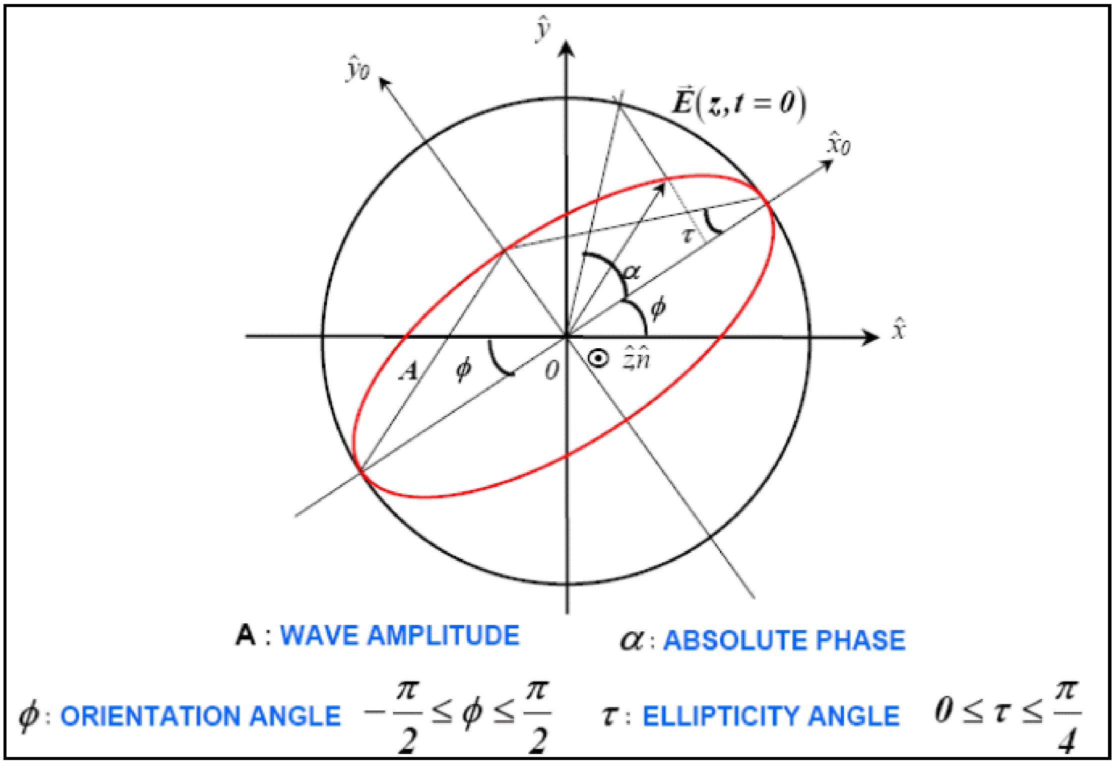
Purpose

Knowledge of the scattering matrix - i.e. the 2x2 complex elements, where the diagonal elements are the co-polar (HH, VV) terms, while the off-diagonal are known as cross-polar (HV, VH) terms - permits the estimation of the received power for any possible combination of transmitting and receiving antennas (i.e. polarization synthesis or formation of the scattering matrix in any arbitrary polarization basis). This functionality provides an estimate of the polarimetric signature of a point-target-like object, whose location is specified either in terms of its range and azimuth coordinates or through its known cartographic coordinates.

The IDL views relevant respectively to the co-polarized and cross-polarized signatures are automatically visualised at process completion. To reload the IDL views of a previous processing (or for processing executed in batch mode), just enter the Output root name.

Technical Note

A particular graphical representation of the backscattering variation as a function of the polarization, known as polarization signature, is quite useful for describing the polarization properties of a target. The response consists of a plot of synthesized (and normalized) scattering cross sections as a function of the ellipticity (τ) and orientation (ϕ) angles of the received wave. Ellipticity (-45° to +45°) describes the flatness of the locus of the electric vector of a fully polarized wave, while orientation (-90° to +90°) is the angle between the major axis of the ellipse and a reference direction.



In addition to the estimation of the polarimetric signature of a point-target-like object, a search of the pixel location corresponding to the HH maximum intensity in a window surrounding the provided location of the point-target-like object is performed. In case the location of the point-target-like object is provided in cartographic co-ordinates, its expected initial location in slant range geometry is estimated through a backward-geocoding process using the nominal product header information. A refined target location is then obtained through a data interpolation process; the maximum backscatter value is identified over a window of about 15 pixels around the input target co-ordinates. An estimate of the residual polarimetric calibration errors, in terms of amplitude and phase imbalance, is provided assuming that the target is a corner reflector.

Input Files

Input HH File

Input file names of the scattering matrix (_slc). This file is mandatory.

Input HV File

Input file names of the scattering matrix (_slc). This file is mandatory.

Input VH File

Input file names of the scattering matrix (_slc). This file is mandatory.

Input VV File

Input file names of the scattering matrix (_slc). This file is mandatory.

DEM/Cartographic System

Output Projection

In case the Georeferenced Point flag is set, the following parameters are compulsory to define the Cartographic System 6:

State

Definition of the country or general projection systems.

Projection

Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid

Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere

Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone

Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters

Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height

In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters

The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Range (column) / X

Range or cartographic (X) co-ordinate of the pixel.

Azimuth (row) / Y

Azimuth or cartographic (Y) co-ordinate of the pixel.

Height / Z

Elevation of the pixel (only for georeferenced points).

Georeferenced Point
When setting this flag (i.e. target identification by cartographic co-ordinates), it is compulsory to set the appropriate Cartographic System.

Orientation Increment
Increment (in degrees) of the orientation angle.

Ellipticity Increment
Increment (in degrees) of the ellipticity angle.

Estimate Theoretical
By setting this flag, an estimate of the theoretical polarimetric signature is calculated.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Root file name. It is also needed if a previously generated signature has to be re-loaded. This file is mandatory.

_co_signature
Co-polar signature with the associated header files (.sml, .hdr).

_cross_signature
Cross-polar signature with the associated header files (.sml, .hdr).

_co_signature.jpg
View of the Co-polar signature graph (jpeg format).

_cross_signature.jpg
View of the Cross-polar signature graph (jpeg format).

_signature.txt

Estimate of the residual polarimetric calibration errors.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

ESA, Polarimetric SAR Interferometry tutorial

Van Zyl, J.J., H. Zebker, and C. Elachi, 1987: "Imaging Radar Polarization Signatures: Theory and Application". Radio Science, vol. 22, no. 4, pp. 529-543.

W. Cameron, N. Youssef and L. Leung: "Simulated polarimetric signatures of primitive geometrical shapes". Geoscience and Remote Sensing, IEEE Transactions on, vol. 34, no. 3, May 1996, pp. 793 - 803.

1.9.3.3 Polarimetric Features

Purpose

The simplest way to represent the polarimetric information contained in the scattering matrix is given by calculating some co- and cross polarized power combinations, as well as some selected ratios. Polarimetric features enable, to some extent, to identify combinations which are possibly suitable for data interpretation or classification purposes.

A Polarimetric Phase Difference (PPD) can be generated using two different polarization of the same polarimetric acquisition. It is worthwhile to mention that, especially working with wavelengths shorter than the P band, it makes sense to generate the PPD using co-polarized master and slave data (i.e. HH or VV polarizations). See the Polarimetric Interferogram Generation 632 module for further details.

Technical Note

None.

Input File(s)

Input HH File
Input file names of the scattering matrix (_slc). This file is mandatory.

Input HV File
Input file names of the scattering matrix (_slc). This file is mandatory.

Input VH File
Input file names of the scattering matrix (_slc). This file is mandatory.

Input VV File
Input file names of the scattering matrix (_slc). This file is mandatory.

Parameters - Principal Parameters

The Following Features (flags) can be selected:

HH HH*

VV VV*

HV HV*

Re {HH VV*}

Im {HH VV*}

Re {HV VV*}

Im {HV VV*}

Re {HH HV*}

Im {HH HV*}

Span = HH+HV+VH+VV

Polarization Ratio = HH HH* / VV VV*

Linear Depolarization Ratio = HV HV* / VV VV*

Polarimetric Phase Difference HH VV

Polarimetric Coherence HH VV

Polarimetric Phase Difference HH HV

Polarimetric Coherence HH HV

Polarimetric Phase Difference HV VV

Polarimetric Coherence HV VV

Normalize
By setting this flag, the selected features are normalized by the Span feature.

Azimuth Looks
Number of looks in azimuth.

Range Looks
Number of looks in range.

Grid Size for Suggested Looks
The grid size, in meters, used to tune range and azimuth looks. If the other parameters are manually set, the grid size will not imply a change in their values.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output root name
Root file name. This file is mandatory.

_span
Span feature with the associated header files (.sml, .hdr).

_hh_hh
HH HH* feature with the associated header files (.sml, .hdr).

_vv_vv
VV VV* feature with the associated header files (.sml, .hdr).

_hv_hv
HV HV* feature with the associated header files (.sml, .hdr).

_re_hh_vv
Re {HH VV*} feature with the associated header files (.sml, .hdr).

_im_hh_vv
Im {HH VV*} feature with the associated header files (.sml, .hdr).

_re_hv_vv
Re {HV VV*} feature with the associated header files (.sml, .hdr).

_im_hv_vv
Im {HV VV*} feature with the associated header files (.sml, .hdr).

_re_hh_hv
Re {HH HV*} feature with the associated header files (.sml, .hdr).

_im_hh_hv
Im {HH HV*} feature with the associated header files (.sml, .hdr).

_polrat
Polarization Ratio feature with the associated header files (.sml, .hdr).

_ldr
Linear Depolarization Ratio feature with the associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

Looks
The most appropriate range and azimuth multi-looking factors are calculated. This calculation is performed by taking into account the Cartographic Grid Size, which is set in the relevant SARscape Default 759 Values panel.

References

ESA, Polarimetric SAR Interferometry tutorial

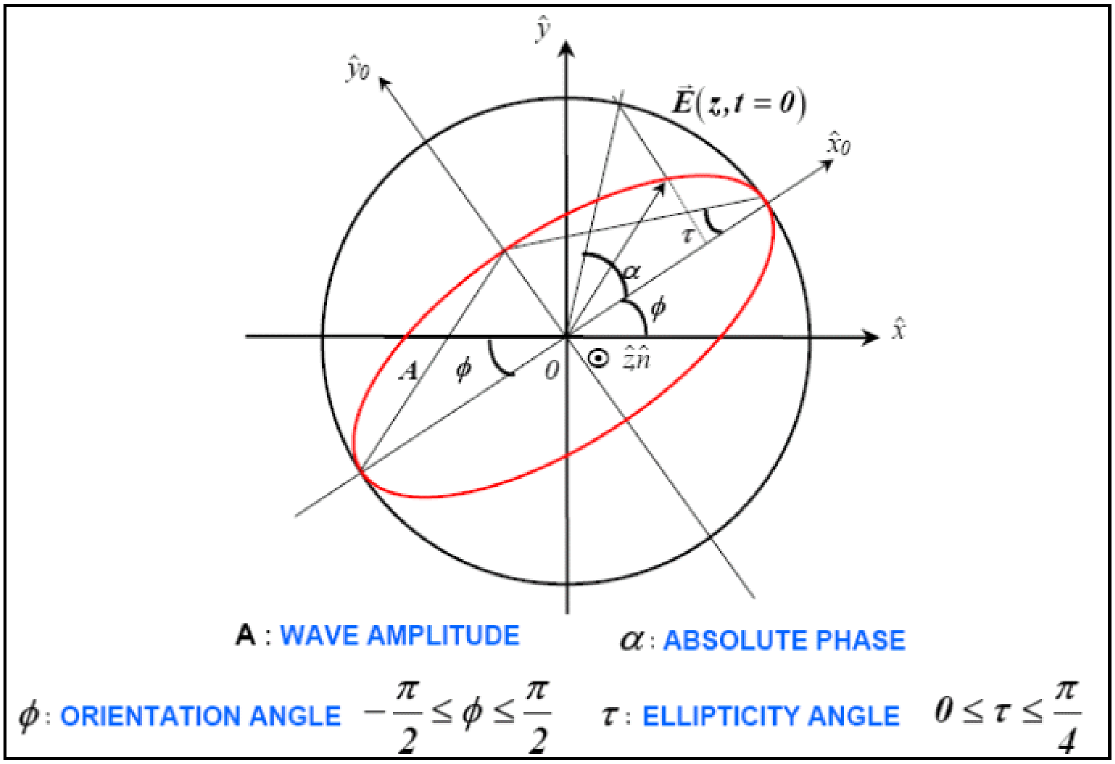
1.9.3.4 Polarimetric Synthesis

Purpose

Knowledge of the scattering matrix - i.e. the 2x2 complex elements, where the diagonal elements are the co-polar (HH, VV) terms, while the off-diagonal are known as cross-polar (HV, VH) terms - permits the estimation of the received power for any possible combination of transmitting and receiving antennas (i.e. polarization synthesis or formation of the scattering matrix in any arbitrary polarization basis). Starting from a set of full-polarimetric linearly-polarized Single Look Complex (SLC) data, this functionality allows to synthesize a new set of SLC data in a desired orthogonal basis, either circular, linear rotated of 45° or generic elliptical of user-defined orientation and ellipticity.

Technical Note

Ellipticity (-45° to +45°) describes the flatness of the locus of the electric vector of a fully polarized wave, while orientation (-90° to +90°) is the angle between the major axis of the ellipse and a reference direction.



© ESA

Note that an elliptical polarization becomes a linear one in case of ellipticity angle equal to 0, while an ellipticity angle of + or - 45 degrees corresponds to a circularly-polarized wave.

The sense of rotation of the tip of the wave in the plane of polarization is called the sense of polarization, or handedness. This sense is called right-handed (left-handed) if the direction of rotation is clockwise (counterclockwise for an observer looking in the direction of propagation).

Input Files

Input HH File
Input file names of the scattering matrix (_slc). This file is mandatory.

Input HV File
Input file names of the scattering matrix (_slc). This file is mandatory.

Input VH File
Input file names of the scattering matrix (_slc). This file is mandatory.

Input VV File

Input file names of the scattering matrix (_slc). This file is mandatory.

Parameters - Principal Parameters

Polarisation Type

One of the following parameter must selected:

Circular
i.e. $\alpha = \pi/2$ and $A_x = A_y$.

Linear 45°
i.e. $\alpha = 0$ with slope $\tan^{-1}(A_y / A_x)$.

Elliptical
i.e. α, A_x, A_y not equal to 0.

Orientation
Orientation angle (in degrees).

Ellipticity
Ellipticity angle (in degrees).

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output root name
Root file name. This file is mandatory.

_ll_slc
Circular (left-left) synthetic polarization with the associated header files (.sml, .hdr).

_lr_slc
Circular (left-right) synthetic polarization with the associated header files (.sml, .hdr).

_rl_slc
Circular (right-left) synthetic polarization with the associated header files (.sml, .hdr).

_rr_slc
Circular (right-right) synthetic polarization with the associated header files (.sml, .hdr).

_xx_slc
Linear (45° horizontal - 45° horizontal) synthetic polarization with the associated header files (.sml, .hdr).

_xy_slc
Linear (45° horizontal - 45° vertical) synthetic polarization with the associated header files (.sml, .hdr).

_yx_slc
Linear (45° vertical - 45° horizontal) synthetic polarization with the associated header files (.sml, .hdr).

_yy_slc
Linear (45° vertical - 45° vertical) synthetic polarization with the associated header files (.sml, .hdr).

_00_slc and **_11_slc**
Elliptical synthetic co-polarizations with the associated header files (.sml, .hdr).

_01_slc and **_10_slc**
Elliptical synthetic cross-polarizations with the associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

[ESA, Polarimetric SAR Interferometry tutorial]

1.9.3.5 Polarimetric Decomposition

Section Content

1.9.3.5.1 Pauli

Purpose

The Pauli coherent decomposition provides an interpretation of a full polarimetric Single Look Complex data set in terms of elementary scattering mechanisms: sphere/plate/trihedral (single- or odd-bounce scattering), dihedral oriented at 0° (double- or even-bounce) and diplane oriented at 45° (qualitatively related also to volume scattering). In general the coherent decomposition approach is suitable for discriminating the scattering of elementary objects (e.g. man made structures).

The results are in Slant Range geometry, therefore each of the output RGB channels shall be geocoded 142 in order to be properly displayed in a cartographic system, afterward a new colour composite 704 of the three geocoded RGB channels will be performed.

Technical Note

The objective of the coherent decomposition is to express the measured scattering matrix *S* as the combination of the scattering responses of elementary objects.

$$[S] = \sum_{i=1}^{k} c_i [S]_i$$

The symbol S_i stands for the response of every one elementary objects, whereas c_i indicates the weight of S_i in the combination leading to the measured *S*.

It has to be pointed out that the scattering matrix *S* can characterise the scattering processes produced by a given object, and therefore the object itself. This is possible only in those cases where both, the incident and the scattered waves are completely polarized. Consequently, coherent target decompositions can be only employed to study the coherent targets. These scatterers are known as point or pure targets.

In a real situation, the measured scattering matrix S corresponds to a complex coherent target. Therefore a direct analysis of the scattering matrix, with the objective to infer the physical properties of the scatterers under study, is often very difficult. Thus the physical properties of the scatterers are extracted and interpreted through the analysis of elementary responses S_i and corresponding coefficients c_i.

The decomposition as exposed in not unique in the sense that it is possible to find number of infinite sets S_i in which the scattering matrix S can be decomposed. Nevertheless, only some of the sets S_i are convenient to interpret the information content of S. Three methods are typically employed to characterize coherent scatterers based on the scattering matrix S :

- The Pauli Decomposition
- The Krogager Decomposition
- The Cameron Decomposition

This functionality provides the decomposition results coming from the Pauli method. Three single channels and their color composite (namely _k2_slc, _k3_slc and _k1_slc respectively assigned to the Red, Green and Blue colors), are generated. The meaning, in terms of scattering mechanism, is as follows:

- Even-bounce (HH-VV)
- Dihedral rotated 45 degree (HV+VH)
- Odd-bounce (HH+VV)

Input Files

Input HH File
Input file names of the scattering matrix (_slc). This file is mandatory.

Input HV File
Input file names of the scattering matrix (_slc). This file is mandatory.

Input VH File
Input file names of the scattering matrix (_slc). This file is mandatory.

Input VV File
Input file names of the scattering matrix (_slc). This file is mandatory.

Output Files

Output root name

Root file name. This file is mandatory.

_pauli_K1_slc
HH + VV polarization combination with the associated header files (.sml, .hdr).

_pauli_K2_slc
HH - VV polarization combination with the associated header files (.sml, .hdr).

_pauli_K3_slc
HV + VH polarization combination with the associated header files (.sml, .hdr).

_pauli_rgb.tif
Color composite using K2, K3, K1 respectively in Red, Green and Blue with the corresponding header file (.sml).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

ESA, Polarimetric SAR Interferometry tutorial

Cloude, S.R. and E. Pottier: "A review of target decomposition theorems in radar polarimetry". IEEE Trans. GRS, vol. 34(2), pp. 498-518, Mar. 1996.

Cloude, S.R. and E. Pottier: "Symmetry, zero correlations and target decomposition theorems". in Proc.

3rd Int. Workshop on Radar Polarimetry (JIPR ’95), IRESTE, University of Nantes, Mar. 1995, pp. 58–68.

1.9.3.5.2 Entropy Alpha Anisotropy

Purpose

The Entropy / Alpha / Anisotropy decomposition performs an eigen-decomposition of the coherency matrix of a full-polarimetric Single Look Complex data set. In order to facilitate the analysis of the physical information provided by the eigen decomposition of the coherency matrix, three secondary parameters are defined as a function of the eigenvalues and eigenvectors:

- Entropy – it is related to degree of randomness of the scattering process. It can vary from 0 to 1.
- Alpha – it relates to the type of scattering mechanism. It can vary from 0° to 90°.
- Anisotropy – it measures the relative importance of the second and third eigenvalue of the eigen decomposition. It can vary from 0 to 1.

In general the incoherent decomposition approach is suitable for discriminating the scattering of complex targets such as natural features.

Technical Note

The scattering matrix *S* is only able to characterize, from a polarimetric point of view, coherent scatterers. On the contrary, this matrix can not be employed to characterize distributed targets. This type of scatterers can be only characterized, statistically, due to the presence of speckle noise. Since speckle noise must be reduced, only second order polarimetric representations can be used to analysed distributed scatterers. These second order descriptors are the 3 by 3, Hermitian average covariance (*C*) and the coherency (*T*) matrices. These two representations are equivalent.

The complexity of the scattering process makes extremely difficult the physical study of a given scatter through the analysis of *C* or *T*. Hence, the objective of the incoherent decompositions is to separate the *C* or *T* matrices as the combination of the second order descriptors corresponding to simple objects, presenting an easier physical interpretation. These decomposition theorems can be expressed as:

$$\langle [C_3] \rangle = \sum_{i=1}^{k} p_i [C_3]_i$$

$$\langle [T_3] \rangle = \sum_{i=1}^{k} q_i [T_3]_i$$

where p_i and q_i denote the coefficients of the components in *C* and *T* .

As in the case of the coherent decomposition, it is desirable that these components present some properties. First at all it is desirable that the components C_i and T_i correspond to pure targets in order to simplify the study. In addition the components should be independent, i.e. orthogonal. The bases in which *C* or *T* are not unique. Consequently different incoherent decompositions can be expressed:

- The Freeman Decomposition
- The Huynen Decomposition
- The Eigenvector-Eigenvalue Decomposition

This functionality provides the decomposition results coming from the Eigenvector-Eigenvalue method. The three single channels (i.e. entropy, alpha and anisotropy) and the color channels (i.e. Red, Green, Blue) coming from their linear combination are generated. This combination, which had already been proposed in PolSARPro, consists of:

- Red channel = SQRT(Lambda) * sin(Alpha) * cos(Beta)
- Green channel = SQRT(Lambda) * sin(Alpha) * sin(Beta)
- Blue channel = SQRT(Lambda) * cos(Alpha)

Lambda, Alpha and Beta are defined according to the original Cloude & Pottier paper.

To properly scale the Red, Green and Blue channels for an RGB colour composite we suggest to use the "Tools>Generate Color Composite704" functionality.

An important property of this decomposition method is its independency from the orientation of the imaged objects respect to the acquisition sensor (roll-invariance).

Filter Window Type and Window Size
The Entropy / Alpha / Anisotropy decomposition is based on the estimated polarimetric coherency matrix (each polarisation against another one); the window type and size correspond respectively to the method (i.e. "Boxcar" or "Adaptive") and window dimension, which are adopted for the coherence estimate (refer to the relevant technical notes300 for additional details). The moving window within which the entropy, alpha, and anisotropy values are calculated, it can either be constant and rectangular (Boxcar), or it can vary following the backscatter behaviour (Adaptive).

Input Files

Input HH File
Input file names of the scattering matrix (_slc). This file is mandatory.

Input HV File
Input file names of the scattering matrix (_slc). This file is mandatory.

Input VH File
Input file names of the scattering matrix (_slc). This file is mandatory.

Input VV File
Input file names of the scattering matrix (_slc). This file is mandatory.

Parameters - Principal Parameters

Azimuth Window Size
Window size (in pixel) in azimuth direction. This shall be set proportionally to the multilooking factor.

Range Window Size
Window size (in pixel) in range direction. This shall be set proportionally to the multilooking factor.

Window Type
One of the following options must selected:

Boxcar
A window of constant shape and size is used.

Adaptive
An adaptive process is used to locally estimate the optimal size and shape of the window; this dimension will never exceed the specified window size (in azimuth and range). The adaptive process is based on the local stationary behaviour of the backscattered signal in the different polarizations.

Azimuth Multilook
Number of looks in azimuth.

Range multilook
Number of looks in range.

Grid Size for Suggested Looks
The grid size, in meters, used to tune range and azimuth looks. If the other parameters are manually set, the grid size will not imply a change in their values.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output root name

Root file name. This file is mandatory.

_alpha
Alpha decomposition parameter and associated header files (.sml, .hdr).

_anisotropy
Anisotropy decomposition parameter and associated header files (.sml, .hdr).

_entropy
Entropy decomposition parameter and associated header files (.sml, .hdr).

.list
List of the decomposition parameters. It is needed for the further Entropy Alpha Anisotropy classification 619.

_red
Linear combination of the decomposition parameters to use as Red channel for an RGB composite, and associated header files (.sml, .hdr).

_green
Linear combination of the decomposition parameters to use as Green channel for an RGB composite, and associated header files (.sml, .hdr).

_blue
Linear combination of the decomposition parameters to use as Green channel for an RGB composite, and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

Looks
The most appropriate range and azimuth multi-looking factors are calculated. This calculation is performed by taking into account the Cartographic Grid Size, which is set in the relevant SARscape Default 759 Values panel.

References

ESA, Polarimetric SAR Interferometry tutorial

Cloude, S.R. and E. Pottier: "A review of target decomposition theorems in radar polarimetry". IEEE Trans. GRS, vol. 34(2), pp. 498-518, Mar. 1996.

Cloude, S.R. and E. Pottier: "Symmetry, zero correlations and target decomposition theorems". Proc. 3rd Int. Workshop on Radar Polarimetry (JIPR '95), IRESTE, University of Nantes, Mar. 1995, pp. 58–68.

S. R. Cloude: "An entropy based classification scheme for polarimetric SAR data". Proc. IGARSS'95, Florence, Italy, July 1995, pp. 2000–2002.

1.9.3.6 Polarimetric Classification

Section Content

1.9.3.6.1 Entropy Alpha Anisotropy

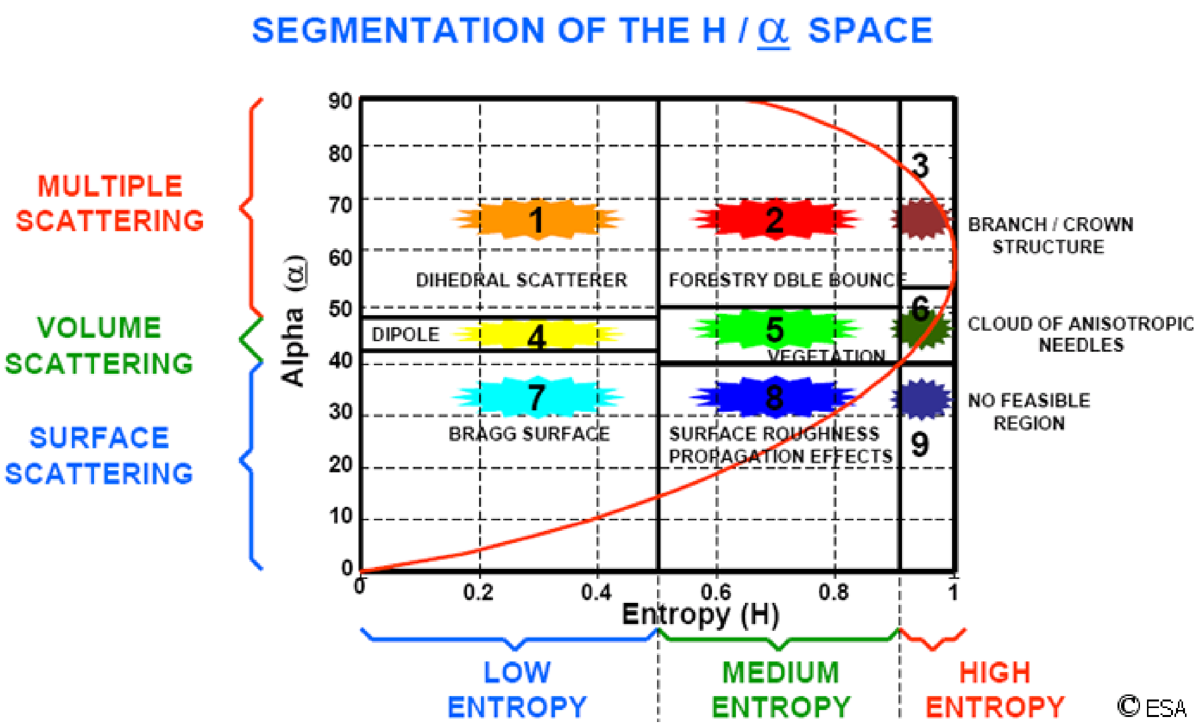
Purpose

An unsupervised classification, enabling to discriminate the main scattering types on the basis of the Entropy Alpha Anisotropy decomposition, is performed. The classification is generated in Slant Range geometry with the original pixel sampling; it can be directly geocoded using the "Basic module>Geocoding 142" functionality (the "Optimal Resolution" resampling method is suggested in order to avoid undesired pixel distortions).

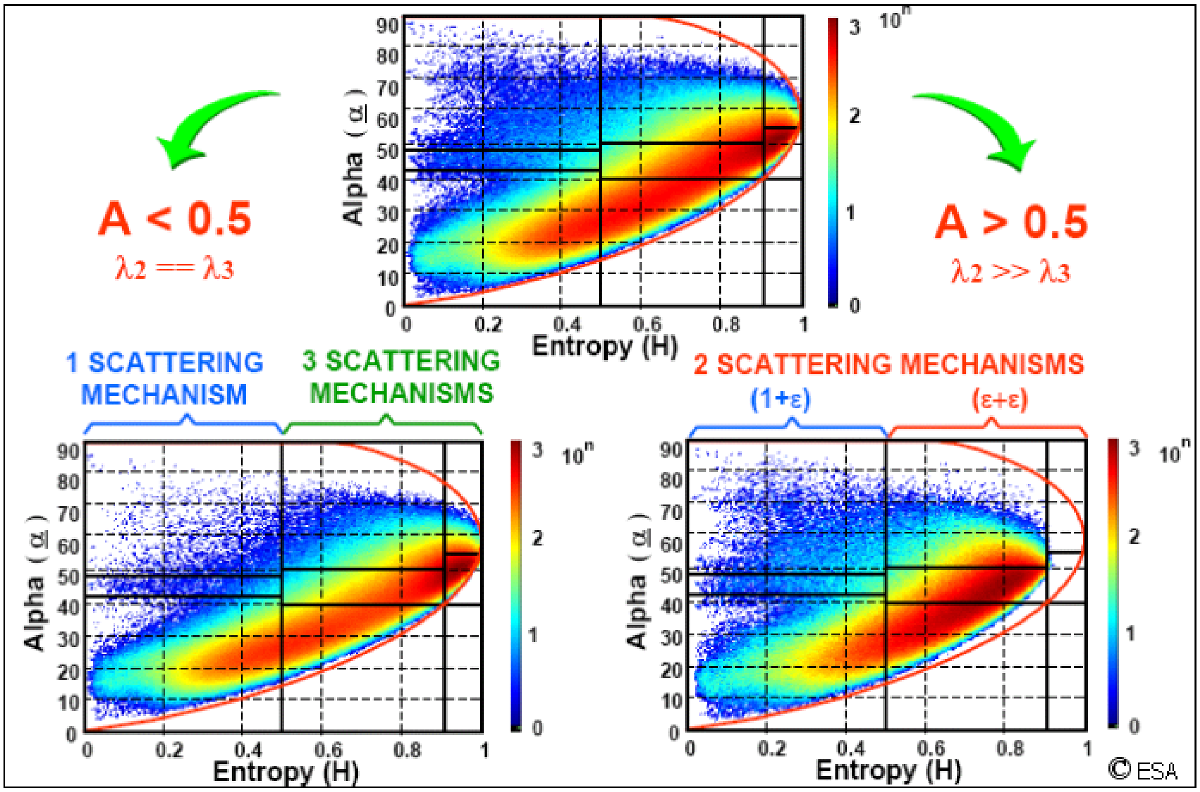
Technical Note

Cloude and Pottier proposed an algorithm to identify, in an unsupervised way, the polarimetric scattering mechanisms in the H-α (Entropy-Mean alpha angle) plane. The basic idea is that entropy arises as a natural measure of the inherent reversibility of the scattering data and that the mean alpha angle can be used to identify the underlying average scattering mechanism.

The H-α plane is divided in 9 basic zones characteristic of different scattering behaviours (see figure below). The basic scattering mechanism of each pixel can be identified by comparing its entropy and mean alpha angle parameters to fixed thresholds. The different class boundaries, in the H-α plane, have been determined in order to discriminate surface reflection, volume diffusion, and double bounce reflection along the α axis; while low, medium, and high degree of randomness are represented along the H axis. The red curve identifies the area in the alpha-Entropy plane where "physically possible" results can be obtained.



The proposed procedure may be further improved by explicitly including the anisotropy information (see figure below). This polarimetric indicator is particularly useful to discriminate scattering mechanisms with different eigenvalue distributions but with similar intermediate entropy values. In such cases, a high anisotropy value indicates two dominant scattering mechanisms with equal probability and a less significant third mechanism, while a low anisotropy value corresponds to a dominant first scattering mechanism and two non-negligible secondary mechanisms with equal importance.



Input Files

Input file
Name of the input file including the Entropy-Anisotropy-Alpha decomposition (.list). This file is mandatory.

Output Files

Output file
Name of the output classification file. This file is mandatory.

Root Name
Classification with the associated header files (.sml, .hdr).

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

ESA, Polarimetric SAR Interferometry tutorial

S. Cloude and E. Pottier: "An entropy based classification scheme for land applications of polarimetric SAR". Geoscience and Remote Sensing, IEEE Transactions on, vol. 35, no. 1, Jan. 1997, pp. 68 - 78.

1.9.4 Reference Guide Polarimetric Interferometry

Section Content

1.9.4.1 SLC Coregistration

Purpose

The coregistration of a pair of polarimetric Single Look Complex acquisitions is performed. This step is necessary to get a correspondence, with sub-pixel accuracy, between the master and slave acquisition in order to enable the further interferometric processing.

It must be noted that, for a proper execution of the polarimetric interferometric processing, calibrated 596 data are required.

Although a full-polarimetric dataset acquired in linear polarization (HH, HV, VH, VV) is the default usage of this functionality, the input file list may be composed by any number of SLC data (linear or synthesized polarization or any other data type).

Technical Note

The slave to master coregistration is performed first by means of the orbital parameters, then using a cross-correlation function between the two Intensity images, and finally the shift is refined by automatically selecting a series of image "chips" where mini-interferograms are calculated. If the coherence is too low the number of points for the fine shift estimate can be not sufficient to optimize the coregistration process. In this case the coregistration will be carried out using the orbits and an improved cross correlation based fit, which allow a coregistration with sub-pixel accuracy.

In case the two acquisitions are very much different in terms of areal coverage, the smallest one should be used as "Input Master files" in order to avoid the coregistration windows to be located in areas with null pixel values, which can eventually cause the coregistration process to fail.

The first file of the list is used to compute the coregistration parameters. Typically the HH polarization is the most suitable for this purpose.

It is possible to perform the coregistration in a manual way, by manually locating the center of the windows (i.e. Cross-correlation Grid 770 and Fine Shift Parameters 770) in the Input reference file (see input "Coregistration file" below).

It must be noted that the output coregistered master and slave data are over sampled (i.e. multiplied by a factor two) in range direction. This has to be taken into account for a proper execution of the further processing steps.

Input Files

Input Master files
Input file names of the master polarimetric data set (_slc). These files are mandatory.

Input Slave files
Input file names of the slave polarimetric data set (_slc). These files are mandatory.

Optional Files

Coregistration file
A previously created Ground Control Point file (.xml), with the points used for the manual coregistration (.xml), is automatically loaded. These points represent the center of the coregistration windows. This file is optional.

Shift Parameter file
Name of the file with the shift parameters used for the coregistration (_par). This file is mandatory. If the Compute shift parameter flag is set, it is generated as output.

Parameters - Principal Parameters

Compute Shift Parameters
By setting this flag, the coregistration shifts between master and slave image are calculated and saved into the _par file.

Compute Shift Parameters only
By setting this flag only the coregistration shift parameters are calculated and saved into the _par file. The input data are not actually coregistered.

Coregistration With DEM
This parameter can not be defined by the user.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Coregistration

It brings to the coregistration section of the Preferences 770 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Master files
Output file names of the master polarimetric data set (_slc). These files are mandatory.

Output Slave files
Output file names of the slave polarimetric data set (_slc). These files are mandatory.

_rsp_slc

Coregistered data with the associated header files (.sml, .hdr).

_par
ASCII file containing the coregistration shift parameters in range and azimuth. This file is generated only if the shift parameters are calculated.

_orbit_off.shp
Shape file with the points used to estimate the orbit based shift. This file contains the following information:

- Pixel position in range direction (Range), in Single Look pixel units.
- Pixel position in azimuth direction (Azimuth), in Single Look pixel units.
- Shift measured in range direction (Dr), in Single Look pixel units.
- Shift measured in azimuth direction (Da), in Single Look pixel units.
- Calculated polynomial shift, to apply in range direction (Drfit), in Single Look pixel units.
- Calculated polynomial shift, to apply in azimuth direction (Dafit), in Single Look pixel units.

The file, which is generated only when the shift parameters are calculated, is over sampled (i.e. multiplied by a factor two) in range direction.

_winCC_off.shp
Shape file with the points used to estimate the cross correlation based shift from the Intensity data. In addition to the information provided by the "_orbit_off.shp" file, this file contains also the cross-correlation value (it is dimensionless and it can vary from 0 to 1) and the following two residual shift measurements (calculated with respect to the orbit and topography related shift):

- Residual shift in range direction (Dr).
- Residual shift in azimuth direction (Da).

The file, which is generated only when the shift parameters are calculated, is over sampled (i.e. multiplied by a factor two) in range direction.

_winCoh_off.shp
Shape file with the points used to estimate the coherence based shift from the complex data (fine shift estimate). In addition to the information provided by the "_orbit_off.shp", this file contains also the the following information:

- Signal to Noise Ratio (SNR), which is a linear dimensionless value.
- Coherence value. It is dimensionless and it can vary from 0 to 1.

The file, which is generated only when the shift parameters are calculated, is over sampled (i.e. multiplied by a factor two) in range direction.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

ESA, Polarimetric SAR Interferometry tutorial

C. Prati, F. Rocca, A. Monti Guarnieri, P. Pasquali: "Report on ERS-1 SAR interferometric techniques and applications". ESA Study Contract Report , ESA Contract N.:3-7439/92/HGE-I, Milano, Italy, 1994.

D.L. Small, C.L. Werner and D.R. Nüesch: "Registration of ERS-1 SLC Products for SAR Interferometry". Proceedings of the Fourth GEOSAR Workshop, 1993, pp. 63-66.

F. Gatelli et al.: "The wavenumber shift in SAR inferometry". Geoscience and Remote Sensing, IEEE Transactions on, vol. 32, no. 4, July 1994, pp. 855 - 865.

M. Schwäbisch and D. Geudtner: "Improvement of Phase and Coherence Map Quality Using Azimuth Prefiltering: Examples from ERS-1 and X-SAR". Proceedings of the IEEE International Geoscience and Remote Sensing Symposium IGARSS, 1995, pp. 205-207.

1.9.4.2 Coherence Optimisation

Purpose

The main scattering mechanisms, of a full polarimetric linearly-polarized Single Look Complex (SLC) acquisition pair, are estimated. It is performed by identifying those mechanisms that correspond to the highest value of interferometric coherence. The corresponding interferograms and coherence data are provided as result.

The data must have been previously coregistered 622.

Technical Note

The dependency of the interferometric coherence from the polarization of the images used to form the interferogram leads to consider the question of which polarization yields the highest coherence. In essence, the problem is to optimize the general formulation of the interferometric coherence, i.e.

$$\tilde{\gamma}(\vec{w}_1, \vec{w}_2) = \frac{< i_1 \; i_2^* >}{\sqrt{< i_1 \; i_1^* > \; < i_2 \; i_2^* >}} = \frac{< \vec{w}_1 [\Omega] \vec{w}_2^+ >}{\sqrt{< (\vec{w}_1 [T] \vec{w}_1^+) > \; < (\vec{w}_2 [T] \vec{w}_2^+) >}}$$

After tedious algebra, it can be demonstrated that the maximum possible coherence value g_{opt1}, which can be obtained by varying the polarization, is given by the square root of the maximum eigenvalue. Each eigenvalue is related to a pair of eigenvectors (w_{1i},w_{2i}): one for each image. The first vector pair (w_{11},w_{21}) represents the optimal polarizations. The second and third pairs (w_{12},w_{22}) and (w_{13},w_{23}), belonging to the second and third highest singular values, represent optimal solutions in different polarimetric subspaces.

These three optimal complex coherence data can be obtained directly by using the estimated eigenvalues:

$$\tilde{\gamma}_{opti}(\vec{w}_{opt1i}, \vec{w}_{opt2i}) = \sqrt{v_{opti}} \exp(i \arg(i_{opt1i} i^*_{opt2i})) = \sqrt{v_{opti}} \exp(i \arg(\vec{w}_{opt1i} [\Omega] \vec{w}^+_{opt2i}))$$

It is important to note that the pixel sampling of the input master/slave data and synthetic phase, must be the same.

If the Range Looks and the Azimuth Looks are set to 1, the output products are over sampled (i.e. multiplied by a factor two) in range direction.

Input Files

Master HH file
Input file name of the master polarimetric HH data (_slc). This file is mandatory.

Master HV file
Input file name of the master polarimetric HV data (_slc). This file is mandatory.

Master VH file
Input file name of the master polarimetric VH data (_slc). This file is mandatory.

Master VV file
Input file name of the master polarimetric VV data (_slc). This file is mandatory.

Slave HH file
Input file names of the slave polarimetric HH data set (_slc). This file is mandatory.

Slave HV file
Input file names of the slave polarimetric HV data (_slc). This file is mandatory.

Slave VH file
Input file names of the slave polarimetric VH data (_slc). This file is mandatory.

Slave VV file
Input file names of the slave polarimetric VV data (_slc). This file is mandatory.

DEM/Cartographic System

Digital Elevation Model file
Name of the Digital Elevation Model file. This should be referred to the ellipsoid.

Output Projection
In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height

In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters

The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Filter Dimensions

The size (in pixels) of the window used during the coherence estimation and maximization process. It shall be set proportionally to the multilooking factors. Note that, in case of "Adaptive Window" type, it corresponds to the maximum window size:

Azimuth Size

Window dimension in azimuth direction.

Range Size

Window dimension in azimuth direction.

Filter Type

The estimation of the coherence and the maximization process can be performed by using:

Boxcar Window

A box-car window of fixed size for the whole image.

Adaptive Window

A window of variable size and shape, which is estimated depending of the local stationarity of the signal Intensity.

Azimuth Looks

Number of looks in azimuth.

Range Looks

Number of looks in range.

Remember that, in case the multilooking factor is manually calculated (i.e. without using the "Looks" button), the input coregistered 622 data are over sampled two times in range direction, thus the range multilooking factor must be doubled with respect to that calculated for the original (i.e. not coregistered) data.

Grid Size for Suggested Looks

The grid size, in meters, used to tune range and azimuth looks. If the other parameters are manually set, the grid size will not imply a change in their values.

Coregistration with DEM
By setting this flag, the input Digital Elevation Model is used in the coregistration process.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Flattening

It brings to the flattening section of the Preferences 775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Coregistration

It brings to the coregistration section of the Preferences 770 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Name of the output file. This file is mandatory.

_max_cc
Maximum estimated coherence with the associated header files (.sml, .hdr).

_max_dint
Interferogram relevant to the maximum estimated coherence with the associated header files (.sml, .hdr).

_med_cc
Medium estimated coherence with the associated header files (.sml, .hdr).

_med_dint
Interferogram relevant to the medium estimated coherence with the associated header files (.sml, .hdr).

_min_cc
Minimum estimated coherence with the associated header files (.sml, .hdr).

_min_dint
Interferogram relevant to the minimum estimated coherence with the associated header files (.sml, .hdr).

_ml_sint
Multilooked synthetic phase with the associated header files (.sml, .hdr).

_ml_srdem
Multilooked slant range Digital Elevation Model with the associated header files (.sml, .hdr). This file is generated only if the original product (i.e. rootname_srdem) is available in the input folder.

_parameter_polarimetric_coh_opt
Parameters set.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

Looks
The most appropriate range and azimuth multi-looking factors are calculated. This calculation takes into account of the over sampling in the input coregistered 622 data.

References

ESA, Polarimetric SAR Interferometry tutorial

S. Cloude and K. Papathanassiou: "Polarimetric SAR interferometry". Geoscience and Remote Sensing, IEEE Transactions on, vol. 36, no. 5, Part 1, Sept. 1998, pp. 1551 - 1565.

A. Monti Guarnieri et al.: "Multi-mode ENVISAT ASAR interferometry: techniques and preliminary results". Radar, Sonar and Navigation, IEE Proceedings -, vol. 150, no. 3, 2 June 2003, pp. 193 - 200.

J. Lee et al.: "Speckle filtering and coherence estimation of polarimetric SAR interferometry data for forest applications" Geoscience and Remote Sensing, IEEE Transactions on, vol. 41, no. 10, Part 1, Oct. 2003, pp. 2254 - 2263.

G. Vasile et al.: "Intensity-driven adaptive-neighborhood technique for polarimetric and interferometric SAR parameters estimation". Geoscience and Remote Sensing, IEEE Transactions on, vol. 44, no. 6, June 2006, pp. 1609 - 1621.

1.9.4.3 Interferogram Generation

Purpose

An interferogram can be generated using the same polarization of the polarimetric interferometric acquisition pair. It must be noted that, for the interferogram generation, master and slave data must have been previously coregistered 622. If the synthetic phase is entered as input, then the topography is removed and the output file will be a flattened interferogram.

Technical Note

For each resolution element two coregistered scattering matrices are available. The complete information measured by the SAR system can be represented in form of three 3 by 3 complex matrices T_{11}, T_{22}, and Ω_{12} formed formed using the outer products of the scattering vectors k_1 and k_2 as:

$$T_{11} = k^T{}_1 . k_1 \qquad T_{22} = k^T{}_2 . k_2 \qquad \Omega_{12} = k^T{}_1 . k_2$$

T_{11} and T_{22} are the conventional polarimetric coherency matrices which describe the polarimetric properties for each individual image separately, and Ω_{12} is a complex matrix containing polarimetric and interferometric information. The two complex scalar images (i_1 and i_2) forming the interferogram are obtained by projecting the scattering vectors (k_1 and k_2) onto two unitary complex vectors w_1 and w_2, which define the polarization of the two images respectively as:

$$i_1 = w^T{}_1 \cdot k_1 \quad \text{and} \quad i_2 = w^T{}_2 \cdot k_2$$

The interferogram related to the polarizations given by w_1 and w_2 is then:

$$i_1 \, i^*_2 = (w^T_1 \cdot k_1) \, (w^T_2 \cdot k_2)^T$$

Two cases should be distinguished:

- w_1 is equal to w_2, i.e. images with the same polarization are used to form an interferogram. In this case the interferometric phase contains only the interferometric contribution due to to the topography and range variation, while the interferometric coherence expresses the interferometric correlation behaviour.
- w_1 is not equal w_2 , i.e. images with different polarization are used to form the interferogram. In this case the interferometric phase contains, besides the interferometric component, also the phase difference between the two polarizations. The interferometric coherence expresses, apart from the interferometric correlation behaviour, also the polarimetric correlation between master and slave:

$$\gamma \, (w_1, \, w_2) = \gamma_{Int} \cdot \gamma_2$$

It is important to note that, when using the synthetic phase as input, its pixel sampling must be the same of the input master/slave data. **Note that in this module only the first case is considered**. If one wishes to use images with different polarization (the second case), the Polarimetric Features 606 module's Polarimetric Phase Difference (PPD), should be used.

If the Range Looks and the Azimuth Looks are set to 1, the output products are generated with the same multilooking factors as the input data. . **It is important to know that, unlike the multi-looked intensity images generated in the "Basic module>Multilooking** 119**", these master and slave intensities cannot be radiometrically calibrated** 142 **due to the spatial varying effect introduced by the spectral shift filter**.

Input Files

Input Master file
File name of the master data (_slc, _rsp_slc). This file is mandatory.

Input Slave file
File name of the slave data (_slc, _rsp_slc). This file is mandatory.

DEM/Cartographic System

Digital Elevation Model File
Name of the Digital Elevation Model file. This should be referred to the ellipsoid. This file is optional. In case it is omitted, the ellipsoidal height and the relevant cartographic reference system, must be entered.

Output Projection

In case that the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System** 6:

State

Definition of the country or general projection systems.

Projection

Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid

Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere

Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone

Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters

Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height

In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters

The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Azimuth Multilooks

Number of looks in azimuth.

Range Multilooks

Number of looks in range.

Grid Size for Suggested Looks

The grid size, in meters, used to tune range and azimuth looks. If the other parameters are manually set, the grid size will not imply a change in their values.

Coregistration With DEM

This parameter can not be defined by the user.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Flattening

It brings to the flattening section of the Preferences 775 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Coregistration

It brings to the coregistration section of the Preferences 770 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output Root Name
Name of the output root. This file is mandatory.

_int
Interferogram with the associated header files (.sml, .hdr).

_dint
Flattened interferogram with the associated header files (.sml, .hdr). This file is generated only if the input synthetic phase is entered.

_pwr
Multi-looked master and slave image with the associated header files (.sml, .hdr).

_orb.sml
Xml file containing the scene orbital parameters.

_cc
Estimated coherence with the associated header files (.sml, .hdr). This file is generated only if the

Coherence Generation flag is selected.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

Looks
The most appropriate range and azimuth multi-looking factors are calculated.

References

ESA, Polarimetric SAR Interferometry tutorial

1.9.4.4 Synthetic Phase Generation

Purpose

The synthetic phase is calculated using orbital data, system and processing parameters and the Digital Elevation Model (alternatively the ellipsoidal height). It contains the constant phase (due to the acquisition geometry) and the phase expected for a flat Earth or for a known topography (in case a Digital Elevation Model is used).

This step is mandatory in case the Coherence Optimisation 626 or the Interferogram Generation 632 (not the Polarimetric Phase Difference - i.e. PPD) has to be carried out.

Technical Note

The phase due to the topography is estimated from the input Digital Elevation Model (if available), which is transformed to the master slant range geometry. In case of precise orbits and accurately geocoded reference Digital Elevation Model, this process is run in a fully automatic way. However, in case of inaccuracy in the satellite orbits or in the Digital Elevation Model geolocation, a Ground Control Point is required to correct the SAR data (i.e. master acquisition of the interferometric pair) with respect to the reference Digital Elevation Model; in this case the corresponding position of the GCP in the slave image is calculated on the basis of the shift parameters coming from a coregistration process.

It is important to note that:

- In case the "Master file" has already been corrected with the the manual 722 or the automatic 719 procedure the GCP is not needed.
- In case the "Master file" is correct (i.e. the nominally geocoded image fits with the DEM), while the orbital parameters of the "Slave file" are not accurate (i.e. the nominally geocoded image does not fit with the DEM), the GCP is not needed but the flag "Automatic Slave Orbit Correction", in the Preferences>Flattening 775, must be checked.

In case the two images are very much different in terms of areal coverage, the smallest one should be used as "Master file" in order to avoid the coregistration windows to be located in areas with null pixel values, which can eventually cause the coregistration process to fail.

In case of baseline conditions - or topographic conditions - which cause the interferometric phase to change very fast and to eventually get lost due to an aliasing problem, it is suggested to over sample the range pixel size by entering negative values in the Range Multilooking (Preferences>Interferometry>Multilooking 779).

It is important to point out that:

- If the synthetic phase has to be used as input to the Coherence Optimisation, the number of looks in Azimuth and Range has to be set to 1 and 1. In this case the master and slave data used for the Synthetic Phase Generation must have been previously coregistered 622.
- If the synthetic phase has to be used as input to the Interferogram Generation, the same multilooking factors must be set in the two processing steps (i.e. Synthetic Phase Generation and Interferogram Generation). However, when coregistered 622 master and slave data are used, it must be taken into account that they are multiplied (i.e. over sampled) by a factor 2 in range direction and thus the multilooking factors must be set accordingly.

The algorithms implemented have been developed in collaboration with the Polytechnic University of Milan.

Input File(s)

Master file
File name of the master data (_slc); any of the 4 polarization can be inputted. This file is mandatory.

Slave file
File name of the slave data (_slc); any of the 4 polarization can be inputted. This file is mandatory.

Digital Elevation Model file
Name of the Digital Elevation Model file. This should be referred to the ellipsoid. This file is optional. In case that Digital Elevation Model data is omitted, an ellipsoidal height, including the cartographic reference system, must be set.

Output Root Name
Name of the output root. It is mandatory.

Load GCP file
A previously created Ground Control Point file (.xml) is loaded. This file is optional.

Create GCP file
The interface to create a new Ground Control Point file is automatically loaded (refer to the "Tools>Generate Ground Control Point 747" for details). This file is optional.

Shift Parameter file
Name of the file with the shift parameters used for the coregistration (_par). This file can be entered only if the Ground Control Point file is used; if the Compute shift parameter flag is set, it is generated as output.

Input Parameter(s)

Cartographic System 6

In case that the Digital Elevation Model is not used, following parameters are compulsory:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
In case that the Digital Elevation Model is not used, a constant ellipsoidal height must be provided. Default Reference Height is 0.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Azimuth looks
Number of looks in azimuth.

Range looks
Number of looks in range.

Coregistration Setting
It brings to the coregistration section of the Preferences 770 parameters. Any modified value will be used and stored for further processing sessions. This button is enabled only using an input Ground Control Point file.

Compute Shift Parameters
By setting this flag, the coregistration shifts between master and slave image are calculated and saved into the _par file. This flag is enabled only using an input Ground Control Point file.

Output(s)

_sint
Synthetic phase with the associated header files (.sml, .hdr).

_srdem
Digital Elevation Model in slant range geometry with the associated header files (.sml, .hdr).

_par
ASCII file containing the coregistration shift parameters in range and azimuth. This file is generated only if the shift parameters are calculated.

_orb.sml
Xml file containing the scene orbital parameters.

_orbit_off.shp

Shape file with the points used to estimate the orbit based shift. This file contains the following information:

- Pixel position in range direction (Range), in Master - or Slave - pixel units.
- Pixel position in azimuth direction (Azimuth), in Master - or Slave - pixel units.
- Shift measured in range direction (Dr), in Master - or Slave - pixel units.
- Shift measured in azimuth direction (Da), in Master - or Slave - pixel units.
- Calculated polynomial shift, to apply in range direction (Drfit), in Master - or Slave - pixel units.
- Calculated polynomial shift, to apply in azimuth direction (Dafit), in Master - or Slave - pixel units.

The file, which is generated only when the shift parameters are calculated, is multilooked (i.e. Azimuth and Range looks) as specified in the Input Parameters.

_winCC_off.shp
Shape file with the points used to estimate the cross correlation based shift from the Intensity data. The information provided by the "_orbit_off.shp" file are updated on the basis of the cross correlation estimate.

The file, which is generated only when the shift parameters are calculated, is multilooked (i.e. Azimuth and Range looks) as specified in the Input Parameters.

_winCoh_off.shp
Shape file with the points used to estimate the coherence based shift. The information provided in the "_winCC_off.shp" are updated by means the coherence based estimate. This file contains also the following additional information:

- Signal to Noise Ratio (SNR), which is a linear dimensionless value.
- Coherence value. It is dimensionless and it can vary from 0 to 1.

The file, which is generated only when the shift parameters are calculated, is multilooked (i.e. Azimuth and Range looks) as specified in the Input Parameters.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

Looks
The most appropriate range and azimuth multi-looking factors are calculated.

References

None.

1.10 General Tools

Section Content

1.10.1 Overview

A suite of multi-purpose utilities is provided to complement the processing functions available in the different modules.

Note that:

- Default setting for selected parameters can be specified in the Preferences panel.
- The SAR Tutorial, which includes basic knowledge on SAR theory and data processing, complements the online help.
- Data geocoded to GEO-GLOBAL cartographic reference system can be automatically displayed into the Google Earth environment by double clicking on the output .kml file.
- Co-ordinate decimal values must be entered using the dot (e.g. 29.30) and not the comma (e.g. 29,30) character.

1.10.2 Frequently Asked Questions

Q. - In the **Digital Elevation Model Extraction** step, the required DEM tiles are not retrieved or in some cases they are only partially downloaded. How is it possible if those DEM tiles actually exist in the relevant WEB site?

A. - This problem is typically due to a temporary failure of the internet connection or to a change of the reference FTP or HTTP address (the FTP or HTTP protocols are used depending on the required DEM). In case one of the DEM tiles is not found in the internet, or the internet connection fails before or during the data downloading, a message is written in the Process.log 825 file where the required DEM tiles (i.e. file name) are mentioned. The user can do an attempt to download those data using a dedicated FTP or HTTP too and then store them in the working directory 756.
The internet addresses, which are used by the program to download the Digital Elevation Model of the different supported products, are subject to changes. They are written (and they can eventually be modified) in the relevant Preferences 791.

Q. - How does SARscape calculate the slope (easting, northing, and combined) in the **Convertion DEM to Slope** tool?

A. - This functionality generates the following files:

- _S2N_slope, which is a real number corresponding to the slope inclination (degrees) in South-North direction.
- _W2E_slope, which is a real number corresponding to the slope inclination (degrees) in West-East direction.
- _slope, which is a complex number corresponding to the South-North slope inclination (imaginary part) and to the West-East slope inclination (real part).

The slope computation in a point P is done by calculating the angles Θ_B and Θ_A, which are related respectively to the previous and to the next pixels:

$$\Theta_B = \text{atan2}((ZP-ZB) /D) * (180/\Pi)$$

$$\Theta_A = \text{atan2}((ZA-ZP) /D) * (180/\Pi)$$

Z is the height difference of the point P with respect to the previous (B) and to the next (A) pixels; D is the distance on the ground between the points P and A.

Q. - Can I use original geocoded data (i.e. standard products such as GEC or GTC formats) as input to the **Mosaicing** tool?

A. - All geocoded products (in SARscape format) can be mosaiced using either the Conventional Mosaicing 712 or the Gradient Mosaicing 714 tool: either original geocoded standard products or slant/ ground range original data geocoded with SARscape.
It remains the fact that we strongly suggest to start from Slant Range Single Look products (instead of Ground Range Resampled data) in order to preserve at the best both radiometry and geometry.

Q. - Can I use original geocoded data (i.e. standard products such as GEC or GTC formats) as input to the **Mosaicing** tool? We have around 7 adjacent paths of PALSAR data to mosaic, each with around 5-6 scenes along the path; what is the best method to create a full mosaic?

A. - The following steps shall be executed in your case:

1. Import 33 your original standard product; GEC and GTC formats are already geocoded but they MUST be imported before any SARscape process is executed.
2. Cut 740 the image border of each scene in case you have corrupted (bad value) pixels.
3. Last overlay 712 mosaic of the 5-6 scenes along each path.
4. Gradient mosaic 714 of the 7 adjacent mosaicked paths. Check both flags: "Absolute Calibration" (aimed at removing constant and linear trends simultaneously in each mosaicked path) and "Local Calibration" (aimed at refining the image matching close to the cut line where two mosaicked path are actually stuck together); the "Use Existing Shape" flag can be possibly checked in a second mosaic iteration (typically not needed), in case you want to edit - and then use - the cut line which was automatically drawn in the first process iteration.

Q. - Is it possible to **Mosaic Interferograms**?

A. - In order to mosaic Interferograms the following procedure must be followed:

1. Interferogram geocoding 142 - Note that both the "Radiometric Calibration" and "Radiometric Normalization" flags must not be checked.
2. Conversion 691 (Complex to Phase and Module) - The geocoded interferograms are split into the phase (_phase) and module (_mod) components.
3. Conventional Mosaicing 712 - The "Last Pixel" method shall be adopted to mosaic - separately - the module and the phase components of the interferograms. The result will be a mosaiced module and a mosaiced phase.
4. Conversion 692 - Phase and Module to Complex - The mosaiced phase and module are combined in order to reconstruct the original complex interferogram.

Q. - I have some acquisitions affected by **Orbital Inaccuracies**, which cause **Geolocation Errors**. I can solve the problem by manually identifying one Ground Control Point that I use as input in the Geocoding and Radiometric Calibration 142 step. However I wondered if there is a tool, which allows correcting the relevant orbital parameters without looking for GCPs.

A. - The Automatic Orbital Correction 719 tool can be used for this purpose. The correction must be performed before the geocoding step.

Q. - After the **Update Orbital Data** step is executed, processing steps such as the Geocoding, the Interferogram Flattening and the Baseline Estimation still provide wrong results (i.e. geolocation error, only null values in the synthetic phase, wrong baseline estimation value). Why does it happen?

A. - The correction of the orbits does not involve the correction of parameters, such as the slant range distance and the acquisition start time, which are used in the above mentioned processing steps. In case these parameters were wrong, the error can be corrected by either using a Ground Control Point in the processing steps where it is foreseen (e.g. Geocoding and Radiometric Calibration 142, Interferometric Workflows, Orbit Correction 722, etc.) or by automatically calculating - and applying - the correction parameters with the relevant Orbit Correction 719 tool.

It must be noted that also the coregistration process can be affected by orbital inaccuracies, unless the Initialisation from Orbit 770 checkbox is set off.

Q. - When do I have to perform the **PRF Correction**?

A. - We found that in some cases geocoding Radarsat-1 data with 1 GCP produced an accurate geolocation close to the GCP while the product became shifted if observed in areas far from the GCP (this was evident when moving, from the GCP position, in azimuth direction). We attributed this problem to a wrong value reported for the Pulse Repetition Frequency (PRF) and, for this reason, we introduced the PRF Correction tool. Considered that, I would suggest to check - running a Geocoding 142 process - whether the above mentioned geolocation problem exists using one GCP only, if it does not you do not need to correct the PRF. Vice versa if you identify a geocoded product shift in areas far from the GCP it means that you must correct the PRF. In case of interferometric processing, this correction has to be executed before flattening the Interferogram.

Q. - Is it possible to **Cut RAW Data** by means of the Sample Selection tool?

A. - Raw data cannot be resized. The "Sample Selections" tool can be used only after the data have been focussed.

1.10.3 Reference Guide

1.10.3.1 Cartographic Transformation

Section Content

1.10.3.1.1 Cartographic Transformation - Raster

Purpose

Geocoded images and Digital Elevation Models may be transformed from one cartographic reference system to another; the pixel spatial resolution can be modified as well.

Technical Note

Complex data type is not admitted.

If the input "Reference file" is entered, its cartographic projection and grid size are used for the file transformation. If the input "Reference file" is not used, the output cartographic projection and grid size must be specified.

Input Files

Input Reference File

Input file to be used as transformation reference. The output transformed data will have same corner points, same cartographic system and same grid size of the reference file.

Input file list
Input file name(s) of the data to be transformed. This file is mandatory.

DEM/Cartographic System

Output Projection
In case the Reference file is not used, the following parameters are compulsory to define the Cartographic System 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Type
One of the following file types can be selected for the cartographic transformation:

Image
All raster data except Digital Elevation Model.

DEM

Digital Elevation Model. This should be referred to the ellipsoid.

Geographical Region
By setting this flag it is possible to specify a spatial region for the output file generation (co-ordinates are referred to the output cartographic reference system).

- **West**
  The Westernmost cartographic co-ordinate.

- **East**
  The Easternmost cartographic co-ordinate.

- **North**
  The Northernmost cartographic co-ordinate.

- **South**
  The Southernmost cartographic co-ordinate.

X dimension
The grid size of the output data in Easting (X) must be defined only if the Reference file is not used; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

X dimension
The grid size of the output data in Northing (Y) must be defined only if the Reference file is not used; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file list

Output file name(s) of the transformed data. This file is mandatory.

_rsp
Transformed data and associated header files (.sml, .hdr).

_rsp_par.sml
Xml file containing temporary processing parameters.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.1.2 Cartographic Transformation - Shape

Purpose

Shape files may be transformed from one cartographic reference system to another.

Technical Note

None.

Input Files

Input file list
Input file name(s) of the vector file to be transformed (only ".shp" data type is admitted). This file is mandatory.

DEM/Cartographic System

Output Projection
In case the Reference file is not used, the following parameters are compulsory to define the Cartographic System 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Output Files

Output file list
Output file name(s) of the transformed vector file. This file is mandatory.

_rsp
Transformed data and associated header files (.sml, .hdr).

_rsp_par.sml
Xml file containing temporary processing parameters.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.1.3 Cartographic Transformation - Point

Purpose

The cartographic co-ordinates of a point can be transformed from one to another reference system to be chosen among those supported.

Technical Note

None.

DEM/Cartographic System

Input Projection/Output Projection
The following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Easting/X Coordinate
East - West cartographic co-ordinate of the point.

Northing/Y Coordinate
North - South cartographic co-ordinate of the point.

Height
Point elevation on the Geoid.

Geoid ondulation
The height difference on the point, between the Geoid and the Ellipsoid, is calculated.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Easting/X coordinate
Easting (X) coordinate of the point to be transformed, the converted value will be displayed on screen.

Northing/Y coordinate
Northing (Y) coordinate of the point to be transformed, the converted value will be displayed on screen.

Height/Z coordinate
Height (Z) of the point to be transformed, the converted value will be displayed on screen.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

The transformed output coordinates will be displayed in a pop-up window.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.1.4 Cartographic Transformation - Point List

Purpose

The cartographic co-ordinates of a list of points can be transformed from one to another reference system to be chosen among those supported.

Technical Note

The input list must be provided in form of three text files containing the X, Y and Z co-ordinates. The output results are generated in form of both a shape (.shp) file, containing all the transformed points, and three text files containing the transformed point co-ordinates (same order and structure of the input list).

Input Files

Input X file
Co-ordinates of the input points in X (or Easting) direction. This file is mandatory.

Input Y file
Co-ordinates of the input points in Y (or Northing) direction. This file is mandatory.

Input Z file
Co-ordinates of the input points in Z direction (or elevation value). This file is optional, if it is not provided the elevation of the points will be set to 0.

DEM/Cartographic System

Input/Output Projection
The following parameters are compulsory to define the **Cartographic System** 6:

State

Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Output Files

Output Root Name
Name of the output root. It is mandatory.

_X.txt
Transformed co-ordinates of the input points in Easting direction.

_Y.txt
Transformed co-ordinates of the input points in Northing direction.

_Z.txt
Transformed elevation values.

.shp
Transformed points in shape format and ancillary files (.shx, .dbf).

.xls
Xls file containing the point co-ordinates.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec

The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.1.5 Geoid Component

Purpose

It allows subtracting or adding the geoid related height from (or to) an input Digital Elevation Model.

Technical Note

In any SARscape processing where the DEM input is foreseen, ellipsoidal heights have to be preferred in order to avoid errors related to the use of geoids, which differ depending on the specific geographic location; vice versa the adoption of ellipsoidal heights ensure consistency with most of the current satellite systems, whose measurements and parameters are referred to earth center.

This tool provides the possibility to subtract the geoid component to a previously imported Digital Elevation Model, before it is actually inputted in any SARscape processing step.

On the other side, if the objective is to get the real geoidal height, this same tool allows adding the geoid component to a previously generated Digital Elevation Model referred to the ellipsoid.

It is important to mention the this tools allows adding or subtracting the WGS 84 Earth Gravitational Model 96 (EGM96) geoid.

Input Files

Input file
Input Digital Elevation Model to be processed. This file is mandatory.

Parameters - Principal Parameters

Geoid Operation

Substract Geoid
The geoid component is subtracted to the input Digital Elevation Model.

Add Geoid
The geoid component is added to the input Digital Elevation Model.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file
Output Digital Elevation Model with the geoid component added or subtracted. This file is mandatory.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close

The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.2 Digital Elevation Model Extraction

Supported Products

The DEM extraction can be performed using one of the following products:

- ACE 657 Digital Elevation Model (around 1 km resolution) .
- The Geoscience Laser Altimeter System (GLAS 662) instrument on the Ice, Cloud, and land Elevation Satellite (ICESat 662). With resolutions from 500 m to 1 km.
- GTOPO30 665 Digital Elevation Model (around 1 km resolution).
- RAMP 669 Digital Elevation Model (around 200 m resolution).
- SRTM-3 (Version 2) 671 Digital Elevation Model (around 90 m resolution).
- SRTM-3 (Version 4) 676 Digital Elevation Model (around 90 m resolution).

1.10.3.2.1 ACE Digital Elevation Model Extraction

Purpose

The Digital Elevation Model tiles, which are needed to cover the specified area, are mosaiced and eventually interpolated.

Technical Note

Before executing this functionality, the ACE compressed files must be manually downloaded from the internet and decompressed within the ACE_DEM_DIR in the default work 20 directory. Note that the specific environment variable (i.e. ACE_DEM_DIR) can be set in order to store the Digital Elevation Model tiles in different user defined folders.

The area of interest, which has to be covered by the extracted Digital Elevation Model, can be specified by entering either the area cartographic co-ordinates or a reference image or a list of images.

With respect to previous versions, the latest ACE GDEM is known to provide improved resolution and accuracy over large parts of the globe and especially over Africa and South America.

Input Files

Optional Reference Slant Range Image
Input file(s) name(s) of the image to be used as geographic reference for the Digital Elevation Model extraction. This file is mandatory if the cartographic co-ordinates are not specified. In case a geocoded image is used, the "Cartographic System" specified below must be the same of the reference image. The geographical extent of the output Digital Elevation Model corresponds to the total coverage of the Reference file list.

DEM/Cartographic System

Output Projection
The parameters relevant to the **Cartographic System** 6 of the output Digital Elevation Model must be entered:

State
Definition of the country or general projection systems.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
A reference ellipsoidal height can be provided. Default Reference Height is 0.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Slope
By setting this parameter, the slope (values ranging from -90 and + 90 degrees) is calculated from the Digital Elevation Model.

By setting the following parameters it is possible to specify a spatial region for the Digital Elevation Model extraction (co-ordinates are referred to the output cartographic reference system).

- **East Start**
  The Westernmost cartographic co-ordinate.

- **East End**
  The Easternmost cartographic co-ordinate.

- **North Start**
  The Northernmost cartographic co-ordinate.

- **North End**
  The Southernmost cartographic co-ordinate.

X Grid Size
The grid size in the X dimension of the output data must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Y Grid Size
The grid size in the Y dimension of the output data must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Different grid size, in Easting and Northing direction, can be specified.

Replace Dummy With Min
By setting this flag all dummy values (i.e. NaN) will be replaced by the value zero, if the geoid has not been subtracted, or by the ellipsoidal equivalent if the geoid has been subtracted.

Subtract Geoid
By setting this flag the output product will be referred to the ellipsoid. The EGM96 geoid is subtracted. Set this flag if the extracted Digital Elevation Model has to be used for further processing in SARscape.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - DEM FTP Address

It brings to the FTP section of the Preferences 791 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output DEM file

Output file name of the extracted and mosaiced Digital Elevation Model. This file is mandatory.

_dem
Extracted Digital Elevation Model, with user-defined projection and grid size, and associated header files (.sml, .hdr).

_dem_wgs84_dem
Extracted and interpolated Digital Elevation Model, with original projection and grid size, and associated header files (.sml, .hdr).

_dem_TMP_wgs84_dem
Extracted and not interpolated Digital Elevation Model, with original projection and grid size, and associated header files (.sml, .hdr).

_wgs84_dem_geoid_geo
Geoid height with original projection and grid size, and associated header files (.sml, .hdr). This file is generated only when the "Subtract Geoid" flag is checked.

_slope
Slope image and associated header files (.sml, .hdr). This file is generated only if the relevant flag is set.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.2.2 GLAS/ICESat

Purpose

The following Digital Elevation Models can be imported:

- **Antarctic** area (500 meters resolution).
- **Antarctic** area (1 kilometer resolution).
- **Greenland** area (1 kilometer resolution).

Technical Note

The Geoscience Laser Altimeter System (GLAS) instrument on the Ice, Cloud, and land Elevation Satellite (ICESat) provides global measurements of elevation, and repeats measurements along nearly-identical tracks; its primary mission is to measure changes in ice volume (mass balance) over time.

These DEMs are generated from the first seven operational periods (from February 2003 through June 2005) of the GLAS instrument. They are provided on polar stereographic grids. The grids cover all of Antarctica north of 86° S and all of Greenland south of 83° N. Elevations for both ice sheets, originally reported as centimeters above the WGS 84 Ellipsoid, are scaled to meters for a better use in the SARscape processing chain.

More detailed information on this project are available through NSIDC (National Snow and Ice Data Centre). This Institute is acknowledged for the provision, and free distribution, of these data.

The relevant "Input file" and corresponding headers must be downloaded via FTP, using the following addresses:

- **Antarctic** area (500 meters resolution) > ftp://sidads.colorado.edu/pub/DATASETS/DEM/nsidc0304_icesat_antarctic_dem
  - NSIDC_Ant500m_wgs84_elev_cm.dat.gz (data file); it must be decompressed and then entered as "Input file".
  - NSIDC_Ant500m_wgs84_elev_cm.dat.hdr (header file); it must be stored in the same folder of the decompressed "Input file" in order to be automatically read by the program.
- **Antarctic** area (1 kilometer resolution) > ftp://sidads.colorado.edu/pub/DATASETS/DEM/

nsidc0422_antarctic_1km_dem

- krigged_dem_nsidc.bin (data file); it must be entered as "Input file".
- krigged_dem_nsidc.bin.hdr (header file); it must be stored in the same folder of the "Input file" in order to be automatically read by the program.

- **Greenland** area (1 kilometer resolution) > ftp://sidads.colorado.edu/pub/DATASETS/DEM/nsidc0305_icesat_greenland_dem
  - NSIDC_Grn1km_wgs84_elev_cm.dat.gz (data file); it must be decompressed and then entered as "Input file"
  - NSIDC_Grn1km_wgs84_elev_cm.dat.hdr (header file); it must be stored in the same folder of the decompressed "Input file" in order to be automatically read by the program.

The products are imported using their native Polar Stereographic projection. It is suggested to keep the original cartographic reference system.

Interpolation

Two interpolation methods can be used to assign a value to dummy (i.e. NaN) pixels :

– Relax Interpolation - This approach works well for small areas, hence it can be used for interpolating the Greenland DEM (dummy areas made of one or very few pixels); the method, which applies an algorithm based on the solution of the heat transfer equation (Poisson equation), adopts a soft surface and adapt it to the dummy surrounding area. Viersa the Antarctica DEM, which contains a very large area with null values in its center (South Pole surroundings), cannot be interpolated with this method.

– Mean Interpolation - This approach can be used, by properly setting the window dimension. Dummy pixels are replaced with valid values if the window size is large at least as the dummy area to be filled.

Input Files

Input file

Name of the file to be imported (.dat file previously decompressed or .bin file). This file is mandatory.

Parameters - Principal Parameters

Subtract Geoid

By setting this flag the output product will be referred to the ellipsoid. The EGM96 geoid is subtracted. Set this flag if the extracted Digital Elevation Model has to be used for further processing in SARscape.

Slope

By setting this flag, the slope (values ranging from -90 and + 90 degrees) is calculated from the Digital Elevation Model.

Relax Interpolation

Set this flag to apply the relax interpolation method (see Technical Note).

Mean Interpolation
Window dimension used to interpolate the input null values (see Technical Note). If zero is entered, the interpolation is not carried out.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file
Output file name of the extracted Digital Elevation Model. This file is mandatory.
_dem
Imported Digital Elevation Model, with user-defined projection and grid size, and associated header files (.sml, .hdr).

_slope
Slope image and associated header files (.sml, .hdr). This file is generated only if the relevant flag is set.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help

Specific help document section.

Specific Function(s)

None.

References

DiMarzio, J., A. Brenner, R. Schutz, C. A. Shuman, and H. J. Zwally. 2007. GLAS/ICESat 500 m laser altimetry digital elevation model of Antarctica. Boulder, Colorado USA: National Snow and Ice Data Center. Digital media.

DiMarzio, J., A. Brenner, R. Schutz, C. A. Shuman, and H. J. Zwally. 2007. GLAS/ICESat 1 km laser altimetry digital elevation model of Greenland. Boulder, Colorado USA: National Snow and Ice Data Center. Digital media.

1.10.3.2.3 GTOPO30 Digital Elevation Model Extraction

Purpose

The Digital Elevation Model tiles, which are needed to cover the specified area, are downloaded from the internet, mosaiced and eventually interpolated.

Technical Note

The area of interest, which has to be covered by the extracted Digital Elevation Model, can be specified by entering either the area cartographic co-ordinates or a reference image or a list of images.

Once the Digital Elevation Model tiles have been downloaded, they are stored in a folder called GTOPO30_DIR in the default work 20 directory. In case the relevant Digital Elevation Model tiles had been previously downloaded and stored in the PC, they are automatically retrieved and used. Note that the specific environment variable (i.e. GTOPO30_DIR) can be set in order to store the Digital Elevation Model tiles in different user defined folders.

In case one of the Digital Elevation Model tiles is not found in the internet, or the internet connection fails before or during the data downloading, a message is written in the Process.log 825 file.

The internet address, which is used by the program to download the GTOPO30 tiles, is subject to changes. In case this happens the new FTP address 791 can be entered and saved as default reference for successive SARscape sessions.

Input Files

OPTIONAL Reference Slant Range Image
Input file(s) name of the image to be used as geographic reference for the Digital Elevation Model extraction. This file is mandatory if the cartographic co-ordinates are not specified. In case a geocoded image is used, the "Cartographic System" specified below must be the same of the reference image. The geographical extent of the output Digital Elevation Model corresponds to the total coverage of the Reference file list.

DEM/Cartographic System

Output Projection
The parameters relevant to the **Cartographic System** 6 of the output Digital Elevation Model must be entered:

State
Definition of the country or general projection systems.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
A reference ellipsoidal height can be provided. Default Reference Height is 0.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Slope
By setting this flag, the slope (values ranging from -90 and + 90 degrees) is calculated from the Digital Elevation Model.

By setting the following parameters it is possible to specify a spatial region for the Digital Elevation Model extraction (co-ordinates are referred to the output cartographic reference system).

- **East Start**
  The Westernmost cartographic co-ordinate.

- **East End**
  The Easternmost cartographic co-ordinate.

- **North Start**
  The Northernmost cartographic co-ordinate.

- **North End**
  The Southernmost cartographic co-ordinate.

X Grid Size
The grid size in X direction of the output data must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Y Grid Size
The grid size in Y direction of the output data must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Different grid size, in Easting and Northing direction, can be specified.

Replace Dummy With Min
By setting this flag all dummy values (i.e. NaN) will be replaced by the value zero, if the geoid has not been subtracted, or by the ellipsoidal equivalent if the geoid has been subtracted.

Subtract Geoid
By setting this flag the output product will be referred to the ellipsoid. The EGM96 geoid is subtracted. Set this flag if the extracted Digital Elevation Model has to be used for further processing in SARscape.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - DEM FTP Address

It brings to the FTP section of the Preferences 791 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output DEM file
Output file name of the extracted and mosaiced Digital Elevation Model. This file is mandatory.

_dem
Extracted Digital Elevation Model, with user-defined projection and grid size, and associated header files (.sml, .hdr).

_dem_wgs84_dem
Extracted and interpolated Digital Elevation Model, with original projection and grid size, and associated header files (.sml, .hdr).

_dem_TMP_wgs84_dem
Extracted and not interpolated Digital Elevation Model, with original projection and grid size, and associated header files (.sml, .hdr).

_wgs84_dem_geoid_geo
Geoid height with original projection and grid size, and associated header files (.sml, .hdr). This file is generated only when the "Subtract Geoid" flag is checked.

_slope
Slope image and associated header files (.sml, .hdr). This file is generated only if the relevant flag is set.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.2.4 RAMP

Purpose

A Digital Elevation Model covering the Antarctic area can be imported.

Technical Note

The RADARSAT Antarctic Mapping Project (RAMP) was initiated in the framework of a collaboration between NASA and CSA. In 1997, RADARSAT was rotated in its orbit so that its SAR antenna looked South towards Antarctica. This allowed high-resolution mapping of the entire continent of Antarctica. More detailed information on this project are available through NSIDC (National Snow and Ice Data Centre).

Two products can be imported:

- **ramp200dem_wgs_v2.bin**
  Elevations for points in this data set are measured in meters above the WGS84 ellipsoid. This is the product to adopt as input for any SARscape processing.

- **ramp200dem_osu_v2.bin**
  Elevations for points in this data set are measured in meters above the OSU91A geoid.

The two products are available on the following FTP server (anonymous login):
Host Name -> sidads.colorado.edu
Download Path -> pub\DATASETS\RAMP\DEM_V2\200M\BINARY

The files to download are marked by the extension ".bin.gz". The downloaded product must be uncompressed before importing it.

The product is imported using its native Polar Stereographic (Southern Hemisphere) projection. It is suggested to keep the original cartographic reference system.

Input Files

Input file
Name of the file to be imported. This file is mandatory.

Parameters - Principal Parameters

Slope
By setting this flag, the slope (values ranging from -90 and + 90 degrees) is calculated from the Digital Elevation Model.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file
Output file name of the extracted Digital Elevation Model. This file is mandatory.

_dem
Imported Digital Elevation Model, with user-defined projection and grid size, and associated header files (.sml, .hdr).

_slope
Slope image and associated header files (.sml, .hdr). This file is generated only if the relevant flag is set.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Liu, H., K. Jezek, B. Li, and Z. Zhao. 2001. Radarsat Antarctic Mapping Project digital elevation model version 2. Boulder, CO: National Snow and Ice Data Center. Digital media.

1.10.3.2.5 SRTM-3 Version 2 Digital Elevation Model Extraction

Purpose

The Digital Elevation Model tiles, which are needed to cover the specified area, are downloaded from the internet, mosaiced and eventually interpolated.

Technical Note

The area of interest, which has to be covered by the extracted Digital Elevation Model, can be specified by entering either the area cartographic co-ordinates or a reference image or a list of images.

Once the Digital Elevation Model tiles have been downloaded, they are stored in a folder called SRTM_DEM_DIR in the default work20 directory. Each tile covers an area of 1° in Latitude and 1° in Longitude (i.e 1200 X 1200 pixels). In case the relevant Digital Elevation Model tiles had been previously downloaded and stored in the PC, they are automatically retrieved and used. Note that the specific environment variable (i.e. SRTM_DEM_DIR) can be set in order to store the Digital Elevation Model tiles in different user defined folders.

In case one of the Digital Elevation Model tiles is not found in the internet, or the internet connection fails before or during the data downloading, the names of the required SRTM tiles are written in the Process.log825 file in order to enable to user to retrieve the files manually and store them in the SRTM_DEM_DIR folder (default work20 directory).

The internet addresses, which are used by the program to download the Digital Elevation Model tiles relevant to the SRTM-3 and GTOPO30 products, are subject to changes. In case this happens the new HTTP address791 can be entered and saved as default reference for successive SARscape sessions.

The SRTM-3 version 2 tiles can be affected by "holes" of no data. Such dummy areas can be replaced either by using the GTOPO30 product or by interpolating the SRTM-3 dummy values using the information available in the surrounding areas (Relax Interpolation method). Any of the two procedures, which are detailed below, is carried out in an automatic way.

- **Dummy replacement by GTOPO30**
  GTOPO30 values are substituted to the SRTM-3 dummy values. An interpolation window is used for smoothing the border line between GTOPO30 and SRTM-3 where, due to the different spatial resolution, abrupt height changes are present.
- **Relax Interpolation**
  In this case information other than the SRTM-3 itself is not used for the dummy values replacement. The interpolation model is represented by a soft surface, which is adapted to the dummy surrounding area. The algorithm, which is based on the solution of the heat transfer equation (Poisson equation), uses known height values to reconstruct at the best the unknown topography; for this reason it is optimally suited to interpolate small zones, especially where abrupt morphological changes (i.e. steep slopes) are not present.

It has to be noted that the SRTM-3 (version 2) tiles show, in some areas of the world, a shift of 1 or 2 pixels with respect to the corresponding SRTM-3 (version 4) reference.

CIAT is acknowledged for the provision, and free distribution, of these data.

Input Files

OPTIONAL Reference Slant Range Image
Input file(s) name of the image to be used as geographic reference for the Digital Elevation Model

extraction. This file is mandatory if the cartographic co-ordinates are not specified. In case a geocoded image is used, the "Cartographic System" specified below must be the same of the reference image. The geographical extent of the output Digital Elevation Model corresponds to the total coverage of the Reference file list.

DEM/Cartographic System

Output Projection
The parameters relevant to the **Cartographic System** 6 of the output Digital Elevation Model must be entered:

State
Definition of the country or general projection systems.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
A reference ellipsoidal height can be provided. Default Reference Height is 0.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Slope
By setting this flag, the slope (values ranging from -90 and + 90 degrees) is calculated from the Digital Elevation Model.

By setting the following parameters it is possible to specify a spatial region for the Digital Elevation Model extraction (co-ordinates are referred to the output cartographic reference system).

- **East Start**
  The Westernmost cartographic co-ordinate.

- **East End**
  The Easternmost cartographic co-ordinate.

- **North Start**
  The Northernmost cartographic co-ordinate.

- **North End**
  The Southernmost cartographic co-ordinate.

X Grid Size
The grid size in X direction of the output data must be defined; the default unit of measure is meters. Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Y Grid Size
The grid size in Y direction of the output data must be defined; the default unit of measure is meters. Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Different grid size, in Easting and Northing direction, can be specified.

Replace Dummy With Min
By setting this flag all dummy values (i.e. NaN) will be replaced by the value zero, if the geoid has not been subtracted, or by the ellipsoidal equivalent if the geoid has been subtracted.

Subtract Geoid
By setting this flag the output product will be referred to the ellipsoid. The EGM96 geoid is subtracted. Set this flag if the extracted Digital Elevation Model has to be used for further processing in SARscape.

Parameters - Global

It brings to the general section of the Preferences759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - DEM FTP Address

It brings to the FTP section of the Preferences791 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output DEM file
Output file name of the extracted and mosaiced Digital Elevation Model. This file is mandatory.

_dem
Extracted Digital Elevation Model, with user-defined projection and grid size, and associated header files (.sml, .hdr).

_dem_wgs84_dem
Extracted and interpolated Digital Elevation Model, with original projection and grid size, and associated header files (.sml, .hdr).

_dem_TMP_wgs84_dem
Extracted and not interpolated Digital Elevation Model, with original projection and grid size, and associated header files (.sml, .hdr).

_wgs84_dem_geoid_geo
Geoid height with original projection and grid size, and associated header files (.sml, .hdr). This file is generated only when the "Subtract Geoid" flag is checked.

_slope
Slope image and associated header files (.sml, .hdr). This file is generated only if the relevant flag is set.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close

The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Jarvis A., H.I. Reuter, A. Nelson, E. Guevara, 2008: "Hole-filled seamless SRTM data V4". International Centre for Tropical Agriculture (CIAT)

H.I. Reuter, A. Nelson, A. Jarvis, 2007: "An evaluation of void filling interpolation methods for SRTM data". International Journal of Geographic Information Science, 21:9, 983-1008.

1.10.3.2.6 SRTM-3 Version 4 Digital Elevation Model Extraction

Purpose

The Digital Elevation Model tiles, which are needed to cover the specified area, are downloaded from the internet and mosaiced.

Technical Note

The area of interest, which has to be covered by the extracted Digital Elevation Model, can be specified by entering either the area cartographic co-ordinates or a reference image or a list of images.

Once the Digital Elevation Model tiles have been downloaded, they are stored in a folder called SRTM_DEM_DIR in the default work 20 directory. Each tile covers an area of 5° in Latitude and 5° in Longitude (i.e 6000 X 6000 pixels). In case the relevant Digital Elevation Model tiles had been previously downloaded and stored in the PC, they are automatically retrieved and used. Note that the specific environment variable (i.e. SRTM_DEM_DIR) can be set in order to store the Digital Elevation Model tiles in different user defined folders.

In case one of the Digital Elevation Model tiles is not found in the internet, or the internet connection fails before or during the data downloading, the names of the required SRTM tiles are written in the Process.log 825 file in order to enable to user to retrieve the files manually and store them in the SRTM_DEM_DIR folder (default work 20 directory).

The internet address, which are used by the program to download the Digital Elevation Model tiles relevant to the SRTM-3 and GTOPO30 products, are subject to changes. In case this happens the new FTP address 791 can be entered and saved as default reference for successive SARscape sessions.

The SRTM-3 version 4 represents an improvement of the previous SRTM-3 versions, where the no-data voids have been filled by means of auxiliary elevation data. This procedure involved the production of vector contours and points, and the re-interpolation of these derived contours back into a raster DEM.

CIAT is acknowledged for the provision, and free distribution, of these data.

Input Files

OPTIONAL Reference Slant Range Image
Input file(s) name of the image to be used as geographic reference for the Digital Elevation Model extraction. This file is mandatory if the cartographic co-ordinates are not specified. In case a geocoded image is used, the "Cartographic System" specified below must be the same of the reference image. The geographical extent of the output Digital Elevation Model corresponds to the total coverage of the Reference file list.

DEM/Cartographic System

Output Projection
The parameters relevant to the **Cartographic System** 6 of the output Digital Elevation Model must be entered:

State
Definition of the country or general projection systems.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Reference Height
A reference ellipsoidal height can be provided. Default Reference Height is 0.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Slope
By setting this flag, the slope (values ranging from -90 and + 90 degrees) is calculated from the Digital Elevation Model.

By setting the following parameters it is possible to specify a spatial region for the Digital Elevation Model extraction (co-ordinates are referred to the output cartographic reference system).

- **East Start**
  The Westernmost cartographic co-ordinate.

- **East End**
  The Easternmost cartographic co-ordinate.

- **North Start**
  The Northernmost cartographic co-ordinate.

- **North End**
  The Southernmost cartographic co-ordinate.

X Grid Size
The grid size in X direction of the output data must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Y Grid Size
The grid size in Y direction of the output data must be defined; the default unit of measure is meters.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Different grid size, in Easting and Northing direction, can be specified.

Replace Dummy With Min
By setting this flag all dummy values (i.e. NaN) will be replaced by the value zero, if the geoid has not been subtracted, or by the ellipsoidal equivalent if the geoid has been subtracted.

Subtract Geoid
By setting this flag the output product will be referred to the ellipsoid. The EGM96 geoid is subtracted. Set this flag if the extracted Digital Elevation Model has to be used for further processing in SARscape.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - DEM FTP Address

It brings to the FTP section of the Preferences 791 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output DEM file
Output file name of the extracted and mosaiced Digital Elevation Model. This file is mandatory.

_dem
Extracted Digital Elevation Model, with user-defined projection and grid size, and associated header files (.sml, .hdr).

_dem_wgs84_dem
Extracted Digital Elevation Model, with original projection and grid size, and associated header files (.sml, .hdr).

_wgs84_dem_geoid_geo
Geoid height with original projection and grid size, and associated header files (.sml, .hdr). This file is generated only when the "Subtract Geoid" flag is checked.

_slope
Slope image and associated header files (.sml, .hdr). This file is generated only if the relevant flag is set.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

Jarvis A., H.I. Reuter, A. Nelson, E. Guevara, 2008: "Hole-filled seamless SRTM data V4". International Centre for Tropical Agriculture (CIAT)

H.I. Reuter, A. Nelson, A. Jarvis, 2007: "An evaluation of void filling interpolation methods for SRTM data". International Journal of Geographic Information Science, 21:9, 983-1008.

1.10.3.3 Digital Elevation Model Fusion

Section Content

1.10.3.3.1 Data Preparation

Purpose

This tool is used to bring two DEM files generated at different resolutions and on different frames at the same Pixel Spacing and on overlapping zones in order to be exploited in Raster Level DEM Fusion.
The quality files of each DEM must be resampled as well. for the SAR and Optical case these files are the following:

- Precison file (_precision) for the SAR case;
- Cross Correlation File (_cc) for the Optical case.

Technical Note

Two input files are needed, a coarser and a finer DEM files. The coarser file will be resampled to the pixel spacing of the finer one. Additionally, the input files will be cut to a common overlapping area, again based on the finer level DEM. The same process is automatically carried out with the respective accuracy/reliability (respectively "_precision" and "_cc") files, given that the root name remains the same. Note that the reference file is always the finer DEM. The files must have been produced with either SARscape or OPTICALscape.

The Input files must be in the same Cartographic System 6.

Input Files

Input File
The file at coarser ground resolution to be resampled. Both the DEM and corresponding Precision/accuracy files should undergo this process. This file is mandatory.

Input Weight File
The Precision/accuracy file at coarser ground resolution to be resampled. This file is mandatory.

Reference DEM File
The DEM file at finer ground resolution to be used as reference file for the resampling. This file is mandatory.

Output Files

Output file
Name of the output root. This file is mandatory.

Output Weight file

Name of the resampled Precision/accuracy output. This file is mandatory.

_dem
Resampled and cut DEM or accuracy/precision file (.sml, .hdr).

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

-

1.10.3.3.2 DEM Fusion Weighted Average

Purpose

Two existing DEMs or DSMs, previously generated with SARscape or OPTICALscape, can be combined by exploiting their pixel resolution and reliability.

Technical Note

This module provides the most straight-forward way to combine two DEMs with respective accuracy/reliability information at raster level. The DEMs information is combined in a weighted way in each pixel location using a weighted average procedure. The program is intended to combine DEM products with:

- same grid size.
- same number of rows and columns.
- same Cartographic System 6 or, in case of slant range products, same pixel sampling and same number of rows and columns.

If these conditions are not met, it is necessary that the lower resolution product ("Low DEM file" input), and the associated files, are resized to the same pixel sampling and pixel number of the high resolution product ("High DEM file" input), in order to have all inputs of the same dimension. The resize operation can be performed using the Data Preparation 681 module.

Input Files

High Resolution DEM File
File name of the higher resolution input DEM. This file is mandatory.

High Resolution Weight File
Input weight file related to the higher resolution input DEM. This can be represented by the resolution (InSAR DEM) or the reliability (Stereo DEM). This file is mandatory.

Low Resolution DEM File
File name of the lower resolution input DEM. This file is mandatory.

Low Resolution Weight File
Input weight file related to the lower resolution input DEM. This can be represented by the resolution (InSAR DEM) or the reliability (Stereo DEM). This file is mandatory.

Parameters - Principal Parameters

High Resolution Weight Type
This flag must be set to define the input weight type of the high resolution input DEM between SAR and Optical, the weights and input DEM will be treated accordingly. The choice is given between:

- Precision, if the corresponding input is an interferometric DEM (necessarily generated with SARscape).
- Reliability, if the corresponding input is a stereo DEM (necessarily generated with OPTICALscape).

Low Resolution Weight Type
This flag must be set to define the input weight type of the low resolution input DEM between SAR and Optical, the weights and input DEM will be treated accordingly. The choice is given between:

- Precision, if the corresponding input is an interferometric DEM (necessarily generated with SARscape).
- Reliability, if the corresponding input is a stereo DEM (necessarily generated with

OPTICALscape).

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file
Name of the output root. This file is mandatory.
_dem
Fusion resulting Digital Elevation Model with the corresponding header files (.sml, .hdr).

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

-

1.10.3.3.3 Wavelet Combination DEM

Purpose

Digital Elevation Models with different spatial resolution can be combined.

Technical Note

A wavelet based fusion process is performed between the two input Digital Elevation Models. The Digital Elevation Models must have:

- same grid size.
- same number of rows and columns.
- same cartographic reference system or, in case of slant range products, same pixel sampling and same number of rows and columns.

The specific transformation tool 645 can be adopted to make the Low Resolution DEM with the same dimension of the High Resolution DEM.

The fusion process is carried out using the coarse height from the low resolution product and the detailed height from the high resolution product. The Number of Levels, which refers to the power of a base 2, determines where the information comes from. As an example, considering input data with grid size of 25 m, a "Number of Levels" of 1 means that the information coarser than 50 m is derived from the Low Resolution input and the information finer than 50 m is derived from the High Resolution input; a "Number of Levels" of 2 means that the information coarser than 100 m is derived from the Low Resolution input and the information finer than 100 m is derived from the High Resolution input; a "Number of Levels" of 3 means that the information coarser than 200 m is derived from the Low Resolution input and the information finer than 200 m is derived from the High Resolution input.

Input Files

High Resolution Digital Elevation Model
File name of the high resolution Digital Elevation Model. This file is mandatory.

Low Resolution Digital Elevation Model
File name of the low resolution Digital Elevation Model. This file is mandatory.

Parameters - Principal Parameters

Number of Levels
Level setting for the wavelet calculation. It determines the proportion of the information coming from the low resolution and the high resolution input DEMs.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output File
File name of the output combined Digital Elevation Model. This file is mandatory.

_w_c_dem
Combined Digital Elevation Model with the associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.3.4 Point Cloud DEM Fusion

Purpose

Two existing DEMs in Point Cloud form (Shapefile), previously generated with SARscape or OPTICALscape, can be combined into a single raster product.

Technical Note

The process initially exploits the information provided by the respective DEM/DSM generation modules provided in OPTICALscape and SARscape to apply both a knowledge-based and an accuracy-based sample selection. The choice strategies vary depending on the type of process:

Optical-Optical
In the case of Optical data, the information contained in the shapefile consists in the Feature Type (grid, point, edge; for details refer to the OPTICALscape documentation), matching cross-correlation and reliability index. Exploiting the knowledge about stereo-optical matching, an edge or point feature will be always chosen rather than a grid point. The choice between identical features is driven by cross-correlation and reliability index.

Optical-SAR
The knowledge based part is exploited in this process as well. An edge feature found in optical images will be chosen against a SAR produced data point. On the opposite, if the optical data point represents a grid point, the SAR data will be preferred. In the case of points equally important, a comparison between the SAR precision and the Matching cross-correlation will be performed.

SAR-SAR
The choice will be solely data-driven, the excluded point will always be the one showing the worst precision.

The final step will be performed exploiting a modified 2D Sheppard local interpolator using Thin Plate Radial Basis Functions, the local RBF support will be automatically set. The approach is inspired by the one proposed by Lazzaro D. et. al., the RBF function is given in Numerical Recipes. Two parameters have to be set by the user, namely the number of nearby points on which to fit the RBF function and the number of nodes defining the radius of influence of the computed interpolant. These two values are usually set to 13 and 10 by default respectively.

Two additional steps can be performed, namely a Mean Filtering and a Relaxation interpolation. The former in order to smooth eventual spikes and the latter to provide a continuous surface without holes.

It is compulsory to provide point clouds produced in the same cartographic system.

Input Files

High Resolution DEM Shape File
File name of the higher resolution input point cloud. For Optical-SAR processing, this file must be the Optical input. This file is mandatory.

Low Resolution DEM Shape File
File name of the lower resolution input point cloud. This file is mandatory.

DEM/Cartographic System

Output Projection
The following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Note that the inputs have to be in **the same cartographic system** as the output.

Parameters - Principal Parameters

High Resolution Data Type
This flag must be set to define the input type of the high resolution DEM, the choice is given between:

- SAR, if the corresponding input is an interferometric DEM (necessarily generated with SARscape).
- Optical, if the corresponding input is a stereo DEM (necessarily generated with OPTICALscape).

Low Resolution Data Type
This flag must be set to define the input type of the low resolution DEM, the choice is given between:

- SAR, if the corresponding input is an interferometric DEM (necessarily generated with SARscape).
- Optical, if the corresponding input is a stereo DEM (necessarily generated with OPTICALscape).

Number Of Coefficient Points
Number of nearby points for the fitting on each node.

Number Of Nodes
Number of nodes defining the radius of influence of the interpolant.

Grid Size
The pixel spacing of the output DEM. This value is mandatory.

Relax Interpolation
Set this flag if a final relax interpolation step has to be executed in order to fill eventual holes..

Mean Filtering
Set this flag if a mean filtering on a regular grid has to be executed.

Mean Window Size
The size of the window for mean filtering. This value is set as 3x3 by default.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and

stored for further processing sessions.

Output Files

Output File
File name of the output combined Digital Elevation Model. This file is mandatory.

_dem
Fusion resulting Digital Elevation Model with the corresponding header files (.sml, .hdr).

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

-Lazzaro D., Montefusco L.B., Radial Basis Functions for the multivariate interpolation of large scattered data sets, *Journal of Computational and Applied Mathematics*, 140, pages 521-536, 2002.

-Numerical Recipes. The Art of Scientific Computing, 3rd Edition, 2007.

1.10.3.4 Data Transformation

Section Content

1.10.3.4.1 Conversion - Complex to Phase and Module

Purpose

The phase and the module components, which are in a complex interferogram, can be split.

Technical Note

This tool can be used to enable manipulating the phase or the module separately and in order to substitute one of the two components of the interferogram. The two components can eventually be joined again 692.

This functionality can also be used to split phase and module components of Single Look Complex (SLC) data.

Input Files

Input Complex file
Input interferogram (_int, _dint, _fint) or complex data (_slc) to be converted. This file is mandatory.

Output Files

Output file
Output root name of the phase and module image. This root name is mandatory.

_phase
Phase component of the interferogram and associated header files (.sml, .hdr).

_mod
Module component of the interferogram and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data

Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.4.2 Conversion - Phase and Module to Complex

Purpose

The phase and the module components, previously split, can be combined again.

Technical Note

A useful application of this functionality it is to combine the phase of a filtered interferogram (_fint) with the Intensity - possibly filtered - of the master (or slave) image. This kind of product can be generated as follows:

- Separate 691 the filtered complex interferogram (_fint) into phase and module components.

- Use this functionality to combine the master or slave Intensity image (i.e. module), with the previously separated phase. Note that a filtered Intensity image (pwr_fil) can also be entered as module.

Generate the Tiff file by means of the appropriate tool (Generate Tiff 710). This enables to properly tune the scale and exponent factors (typically values of respectively 0.3 and 0.5 are suitable for this purpose) in order to have a better visualisation of either the interferometric fringes and the Intensity image texture.

Input Files

Module file
Input module image. This file is mandatory.

Phase file
Input phase image. This file is mandatory.

Parameters - Principal Parameters

Data Units
One of the following products must be selected depending input phase origin.

Interferogram
If the phase component had been extracted from an _int file.

Flattened Interferogram
If the phase component had been extracted from an _dint or a _fint file.

Single Look Complex
If the phase component had been extracted from an _slc file.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file

Output file name of the combined phase+module image. This file is mandatory.

_out
Image combining the phase and module components, and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.4.3 Conversion DEM to Slope

Purpose

Given a Digital Elevation Model file (in SARscape format) the slope is calculated (in degrees) in the Easting and Northing directions.

Technical Note

None.

Input Files

DEM File
Input Digital elevation Model (_dem). This file is mandatory.

Output Files

Output file
Output file name of the slope image. This file is mandatory.

_W2E_slope
Easting direction slope image and associated header files (.sml, .hdr).

_S2N_slope
Northing direction slope image and associated header files (.sml, .hdr).

_slope
Combined slope image and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.4.4 Transform Raster Data

Purpose

The following raster transformation can be performed:

- Data type (e.g. 16 bit to 8 bit).
- Data unit (e.g. Intensity to Amplitude). This functionality does not change the pixel value, but just the annotation in the product header file (.sml).
- Value assigned to dummy pixels.
- Density slicing.
- Bytes and/or pixel swapping.
- Data normalisation.

Technical Note

None.

Input File

Input file
Input file name of the data to be processed. This file is mandatory.

Parameters - Principal Parameters

Data Type
A new data type can be specified.

Data Units
A new data unit can be specified.

New Dummy Value
By setting this flag, a new value is assigned to dummy pixels in the input data. The new dummy value replaces the old one in the output file header.

NaN

By setting this flag, the new value assigned to dummy pixels is "Not a Number".

Value
The entered value will be assigned to dummy pixels.

Value to set to Dummy
By setting this flag, pixels with the specified value will be transformed to dummy.

Value
Value of the pixels to be transformed to dummy.

Set Dummy to Value
By setting this flag, the value of dummy pixels is transformed to a new one. The original dummy value is not changed in the output file header.

Value
The entered value will be assigned to dummy pixels.

Byte Order MSBF
By setting this flag to true the output byte order is Motorola (or Big Endian) binary type. If set to false (default), the byte order is LSBF or Intel/Little Endian binary type.

Normalize
By setting this flag, the following formula is adopted to define the new scaling factor for the output image:

Value/input mean + (std multi * std input)

Norm Value
The mean value for the output transformed image (see formula above).

Norm Standard Multi
The standard deviation multiplier (see formula above).

Set Norm Scale
By setting this flag, a parameter allowing to back transform the data from the normalization is stored.

Swap Rows with Columns
By setting this flag the input image is rotated of 90° clockwise and mirrored with respect to the vertical axis.

Swap Rows
By setting this flag the input file is mirrored with respect to the horizontal axis.

Swap Columns
By setting this flag the input file is mirrored with respect to the vertical axis.

Maximum Slicing Limits
Maximum pixel value for the slicing. Only pixels whose value ranges from the Min to the Max thresholds are extracted.

Minimum Slicing Limit
Minimum pixel value for the slicing. Only pixels whose value ranges from the Min to the Max thresholds are extracted.

Set Outsiders to Limits
By setting this flag, the values lower than Min or higher than Max are set respectively to the Min and Max value. If this flag is unchecked the input values outside the Min - Max range are set to dummy.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file
Output file name of the transformed data. This file is mandatory.

_rsp
Transformed data and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.4.5 Image Interpolation

Purpose

Pixel with no-value can be interpolated, over a window of specified dimension, in order to remove dummy areas. Data filtering based on the pixel mean value calculation can be performed.

A special algorithm (relax) can be used for the interpolation of dummy areas in Digital Elevation Models.

Technical Note

The interpolated value is calculated as the average of the valid values in a window of the specified size. When the *relax* flag is set, the interpolation process uses a soft surface, which is adapted to the dummy surrounding area. The relax model, which applies an algorithm based on the solution of the heat transfer equation (Poisson equation), uses known height values to reconstruct at the best the unknown topography; for this reason it is optimally suited to interpolate Digital Elevation Models. The result of the relax interpolation can be not reliable in case abrupt slope changes are present within the same dummy area to be interpolated.

Input Files

Input file
Input file name of the data to be processed. This file is mandatory.

Parameters - Principal Parameters

Interpolation window size
Window dimension used for the interpolation. In case all dummy pixels have to be replaced with valid values, the window size must be at least as big as the largest dummy area in the input data. If zero is entered, the interpolation is not applied.

Mean window size
Window dimension for the mean filtering. This filter is aimed at reducing the noise and smoothing pixel value variations within the specified window. If zero is entered, the mean filtering is not applied.

Relax Interpolation
By setting this flag the relax interpolation is carried out.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file
Output file name of the interpolated/filtered data. This file is mandatory.

_rsp
Interpolated/filtered data and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.5 GPS

Section Content

1.10.3.5.1 GPS Filtering- Undersampling

Purpose

It allows performing a filter on the temporal series and/or an under-sampling of the collected measurements.

The input data must have been previously imported 96.

Technical Note

This tool allows to perform two types of filtering:

- **Low pass** - it produces a smoothed temporal series.
- **Linear Fit** - it converts the input temporal series into point positions and related displacement velocities.

Additionally the number of measurement can be reduced (i.e. under-sampled) by keeping only those corresponding to the acquisition dates in the "Input file list". This under-sampling is activated by entering at least one SAR image in slant range geometry in the "Input file list".

The output data consist of an xml (SARscape GCP standard format) file. Moreover a kml (geographic LAT/LONG co-ordinates) and a shape file are generated.

If the "Input file list" is entered (this is required when the under-sampling must be performed), the shape file is generated also in the slant range geometry of the first input and the points falling outside the imaged area are automatically removed. It must be outlined that the shape and kml files are only for visualization purpose.

The shape file is intended to be visualized by means of the Time Series analyzer 746; what is shown it is the measurement history (referred to the earliest measurement) along the vertical component; if the "LOS Time Series" flag is checked, the measurement history is displayed along the satellite line of sight (viewing geometry of the first file in the "Input file list"). In case only the Linear fit is selected, the output shape does not contain the temporal series to be visualized. If only the Low pass filtering is selected, it can happen that the input number of measurements are too many (more than 2000) for the shape to be visualized or for the output to fit in a single shape; is such case the use of an "Input file list" allows to under-sample the input series and to properly visualize the measurements in a single output shape file.

Input Files

Input file
Previously imported GPS series (.xml). This file is mandatory.

Input file list
Reference SAR images (_slc, _pwr), which are used for the under-sampling. This file list is optional.

Parameters - Principal Parameters

Low Pass Filter Size
Number of days to perform the smoothing. By entering the value 0, the filter is not executed.

Linear Fit
By setting this flag the linear fit filter is performed.

LOS Time Series
By setting this flag the time series of the shape files (.shp) is referred to the the first input line of sight.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file

Output file name of the processed data. This file is mandatory.

.xml
Xml file containing the processed data.

_slant.shp
Shape file (plus .dbf and .shx) containing the measurement history in the first input slant range geometry. This file is generated only if the "Input file list" is entered.

_geo.shp
Shape file (plus .dbf and .shx) containing the geocoded measurement history.

.kml
ASCII file containing the GPS points location in geographic co-ordinates. Double clicking on this file will automatically position the boundaries of the scene into the Google Earth environment.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.6 Data Export

Section Content

1.10.3.6.1 Generate Color Composite

Purpose

An RGB image can be generated from coregistered or geocoded images. Predefined RGB combination schemes are available.

Technical Note

Specific scale and exponent values can be applied to modify the Red, Green and Blue component in the RGB composite. The suggested procedure it is to first run the processing using the default parameters; the "leave temporary file" flag must be set in order to leave the three separated colour channels (temporary files) after the process is completed. In a possible successive processing iteration, increase one or more "Scale" values in order to give more weight to a specific color channel. The "Exponent" shall be changed in case the image contrast has to be modified. After the first process iteration, the flag "Only RGB generation" must be set in order to re-use previously generated temporary files.

The flag "Use Entered Values Only" can be set in order to scale the original pixel values only on the basis of the figures provided in the "Scale" and "Exponent" boxes; in such case the formula applied is:

$$\text{output value} = \text{scale} \cdot \text{input value}^{\text{exponent}}$$

If the option "Use Entered Values Only" is not used, the original data will be scaled by means of the following formula:

$$\left[(254 \cdot 0.33333 \cdot \mathit{Scale}) / \text{Mean value}\right]^{\mathit{exponent}}$$

In case negative values were present, the flag "Negative" must be set for the relevant layer when the option "Use Entered Values Only" is selected.

The histogram scaling values - relevant respectively to the Red, Green and Blue channels - are written in the "SARscape>View Files>Process.log" file.

In case the output product must have the same size (i.e. same number of pixels) of a reference image, this image has to be entered as "Input reference file".

All images geocoded to the GEO-GLOBAL reference system (LAT/LONG co-ordinates) can be automatically displayed into the Google Earth environment by double clicking on the output kml file.

Input Files

Input files list
Input files (_pwr, _geo, _fil) to make the RGB image. These files are mandatory.

Optional Files

Input reference file
Input file to be used as reference for the output file dimension. The output color composite will have the same size of the input reference file. This file is optional.

Parameters - Principal Parameters

Operation type
One of the following operations can be performed on the input files:

standard_RGB
The three input files are assigned respectively to the Red, Green and Blue channel in a color combination.

hh_hv_composite1
The following color combination is obtained: Red = (input 1 - input 2) / (input 1 + input 2); Green = input 2; Blue = input 1.

hh_hv_composite2
The following color combination is obtained: Red = input 1; Green = input 2; Blue = arctg (input 2/ input 1).

unsigned_coherence_combination
The coherence (1st input) and two Intensity images (2nd and 3rd input) must be provided as input. In the output RGB image (unsigned format) the Red channel is the coherence; the Green channel is the mean Intensity; the Blue channel is the Intensity difference (2nd - 3rd).

signed_coherence_combination
As above, but in signed format.

RED/GREEN/BLUE Scale
Changing this value affects the brightness of each output color layer: the higher these values the brighter the image.

RED/GREEN/BLUE Exponent
An exponential scaling factor is applied. Changing this value affects the contrast of each output color layer: values higher than 1 enable to optimize the stretch of high pixel values (bright areas); values lower than 1 enable to optimize the stretch of low pixel values (dark areas).

RED/GREEN/BLUE Use Entered Values Only
The input values are scaled only on the basis of the specified "Scale" and "Exponent".

RED/GREEN/BLUE Negative
This flag must be checked in case the input files contain negative pixel values.

Only RGB Generation
By setting this flag the only the RGB file is generated.

White dummy
By setting this flag the RGB image background, as well as dummy pixels within the imaged area, are shown in white (default is black).

Common scaling
By setting this flag the scaling factor is not calculated independently for each RGB layer; the same scaling factor, which is calculated for the first layer (Red channel), is applied to the other 2 layers (Green and Blue channels).

Mean in common scaling
By setting this flag the same scaling factor, which is calculated from the mean of the three layers, is applied to each of the three layers.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file
Enter the name of the output file (Tiff format). This file is mandatory.

.tif
Tiff image and corresponding header file (.sml).

.kml
ASCII file containing the information to visualize the Tiff image in Google Earth. It is generated only for images geocoded using the GEO-GLOBAL reference system.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.6.2 Generate Google Earth KML File

Purpose

Images geocoded to any supported cartographic reference system can be displayed in the Google Earth environment. A kml file is generated for this purpose.

Technical Note

Only data in GEO-GLOBAL cartographic reference system (LAT/LONG co-ordinates) can be used for the visualisation into the Google Earth environment.

This tools allows the cartographic transformation of products (raster and vector data) geocoded to any map projection supported by SARscape.

When raster data are processed, the Geotiff and the corresponding kml file are stored in the input directory. When vector data (in .shp format) are processed, a kml file is stored in the input directory; in this case the output kml is marked by a suffix, which describes the vector type (i.e. _polygons, _points, _arcs).

Vector files must be previously imported 99.

Double clicking on the kml file will start the Google Earth program and properly superimpose the Geotiff image.

Input Files

Input file
Raster images in Geotiff format can be entered only if the cartographic reference system is GEO-GLOBAL; any other SARscape geocoded image can be used by entering the _geo product. Vector files in shp format are also supported. This file is mandatory.

Parameters - Principal Parameters

Name
A name can be specified, which identifies the image into the Google Earth environment.

Description
An image caption, which is readable from the Google Earth environment, can be entered.

Tilt
The view direction angle, with respect to the vertical, can be set (in degrees).

Distance
The point of view distance from the ground can be set (in meters).

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

_GE_geo
Transformed data and associated header files (.sml, .hdr). This file is removed by setting the "Delete temporary files" flag.

_GE_geo.tif
Geotiff image and corresponding header file (.sml).

.kml
ASCII file containing the information to visualize the Tiff image in Google Earth.

_GE_geo_par.sml
Xml file containing temporary processing parameters.

_parameter_google_earth_kml.par
Parameters set for the kml file generation.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.6.3 Generate Tiff

Purpose

An 8 bit Tiff image can be obtained from any SARscape product. This tool is mostly intended to optimize the scaling of the original histogram for image visualization purposes. If used for generating the Tiff image of an interferogram, it enables to display the interferometric fringes with the classical color look up table.

Technical Note

The histogram scaling is performed using the following formula:

$$\text{output value} = 1+(254 \cdot\ 0.33333 \cdot \text{Scale} \cdot \text{input value}^{\text{exponent}}\ ) / \text{Mean value}$$

The scale factor can be tuned in order to optimize the visualisation rendering. By setting the flag "Use Entered Values Only" the original pixel values are stretched only on the basis of the figures provided in the "Scale" and "Exponent" boxes; in such case the "Mean Value" term becomes equal to 1.

All images geocoded to the GEO-GLOBAL reference system (LAT/LONG co-ordinates) can be automatically displayed into the Google Earth environment by double clicking on the output kml file.

Input Files

Input file list
Input file name(s) of the data to be processed. This file is mandatory.

Parameters - principal Parameters

Scale
Changing this value affects the output image brightness: the higher this value the brighter the image.

Exponent
An exponential scaling factor is applied. Values higher than 1 enable to optimize the stretch of high pixel values (bright areas); values lower than 1 enable to optimize the stretch of low pixel values (dark areas).

Use Entered Values Only
The input values are scaled only on the basis of the specified "Scale" and "Exponent".

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file list
Output file name(s) of the extracted data. This file is mandatory.

_ql.tif
Tiff image and corresponding header file (.sml).

.kml (only for images geocoded in GEO-GLOBAL)
ASCII file containing the information to visualize the Tiff image in Google Earth.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.7 Mosaicing

Section Content

1.10.3.7.1 Conventional Mosaicing

Purpose

Terrain geocoded, radiometrically calibrated and normalized backscattering coefficient data acquired over different satellite orbits are usually mosaiced, making it possible to cover large areas. This functionality can be used also for mosaicing Interferometric products such as Digital Elevation Models and Displacement Maps.

Technical Note

None.

Input Files

Input file list
Input file list of the geocoded data (_geo). This file list is mandatory.

Parameters - Principal Parameters

Interpolation Type
By setting this flag it is possible to specify a spatial region for the Digital Elevation Model extraction (co-ordinates are referred to the output cartographic reference system).

- **Last Pixel**
  In the overlapping areas, pixel values belonging to the last image (with respect to the input file list) are considered as representative.

- **Mean**
  In the overlapping areas, the average of the pixel values are considered as representative.

- **Optimal Resolution Approach**
  This option is exclusively applicable to mosaic Digital Elevation Model generated with SARscape. In the overlapping areas, the height value is chosen according to the best spatial resolution. The _resolution file is generated during the Digital Elevation Model 314 generation.

- **Precision**
  This option is exclusively applicable to mosaic Digital Elevation Model and Displacement Maps generated with SARscape. In the overlapping areas, the phase value is chosen on the basis of the coherence and baseline. The _precision file is generated during the Digital Elevation Model 314 as well as during the Displacement Maps 320 generation.
- **Feathering**
  In the overlapping areas, a weighted average of the pixel values according to the feathering window is calculated. It is of advantage to set the Feathering Window size to at least the width of the overlapping area.

Feathering Window Size
This parameter is activated if Feathering interpolation is chosen. This parameter controls the window size on which a weighted average of the pixel values will be executed.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file
Output file name of the mosaiced data. This file is mandatory.

_msc
Mosaic and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.7.2 Gradient Mosaicing

Purpose

Terrain geocoded, radiometrically calibrated and normalized backscattering coefficient data acquired over different satellite orbits are usually mosaiced, making it possible to cover large areas.

It is not possible to use this functionality to mosaic data which are not partially overlapping. For this purpose the Conventional Mosaic>Last Pixel 712 method is suggested.

Technical Note

Gradient mosaicing is implemented by creating cut lines within the overlapping areas of the images. These lines are automatically identified (using edge detection techniques) along image discontinuities, in order to minimize (by calibrating the image histograms) the visibility of the mosaic junction. It has to be pointed out that this method includes an automatic image calibration algorithm which is essentially articulated in three steps:

- The intensity ratio is estimated between neighbouring images in the overlapping areas.
- The correction factors are obtained by means of a global optimization.
- Outlier images are treated in advance, hence allowing more degree of freedom in the calibration step.

The adopted model for the images equalization is performed as follows:

- For standard images the applied calibration factor is

$$I_{cal}\,(r,a) = I_{uncal}\,(r,a) \cdot (k_1 + k_2 \cdot r)$$

- For images at the borders the applied calibration factor is

$$I_{cal}\,(r,a) = I_{uncal}\,(r,a) \cdot (k_2 \cdot r)$$

- For temporal outlier images the applied calibration factor is

$$I_{cal}\,(r,a) = I_{uncal}\,(r,a) \cdot (k_1 + k_2 \cdot r + k_3 \cdot a)$$

  where r is the range coordinate, a the azimuth one.

The calibration process will result in the value of coefficients k_1 , k_2 , k_3 for each single image. They are estimated as solution of a global minimization problem, in order to ensure the global continuity of the data radiometry. The relationship to be fulfilled for each possible image pair is

$$R \cdot (k_{11} + k_{12} \cdot r + k_{13} \cdot a) / (k_{21} + k_{22} \cdot r + k_{23} \cdot a) = 1$$

where R is defined as the ratio between I_1 and I_2.

The calibration process is performed first with an "Absolute Calibration", which is intended for removing constant and linear trends in all input data; these trends are calculated by means of a certain number of points (Preferences>Mosaic-Filtering>Absolute Calibration 763) collected in the overlapping areas. The calibration is the locally refined by using a Krigging interpolation on a new grid of points

(Preferences>Mosaic-Filtering>Local Calibration 763), which are located along each cut line where each image will be mosaicked to the adjacent one.

Input Files

Input file list
Input file list of the geocoded data (_geo). This file list is mandatory.

Parameters - Principal Parameters

Absolute Calibration
An absolute and linear calibration is carried out considering the pixel values in the overlapping area.

Local Calibration
The previous absolute calibration is locally refined around the cut line within the overlapping area.

Use Existing Shape
If a previously generated shape (possibly edited) exists, it will be used as mosaic cut line.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output file
Output file name of the mosaiced data. This file is mandatory.

_msc
Mosaic and associated header files (.sml, .hdr).

_shape.shp
Shape file containing the mosaic cut line.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data

Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.7.3 Slant Range Mosaicing

Purpose

Slant Range or Ground Range (i.e. not geocoded) SAR products, which have been acquired along the same orbit and with the same viewing geometry, can be mosaiced. The functionality supports only data generated with zero-Doppler annotation.

Technical Note

This functionality is intended to generate a single file, in the original SAR viewing geometry, from a set of independent frames. Even if this functionality is conceived especially for Slant Range products, it is also suitable for Ground Range data; in this last case the program first performs a transformation from ground to slant geometry and then the mosaic is generated in the slant "rebuilt" geometry.

It is important to outline that this tool does not take into account doppler variations from one to the other frame along the mosaiced segment. This means that, if such variations exist in the mosaiced frames, the resulting product is not suitable for interferometric processing.

Input Files

Input file list
Input file list of the slant or ground range data (_slc, _gr, _pwr). This file list is mandatory.

Output Files

Output file
Output file name of the mosaiced data. This file is mandatory.

_slant_msc
Mosaic and associated header files (.sml, .hdr).

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.8 Orbital Correction

Section Content

This suite of tools provide the possibility to apply different kind of corrections to the original orbital parameters, which are associated with SAR products; in particular the following functions are available:

- Automatically correct 719 the azimuth start time and the slant range distance on the basis of a synthetic SAR image.

- Manually correct 722 the azimuth start time and the slant range distance on the basis of a manually located Ground Control Point.

- Update ERS, ENVISAT and RADARSAT-2 723 orbital parameters with the precise orbits made available by different providers/institutes.

- Correct the Pulse Repetition Frequency 728, which is annotated in the original products, with a new value calculated by means of manually selected GCPs.

1.10.3.8.1 Automatic Orbital Correction

Purpose

This functionality can be used when the result of the nominal geocoding comes with geo-location inaccuracies. It allows to correct the azimuth start time and/or the slant range distance on the basis of a reference Digital Elevation Model and, optionally, an optical or SAR geocoded image.

It is important to outline that the reliability, in terms of absolute geo-location accuracy, of the corrected product depends on the reliability of the reference Digital Elevation Model.

The properly corrected product does not require any further manual correction either for the slant-to-geocoded or for the geocoded-to-slant related processes (e.g. GCP-based Geocoding 142, Interferogram Flattening 465, etc.)

Technical Note

The process consists of creating a SAR synthetic image, which is used for a cross-correlation based coregistration of the "Input file". This synthetic image is simulated starting from the input Digital Elevation Model and, optionally, the input "Reference Image". The latter, if available, allows to improve the correction by adopting a hybrid approach, which exploits the DEM for the morphology/slope aspect and the "Reference Image" for the identification of land features such as roads, rivers, urban infrastructures, field boundaries etc. The selected "Resampling" method is used for projecting the "Reference Image" onto the "Input file" geometry.

The most suitable optical images to use are: an NDVI index, a Near Infrared channel, a panchromatic image.
Any SAR image can be used as "Input file": single look complex or detected single look amplitudes, as well as multilooked products are admitted.

This step does not generated any output file except the parameter file (_par), where the azimuth and range shift correction are provided. However it is possible to save also the intermediate products (e.g. the simulated SAR image) by de-selecting the Delete Temporary Files 760 flag ("Preferences>General" panel). As result of the processing the header (.sml) of the "Input file" is modified by changing the original azimuth start time and/or the slant range distance with the corrected values.

Whether the correction results are inaccurate, given that the reference data (Digital Elevation Model and reference image) are fully reliable both in terms of geolocation and height, the number of windows (and if necessary also their size), in range and azimuth direction, should be increased and the process reiterated.

It has to be mentioned that, being the process based on the topographic aspect of the input "DEM file", in case of completely flat areas the coregistration can fail.

Input Files

Input file
Input file name of the data to correct. This file is mandatory.

DEM file
Input reference Digital Elevation Model. This file is mandatory.

Optional Files

Input Reference Image
Input reference SAR or Optical image. This file is optional.

Parameters - Principal Parameters

Interpolation window size
Window dimension used for the interpolation of dummy pixels in the synthetic simulated image. If zero is entered, the interpolation is not applied.

Range Window Number
Number of windows, in range direction, which are used for the "Input file" coregistration process.

Azimuth Window Number
Number of windows, in azimuth direction, which are used for the "Input file" coregistration process.

Range Window Size
Range dimension, in pixels, of the coregistration windows.

Azimuth Window Size
Azimuth dimension, in pixels, of the coregistration windows.

Cross Correlation Oversampling
The data are oversampled in order to improve the coregistration shift estimate. The higher this value the longer the processing time. Typically it is not not necessary to oversample more than 1/4 of pixel (standard setting).

Cross Correlation Threshold
If the correlation value is below this threshold, then the window is not used for the shift estimate.

Coregistration With DEM
If this flag is set, the input file will be coregistered with the input DEM.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Coregistration

It brings to the Coregistration section of the Preferences 770 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch

processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

Undo
The original azimuth start time and/or the slant range distance are restored. Only the "Input file" is required to run this function.

References

None.

1.10.3.8.2 Manual Orbital Correction

Purpose

This functionality can be used when the result of the nominal geocoding comes with geo-location inaccuracies. It allows to correct the azimuth start time and/or the slant range distance on the basis of a Ground Control Point.

The properly corrected product does not require any further manual correction either for the slant-to-geocoded or for the geocoded-to-slant related processes (e.g. GCP-based Geocoding142, Interferogram Flattening465, etc.)

Technical Note

As result of the processing, the header (.sml) of the "Input file" is modified by changing the original azimuth start time and/or the slant range distance with the corrected values.

Input Files

Input file
Input file name of the data to correct. This file is mandatory.

Geometry GCP file

Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File) or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the "Tools>Generate Ground Control Point" 747 for details). This file is mandatory.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

Undo
The original azimuth start time and/or the slant range distance are restored. Only the "Input file" is required to run this function.

References

None.

1.10.3.8.3 Update to Precise Orbits

Supported Products

The update of ERS and ENVISAT orbital parameters can be performed by using the precise orbits provided by DLR (precise "PRC" or preliminary "PRL" orbits 725) or by the Delft University (DEOS orbits 724):

- PRC and PRL data can be used to update ERS-1 and ERS-2 orbital parameters.
- DEOS data can be used to update ENVISAT, ERS-1 and ERS-2 orbital parameters.

The update of RADARSAT-2 727 orbital parameters can be performed by using the precise orbits provided by MDA

1.10.3.8.3.1 DEOS

Purpose

Standard orbits, which are provided with ERS-1/2 and ENVISAT ASAR products, can be updated using precise ones.

Technical Note

Precise orbits, which are made available through the Delft University, can be downloaded and used to update the relevant information in the SARscape header file (a copy of the original header files is automatically saved on disk). This procedure is especially useful for interferometric processing purposes, where an improvement of just 1 meter or less - in terms orbital parameters accuracy - can dramatically improve the quality of the final processing results.

A two step procedure has to be followed:

1. Create a folder named "Arclist" containing three sub-folders which, depending on the acquisition sensor, are:
   - ERS1
   - ERS2
   - ENVISAT

2. Download the Arclist file as well as the orbital files (ODR) from the Delft University WEB site and store them in the relevant sub-folder (ERS1, ERS2 or ENVISAT).

Orbits (ODR) and Arclist, which can be downloaded from the closest FTP server (e.g. the French one for Europe), must be stored in the same folder.

If the required orbital file name is in the Arclist, but the relevant orbital data (ODR) has not been downloaded, an error appears with the name of the missing orbital data (ODR).

It must be noted that some ERS orbital data can be not available in the Delft data base; a more comprehensive set is available in the DLR data base 725.

Input Files

Arclist file
Path of the input folder containing the relevant Arclist and orbital data. This file is mandatory.

File to Update
Input file name of the SAR data (e.g. _slc) to update. This file is mandatory. The data must have been

previously imported.

Output Files

_OLD...
Copy of the header files (.sml, .hdr) containing the old - not updated - orbital parameters.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.8.3.2 PRC/PRL

Purpose

Standard orbits, which are provided with ERS-1/2 products, can be updated using precise (PRC) or preliminary (PRL) ones.

Technical Note

Precise and preliminary orbits, which are made available through the DLR ftp server, can be used to update the relevant information in the data header file. This procedure is especially useful for interferometric processing purposes, where an improvement of just 1 meter or less - in terms orbital parameters accuracy - can dramatically improve the quality of the final processing results.

Access to these data can be required to the ESA Earth Observation Help Desk. The zipped orbital data are stored, in the "orbprc" or "orbprl" folder, within directories named according to the satellite name (i.e. ERS1 or ERS2) and acquisition year.

The zip file nomenclature contains information relevant to both acquisition period and absolute orbit number (i.e. validity time begin), which enable to identify the file to download. The orbit file to use must be the closest, but previous (in terms of date/orbit), with respect to the input satellite acquisition date/orbit.

Input Files

Input Orbit File
Unzipped orbital data. This file is mandatory.

File to Update
Input file name of the SAR data (e.g. _slc) to update. This file is mandatory. The data must have been previously imported.

Output Files

_OLD...
Copy of the header files (.sml, .hdr) containing the old - not updated - orbital parameters.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close

The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.8.3.3 RADARSAT-2

Purpose

Standard orbits, which are provided with RADARSAT-2 products, can be updated using the precise ones.

Technical Note

RADARSAT-2 orbit files are provided by the MDA client services department.

Input Files

Input Orbit File
Unzipped orbital data. This file is mandatory.

File to Update
Input file name of the SAR data (e.g. _slc) to update. This file is mandatory. The data must have been previously imported.

Outpu Files

_OLD...
Copy of the header files (.sml, .hdr) containing the old - not updated - orbital parameters.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.8.4 PRF Correction

Purpose

In some cases - i.e. for Radarsat-1 data - it has been experienced that the original azimuth pixel spacing is not in agreement with the original Pulse Repetition Frequency. This problem, if not corrected, affects the geocoding.

A new value, corresponding to the corrected Pulse Repetition Frequency, is calculated. This will be used for further processing.
The original Pulse Repetition Frequency value, even if not used anymore, is not erased from the header file. The original Pulse Repetition Frequency can be possibly restored.

To execute this step a Ground Control Point 747 file must be previously created.

Technical Note

This functionality can be used only for slant range products.

This step does not generated any relevant output file. The process consists of recomputing the Pulse Repetition Frequency and substitute the newly calculated value to that stored in the header file of the input data.

The Ground Control Point file must contain at least two points (their position will be entered both in the input SAR geometry and in cartographic co-ordinates), which are as much as possible separated in azimuth direction in order to optimize the Pulse Repetition Frequency value correction. It is important to note that only those points, which are labelled as "reference_gcp", are used in this process.

Input Files

Input file
Input file name of the data to correct. This file is mandatory.

Geometry GCP file
Either a previously created Ground Control Point file (.xml) is loaded (Load GCP File) or the interface to create a new Ground Control Point file is automatically loaded (Create GCP File, refer to the "Tools>Generate Ground Control Point747" for details). This file is mandatory.

Parameters - Principal Parameters

Restore Original Value
The original Pulse Repetition Frequency value is restored.

Parameters - Global

It brings to the general section of the Preferences759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences759 parameters. Any modified value will be used and stored for further processing sessions

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.9 Quality Analysis

Section Content

1.10.3.9.1 DEM Validation

Purpose

The Quality of a Digital Elevation Model can be compared against existing reference products (e.g. Reference DEMs, GPS points, etc.).

The validation data are generated as .txt, .xls, .xml and .shp files.

Technical Note

A standard deviation based coregistration is carried out to estimate the shift between reference and input DEM.
This tool is intended for validating the quality of products where the maximum spatial shift between "Reference DEM file" and "DEM file" is in the order of a few pixels; in case of shift values larger than 40 pixels this tool has not to be used for validation purposes.

Input Files

DEM file
Input Digital Elevation Model to validate. This file is mandatory.

Input Reference file
Digital Elevation Model to use as reference in the validation process. This file is mandatory if the "Shape File" (with Easting, Northing and Height values) is not provided.

Input Shape File
This file must be in .shp format. It can made of points (each provided with Easting, Northing and Height values) or polygons. This file (made of points) is mandatory if the "Reference DEM File" is not available. If this file is entered, the validation statistics relevant to each point/polygon - and to any label/class of the shape - are also generated.

Optional Files

Mask File
This is a classification-like input. This file is optional. If it is entered the validation statistics relevant to each input class are also generated.

Parameters - Principal Parameters

Shape Height Field Name
In case a "Shape File" of points is used, where the height values are in a field whose name is not "Height", the name of the field containing the height values must be provided.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output File

Output Root Name
Name of the output root. This file is mandatory.

_raster_stat
Overall validation statistics (.txt and .xls format). If the "Mask File" is entered, the validation results are also provided specifically to each input class.

_shape_stat
Validation statistics (.shp, .xml, .txt and .xls format) related to the input "Shape File" . If the "Mask File" is entered, the validation results are also provided specifically to each input class.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.9.2 Point Target Analysis

Purpose

Information useful for calibration purposes are extracted from the data. The tool is intended for checking SAR data calibration parameters by analysing the signal response on corner reflectors.

Technical Note

Only slant range data are admitted. The response of the SAR signal impulse, which comes from a target on the ground, is calculated both in azimuth and range direction. Results are shown on IDL application graphs; calibration relevant figures are also displayed on screen.

Input Files

Input file
Input file name of the data to examine. When opening the widget, the user is prompted to select an opened image in the ENVI Layer Manager. This file is mandatory.

Parameters

Azimuth (row)
Azimuth co-ordinate of the pixel to examine.

Range (column)
Range co-ordinate of the pixel to examine.

Output Files

_pta.txt
List of parameters extracted and corresponding values.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Close

The window will be closed.

Help
Specific help document section.

Specific Function(s)

Position
The file co-ordinates (row and rolumn), corresponding to the cursor location, is identified.

References

None.

1.10.3.9.3 Data Statistics

Purpose

Statistical parameters, for one or more data files, are extracted.

The calculated values are automatically visualized at process completion. When two or more input files are entered, the program generates two IDL views showing the temporal signature in dB and linear backscatter values.

Technical Note

The following parameters are calculated:

- **Number of data points**.
- **Minimum pixel value**.
- **Maximum pixel value**.
- **Mode value**.
- **Standard deviation value**.
- **Normalisation Factor**.
- **Median value**.
- **Mean value**.
- **Radiometric Resolution** (in dB). It is calculated for power images using the following formula: $10 * \log_{10}((1.0 + aQR));$

where aQR = Standard Deviation / Mean value

- **Equivalent Number of Looks**. It is calculated using the following formula: $mean^2$ / standard $deviation^2$

The calculation can be performed on the entire scene or on a selected area of interest. The "Input file list" is automatically sorted in chronological order before generating the temporal signature.

Input Files

Input file list
Input file name(s) of the data to analyse. This file list is mandatory.

Optional Files

Vector File
A vector file (.shp) can be entered to specify the area to be processed. This file is optional.

Parameters - Principal Parameters

If a vector file defining the **Area of Interest** is not specified, cartographic co-ordinates (geocoded data) or file co-ordinates (not geocoded data) can be entered as follows:

West/First column
The Westernmost cartographic co-ordinate or the first column file co-ordinate.

East/Last column
The Easternmost cartographic co-ordinate or the last column file co-ordinate.

North/First row
The Northernmost cartographic co-ordinate or the first row file co-ordinate.

South/Last row
The Southernmost cartographic co-ordinate or the last row file co-ordinate.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output File

Enter the name of the output file. This file list is mandatory.

The calculated statistical parameters and related graphs are shown on screen.

_sta
Text file containing the value calculated for each statistical parameter.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.10 Sample Selections

Section Content

1.10.3.10.1 Sample Selection Slant Data

Purpose

A spatial subset can be performed on a data temporal series.

Technical Note

In case the processing, has to be executed on a portion of the original data, the data resize can be executed using this tool. The entire data set is coregistered using the first image of the series as reference; the subset area, which must be defined on the reference data (1st of the input list), is extracted from each coregistered scene.

The coregistration process is executed by estimating the orbital shift only (cross-correlation as well as coherence based shift estimates are not performed), thus in case of largely imprecise orbits the subset results can be wrong.

Those data where the coregistration process fails are discarded and a warning message is prompted.

This functionality is especially suitable to extract a portion from an interferometric series of Single Look Complex full frames, however it can be used also on intensity images (_pwr).

Input Files

Input file list
Input file name(s) of the data to be processed. This file is mandatory.

Optional Files

Vector File
A vector file (.shp) can be entered to specify the area to be processed. In case the area is irregular, the circumscribed rectangular area is considered.
This file is optional.

DEM File
This file is needed when the sample area is specified in cartographic co-ordinates. Alternatively the Cartographic System (together with the "Reference Height") must be entered. This file is optional.

Parameters - Principal Parameters

Make Coregistration
By setting this flag the input files will be coregistered with the optional input DEM according to the Preferences 770 parameters.

Coregistration With DEM
By setting this flag the input files will be coregistered with the optional input DEM according to the Preferences 770 parameters.

Geographical Region
By setting this flag the area to be processed is specified in cartographic co-ordinates or georeferenced vector file (referred to the input DEM or Cartographic system); otherwise file co-ordinates (i.e. slant range geometry) must be entered. The selected region is referred to the master data. Co-ordinate decimal values must be entered using the dot (e.g. 29.30) and not the comma (e.g. 29,30) character.

- **West/First column**
  The Westernmost cartographic co-ordinate or the first column file co-ordinate.

- **East/Last column**
  The Easternmost cartographic co-ordinate or the last column file co-ordinate.

- **North/First row**
  The Northernmost cartographic co-ordinate or the first row file co-ordinate.

- **South/Last row**
  The Southernmost cartographic co-ordinate or the last row file co-ordinate.

Use Min and Max Coordinates
By setting this flag only the corners provided in the optional vector file will be used to select the data from the input file(s).

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Cut

See the Principal Parameters section for the parameters description.

Parameters - Coregistration

It brings to the coregistration section of the Preferences 770 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and

stored for further processing sessions.

Output Files

Output file list
Output file name(s) of the extracted data. This file is mandatory.

_rsp
Resized data and associated header files (.sml, .hdr).

.xml
Xml file containing the geographic co-ordinates of the scene corners.

.shp
Shape file and associated header files (.sml, .hdr) containing the image perimeter in geographic co-ordinates.

.kml
ASCII file containing the image perimeter in geographic co-ordinates. Double clicking on this file will automatically position the boundaries of the scene into the Google Earth environment.

_orb.sml
Xml file containing the scene orbital parameters. This file is generated only for ASAR_WS products.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.10.2 Sample Selection Geographic Data

Purpose

A spatial subset of the data can be performed either manually or automatically. Manual selection can be performed specifying the area of interest either with its corner co-ordinates or using a vector file, while the automatic process is performed by extracting a common area of an image series.

Technical Note

In case the processing has to be executed on a portion of the original data, the data resize must be executed using this tool instead of the ENVI own functionality (i.e. Basic Tools>Resize Data). Indeed the image subset has to keep all the information contained in the original data, otherwise any further process - executed within SARscape - would fail.

In case the input data are not geocoded, the sample area can be specified either in raster (column/row) or in cartographic co-ordinates. If the input data are geocoded the sample area can be specified either as file co-ordinates or in any supported cartographic system. This functionality also supports an "Input file list", which is made of images referred to different cartographic systems and/or in slant geometry.

In case of an automatic selection, the extracted data have all the same number of rows and columns. Data with different grid size are not supported.

Input Files

Input File list
Input file name(s) of the data to be processed. This file is mandatory.

Optional Files

Vector File

A vector file (.shp) can be entered to specify the area to be processed. This file is optional.

DEM/Cartographic System

DEM File
This file is needed when the sample area is specified in cartographic co-ordinates. Alternatively the Cartographic System (together with the "Reference Height") must be entered. This file is optional.

Output Projection
In case that the sample area is entered in cartographic co-ordinates and the Digital Elevation Model is not used, the following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Parameters - Principal Parameters

Make Maximum Common Area
By setting this flag the automatic process to extract the common area of an image series is performed.

Common Dummy area
By setting this flag, pixels with no value (dummy pixels) are not taken into account to define the number of rows and columns in the output files. Moreover dummy pixels in one of the input data are set to dummy in all output files.

Geographical Region
By setting this flag the area to be processed is specified in cartographic co-ordinates or georeferenced vector file (referred to the input DEM or Cartographic system); otherwise file co-ordinates (i.e. slant range geometry) must be entered. Co-ordinate decimal values must be entered using the dot (e.g. 29.30) and not the comma (e.g. 29,30) character.

- **North/First row**
  The Northernmost cartographic co-ordinate or the first row file co-ordinate.

- **South/Last row**
  The Southernmost cartographic co-ordinate or the last row file co-ordinate.

- **West/First column**
  The Westernmost cartographic co-ordinate or the first column file co-ordinate.

- **East/Last column**
  The Easternmost cartographic co-ordinate or the last column file co-ordinate.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Cut

See the Principal Parameters section for the parameters description.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output File list
Output file name(s) of the extracted data. This file is mandatory.

_rsp
Resized data and associated header files (.sml, .hdr).

.xml
Xml file containing the geographic co-ordinates of the scene corners.

.shp
Shape file and associated header files (.sml, .hdr) containing the image perimeter in geographic co-ordinates.

.kml
ASCII file containing the image perimeter in geographic co-ordinates. Double clicking on this file will automatically position the boundaries of the scene into the Google Earth environment.

_orb.sml
Xml file containing the scene orbital parameters. This file is generated only for ASAR_WS products.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.10.3 Maximum Common Area

Purpose

A spatial subset of geocoded data is performed in order to extract the common area of an image series.

Technical Note

The extracted data have all the same number of rows and columns.
Data with different grid size are not supported.

Input File(s)

Input file list
Input file names of the geocoded (e.g. _geo) data to be processed. These files are mandatory.

Output file list
Output file names of the subset data. These files are mandatory.

Input Parameter(s)

Common Dummy area
By setting this flag, pixels with no value (dummy pixels) are not taken into account to define the number of rows and columns in the output files. Moreover dummy pixels in one of the input data are set to dummy in all output files.

Output(s)

_rsp
Subset data and corresponding header file (.sml).

_meta
This file allows to load the specific processing results together with the input reference file.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Start
Start of the processing.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Cancel
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

None.

1.10.3.11 Time Series Analyzer

Section Content

1.10.3.11.1 Raster

Purpose

It is intended to generate, given a raster dataset, a graphic representation of the temporal trend/ signature.

It is typically adopted to represent the displacement history from the SBAS raster results.

Technical Note

The graphic representation can be created as follows:

1. Load the meta file (_meta) which refers to the measurements to plot.
2. Launch the "Time Series Raster Analyzer" program.
3. Identify the area to plot and specify its dimension (average window size). Click "Apply" and then "Plot" in order to display the graph.

It is possible to copy and paste the temporal plot (e.g. displacement history), from one to another graph, for comparison purposes.

1.10.3.11.2 Vector

Purpose

It is intended to represent the fields of a shape (dbf) file, with different colors.

It is typically adopted for the Persistent Scatterers or the SBAS shape results.

Technical Note

The graphic representation can be created as follows:

1. Open a geocoded raster image in the ENVI view.
2. Open, from "File>Open Vector File" (ENVI main menu command bar), the shape file; this must have been generated with the same areal extent and geographic projection of the geocoded image (point 1).
3. Launch the "Time Series Vector Analyzer" program, select the relevant .shp file and load it in the same display of the geocoded raster file.
4. By clicking the "Multicolor" button, in the "Vector Analyzer" interface, you are prompted to specify the attribute to display. It is possible to modify the display parameters such as the Min/Max displacement values for the color scaling.
5. Locate the mouse and click the left button; then push the "Plot Time Series" button ("Vector Analyzer" panel) in order to display the relevant graph.

1.10.3.12 Cursor Location / Value

Purpose

This functionality must be operated under ENVI Classic.

1.10.3.13 Generate Ground Control Point File

Purpose

The Ground Control Point file (xml or ASCII format), which can be required as input for processes such as Orbital Correction, Geocoding, Interferogram Flattening, Persistent Scatterers and others, is generated.

Technical Note

The use of the Ground Control Point file is foreseen (as possible or mandatory) in different processing steps; their number and position depend on the specific SARscape functionality where they are used (refer to the relevant Technical Note).

The GCP creation workflow is executed in three steps:

1. **File Selection** - the following images are entered: i) "Input File" where the GCP is placed; ii) "DEM File" (optional) to retrieve the GCP elevation; iii) "Reference File" (optional), which must be a geocoded image, to retrieve the GCP Easting and Northing co-ordinates. The "DEM" and the "Reference File" must be referred to the same cartographic system, which will be adopted also for the output GCP file. When the "Reference File" is entered the next GCP selection interface will provide two images in the view: the "Input File" to the left and the "Reference File" to the right. When the "Reference File" is omitted the next GCP selection interface will provide in the view only the "Input File".
2. **Select GCPs** - this is where the GCPs are actually inserted (using the *star* symbol annotation tool) and moved/modified (using the *arrow* select tool). The program is able to predict the co-ordinates and the relevant position in the "Reference File", for each GCP located in the "Input File". It is also possible to ingest and drape, onto the visualised image/s, an existing set of GCPs (.xml format). This panel provides: i) the point selection interface ("GCPs" tab); ii) the cartographic system definition interface ("Cartographic System" tab); ii) the output format definition interface ("Export" tab).
3. The GCP creation process is completed by clicking the "Finish" button. Note that this action will close the GCP interface; it is possible to save the GCP file and to leave the interface open by clicking on the "Save GCPs" icon.

When the "Displacement GCP file" is generated (PS 504 or SBAS 538 processing), the coordinates must be provided in cartographic units. In particular for the Refinement and Re-Flattening 525 step, in the SBAS processing, the "Input File" must be the Super Master 510 intensity image.

It is not possible to associate different Cartographic Systems to different points of the same GCP file. If the input "DEM file" is used, its Cartographic System will be the reference for all GCPs.

$Vel_{x,y,z}$

These parameters are entered only when the GCP file has to be used for interferometric related processing and in particular for displacement mapping. The GCPs come from measurements, typically collected during ground truth campaigns, which must be entered here as velocity units (mm/year). In

case the collected information is available in metric units (e.g. millimeters or centimeters) instead of velocity, it must be transformed by considering the time interval between master and slave acquisition.
As an example a co-seismic displacement of 50 cm for an interferometric pair acquired at 35 days distance will correspond to a velocity of around 5214 mm/year.

It is important to note that these velocity fields can be associated only to GCPs whose location is provided in cartographic co-ordinates (i.e. "Map X", "Map Y" and optionally "Height"); vice versa these fields are not taken into account when the GCPs location is entered as file co-ordinates (i.e. "Image X" and "Image Y"). If this parameter is not provided the GCP displacement velocity is set to zero (stable point).

Input File
It is considered for:

- Determining the multilooking factors of the image where the GCPs have been located. Note that it is possible to use the same set of GCP onto the same "Input File", even if processed with different multilooking factors.
- Determining the reference time of the GCP measurement (position and velocity).

File Selection

Input File
The SAR image which the GCP (or GPS points) refers to. This file is mandatory.

DEM file
It is used to retrieve the height of those GCPs whose height ("Z") has not been entered. This file is optional.

Reference file
Geocoded image to be used as reference for the GCP identification. This file is optional.

GCPs

Properties

- **Column**
  File co-ordinate, in the "Reference file" geometry, of the selected pixel (x direction).

- **Row**
  File co-ordinate, in the "Reference file" geometry, of the selected pixel (y direction).

- **Label**
  A text identifier can be entered for each point. If the GCP file has to be used afterward in the Pulse Repetition Frequency 728 functionality, this label is mandatory and it must be: "reference_gcp".

- **Collection Date**

The date (DD-MMM-YYYY; e.g. 12-JUL-2010) which the GCP position, and its displacement velocity, refers to. This parameter is optional, in case it is omitted the acquisition date of the "Reference file" is used instead.

- **X** (Easting)
  East-West cartographic co-ordinate of the selected pixel.

- **Y** (Northing)
  North-South cartographic co-ordinate of the selected pixel.

- **Z** (Height)
  Elevation in meters (above the ellipsoid) of the selected pixel.

- $\mathbf{V_x}$
  Displacement velocity (mm/year) in East-West direction. This parameter is normally (not necessarily) entered only when the GCP file has to be used in the "Refinement and Re-flattening" processing step aimed at Displacement Mapping.

- $\mathbf{V_y}$
  Displacement velocity (mm/year) in North-South direction. This parameter is normally (not necessarily) entered only when the GCP file has to be used in the "Refinement and Re-flattening" processing step aimed at Displacement Mapping.

- $\mathbf{V_z}$
  Displacement velocity (mm/year) in vertical direction. This parameter is normally (not necessarily) entered only when the GCP file has to be used in the "Refinement and Re-flattening" processing step aimed at Displacement Mapping.

Cartographic System 6

In case that the Digital Elevation Model is not used, following parameters are compulsory:

State
Definition of the country or general projection systems.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Datum Shift
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Export

Output XML File
Output file name of the Ground Control Point XML file. This file is mandatory.

Export ASCII file
If this flag is set, the Ground Control Point file will be exported as ASCII. This file is mandatory.

Output ASCII file
Output file name of the Ground Control Point ASCII file. This file is mandatory.

Output Formats

.xml
Ground Control Point file to use as input in any processing step where it is required.

.shp
Shape file of the Ground Control Points.

.pts
ASCII file of the Ground Control Points.

Details specific to the Units of Measure and Nomenclature of the output products can be found in the Data Format 21 section.

General Functions

Back
It goes back to the previous interface.

Next
It proceeds with the next interface.

Finish
The GCP generation step is completed with the relevant file creation.

Cancel
The GCP interface is closed to restore the original ENVI view.

Help
Specific help document section.

Specific Function(s)

Delete GCP
The selected GCP is removed.

Delete All GCPs
All GCPs are removed.

Load GCPs
An existing set of GCPs (.xml) can be entered.

Save GCPs
The existing GCPs are saved.

References

None.

1.10.3.14 Point Gridding

Purpose

An existing DEM in Point Cloud form (Shapefile), previously generated with SARscape, OPTICALscape, or composed by XYZ information can be converted into a raster product.

Technical Note

The process initially exploits the information provided by the respective DEM/DSM generation modules provided in OPTICALscape and SARscape to apply both a knowledge-based and an accuracy-based sample selection. This is imposed by a minimum proximity radius between points which is a constraint of the used interpolator. The choice strategies vary depending on the type of process:

Optical Data
In the case of Optical data, the information contained in the shapefile consists in the Feature Type (see the "OPTICALscape>DSM generation module" for the identifiers), matching cross-correlation and reliability index. Exploiting the knowledge about stereo-optical matching, an edge or point feature will be always chosen rather than a grid point. The choice between identical

features is driven by cross-correlation and reliability index.

SAR Data
The choice will be data-driven, the excluded point will always be the one showing the worst precision.

XYZ Data
The choice will be ordering-driven, the excluded point will always be the one following the inspected point.

The final step will be performed exploiting a modified 2D Sheppard local interpolator using Thin Plate Radial Basis Functions, the local RBF support will be automatically set. The approach is inspired by the one proposed by Lazzaro D. et. al., the RBF function is given in Numerical Recipes. Two parameters have to be set by the user, namely the number of nearby points on which to fit the RBF function and the number of nodes defining the radius of influence of the computed interpolant. These two values are usually set to 13 and 10 by default respectively.

Two additional steps can be performed, namely a Mean Filtering and a Relaxation interpolation. The former in order to smooth eventual spikes and the latter to provide a continuous surface without holes.

Input Files

Input Shape File
File name of the input point cloud. This file is mandatory.

DEM/Cartographic System

Output Projection
The following parameters are compulsory to define the **Cartographic System** 6:

State
Definition of the country or general projection systems.

Projection
Definition of the projection system of the selected State. In case that a general projection system is selected in State, the Projection is automatically set.

Ellipsoid
Definition of the ellipsoid. This is chosen according to the selected State and Projection.

Hemisphere
Definition of the hemisphere. This is chosen according to the selected State and Projection.

Zone
Definition of the zone. This is chosen according to the selected State and Projection.

Datum Shift Parameters
Definition of the datum shift parameters. These are chosen according to the selected State and Projection.

Cartographic Parameters
The reference parameters for some projection systems (e.g. Stereographic, Polar Stereographic, Gnomonic, Mercator, Miller, Albers, etc.) can be set.

Note that the input has to be in **the same cartographic system** as the output.

Parameters - Principal Parameters

Input Type
This flag must be set to define the input type of the point cloud DEM, the choice is given between:

- SAR, if the corresponding input is an interferometric DEM (necessarily generated with SARscape).
- Optical, if the corresponding input is a stereo DEM (necessarily generated with OPTICALscape).
- XYZ, if the corresponding input is a DEM generated outside the SARscape/OPTICALscape ecosystem. The coordinate ordering has to follow the description, hence: X (longitude), Y (latitude), Z (altitude).

Number Of Nodes
Number of nodes defining the radius of influence of the interpolant.

Number Of Coefficient Points
Number of nearby points for the fitting on each node.

Grid Size
The pixel spacing of the output DEM. This value is mandatory.

Relax Interpolation
Set this flag if a final relax interpolation step has to be executed in order to fill eventual holes..

Mean Interpolation
Set this flag if a mean filtering on a regular grid has to be executed.

Mean Window Size
The size of the window for mean filtering. This value is set as 3x3 by default.

Parameters - Global

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Parameters - Other Parameters

It brings to the general section of the Preferences 759 parameters. Any modified value will be used and stored for further processing sessions.

Output Files

Output File
File name of the output combined Digital Elevation Model. This file is mandatory.

_dem
Fusion resulting Digital Elevation Model with the corresponding header files (.sml, .hdr).

General Functions

Exec
The processing step is executed.

Store Batch
The processing step is stored in the batch list. The Batch Browser 802 button allows to load the batch processing list.

Close
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

References

-Lazzaro D., Montefusco L.B., Radial Basis Functions for the multivariate interpolation of large scattered data sets, *Journal of Computational and Applied Mathematics*, 140, pages 521-536, 2002.

-Numerical Recipes. The Art of Scientific Computing, 3rd Edition, 2007.

1.11 Preferences

Purpose

This panel enables to specify the "Name" of the default processing parameters, which are used to run various functions available under all SARscape modules. The various settings are stored in the ENVI "File>Preferences>Directories>Temporary Directory".

It must be noted that the Preferences setting may vary depending on the input data characteristics and they can be modified on the basis of user-specific needs. SARscape provides a few general settings, which are suggested in order to either optimize the processing of any supported products and sensors or to cope with specific data set conditions. However additional user defined Preferences settings can be saved and used in alternative to the standard ones.

Technical Note

Eight different settings are suggested as possible alternative default processing values:

- **General**
  This setting is not specifically tuned for an input data type. It corresponds to the unique default setting, which was provided in SARscape versions older than the 4.2.

- **VHR (better than 10m)**
  This setting is suitable for very high resolution data (pixel size in the order of the meter).

- **HR (between 10m and 30 m)**
  This setting is suitable for high resolution data (pixel size in the order of the tens of meters).

- **MR (coarser than 30m)**
  This setting is suitable for medium resolution data (in the order of several tens or a hundred of meters).

- **Interferometry-LowCoherence**
  This setting is suitable for Interferometric data pairs where the coherence is low or the presence of features, which are useful for the cross-correlation based coregistration, is limited.

- **WrongOrbitalData**
  This setting is suitable for Interferometric data sets, or multitemporal amplitude series to coregister, where the orbital parameters are not reliable.

- **TSX1_TDX1_TANDEM**
  This setting is suitable for Interferometric data pairs, which are made of a TerraSAR-X + Tandem-X acquisition in bistatic mode.

- **ERS-ASAR_interferometry**
  This setting is suitable for Interferometric data pairs, which are made of an ERS and an ASAR.

Section Content

General Functions

Select
The selected default processing parameters are loaded.

Cancel
The window will be closed.

Help
Specific help document section.

1.11.1 Directories and batch file name

Purpose

This panel enables to set the location of some directories, which are used for storing or retrieving files during the data processing.

Technical Note

Working Directory

Three possible cases, where it makes sense to change the default working directory, are foreseen:

1. When the software is operated by users without administration privileges (in this case the working directory must be located in a folder with "writing" privileges).
2. To avoid overwriting processing related data, when more users operate SARscape on the same computer.
3. When more processing steps have to be executed in parallel on the same computer.

It is possible to remove the files 802 stored within this folder.

DORIS Directory

The DORIS (Doppler Orbitography and Radiopositioning Integrated by Satellite) precise orbits can be used as input - in some cases they are mandatory (e.g. data focusing) - for processing ENVISAT ASAR data. If the relevant DORIS files are already stored in the computer, they will be automatically retrieved by the program. For this purpose the DORIS files must be available in one of the following two folders within the DORIS directory:

- **VOR** for verified orbits. These are the most precise ones, but they are made available not earlier than one month after the actual satellite acquisition.
- **POR** for precise orbits. These are slightly less precise than the verified ones, but they are made available on the ASAR acquisition date.

The path provided as "DORIS Directory" must correspond to the folder which contains both the "VOR" and "POR" directories.

PRC/PRL Directory

The PRC or PRL precise orbits can be used as input - in some cases they are mandatory (e.g. data focusing in ENVISAT format) - for processing ERS-1 and ERS-2 data. If the relevant orbit files are already stored in the computer, they will be automatically retrieved by the program. For this purpose the orbit files must be available in one of the following two folders within the "PRC/PRL directory":

- **ERS1** for ERS-1 data.
- **ERS2** for ERS-2 data.

The path provided as "DORIS Directory" must correspond to the folder which contains both the "ERS1" and "ERS2" directories.

Batch file name

In order to avoid the accidental removal 802 of previously saved batch file/s, it is suggested to set this folder using a path which is not the same as the one selected for the "Working Directory".

Parameters - Directories and batch file name

Working Directory

Various processing files (e.g. Process.log 825 and Process.trace 826 files) are saved in the working directory. The original default setting is "SARMAP SA\SARscape x.x.xxx\work"; any other specific location can be set.

SRTM Directory

It is possible to set a specific folder where the SRTM-3 Digital Elevation Model tiles (compressed files), which are downloaded from the internet, are stored. The original default setting is "SARMAP SA \SARscape x.x.xxx\work\SRTM_DEM_DIR".

GTOPO30 Directory

It is possible to set a specific folder where the GTOPO30 Digital Elevation Model tiles (compressed files), which are downloaded from the internet, are stored. The original default setting is "SARMAP SA \SARscape x.x.xxx\work\GTOPO30_DEM_DIR".

ACE Directory

It is possible to set a specific folder where the ACE Digital Elevation Model tiles (compressed files), which are downloaded from the internet, are stored. The original default setting is "SARMAP SA\SARscape x.x.xxx\work\ACE_DEM_DIR".

DORIS Directory

A specific folder is set, where the program look for the required DORIS file.

PRC/PRL Directory

A specific folder is set, where the program look for the required ERS precise orbit files.

RADARSAT-2 Directory

A specific folder is set, where the program look for the required RADARSAT-2 precise orbit files (.orb).

Batch file name

A specific folder is set, where the program stores and retrieves 802 the batch processing list.

.

General Functions

Store

The parameters are stored in the current Preferences.

Restore

The original default parameters are restored.

Save
The current parameters are saved with a user defined name.

Load
A previously exported ("Export" function) default setting can be loaded to replace the actual one.

Export
The current values are saved in a .txt file, which can be loaded ("Load" function) and used afterwards.

Remove
The user is prompted to enter the name of an existing default setting, which will be removed from the list.

Cancel
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

1.11.2 General

Purpose

This panel enables to modify some general processing parameters.

Technical Note

Smoothing Factor
The ENVI image window provides functionalities (Tools>Profiles) to generate X and Y profiles of a loaded image. Two additional options have been added, which allow to smooth the data in both direction (X and Y) before plotting them. Profiles can be plotted in either linear (Plot Function>Smooth) or logarithmic (Plot Function>Smooth dB) scale. <u>This functionality can be exploited only using ENVI Classic</u>.

Doppler Polynomial
The original doppler polynomial is converted into the SARscape standard. The doppler variations are mostly in range direction, but in some cases (e.g. spotlight or topsar acquisition modes) the doppler

varies notably also in azimuth direction. For this reason the image is divided into stripes, whose number in azimuth direction is defined by the "Azimuth Poly Number" parameter; a new doppler polynomial is estimated for each strip. The doppler variation, from one to the next strip, is defined by the "Azimuth Doppler Dependency".

Parameters - General Parameters

General Platform Type
The GPU parallel compute platform (CUDA/OpenCL).

General Device Type
The GPU compute device identification.

SARscape Trace Level
The parameter controls the extent of the information written into the SARscape trace file. A low number allows more information to be written, a higher the opposite.

Byte Order for Import
By setting the relevant flag the data are imported or transformed using the specified byte order.

MSBF
The output byte order is Motorola (or Big Endian) binary type.

LSBF
The output byte order is Intel (or Little Endian) binary type.

Delete Temporary Files
By setting this flag the temporary files are removed at the process completion.

Generate Tiff
By setting this flag the output file is generated also in Tiff format. Tiff files are intended essentially for visualisation purposes. Tiff files are not generated in case of newly imported data. The extension "_ql" is automatically added to the output file name.

Saturation Default
The default saturation value for the TIFF format.

Automatic Look Computation
The number of looks will be computed automatically.

Dummy Removal
By setting this flag the output geocoded files, generated in the Geocoding and Radiometric Calibration 142, Phase to Displacement Conversion (Interferometry 320 and ScanSAR Interferometry 582 modules) and Phase to Height Conversion (Interferometry 314 and ScanSAR Interferometry 578 modules), will be automatically resized in order to remove the dummy area exceeding the frame border.

Generate Multilook

This option generates a multilooked image specifically tuned for getting a square pixel using SAR-Lupe data. The multilooked file is generated as output of the data import 66.

Y Profile Smoothing Factor

The smoothing factor is specified as number of rows.

X Profile Smoothing Factor

The smoothing factor is specified as number of columns.

Doppler Polynomial

In the formulas below R and A are the pixel position respectively in range and in azimuth direction.

Doppler RG Poly Degree

Polynomial degree in range direction.

$$doppler = K_1 + K_2R + K_3R^2 + K_4R^3$$

Doppler AZ Poly Degree

Polynomial degree in azimuth direction.

$$doppler = K_1 + K_2A + K_3A^2 + K_4A^3$$

Doppler AZ Poly Number

Number of stripes in azimuth direction.

Multilooking

Azimuth looks

Number of looks in azimuth direction.

Range looks

Number of looks in range direction.

Block Size

In order to speed up the processing of large files, the data are divided in blocks whose dimension is specified here in pixels. Depending on the specific resolution of the system, this parameter should be set in order not to exceed 1.5 Gigabytes of memory allocation. The default setting is suitable for sensors such as ERS and ENVISAT ASAR. In order to check what is the maximum value to set, the following formula can be adopted:

Block Size = 1.5/2*4*Number of Columns

Block Overlap

The number of overlapping pixels between adjacent blocks is specified.

Scene Limit Increment
In order to avoid the possibility to cut out some image portions during processes where a rotation (such as the geocoding process) is involved, an additional area - to add on each of the four image sides - is specified in metres. Values different from zero must be entered.

Cartographic Grid Size
The default output grid spacing, which is used when the geocoding/transformation onto a cartographic reference system is carried out (e.g. geocoding, Digital Elevation Model generation, etc.); the default unit of measure is meters. The same grid size in Easting and Northing direction must be entered; however different Easting and Northing grid sizes can be specified in the specific processing panels.
Note that - for the Geographic projection - if values higher than 0.2 are entered they will be considered as metric units and then automatically, and roughly, converted from meters to degrees; if values lower than 0.2 are entered they will be considered as degree and used as such without any conversion.

Mean Window Size
The window for the mean filtering is specified.

Interpolation Window Size
The window for the interpolation of dummy (i.e. Not a Number) values is specified.

Orbit Interpolation
It represents the multiplying factor, which is used to calculate the orbit position by means of the point distribution in azimuth direction. The higher the value the longer the processing time.

Resampling Method
By setting the relevant flag, the interpolation method - which is used during processes where pixel geometric transformations occur (e.g. under/over sampling, file transformation, etc.) - is specified.

Nearest Neighbour

Bilinear Interpolation

3rd Order Cubic Convolution

4th Order Cubic Convolution

General Functions

Store
The parameters are stored in the current Preferences.

Restore

The original default parameters are restored.

Save
The current parameters are saved with a user defined name.

Load
A previously exported ("Export" function) default setting can be loaded to replace the actual one.

Export
The current values are saved in a .txt file, which can be loaded ("Load" function) and used afterwards.

Remove
The user is prompted to enter the name of an existing default setting, which will be removed from the list.

Cancel
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

1.11.3 Mosaic and Filtering

Purpose

This panel enables to set the default processing parameters, which are used in the Filtering and Mosaicing functions.

Technical Note

The setting of these processing defaults is relevant to the Conventional Mosaic>Last Overlay 712, Gradient Mosaic 714 and to the Anisotropic Non-Linear Diffusion Filtering (Single image 127 and Multi-temporal 135).

Parameters - Mosaic and Filtering

Conventional Mosaic

Histogram Scaling Min Value
The image histogram matching is performed using only those pixel whose value (expressed in linear scale) is equal or higher than this threshold.

Histogram Scaling Max Value
The image histogram matching is performed using only those pixel whose value (expressed in linear scale) is equal or lower than this threshold.

Histogram Scaling
By setting this flag, the "Last Overlay" mosaic is performed after an image histogram matching aimed at reducing as much as possible average value differences in the overlapping areas.

Gradient Mosaic

Gradient Mosaic Window Size
The window for the calculation of the ratio between standard deviation and mean. This value is used for the edge identification: the larger the window the better the edge detection. Evident edges are detected by large windows.

Gradient Mosaic Edge Threshold
This value can vary from 0 to 1. In case only sharp/evident edges have to be identified a value close to 1 must be used.

Gradient Mosaic Absolute Calibration
The number of points, which are identified on each of the image overlapping areas, can be specified. The calibration polynomia are calculated in order to calibrate the radiometric value in the whole image (all input data). The larger this value the more precise the calibration, the longer the processing time.

Gradient Mosaic Local Calibration
The number of points, which are identified on each of the image overlapping areas, can be specified. This calibration is used for correcting the radiometric value in the overlapping area. The larger this value the more precise the calibration, the longer the processing time.

Anisotropic Non-Linear Diffusion

ANLD Gaussian Blur Kernel Variance
This parameter describes the size and amount of Gaussian applied to the image before performing the diffusion. Increasing the size of the kernel will lead to strongly smoothed image but also to the loss of image small details.

ANLD Window Size
The algorithm performs an adaptive threshold selection across the image in order to retrieve the

adequate gradient values for preserving the edges. This is done by dividing the image in square windows where an individual threshold value is computed. Small windows will better keep fine details, while big windows will smooth more preserving only the most evident structures.

ANLD Step Size
This parameter is a positive integer that can be used to reshape the gradient sensitivity function of the diffusion. Low values of this parameters produce smooth curves (isotropic diffusion decreases slowly around edges) whereas high values lead to sharper curves (isotropic diffusion decreases quickly around edges).

ANLD Anisotropy
This value can vary from 0 to 1. It tunes the amount of filter diffusion along the edges. Higher values increase the filtered edges sharpness, but possibly introduce edge deformations. Changing this parameter has an effect only whether some Anisotropic iterations are specified.

ANLD Threshold Recomputation
Among the algorithm steps, the most time consuming is certainly the threshold estimation. This parameter adds the possibility to recompute the threshold for the number of iterations specified by the user. Setting it to values higher than 1 can considerably decrease the image processing time (especially when inputting large images) since the threshold are recomputed less times.

ANLD Global Iterations
It determines the number of processing iterations (both non-linear and anisotropic diffusion steps).

ANLD Non-Linear Iterations
It determines the number of non-linear diffusion iterations. This part of the algorithm leaves the high gradient zones unfiltered. Therefore, it preserves the maximum of details while smoothing homogenous areas. It must be noted that, to have an evident effect in terms of filtering variation, the iterations number has to be modified with steps of 5.

ANLD Anisotropic Iterations
It determines the number of nonlinear diffusion iterations. This part of the algorithm smoothes the high gradient zones, improving the image edge appearance. It must be noted that, to have an evident effect in terms of filtering variation, the iterations number has to be modified with steps of 5.

General Functions

Store
The parameters are stored in the current Preferences.

Restore
The original default parameters are restored.

Save

The current parameters are saved with a user defined name.

Load
A previously exported ("Export" function) default setting can be loaded to replace the actual one.

Export
The current values are saved in a .txt file, which can be loaded ("Load" function) and used afterwards.

Remove
The user is prompted to enter the name of an existing default setting, which will be removed from the list.

Cancel
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

1.11.4 Geocoding

Purpose

This panel enables to set the default processing parameters, which are used in those functions where the multilooking or the geocoding processes are executed.

Technical Note

Radiometric Calibration ("True Area" approach)
In order to precisely estimate the scattering area, the input DEM is oversampled; the amount of DEM pixels falling in the original SAR geometry within the corresponding cell, determines the scattering area. The "Oversampling factor" is determined by the DEM grid size and the SAR data pixel sampling. The following settings are suggested (any other integer value can be however specified):

- **Factor 4**
  The original DEM cell is oversampled to 1/4 of the SAR pixel sample.

- **Factor 5**
  The original DEM cell is oversampled to 1/5 of the SAR pixel sample.

- **Factor 6**
  The original DEM cell is oversampled to 1/6 of the SAR pixel sample.

- **Factor 8**
  The original DEM cell is oversampled to 1/8 of the SAR pixel sample.

- **Factor 10**
  The original DEM cell is oversampled to 1/10 of the SAR pixel sample.

As a rule of thumb it must be noted that the larger the oversampling factor the better the scattering area is estimated and the longer is the processing time. Of course it make sense to set the "Oversampling factor" in relationship with the DEM resolution, which practically means that the scattering area estimate will not improve by increasing the "Oversampling factor" whether the input DEM has a resolution coarser than the SAR image.

Radiometric Normalization ("Semi-empirical correction" approach)
The backscatter dependency from the range position and from the topography is estimated by computing a linear regression between the cosine of the local incidence angle and the backscattering coefficient in logarithmic form. In order to compute the regression, a certain number of pixel samples are collected; the amount of samples can be defined on the basis of the following criteria:

- **Minimum value in dB**
  Only pixels with backscatter coefficient above this threshold are considered.

- **Maximum value in dB**
  Only pixels with backscatter coefficient below this threshold are considered.

- **Azimuth Sampling Factor**
  It defines the sampling frequency (in pixels) in azimuth direction.

- **Range Sampling Factor**
  It defines the sampling frequency (in pixels) in range direction.

Parameters - Geocoding

Radiometric Calibration
By setting this flag the calibration is executed. This flag must be checked also when the "Normalized Radiometric Calibration" is selected.

Radiometric Normalization

By setting this flag the backscatter coefficient is normalized for variations related to the position in range direction and the topography.

Keep DEM Dimension
By setting this flag the areal extent of the output file, which is generated in the geocoding 142 process, will have the same dimension of the input Digital Elevation Model.

Normalization Method
The normatization process can be executed by following two different approaches (refer to the relevant reference guide 142 for details) :

- Cosine correction - a correction factor is applied to compensate only for range variations.

- Semi-empirical correction - a correction factor is applied to compensate for both range and topographic variations.

Scattering Area Method
The radiometric calibration process can be executed by following two different approaches:

- Local incidence angle - this is the fastest approach in terms of processing time, but it is not the most accurate way to calibrate the data in presence of topography.

- True area - it requires more computing resources, but it is the most accurate approach to calibrate the data in presence of topography. It makes sense to apply this method when a good (in terms of quality and spatial resolution) Digital Elevation Model is available.

Max Calibrated Value
The maximum admitted value for calibrated data can be set. Values higher than this threshold, which can eventually be reported on calibrated data for strong local scatterers, are automatically transformed into the specified "Max Calibrated Value". In case any output calibrated value is admitted, this threshold must be set lower than 1.

Minimum value dB
The minimum acceptable value for the sample collection is specified. This parameter is used only for the "Semi-empirical correction" approach.

Maximum value dB
The maximum acceptable value for the sample collection is specified. This parameter is used only for the "Semi-empirical correction" approach.

Azimuth Sampling factor
The sampling frequency (in pixels) in azimuth direction is specified. This parameter is used only for the "Semi-empirical correction" approach.

Range Sampling factor

The sampling frequency (in pixels) in range direction is specified. This parameter is used only for the "Semi-empirical correction" approach.

Oversampling Factor
Defines how many times the original DEM cell is oversampled (refer to the Technical Note).

Normalization Factor
This value should be increased proportionally to the difference between the near and the far range Incidence Angle. The default setting (i.e. 2) is valid for ERS-like acquisition geometries.

Normalization Angle
If it is set to negative values, the Incidence Angle in the scene center is used. Any other positive value can be specified.

Local Incidence Angle
By setting this flag the map of the local incidence angle – in degree – is generated.

Layover/Shadow Map
By setting this flag a layover and shadow map is generated.

Resampling Method
By setting the relevant flag, the interpolation method is specified.

Nearest Neighbour

Bilinear Interpolation

3rd Order Cubic Convolution

4th Order Cubic Convolution
Optimal Resolution

Calibration Unit Sigma Nought
It is the backscattering coefficient; the value in dB is usually adopted as conventional measure of the strength of radar signals reflected by a distributed scatterer. The Sigma Nought corresponds to the Beta Nought normalized with the scattering area (i.e. sine of the incidence angle).
In SARscape it is typically presented in linear units; the corresponding value in dB can be calculeted as: $10*\log_{10}$ (calibrated pixel linear value). It is a normalized dimensionless number, which compares the strength observed to that expected from an area of one square meter. It is defined with respect to the nominally horizontal plane, and in general has a significant variation with incidence angle, wavelength, and polarization, as well as with properties of the scattering surface itself.

Calibration Unit Gamma Nought
It is the backscattering coefficient normalised (i.e. divided by) with the cosine of the incidence angle.

Calibration Unit Beta Nought
It is the radar brightness (or reflectivity) coefficient. This reflectivity per unit area - in slant range - depends on the system calibration only and it is dimensionless. This value is independent from the local incidence angle; it is obtained by applying the radar equation without considering the scattering area.

General Functions

Store
The parameters are stored in the current Preferences.

Restore
The original default parameters are restored.

Save
The current parameters are saved with a user defined name.

Load
A previously exported ("Export" function) default setting can be loaded to replace the actual one.

Export
The current values are saved in a .txt file, which can be loaded ("Load" function) and used afterwards.

Remove
The user is prompted to enter the name of an existing default setting, which will be removed from the list.

Cancel
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

1.11.5 Coregistration

Purpose

This panel enables to set the default processing parameters, which are used in those functions where the coregistration process is executed.

Technical Note

The coregistration consists of spatially register two or more images with sub-pixel accuracy. In case of SAR Intensity products this process is initialised using the satellite orbital parameters and then optimized by means of a cross-correlation based function. In case of Single Look Complex data the coregistration shift estimate is further refined ($1/100_{th}$ of pixel accuracy) by automatically selecting a series of image "chips" throughout the image, where "mini-interferograms" are calculated.

The cross-correlation process is based on the following consecutive steps:

- A first shift estimate is performed by using a large "central window". This is performed only if the orbit based initialisation fails or it is not selected.
- The shift estimate is improved (sub-pixel accuracy) by using a grid of "small windows".
- The final shift is further refined ($1/10_{th}$ of pixel accuracy) by using over sampled data.

Orbit Accuracy
This setting enables to check the accuracy of the coregistration polynomial, which is only based on the orbital parameters. If this check evidences orbital errors, then the first shift estimate is performed by means of the cross-correlation on a large "central window" and the orbit based initialisation is automatically disabled.

Window Size
In case of small data sets (i.e. few hundred pixels in range and azimuth direction), the default window size must be reduced accordingly.

Reject Threshold
The shift polynomial, which is based on the interferometric coherence, is compared with the cross correlation shift polynomial (refer to the "Cross-correlation Grid" mentioned below). If the standard deviation or the root mean square error results higher that this threshold, the coherence based shift is discarded and the cross correlation shift (refer to the "Fine Shift Parameters" mentioned below) is adopted.

Parameters - Coregistration

Number Coefficient Range
The number of coefficients (from 1 to 6) used for the coregistration polynomial, in range direction, is set. It makes sense to have this value set to 4 especially in case of squinted geometry or using large baseline. It is suggested to use values lower or equal to 3 in case of small data subsets (1000 pixels or less in range direction).

$$\Delta range = K_1 + K_2X + K_3Y + K_4X^2 + K_5Y^2 + K_6XY$$

Number Coefficient Azimuth

The number of coefficients (from 1 to 6) used for the coregistration polynomial, in azimuth direction, is set. It makes sense to have this value set to 4 especially in case of squinted geometry or using large baseline. It is suggested to use values lower or equal to 3 in case of small data subsets (1000 pixels or less in azimuth direction).

$$\Delta azimuth = K_1 + K_2X + K_3Y + K_4X^2 + K_5Y^2 + K_6XY$$

Number Residual Coefficient Range

The number of coefficients (from 1 to 5) used for the residual coregistration polynomial (i.e. after the shift estimated from the Digital Elevation Model), in range direction, is set.

$$\Delta range = K_1 + K_2X + K_3Y + K_4X^2 + K_5Y^2$$

Number Residual Coefficient Azimuth

The number of coefficients (from 1 to 5) used for the residual coregistration polynomial (i.e. after the shift estimated from the Digital Elevation Model), in azimuth direction, is set.

$$\Delta azimuth = K_1 + K_2X + K_3Y + K_4X^2 + K_5Y^2$$

Border Distance Range

Pixel co-ordinate, in range direction, corresponding to the upper left corner of the grid of windows used for the fine coregistration (cross-correlation and coherence based) process.

Border Distance Azimuth

Pixel co-ordinate, in azimuth direction, corresponding to the upper left corner of the grid of windows used for the fine coregistration (cross-correlation and coherence based) process.

Range Window Number

Number of windows, in range direction, which are used for the cross-correlation process.

Azimuth Window Number

Number of windows, in azimuth direction, which are used for the cross-correlation process.

Skip Coregistration

By setting this flag the input data are not coregistered. This option is considered only for Tandem-X 70 data.

Initialization from Orbits

By setting this flag the orbital parameters (and the Digital Elevation Model if this is provided as input) are used for a preliminary shift estimate. This flag must be checked when the coregistration process is performed using the input DEM.

Initialization from Amplitude

By setting this flag the shift estimate, which has been initialized from the orbits (if the relevant flag has been checked), is improved by using a cross-correlation approach on the master/slave(s) Intensity images.

Initialization from Coherence

By setting this flag the shift estimate, which has been computed from the orbits and/or the amplitude data (if one or both the relevant flags have been checked), is improved by means of the interferometric coherence. Note that this option is possible only when Single Look Complex data are inputted.

Activate Test on Orbit

By setting this flag a crosscheck between the orbital polynomial shift and the cross correlation value is performed.

Orbit Interpolation

It represents the multiplying factor, which is used to calculate the orbit position at sub pixel level in azimuth direction. The higher the value the longer the processing time and the accuracy. Values higher then 10 are typically not required.

Cross-correlation Central Window

Initial Range Window Size

Range dimension, in pixels, of the large "central window".

Initial Azimuth Window Size

Azimuth dimension, in pixels, of the large "central window".

Initial Range Position

Pixel co-ordinate, in range direction, corresponding to the center of the large "central window". The default setting (i.e. -1) locates it in the image center.

Initial Azimuth Position

Pixel co-ordinate, in azimuth direction, corresponding to the center of the large "central window". The default setting (i.e. -1) locates it in the image center.

Cross-correlation Grid

Range Window Size

Range dimension, in pixels, of the "small windows".

Azimuth Window Size

Azimuth dimension, in pixels, of the "small windows".

Cross Correlation Threshold

If the correlation value is below this threshold, then the window is not used for the shift estimate.

Fine Shift Parameters

Oversampling Fine
In case the fine shift estimate, which is based on the coherence (mini-interferograms), fails - or in case of Intensity data - a cross-correlation based function is applied on over sampled data. The higher this value the longer the processing time and the accuracy. Values higher then 16 are typically not required.

Range Window Number Fine
Number of windows, in range direction, where the fine shift is estimated.

Azimuth Window Number Fine
Number of windows, in azimuth direction, where the fine shift is estimated.

Range Window Size Fine
Range dimension, in pixels, of the windows where the fine shift is estimated.

Azimuth Window Size Fine
Azimuth dimension, in pixels, of the windows where the fine shift is estimated.

SNR (Signal to Noise Ratio) Threshold
If the interferometric Signal to Noise value is below this threshold, the window is not used for the coherence based (mini-interferograms) fine shift estimate. The relationship between the Signal to Noise Ratio (SNR) value and the coherence (γ) value is:

$$SNR = \gamma^2/1-\gamma^2$$

Reject Threshold
If the difference between the cross correlation and the coherence based polynomia is higher than this threshold, the coregistration shift is computed on the basis of the cross correlation only (refer to the "Cross Correlation Oversampling" mentioned above).

Oversampling Coherence
In order to retrieve the highest coherence values, an optimal shift is calculated by "moving" the slave data with steps equal to the inverse of this value. The higher the value the longer the processing time and the accuracy. Values higher then 4 are typically not required.

Coregistration With DEM
The input will be coregistered with the provided Digital Elevation Model.

General Functions

Store
The parameters are stored in the current Preferences.

Restore

The original default parameters are restored.

Save
The current parameters are saved with a user defined name.

Load
A previously exported ("Export" function) default setting can be loaded to replace the actual one.

Export
The current values are saved in a .txt file, which can be loaded ("Load" function) and used afterwards.

Remove
The user is prompted to enter the name of an existing default setting, which will be removed from the list.

Cancel
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

1.11.6 Flattening

Parameters - Flattening

Synthetic Phase Generation

Optimal Resolution Approach
By setting this flag the optimal resolution interpolator (see Geocoding 142 step) is used to generate the synthetic phase and related products.

Digital Elevation Model Resampling Factor
To set the pixel sampling of the input reference Digital Elevation Model, for the synthetic phase generation. This factor is considered for the transformation of the DEM from geocoded to slant projection. The default setting (-1) foresee two possible cases:
- Optimal Resolution Approach: a slant range DEM with pixel sampling equal to 2 times the SAR

image ground range resolution is used; in case the DEM original resolution is better than the SAR image ground range resolution, this last one will be used.

- Optimal Resolution Approach not flagged: a slant range DEM with pixel sampling equal to half the SAR image ground range resolution is used; in case the DEM original resolution is better than half the SAR image ground range resolution, the original DEM sampling will be used.

Any value other than the default setting (-1) represents the ratio factor applied to the original DEM sampling in the transformation from geocoded to slant projection. The example below refers to an original 100 m resolution DEM:

✓ 2: Slant range DEM resampled to 50 m resolution
✓ 3: Slant range DEM resampled to about 33 m resolution
✓ 5: Slant range DEM resampled to 20 m resolution

Orbit Interpolation

It represents the multiplying factor, which is used to calculate the orbit position at sub pixel level in azimuth direction. The higher the value the longer the processing time and the accuracy.

Window Size Interpolation

This window dimension is used for the pixel interpolation of the slant range product.

Window Size Mean Filter

This window dimension is used for the mean filtering of the slant range product.

Automatic Slave Orbit Correction

This flag must be set, in those processes where master and slaves SAR images have to be coregistered with respect to a reference DEM (e.g. Coregistration, Interferometric Workflows, etc.), whenever the master image is correct (i.e. the nominally geocoded image fits with the DEM) while the slave image orbits are not accurate (i.e. the nominally geocoded image does not fit with the DEM). By setting this flag the slave orbits are corrected using the master orbits and the coregistration shift.

Remove Residual Phase Frequency

By setting this flag the residual phase frequency is estimated on the wrapped phase (differential interferogram), removed from it and added to the synthetic phase (_sint). The objective is to get rid of those fringes, which remains after the removal of the phase component due to topography (i.e. DEM) and/or flat earth. This function is especially intended for those data which are affected by orbital inaccuracies. It must be noted that the original synthetic (_sint) and differential (_dint) interferograms, which are modified as result of phase removal, are saved with the prefix "original_".

The parameters below are active only when this flag is checked.

Azimuth Window Size

Window Size in azimuth direction – better using power of 2 values – which is used to estimate the local fringe frequency. The window size must be larger than the orbital fringe dimension (in pixels) in order to have an optimal performance. If the window is too big, with respect to the image size, the program will automatically reduce it.

Range Window Size

Window Size in range direction – better using power of 2 values – which is used to estimate the local fringe frequency. The window size must be larger than the orbital fringe dimension (in pixels) in order to have an optimal performance. If the window is too big, with respect to the image size, the program will automatically reduce it.

Azimuth Window Number

Number of windows, in azimuth direction, which are used for the removal process. If set to zero, the polynomial removal is not applied.

Range Window Number

Number of windows, in range direction, which are used for the removal process. If set to zero, the polynomial removal is not applied.

Polynomial Degree

The number of coefficients (from 1 to 10) used for the residual phase removal. It makes sense to have this value set at least to 2, since a dominant dependency in range is expected.

$$\varphi = K_1 + K_2X + K_3Y + K_4X^2 + K_5XY + K_6Y^2 + K_7X^3 + K_8X^2Y + K_9XY^2 + K_{10}Y^3$$

Low Pass Filter (m)

Window size (meters) for the Low Pass atmospheric removal, in range and azimuth direction, which is used for the removal process. If set to zero, the Low Pass removal is not applied. Suggested values are more than 15000 meters, only in case of small spatial size displacement pattern.

Refinement and Re-flattening

Refinement Method

Different ways to perform the phase refinement (both in case of Digital Elevation Model and Displacement Map generation) are possible. One of the following methods can be selected to be used in the "Refinement and Re-flattening" processing step:

- Automatic: by setting this flag the orbit configuration is first estimated on the basis of the input Ground Control Points. If the "A-priori check>Achievable RMS" is larger than the threshold, or the absolute normal baseline is smaller than the "A-priori check>Minimum Baseline", or the "A-posteriori check>Final RMS" is larger than the threshold, or the "A-posteriori check>RMS Ratio" is larger than the threshold, or the number of GCP is lower than 7, than the program automatically switch to the "Residual Phase" method; otherwise the "Orbital" correction method is applied.
- Orbital: by setting this flag the orbital correction parameters are estimated using the Ground Control Points. Selecting this flag both the "A-priori" and the "A-posteriori" checks are disabled, while the only necessary condition for this method to work it is that at least 7 GCPs are available.
- Polynomial Refinement: by setting this flag a phase ramp is estimated from the unwrapped phase without considering the orbit configuration. In this case the minimum number of Ground Control Points has to be equal to the "Residual Phase Poly Degree", otherwise the poly degree is

automatically decreased accordingly.

Residual Phase Poly Degree
Degree of the polynomial used to estimate the phase ramp, which will be removed from the input unwrapped phase during the Re-flattening operation. In case this value is higher that the number of input Ground Control Points, it will be automatically decreased. The default values of 3 means that a phase ramp in range and azimuth direction plus a constant phase offset will be corrected. In case only the phase offset correction is needed, the polynomial degree will be set to 1.

A-priori check (active only when the "Default" refinement method is checked)
- Achievable RMS: the interferometric Signal to Noise value is considered in combination with the baseline value using the following formula:

$$((\gamma^2/1-\gamma^2)/2\pi)H$$

  where γ is the interferometric coherence and H is the height of ambiguity.

  The maximum acceptable height error (GCP average value expressed in meters) must be entered.
- Minimum Baseline: If the baseline absolute value is lower than this threshold the orbital refinement is not carried out.

A-posteriori check (active only when the "Default" refinement method is checked)
- Final RMS: once the orbital configuration has been estimated, the real height error for each GCP can be calculated. The maximum acceptable value must be entered.
- RMS Ratio: the maximum acceptable value of the ratio between "Final RMS" and "Achievable RMS" must be entered.

General Functions

Store
The parameters are stored in the current Preferences.

Restore
The original default parameters are restored.

Save
The current parameters are saved with a user defined name.

Load
A previously exported ("Export" function) default setting can be loaded to replace the actual one.

Export
The current values are saved in a .txt file, which can be loaded ("Load" function) and used afterwards.

Remove
The user is prompted to enter the name of an existing default setting, which will be removed from the

list.

Cancel
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

1.11.7 Interferometry

Purpose

This panel enables to set the default processing parameters, which are used in those functions related only to interferometric (and polarimetric interferometric) processing.

Technical Note

Multilooking
This parameter is normally set with the same values as the Preferences>General 759; however when the baseline conditions - or topographic conditions - are such that the interferometric phase changes very fast and it eventually get lost due to an aliasing problem, a pixel over sample in range direction is required specifically for the interferometric processing. This can be achieved by entering negative multilooking values in Range direction. Actually one of the typical cases is represented by ERS-ASAR interferometric tandem pairs, which are characterized by a very small ambiguity height (hence very dense/frequent interferometric fringes); in this case the Interferometric multilooking factors shall be set to -2 and 3 (respectively in Range and Azimuth).

Here below are mentioned those steps where the "Interferometry>Multilooking" Preferences (instead of those reported in the General 759 Preferences section) are considered for the processing:

- Coherence Generation 163 (Basic module).

- Interferometry Module.
- Interferometric Stacking>SBAS 519

Decomposition Levels

The process is normally executed with the original pixel sampling (i.e. -1) or with the minimum decomposition level (i.e. 1). The use of the decomposition is intended to multilook and undersample the data in an iterative way: the interferogram is unwrapped at the lower resolution and then reconstructed back at the original resolution. The use of the decomposition can be of help to reduce unwrapping errors (e.g. in case of distributed low coherence areas) and it reduces the processing time and it limits the use of computer resources.

The user can specify the number of iterations (i.e. decompositions) to execute; each iteration corresponds to an undersampling factor of 3. We suggest to avoid setting this value higher than 3.

In case of very large displacements or very steep topography (fast phase/dense fringe distribution) the use of the decomposition can cause aliasing effects. In this case the decomposition process should be avoided by setting its value to -1.

Tile Size and Overlap

These parameters, which are used only when the Minimum Cost Flow Unwrapping (with square grid only) is executed, are intended to avoid (or reduce) possible discontinuities in the unwrapped phase. These discontinuities are most probable to occur when the displacement fringe patterns are bigger (in azimuth and/or range direction) than the "Tile Size" entered here; in such case the increase of either the "Tile Size" or the "Overlap" can solve the problem. It must be noted that the processing time exponentially increases by increasing these processing parameters.

It is important to outline that:

- If the phase image to unwrap is smaller than 4000000 $pixel^2$ (e.g. 2000 X 2000 pixels) the program will not split it in tiles and the whole scene will be processed as a single block.
- Tile areas larger than 4000000 $pixel^2$ should not be used in order to avoid program failures.

Minimum Cost Coherence

This parameter is used only when the Minimum Cost Flow Unwrapping (with or without Delaunay grid) is executed. This unwrapping algorithm uses a "cost-based" system, which depends on the coherence values, to decide where it is better to locate possible phase jumps (related for instance to phase errors or aliasing problems).

This threshold it is intended to define the minimum coherence value, which is considered for the cost estimate; below this threshold a fixed cost is adopted.

.

Parameters - Interferometry

Spectral Shift Filter

The spectra of master and slave acquisitions are not completely overlapping unless the pair is acquired with zero baseline; the filter is intended to remove the part of the master and slave spectra, which are not overlapping. In case the DEM is inputted in the Interferogram Generation 293 step, the spectral filter is

adapted to the topographic local variations.
This option should always be activated. By unsetting this flag the interferogram is generated without spectral shift filter.

Doppler Filter
This option enables to remove the portion of the azimuth spectra, which are not common between master and slave image. This is especially useful when the data pair is characterized by a large doppler centroid difference.

Coherence Thresholds

Phase Unwrapping
Pixels with coherence values smaller than this threshold are not unwrapped.

Product Generation
Pixels with coherence values smaller than this threshold will be set to dummy (NaN) in the generation of the following products:

- Digital Elevation Model (ScanSAR 578 and StripMap 314).
- Displacement Map (ScanSAR 582 and StripMap 320).
- Dual Pair Differential Interferometry 325 (final products).

Unwrapping

Decomposition Levels
The number of multilooking and undersampling iterations can be specified (refer to the Technical Note).

Tile Size in Range
Dimension of the tiles in range direction, which are processed as separate blocks when the Minimum Cost Flow Unwrapping is executed.

Tile Size in Azimuth
Dimension of the tiles in azimuth direction, which are processed as separate blocks when the Minimum Cost Flow Unwrapping is executed.

Range Overlap
Number of pixels, which are overlapping with the adjacent tile in range direction.

Azimuth Overlap
Number of pixels, which are overlapping with the adjacent tile in azimuth direction.

Minimum Cost Coherence
Coherence threshold below which a fixed cost is adopted. Reducing this threshold, the phase errors are more easily propagated to reliable phase zones. When this value is set to -1 (default setting), the "Unwrapping Coherence Threshold" specified in the relevant unwrapping processing panel (i.e.

ScanSAR 570 or StripMap 305) is adopted also as "Minimum Cost Coherence".

Unwrapping 3D
These parameters are considered only in the SBAS unwrapping process 519.

Height - Number of Samples
It corresponds to the number of samples, which is used to estimate the residual height variation. The higher the value the more precise the result, but the processing time increase exponentially.

Max Residual Height Variation
It corresponds to the maximum residual height difference (in meters) between two spatially linked pixel (2D Delaunay network). This parameter can be increased when the topographic residuals have a strong spatial variation.

Displacement - Number of Samples
It corresponds to the number of samples, which is used to estimate the displacement velocity variation. The higher the value the more precise the result, but the processing time increase exponentially.

Max Displacement Velocity Variation
It corresponds to the maximum displacement velocity difference (in mm/year) between two spatially linked pixel (2D Delaunay network). This parameter is considered only in the SBAS unwrapping process. This parameter can be increased when the displacement has a strong spatial variation.

Min Valid Pairs Percentage
It corresponds to the minimum percentage of valid pairs to perform the 3D unwrapping process (3D Delaunay network). Increasing this percentage the extent of the unwrapped area will shrank.

Multilooking

Range looks
Number of looks in range direction.

Azimuth looks
Number of looks in azimuth direction.

Interferogram Generation

Block Size
In order to speed up the processing of large files, the data are divided in blocks whose dimension is specified here in pixels. It is advised to increase this value up to 4000 in case the processing is executed on machines with large RAM (1 Gbytes or higher).

Block Overlap
The number of overlapping pixels between adjacent blocks is specified.

General Functions

Store
The parameters are stored in the current Preferences.

Restore
The original default parameters are restored.

Save
The current parameters are saved with a user defined name.

Load
A previously exported ("Export" function) default setting can be loaded to replace the actual one.

Export
The current values are saved in a .txt file, which can be loaded ("Load" function) and used afterwards.

Remove
The user is prompted to enter the name of an existing default setting, which will be removed from the list.

Cancel
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

1.11.8 Adaptive Filter

Purpose

This panel enables to set the default processing parameters, which are used in those functions related to the generation of interferometric products.

Technical Note

None.

Input Parameter(s)

Filtering Method
This option enables to specify the Interferogram filtering method (i.e. Adaptive, Boxcar or Goldstein), which is used as default.

Coherence from Fint
By setting this flag the coherence image will be generated from the filtered interferogram (_fint); otherwise the unfiltered interferogram (_dint) will be adopted.

Goldstein Coherence Range Window Size
Size (in range direction) of the moving window – in pixel odd number – for the coherence estimation. The default value can be increased working with lower resolution products (i.e. ScanSAR data).

Goldstein Coherence Azimuth Window Size
Size (in azimuth direction) of the moving window – in pixel odd number – for the coherence estimation. The default value can be increased working with lower resolution products (i.e. ScanSAR data).

Goldstein Coherence Removal Local Frequency Range Box Size
Size (in range direction) of the moving window – in pixel odd number – for the calculation of the local residual phase which is removed before the coherence estimation. The default value can be increased working with lower resolution products (i.e. ScanSAR data). It is mandatory that this value is higher than the "Coherence Range Window Size". By setting this value to 0, the residual phase removal is not performed for the coherence estimation.

Goldstein Coherence Removal Local Frequency Azimuth Box Size
Size (in azimuth direction) of the moving window – in pixel odd number – for the calculation of the local residual phase which is removed before the coherence estimation. The default value can be increased working with lower resolution products (i.e. ScanSAR data). It is mandatory that this value is higher than the "Coherence Azimuth Window Size". By setting this value to 0, the residual phase removal is not performed for the coherence estimation.

Goldstein Interferogram Window Size
Size of the moving window – better using power of 2 values – for the interferogram filtering. The bigger this window the lower is the filter sensitivity to small details (i.e. local fringe patterns). This value should be set between 32 (light filtering) and 512 (strong filtering).

Goldstein Window Overlap Percentage
A strong filter setting can introduce border line artifacts in the filtering window. These effects can be

minimised/removed by increasing the window overlap percentage. The bigger this value the longer the processing time.

Goldstein Smooth Window Size

The power spectrum in convolved with a rectangular smoothing window, whose size can be specified in pixel odd number. The smaller this window the lower is the filter sensitivity to small details (i.e. local fringe patterns). This value should be set between 3 (strong filtering) and 11 (light filtering).

Goldstein Low Pass Percentage

This additional filter can be carried out in order to remove the phase noise (high frequency noise). This filter must be used carefully as it can remove also real phase information. The bigger the percentage the larger the frequency band, which is removed. If this value is set to 0 the low pass filter is not executed.

Goldstein Minimum/Maximum Alpha

It is the exponent applied to the power spectrum of the data. This is the most important parameter to tune the filter strength. In particular the "Alpha Min Value" is applied where the coherence is 1, while the "Alpha Max Value" is applied where the coherence is 0; in between them Alpha varies linearly from its minimum to its maximum value. The higher is Alpha (both Min and Max) the stronger is the filter smoothing.
The "Alpha Max Value" should vary between 0.5 (light filtering) and 4 (strong filtering); the "Alpha Min Value" should vary between 0.3 (light filtering) and 3 (strong filtering). When changing one of these two parameters, the other must be linearly modified.

Boxcar Width

Size of the moving window – better using power of 2 values – for the interferogram adaptive filtering.

Boxcar SNR (Signal to Noise Ratio)

Minimum value of the Signal-to-Noise Ratio to carry out the interferogram filtering.

$$SNR = \gamma^2/1-\gamma^2$$

Boxcar Coherence Range Box Size

Size (in range direction) of the moving window – in pixel odd number – for the coherence estimation. The default value can be increased working with lower resolution products (i.e. ScanSAR data).

Boxcar Coherence Azimuth Box Size

Size (in azimuth direction) of the moving window – in pixel odd number – for the coherence estimation. The default value can be increased working with lower resolution products (i.e. ScanSAR data).

Boxcar Coherence Removal Local Frequency Range Box Size

Size (in range direction) of the moving window – in pixel odd number – for the calculation of the local residual phase which is removed before the coherence estimation. The default value can be increased working with lower resolution products (i.e. ScanSAR data). It is mandatory that this value is higher than the "Coherence Range Window Size". By setting this value to 0, the residual phase removal is not performed for the coherence estimation.

Boxcar Coherence Removal Local Frequency Azimuth Box Size
Size (in azimuth direction) of the moving window – in pixel odd number – for the calculation of the local residual phase which is removed before the coherence estimation. The default value can be increased working with lower resolution products (i.e. ScanSAR data). It is mandatory that this value is higher than the "Coherence Azimuth Window Size". By setting this value to 0, the residual phase removal is not performed for the coherence estimation.

Adaptive Coherence Max Range Size
Maximum size (in range direction) of the moving window used for the interferogram filtering and coherence estimation.

Adaptive Coherence Max Azimuth Size
Minimum size (in range direction) of the moving window used for the interferogram filtering and coherence estimation.

Adaptive Mean Factor
Mean Intensity difference among the pixels within an area to be considered stationary. This value is used for optimising the interferogram filter.

General Functions

Store
The parameters are stored in the current Preferences.

Restore
The original default parameters are restored.

Save
The current parameters are saved with a user defined name.

Load
A previously exported ("Export" function) default setting can be loaded to replace the actual one.

Export
The current values are saved in a .txt file, which can be loaded ("Load" function) and used afterwards.

Remove
The user is prompted to enter the name of an existing default setting, which will be removed from the list.

Cancel
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

1.11.9 Persistent Scatterers

Purpose

This panel enables to set the default processing parameters, which are used in the Interferometric Stacking module and, in particular, within the Persistent Scatterers functionalities.

Technical Note

Multilooking
There are two different settings for the multilooking process:

- **Multilooking Factor**
  These correspond to the factors used in between the coregistration and the generation of the interferograms. The negative "Range Looks" is because the program oversamples the input with the specified factor; the default value is mostly intended to cope with large baseline pairs.

- **Multilooking Differential Interferograms**
  These correspond to the factors used for the generation of the differential interferograms (_dint). The values entered here are typically set to obtain approximately square pixels starting from the original single look geometry.

PS Density
Typcal values, for systems like ERS, ENVISAT and RADARSAT-1, are 200 PS/sqkm in urban areas and 20 PS/sqkm in rural areas.

GCP Average Distance
The correction parameters are weighted on the basis of: i) the distance from the GCP; ii) the coherence value. The window size, which is set here in meters, has to be defined by considering the pixel sampling (ground range projected) of the input data.

Atmospheric Pattern Estimate
These parameters are used to estimate - and remove before the displacement velocities are calculated -

atmospheric induced phase variations. It is done by specifying the expected scale and temporal frequency of atmospheric variation. Spatial variation in the same acquisitions are typically slow and thus a low pass filter is adopted; vice versa the changes over the time (from one to another acquisition) are much stronger and thus a high pass filter is adopted.

– **Atmosphere Low Pass**, this accounts for the spatial distribution of the atmospheric variations. It is implemented by using a square window: large windows are more suitable to correct large scale variations, while small windows are better to correct isolated artifacts due to localized variations. The smaller is the window size, stronger will be the filter effect.

– **Atmosphere Hi Pass**, this accounts for the temporal distribution of the atmospheric variations. It is implemented by using a temporal window: large windows are more suitable to correct effects with low temporal variability, while small windows are better to correct frequent atmospheric variations. The bigger is the window size, stronger will be the filter effect.

Model Solution Parameters
Depending on the displacement mechanism and dynamics it is possible to set different values for the maximum and minimum admitted residual height, which is measured respect to the reference DEM. For instance, when analysing a data set acquired over a subsidence affected area, we can set the "Min Residual Height" definitely higher than the "Max Residual Height" since the area is expected to have height values lower than those reported in the reference DEM. The opposite will happen if the area is subject to an uplift.

Parameters - Persistent Scatterers

Baseline Threshold
This threshold corresponds to the maximum baseline value, which is considered acceptable for the PS analysis. Data pairs with baseline values outside this limit are not taken into account. This value is expressed as percentage of the critical baseline (original default is 5 times the critical value).

Range looks
Number of looks in range direction.

Azimuth looks
Number of looks in azimuth direction.

Range looks for Quik View
Number of looks in range direction.

Azimuth looks for Quick View
Number of looks in azimuth direction.

PS Density for Statistics

The measurement precision (i.e. mean velocity error in mm/year) is estimated considering a number of PS/sqkm, which is equal to the value specified here. The higher this value the lower the estimated mean velocity error.

Product Coherence Threshold
Pixels with coherence values smaller than this threshold cannot be kept as Persistent Scatterers.

Athmosphere Low Pass Size (m)
Dimension (in meters) of the window to set for the low frequency (spatial) atmospheric removal.

Area for Single Reference Point (sqkm)
Area (in square kilometers) used to define the subsets in which the dataset is divided. A single reference point is set for each zone under the area threshold.

Atmosphere High Pass Size (days)
Dimension (in days) of the window to set for the high frequency (temporal) atmospheric removal.

Area Overlap for Sub-areas (%)
Overlap Area (in percentage) between the subsets generated following the Area for Single Reference Point parameter.

Residual Height (Max and Min)
These correspond to the maximum (positive value) and minimum (negative value) residual height, with respect to the reference Digital Elevation Model.

Displacement Velocity (Max and Min)
This corresponds to the value expected (in mm/year) as the maximum displacement velocity.

Residual Height Sampling
This corresponds to the sampling frequency (in meters) which is used to estimate the residual height.

Displacement Sampling
This corresponds to the sampling frequency (in mm/sec) which is used to estimate the displacement velocity.

Shape Max Nr of Points
If values other than -1 are entered, the output shape file is split in several parts (each marked by a progressive numbering - _01; _02; etc.); each part of the shape contains a portion of the total number of points, which corresponds to the value entered. It is suggested not to exceed 100000 points in order to avoid visualization problems.

KML Max Nr of Points
If values other than -1 are entered, the output KML file is split in several parts (each marked by a progressive numbering - _01; _02; etc.); each part of the KML contains a portion of the total number of points, which corresponds to the value entered. It is suggested not to exceed 50000 points in order to

avoid visualization problems.

Generate Dint Multilooked
By setting this flag the differential interferograms, with the multilooking factors specified below, are also generated as processing outputs.

Generate Geocoded Shape file
By setting this flag the output shape file/s are generated.

Generate Geocoded Kml file
By setting this flag the output kml file/s are generated.

Generate Shape Time Series
By setting this flag the output shape file/s, with the displacement temporal evolution, are generated.

Generate Kml Time Series
By setting this flag the output kml file/s, with the displacement temporal evolution, are generated.

Refer Output List to Older
By setting this flag the displacements are referred to the oldest acquisition in the input file list.

General Functions

Store
The parameters are stored in the current Preferences.

Restore
The original default parameters are restored.

Save
The current parameters are saved with a user defined name.

Load
A previously exported ("Export" function) default setting can be loaded to replace the actual one.

Export
The current values are saved in a .txt file, which can be loaded ("Load" function) and used afterwards.

Remove
The user is prompted to enter the name of an existing default setting, which will be removed from the list.

Cancel
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

1.11.10 FTP

Purpose

This panel enables to change the Host Name and the Download Path, which are used for retrieving:

- the tiles of the supported Digital Elevation Model products 657 in the relevant FTP or HTTP server.
- the earthquake related parameters from the Global Centroid Moment Tensor (CMT) catalogue.

It must be noted that the Preferences setting may vary depending on the input data characteristics and they can be modified on the basis of user-specific needs. SARscape provides a few general settings, which are suggested in order to either optimize the processing of any supported products and sensors or to cope with specific data set conditions. However additional user defined Preferences settings can be saved and used in alternative to the standard ones.

Technical Note

The internet addresses, especially those used to download the Digital Elevation Model tiles, are subject to changes. In case this happens the new login details can be entered and saved as default parameters.

Parameters - FTP

Host name and **Download Path** of the FTP/HTTP servers, where each specific product is available for download, can be set.

General Functions

Store
The parameters are stored in the current dePreferences.

Restore
The original default parameters are restored.

Save
The current parameters are saved with a user defined name.

Load
A previously exported ("Export" function) default setting can be loaded to replace the actual one.

Export
The current values are saved in a .txt file, which can be loaded ("Load" function) and used afterwards.

Remove
The user is prompted to enter the name of an existing default setting, which will be removed from the list.

Cancel
The window will be closed.

Help
Specific help document section.

Specific Function(s)

None.

1.11.11 Modeling

Purpose

This panel enables to set the default processing parameters, which are used in those functions related only to the Interferometry Modeling functionalities.

Technical Note

The GENERIC PARAMETERS section contains parameters related to the statistical properties of InSAR dataset 432. They describe the spatial autocorrelation, which is assumed to exponentially decay according to

$$C(d) = C_0 \cdot e^{-d/k} \qquad [1]$$

where *d* is the distance between two points in the unwrapped map, C_0 is the covariance at zero distance and k is a coefficient describing the covariance decrease with distance. We remark that the covariance at zero distance is not the data variance, which is higher. Default values for X, C and L bands, derived from empiric semi-variograms, are provided.

The **NON-LINEAR PARAMETERS** section allows the parameter setup of the Non-Linear Inversion 413 algorithm; the algorithm is based on the Levemberg-Marquardt procedure [Marquardt, 1963], which is a mix of Gauss-Newton algorithm and the gradient descent method. The algorithm is implemented with multiple restarts starting from random configurations to get the global minimum of the cost function.
The cost function is a weighted mean of the χ-square value of every inverted dataset, according to

$$CostFunction = \sum_{j=1}^{M} \left(\frac{1}{N_j} \sum_{i=1}^{N_j} \left(\frac{s_i - \tilde{s}_i}{\sigma_i} \right)^2 \cdot \frac{\alpha_j}{\sum_{j=1}^{M} \alpha_j} \right) \qquad [2]$$

where M is the number of datasets, j is the dataset index, i is the index of a single measurement in the j^{th} dataset, α_j is the weight of the j^{th} dataset, N_j is the number of measurements in the j^{th} dataset, s_i, s_j and σ_i are the observed and predicted displacement and the standard deviation of the i^{th} measurement, respectively.
The computation length depends also on the data quality; when the displacement pattern is clear and the signal is strong, the cost function has a well-shaped global minimum and the algorithm is more effective. Parameter uncertainty and trade-offs can also be obtained: they are calculated perturbing, several times, data with a correlated noise (based on the GENERIC PARAMETERS values) and performing a new inversions.

The **LINEAR PARAMETERS** section allows the parameter setup of the Linear Inversion 417 algorithm (see Menke [1989] for a complete review of the inversion techniques). The most important is the damping factor, applied to the parameter Laplacian operator, which affect the smoothness of the solution: the higher is the damping, the more smoothed is the solution. Although a default value is provided, it is strongly problem-dependent and *ad hoc* values must be considered. In tectonic modeling, it is possible to specify a different damping value for every source, from the source setting panel.

Parameters - Modeling

Non Linear Inversion: Test for global minimum
Number of times that the algorithm must find the same minimum in the cost function to keep it as global minimum. A default value of 3, in general, is enough to get good results.

Non Linear Inversion: Selected the report format
An already formatted report is provided in the selected format: HTML, PDF or Microsoft Office Document (.doc).

Non Linear Inversion: Cost function Tolerance
During the algorithm iterations, two consecutive configurations are considered equivalent when their cost

function difference is below the tolerance. The default value is 0.0001.

Non Linear Inversion: Maximum Lev-Marq. iterations
Maximum number of algorithm restarts; this constraint plays a role only when data have a poor quality and the cost function global minimum is blurred among local minima. A default value of 300 is supplied.

Non Linear Inversion: Output Shapefiles for Sources
Set this flag to generate, for every source, a vector shapefile with the source parameters.

Non Linear Inversion: Output Shapefiles for Datasets
Set this flag to generate, for every dataset, a point shapefile.

Non Linear Inversion: Compute standard deviation and trade-offs
By setting this flag, standard deviations and trade-offs between parameters are also calculated .

Non Linear Inversion: Maximum iterations
Number of inversion to perform to calculate the scatter plot of the parameter standard deviations and trade-offs. Standard value is 50, but it can be significantly increased to get a denser scatter plot.

Non Linear Inversion: Statistic file name
Name of the file where the results of the Standard deviation and trade-off computation are stored.

Linear Inversion: Output Shapefiles for Sources
Set this flag to generate, for every source, a vector shapefile with the source parameters.

Linear Inversion: Output Shapefiles for Datasets
Set this flag to generate, for every dataset, a point shapefile.

Linear Inversion: Selected the report format
An already formatted report is provided in the selected format: HTML, PDF or Microsoft Office Document (.doc).

Linear Inversion: Default dumping factor
This factor affect the solution smoothing. Although a 0.05 default value is provided, it is strongly problem-dependent and *ad hoc* values must be considered.

Linear Inversion: Inversion algorithm
One of the following two can be selected:

- Non-Negative Least Squares: parameters are not allowed to assume negative values
- Unconstrained: parameters can assume negative values

Seismic Moment
??

X-/C-/L-band Data variance
Variance of the data, in m^2.

X-/C-/L-band Value at zero (this parameter is currently not used)
Covariance value at zero distance, C_0 in the equation in Technical Note, in m^2.

X-/C-/L-band Decreasing coefficient (this parameter is currently not used)
Coefficient describing how fast covariance decreases with distance, in m. Higher values correspond to a faster decay of the spatial correlation.

Lame's coefficient Lambda
Lamé's first parameter λ, in Pa or N/m^2. Default values are $30 \cdot 10^9$ Pa.

Lame's coefficient Mu
Lamé's second parameter μ or shear modulus, in Pa or N/m^2. Default values are $30 \cdot 10^9$ Pa.

Default Output Directory
The default directory in which all the chosen outputs will be generated.

General Functions

Store
The parameters are stored in the current Preferences.

Restore
The original default parameters are restored.

Save
The current parameters are saved with a user defined name.

Load
A previously exported ("Export" function) default setting can be loaded to replace the actual one.

Export
The current values are saved in a .txt file, which can be loaded ("Load" function) and used afterwards.

Remove
The user is prompted to enter the name of an existing default setting, which will be removed from the list.

Cancel
The window will be closed.

Help

Specific help document section.

Specific Function(s)

None.

References

Marquardt, D. (1963), An algorithm for least-squares estimation of nonlinear parameters, SIAM J. Appl. Math., 11, 431 – 441, doi:10.1137/
0111030.

Menke, W. (1989), Geophysical Data Analysis: Discrete Inverse Theory, Academic Press, Inc., San Diego (California)

1.12 Catalogue of Processing Messages

Purpose

This section is intended to provide preliminary information, which are useful to better understand data processing related messages such as warnings and errors.

Error List

Connection failure (E.C. 260001) - The downloading process got stuck due to an internet connection failure. It can happen for instance when the Tools>Digital Elevation Model Extraction 657 functionality is executed and the SRTM-3 or GTOPO30 tiles are being downloaded. In case one of the Digital Elevation Model tiles is not found in the internet, or the internet connection fails before or during the data downloading, the names of the required DEM tiles are written in the Process.log 825 file in order to enable to user to retrieve the files manually and store them in the appropriate folder (default work 20 directory).

Connection login failure (E.C. 260002) - The downloading process got stuck due to an internet connection failure. It can happen for instance when the Tools>Digital Elevation Model Extraction 657 functionality is executed and the SRTM-3 or GTOPO30 tiles are being downloaded. In case one of the Digital Elevation Model tiles is not found in the internet, or the internet connection fails before or during the data downloading, the names of the required DEM tiles are written in the Process.log 825 file in order to enable to user to retrieve the files manually and store them in the appropriate folder (default work 20 directory).

Connection timeout elapsed (E.C. 260003) - The downloading process got stuck due to an internet connection failure. It can happen for instance when the Tools>Digital Elevation Model Extraction 657 functionality is executed and the SRTM-3 or GTOPO30 tiles are being downloaded. In case one of the Digital Elevation Model tiles is not found in the internet, or the internet connection fails before or during the data downloading, the names of the required DEM tiles are written in the Process.log 825 file in order to enable to user to retrieve the files manually and store them in the appropriate folder (default work 20 directory).

Coregistration central window anomaly (E.C. 100011) - An anomaly has been reported in the definition of the coregistration central window. This error must be checked by the sarmap team for a solution; for this purpose the relevant error report 824 must be saved and e-mailed.

Coherence threshold must be lowered (E.C. 240001) - The "Product Coherence Threshold" has been set too high and none Persistent Scatterer has been found. The threshold 505 must be lowered according to the value of the scene specific multi-temporal coherence (_cc output product) and the processing iterated after having selected only the "Generated Geocoded Products" flag.

Coregistration window grid anomaly (E.C. 100012) - An anomaly has been reported in the definition of the coregistration central window. This error must be checked by the sarmap team for a solution; for this purpose the relevant error report 824 must be saved and e-mailed.

Computation error (E.C. 80000) - A math error has been reported. This error must be checked by the sarmap team for a solution; for this purpose the relevant error report 824 must be saved and e-mailed.

Coregistration error (E.C. 100006) - The cross-correlation process fails with the current coregistration parameters setting 770; consequently the coregistration step is not performed. In this case the number of windows (and if necessary also their size), in range and azimuth direction, should be increased. A manual location of the coregistration window 121 can also be done.

Coregistration initialization failure (E.C. 100010) - The coregistration process initialization fails due to an unexpected anomaly. This error must be checked by the sarmap team for a solution; for this purpose the relevant error report 824 must be saved and e-mailed.

Data Formatting anomaly (E.C. 130004) - Anomalies, such as missing sections and parameters or not initialized arrays, have been found in the data. This error must be checked by the sarmap team for a solution; for this purpose the relevant error report 824 must be saved and e-mailed together with the .sml input file/s header.

Data Formatting anomaly (E.C. 130005) - Anomalies, such as missing sections and parameters or not initialized arrays, have been found in the data. This error must be checked by the sarmap team for a solution; for this purpose the relevant error report 824 must be saved and e-mailed together with the .sml input file/s header.

Data Formatting anomaly (E.C. 130006) - Anomalies, such as missing sections and parameters or not initialized arrays, have been found in the data. This error must be checked by the sarmap team for a solution; for this purpose the relevant error report 824 must be saved and e-mailed together with the .sml input file/s header.

File Path too long (E.C. 40007) - This error occurs, only using a WINDOWS operating system, when a file path is longer than 260 characters. It often happens when TerraSAR-X and Tandem-X data, acquired in bistatic mode 70, are being imported.

Data Formatting anomaly (E.C. 130007) - Anomalies, such as missing sections and parameters or not initialized arrays, have been found in the data. This error must be checked by the sarmap team for a solution; for this purpose the relevant error report 824 must be saved and e-mailed together with the .sml input file/s header.

Data incompatibility (E.C. 100000) - Generic error message related to differences identified in the input data, which should have had same pixel size and/or same number of pixels and or same geographic location/projection.

Different cartographic system (E.C. 100004) - The cartographic reference system must be the same for all input data. This is a mandatory requirement for some processing steps, such as the Conventional Mosaic 712.

Different number of columns (E.C. 100002) - The number of columns is not the same for all input data. This is a mandatory requirement for some processing steps, such as the Phase to Height Conversion and Geocoding 314, where all inputs must have the same number of pixels.

Different number of rows (E.C. 100003) - The number of rows is not the same for all input data. This is a mandatory requirement for some processing steps, such as the Phase to Height Conversion and Geocoding 314, where all inputs must have the same number of pixels.

Expired license (E.C. 110002) - Your SARscape license has expired. Contact your local SARscape distributor to know how to renew it.

Fatal Error (E.C. 140000) - Hardware as well as software or data related problems can cause this kind of error. The problem must be investigated by the sarmap team for a solution; for this purpose the relevant error report 824 must be saved and e-mailed together with the .sml input file/s header.

Fatal Error (E.C. 140001) - Hardware as well as software or data related problems can cause this kind of error. The problem must be investigated by the sarmap team for a solution; for this purpose the relevant error report 824 must be saved and e-mailed together with the .sml input file/s header.

Fatal Error (E.C. 140000) - Hardware as well as software or data related problems can cause this kind of error. The problem must be investigated by the sarmap team for a solution; for this purpose the relevant error report 824 must be saved and e-mailed together with the .sml input file/s header.

File error (E.C. 40000) - It can be related to different kind of software or data problems. This error must be checked by the sarmap team for a solution; for this purpose the relevant error report 824 must be saved and e-mailed.

File inconsistency (E.C. 40001) - It can be related to different kind of software or data problems. This error must be checked by the sarmap team for a solution; for this purpose the relevant error report 824 must be saved and e-mailed.

File not found (E.C. 40002) - The required input file is missing. This can happen for instance when the processing is executed in batch mode 802 and the file name, extension or repository folder is wrongly entered.

File create error (E.C. 40003) - It is not possible to create the file in the output folder. This can happen when the user has not the required privileges to write in the specified folder or the output folder has been wrongly located in the CD or DVD. Change the output directory or modify the user privileges and try again.

File write error (E.C. 40004) - It is not possible to write the file in the output folder. It can happen when the disk is full or the connection to the output drive get lost (this last is typically reported when writing on external drives).

Fine coregistration failure (E.C. 100013) - The final part of the coregistration process (fine shift estimate) fails due to an unexpected anomaly. This error must be checked by the sarmap team for a solution; for this purpose the relevant error report 824 must be saved and e-mailed.

Generic error (E.C. 20000) - It can be related to different kind of software or data problems. This error must be checked by the sarmap team for a solution; for this purpose the relevant error report 824 must be saved and e-mailed.

Geocoding inconsistency (E.C. 160001) - An inconsistency has been found while executing the Geocoding 142 process. It can happen for instance when the "GCP File" is outside the input file/s coverage.

Header file anomaly (E.C. 130001) - Mandatory fields are missing in the .sml file. This error must be checked by the sarmap team for a solution; for this purpose the relevant error report 824 must be saved and e-mailed together with the .sml input file/s header.

Header file inconsistency (E.C. 130000) - A generic problem has been detected in the .sml file. This error must be checked by the sarmap team for a solution; for this purpose the relevant error report 824 must be saved and e-mailed together with the .sml input file/s header.

Inconsistent option selection (E.C. 70008) - It is related to the attempt of performing an operation, which has already been done and it cannot be executed twice. It typically happens when the user is either adding the geoid 655 to a geoidal DEM or subtracting the geoid from an ellipsoidal DEM.

Inconsistent pixel spacing (E.C. 100001) - The pixel dimension is not the same for all input data. This is a mandatory requirement for some processing steps such as the Conventional Mosaic 712.

Input files are not enough (E.C. 70006) - The number of input data is not sufficient to execute the processing. It can happen for instance when the Persistent Scatterers 484 functionality is executed with just a few acquisitions.

Installation error (E.C. 120000) - Uninstall SARscape from your PC and install the latest software version. Contact your local SARscape distributor in case the problem persists.

Invalid dongle (E.C. 110003) - A problem has been detected in your license hardware key (USB dongle). The following procedure can be attempted to solve it:

1. Remove the SARscape dongle, which is currently plugged in the PC, and restart it.
2. Run the "Install.exe" file, which is stored in the original SARscape installation package (SARscape x.x.xxx\install_sar_scape_directory\config_file folder).
3. Select both the flags "USB Dongle" and "Standalone" ("Install.exe" panel) and then click the "Begin Install" button.
4. Plug the SARscape dongle in the PC and follow the USB installation procedure.

Contact your local SARscape distributor in case the problem persists.

Invalid License (E.C. 110000) - A license related problem has been detected. Contact your local SARscape distributor.

Memory not found (E.C. 30000) - It can be related to different kind of software or data problems. This error must be checked by the sarmap team for a solution; for this purpose the relevant error report

824 must be saved and e-mailed.

Missing data record (E.C. 130003) - Some data records are missing in the .sml file. This error must be checked by the sarmap team for a solution; for this purpose the relevant error report 824 must be saved and e-mailed together with the .sml input file/s header.

Missing information (E.C. 130002) - Some parts of the header (.sml file) are missing or corrupted. This error must be checked by the sarmap team for a solution; for this purpose the relevant error report 824 must be saved and e-mailed together with the .sml input file/s header.

Missing license for this module (E.C. 110001) - Your SARscape license does not allow operating this module. Contact your local SARscape distributor for more information.

Missing mandatory step (E.C. 70007) - The specific processing requires a previous mandatory step to be executed first. It can happen for instance when the Phase to Height Conversion and Geocoding 314 functionality is executed without having previously performed the Refinement and Re-flattening 308 or even during the execution of the SBAS processing chain where a step can be compulsory for the execution of the next one.

Missing reference file (E.C. 240004) - The "Reference file" acquisition is not among the data in the "Input File List" when the Persistent Scatterer 484 processing is executed.

Only null values (E.C. 40006) - All image pixels are NaN (null values or dummy pixels).

Process cancelled (E.C. 50000) - The user has deliberately interrupted the process (for instance by clicking the "cancel" button in the running bar) or the process stopped automatically due to a conflict with another processing initiated in parallel using the same working directory 756.

Processing information are missing (E.C. 70009) - Some mandatory flag has not been set in the processing panel. It can happen for instance when none processing option has been set in the Dual Pair Differential Interferometry 325 step; in such instance or more of the following three flags must necessarily be checked: i) From SLC to Phase Unwrapping; ii) Generate Slant Range Products; iii) Generate Geocoded Products.

Refinement/Re-flattening error (E.C. 170001) - An inconsistency has been found while executing the Refinement and Re-flattening process in any of the modules where it is foreseen (i.e. Interferometry 308, ScanSAR Interferometry 572, Interferometric Stacking 525). It happens when the number of GCPs, which are used to remove erroneous phase components (ramps or constant terms), is not sufficient to execute the process (refer to the Preferences>Flattening 777 for details).

Statistic calculation failure (E.C. 150000) - An inconsistency has been found while executing the Data Statistic 734 functionality. It can happen for instance when the "Vector File" (or the area of interest co-ordinates) are located outside the input file/s coverage.

Statistic calculation failure (E.C. 150001) - An inconsistency has been found while executing the Data Statistic 734 functionality. It can happen for instance when the "Vector File" (or the area of interest co-ordinates) are located outside the input file/s coverage.

Statistic calculation failure (E.C. 150002) - An inconsistency has been found while executing the Data Statistic 734 functionality. It can happen for instance when the "Vector File" (or the area of interest co-ordinates) are located outside the input file/s coverage.

Statistic calculation failure (E.C. 150003) - An inconsistency has been found while executing the Data Statistic 734 functionality. It can happen for instance when the "Vector File" (or the area of interest co-ordinates) are located outside the input file/s coverage.

Statistic calculation failure (E.C. 150004) - An inconsistency has been found while executing the Data Statistic 734 functionality. It can happen for instance when the "Vector File" (or the area of interest co-ordinates) are located outside the input file/s coverage.

Statistic calculation failure (E.C. 150005) - An inconsistency has been found while executing the Data Statistic 734 functionality. It can happen for instance when the "Vector File" (or the area of interest co-ordinates) are located outside the input file/s coverage.

Statistic calculation failure (E.C. 150006) - An inconsistency has been found while executing the Data Statistic 734 functionality. It can happen for instance when the "Vector File" (or the area of interest co-ordinates) are located outside the input file/s coverage.

Statistic calculation failure (E.C. 150007) - An inconsistency has been found while executing the Data Statistic 734 functionality. It can happen for instance when the "Vector File" (or the area of interest co-ordinates) are located outside the input file/s coverage.

Statistic calculation failure (E.C. 150008) - An inconsistency has been found while executing the Data Statistic 734 functionality. It can happen for instance when the "Vector File" (or the area of interest co-ordinates) are located outside the input file/s coverage.

Statistic calculation failure (E.C. 150009) - An inconsistency has been found while executing the Data Statistic 734 functionality. It can happen for instance when the "Vector File" (or the area of interest co-ordinates) are located outside the input file/s coverage.

Warning message (E.C. 10000) - It is not an error message and it does not cause a processing interruption. The message informs the user of an anomaly detected during the data processing. As an example this kind of message is provided when the ENVISAT ASAR data are imported and some mandatory ancillary file is missing 43.

Wrong input format (E.C. 90000) - The input file/s type or format is not correct. It can happen for instance when: i) a wrong sensor or data type is specified in the import functionality 32; ii) an input product is entered, which is not suitable for a specific processing (e.g. an amplitude/intensity SAR image to convert a DEM to Slope image 694.

Wrong input parameters (E.C. 70000) - One or more parameters in the processing panel has been wrongly entered or there is someone missing.

Wrong window size (E.C. 70001) - Not admitted values have been entered as window dimension. It can happen when the widow size, in any processing step where this parameter is foreseen, is set to values which cannot be used (for instance the filter window size cannot be set to 0 or decimal values).

1.13 Clean Working Directory

Purpose

The files stored in the working directory 756 are erased.

Technical Note

In case folders were stored in the working directory (e.g. SRTM_DEM_DIR, GTOPO30_DIR, etc.), they are not removed.

1.14 Batch Processing

Purpose

It allows to perform several checks and editing actions in a previously stored processing sequence ("Store Batch" function available in each processing panel).

Technical Note

The tasks to be executed must be previously stored, using the Store Batch button, in the relevant processing panel. Note that the input file names must include the root name and the suffix (refer to the default SARscape extensions 22); this has to be taken into account when a batch list is prepared with input files which are not yet available (i.e. they have to be generated during the batch list execution).

In addition to the "General Functions" and "Specific Function" (see below), the panel provides the following commands activated with the right mouse button clicked on the specific step:

- **Delete**, to cancel a step from the processing sequence.
- **Copy**, to duplicate a step in the processing sequence.
- **On/Off**, to select or deselect a step before the processing sequence execution.

It is possible to Change the processing parameters by editing the relevant fields in the right side of the panel. After editing, just push the "Enter" keyboard button to make the change effective (a message in the lower part of the panel will confirm that the parameter has been successfully modified).

The batch processing is based on the SARscape IDL scripting technology: an array of objects, each representing a step of the batch processing sequence, is created exploiting the 'SARscapeBatch' class. This array is saved in the the default batch file 758.

Refer to the specific IDL scripting 805 section to know more about this functionality.

Input Parameter(s)

Ignore Errors and Continue Batch
If a step is not completed, due to a processing error, the batch execution proceeds with the successive step. By unsetting this flag the batch execution stops as soon as a step fails.

General Functions

Save
The actual batch list is saved. In case the file name is different from the default batch file 758, this last one will be replaced.

Load
The previously prepared batch list is loaded. The default input path 758 can be modified.

Run
The actual batch list is executed.

Help
Specific help document section.

Specific Function(s)

Reset
The actual batch list is cancelled.

1.15 OpenCL FAQ

Q.- What is OpenCL?

A. - The Open Computing Languange (OpenCL) is a framework for writing applications capable of taking advantage of the parallel power provided by modern computational devices like multicore processors, graphics processing units (GPUs), co-processors (Xeon Phi), field/programmable gate arrays (FPGAs), etc. OpenCL is an open standard adopted by the majority of today's hardware manufacturers. We used OpenCL to improve the performance of the core units of selected algorithms in SARscape 5.1. Unlike other similar products like NVIDIA CUDA, OpenCL is not tight to any specific vendor, operating system, or hardware platform.

Q.- Why using OpenCL in SARscape?

A. - Since about one decade, processors are providing additional computational power through improved parallelism rather than higher clock frequencies. For this reason, we already parallelized several portions of the SARscape pipelines to cope with this shift in the programming paradigm. GPUs and other modern massively parallel devices (such as Xeon Phi coprocessors) are providing a significantly higher level of parallelism within a reasonable cost/benefit ratio. By writing our core units in OpenCL, we allow SARscape to take advantage not only of multicore CPUs, but also (when available) of the parallel computational power provided by those dedicated devices.

Q.- What portions of SARscape are taking advantage of OpenCL?

A. - OpenCL has been introduced as a strict requirement in SARscape version 5.1. Currently, the Persistence scatterer and Geocoding processing pipelines have been ported to OpenCL, in addition to several global routines used in many parts of SARscape. Additional OpenCL support will be progressively introduced with the future releases of SARscape.

Q.- Do I need a recent graphics card to run SARscape 5.1?

A. - No. Unlike CUDA, where an NVIDIA GPU is required to run the code, OpenCL provides at least two CPU-only implementations that can be used to run SARscape to any computer. These CPU-only implementations are much more than a simple fallback for machines not equipped with a recent GPU since they are optimized for exploiting the hardware resources of the CPU (like multiple cores and advanced instruction sets). In any case, SARscape 5.1 requires a GPU (or OpenCL accelerator) with at least 1 GB of memory. If you plan to buy some hardware for explicit usage with SARscape 5.1, we recommend AMD and Intel (Xeon Phi) products. While SARscape runs smoothly on NVIDIA hardware too, the NVIDIA OpenCL support is significantly inferior than the one provided by other hardware manufacturers.

Q.- I don’t have any GPU in my computer: can I run SARscape 5.1?

A. - Yes: by default, the SARscape 5.1 installer inspects the underlying system and, if no CPU-only OpenCL runtime is detected, the Intel CPU-only OpenCL runtime is automatically installed. The Intel CPU-only OpenCL runtime supports most of the recent Intel CPUs. If your CPU is not Intel or if it is not supported by the Intel runtime, you can always download and install the AMD CPU-only OpenCL runtime, which is slightly less optimized than Intel’s one but works on a broader series of processors. For legal reasons, we cannot redistribute the AMD runtime with SARscape, but it is integrated within the AMD APP SDK that can be freely downloaded at the AMD developer portal (developer.amd.com). At the moment, we recommend to use the AMD APP SDK version 2.8.1 even if more recent versions are available.

Q.- Will SARscape run faster on my computer with two (or more) GPUs connected through SLI/CrossFire?

A. - SLI (NVIDIA) and CrossFire (AMD) are technologies exploited only when the GPUs are used for graphics rendering: they don’t have any impact on OpenCL. At the moment, only one single device can be used by SARscape: if several devices are available, it is up to the user to specify which one to use. On the other hand, multiple instances of SARscape can be open and independent processes can be assigned to different GPUs.

1.16 IDL Scripting

Purpose

It allows to execute one or more processing steps by preparing an IDL script, which actually calls specific SARscape routines.

The SARscapeBatch_object 807 has to be used to call any SARscape functionality by means of an IDL script.

Technical Note

The use of this functionality foresees the knowledge of the IDL programming language. The SARscape IDL scripting technology is also exploited in the batch processing 802.

The IDL script must be structured as shown in the example file (SARMAP SA\SARscape x.x.xxx\exe_envi\IDLscript_example_geocoding.pro), which is relevant to the execution of a geocoding 142 process. The content of the IDL example script is synthetically described here below:

1) SARscape batch initialization and temporary directory setting (1st preparatory step)
The SARscape extension file is restored from the original repository folder. The folder path, where the default processing values are copied, is defined. It has to be noted that all the alternative default settings (General, VHR, HR, MR, etc.) are stored within this folder, but the one which is used is always the "SARscape_default_values_dataset_General 755.txt".

It is convenient to set a different directory from that selected in the ENVI "File>Preferences>Directories>Temporary Directory", in order to avoid overwriting the standard SARscape default settings.

2) Load the user-specific default file (2nd preparatory step, optional)
It is possible to enter an existing default file where the user-specific processing parameters have been previously set. If this file contains also the location of the working directory ("working_directory" tag), then the next preparatory step (3rd) is not needed.

If this step is not executed the latest used default file is adopted.

3) Set the working directory (3rd preparatory step, optional)
The folder path, where the processing related information (e.g. trace files, log files, working files, etc.) are written, is entered.

4a) Show all SARscape functions (4th preparatory step, optional)
It is possible to list all SARscape functions, which can be executed afterwards.

4b) Show specific SARscape functions (4th preparatory step, optional)

Alternatively to the step 4b, it is possible to enter a portion of the reference name relevant to the SARscape functionality to list. In our example the name of the functionality to call is the "Geocoding".

5) **Geocoding input data and parameters** (Input data and parameter definition)
The input/output data and parameters are entered. In our example they consist of: two input SAR images (..._slc); an input Digital Elevation Model (..._dem); two output SAR geocoded images (..._geo); the parameters relevant to both the output grid size (25.0) and the resampling method (optimal resolution).

6) **Create the BasicGeocoding object** (Processing functionality creation and validation)
The object relevant to the previously retrieved SARscape functionality (refer to step 4) is now created and afterwards the program checks its validity.

7) **Show the actual parameters** (Input and output files and processing parameters are detailed, optional)
This command allows to distinguish the mandatory fields ("USER_PARAMETER_TO_FILL" tag) from the optional ones ("USER_OPTIONAL_PARAMETER" tag).

8) **Get the parameter type** (Different parameters are detailed, optional)
This command is intended to list the different options, which can be used for setting any processing parameter. In the example the different available resampling methods ("geocode_resampling_type" tag) are listed.

9) **Fill the parameters** (Input and output files and processing parameters are set)
First the list of input files, then the list of output files, then the Digital Elevation Model file name and finally the output grid size and the resampling method are entered.

10) **Verify the parameters** (All previous settings are checked, optional but important)
All details relevant to the specific process, which is going to be executed, are reported; in case the instruction is modified using "silent=0" (instead of "silent=1") the details are not shown. In any case, if all previous steps have been properly done, this function provides the code 1 (i.e. ok message); if any mandatory field was missing, this function provides the code 0 (i.e. failure message).

11) **Process execution** (The process is executed)
If the previous setting was properly done this function provides the code 1 (i.e. ok message) and the processing is successfully executed; otherwise the function provides the code 0 (i.e. failure message).

12) **Exit from SARscape batch mode** (The SARscape Batch session is end)

Section Content

Input Parameter(s)

Refer to the Technical Note.

General Functions

Refer to the IDL help documentation.

Specific Function(s)

Refer to the IDL help documentation.

1.16.1 SARscapeBatch object

This function returns a reference to a SARscapeBatch object. Your code must start the ENVI application in batch mode in order to recognize SARscapeBatch as valid routine, or alternatively you must perform an initialization steps before referencing the object.

SARscapeBatch allows executing any SARscape functionality in batch mode and the definition of all the parameters needed by the SARscape functionality.

Example

This example shows how to initialize a SARscapeBatch object inside an ENVI session. Copy and paste the following code into the IDL command line.

```
; Launch ENVI

ENVI, /RESTORE_BASE_SAVE_FILES

ENVI_BATCH_INIT

oSB = SARscapeBatch()

help,oSB
```

This example shows how to initialize a SARscapeBatch object without an ENVI session.

```
; Step 1) Load the SARscape extension in IDL

TempDir = 'c:\temp'

Sarscape_batch_init,temp_directory=TempDir


; Step 2) Load user defined profile (Default parameters)   - Optional Step

ParamsFileName  = ‘c:\test\mySARscapedefault.txt’
```

```
ok = SARscape_Dialog_Load_xml_Default (DEFAULT_FILE_NAME=ParamsFileName)

oSB = SARscapeBatch()
help,oSB
```

Syntax

oSB = SARscapeBatch(Module=ModuleName)

Methods

Execute
ExecuteProgress
GetParam
ListParams
Manifest
SearchModule
SetParam
SetUpModule
VerifyParams
xManifest

Properties

Properties marked as (Get) can be retrieved, but not set.

DESCRIPTION (Get)

A string describing the SARscape module currently handled by the object

HASSCHEMA (Get)

Returns 1 (TRUE) if a schema definition exists for the module, and 0 (FALSE) if not.

MODULE (Get,Set)

A string specifying the name of SARscape module currently handled by the object.

Keywords

MODULE

Set this keyword to a valid module name, one out of the list of available modules as obtained with the MANIFEST method, called after initialized the object without this keyword set.

SARscapeBatch::Execute

This method executes the SARscape module that has been defined. Before the executing it performs a sanity check on the parameters defined and after the validation it starts the process.

Example

This example shows how to initialize a SARscapeBatch object inside an ENVI session and its execution.

```
; Launch ENVI

ENVI, /RESTORE_BASE_SAVE_FILES

ENVI_BATCH_INIT, /NO_STATUS_WINDOW

oSB = SARscapeBatch(Module='ImportCskFormat')

FileIn = 'MyCosmoScene'

FileOut = 'MyFileout'

ok = oSB.SetParam('input_file_list',FileIn)

ok = oSB.SetParam('output_file_list',FileOut)

oK =oSB.Execute()
```

Syntax

Result = SARscapeBatch.Execute(WORKING_DIRECTORY=varIn, ERRMSG=varOut)

Return Value

Returns a 1 if successful in executing the module, 0 otherwise

Arguments

None

Keywords

WORKING_DIRECTORY
Set this keyword to a valid directory to supersede the default directory of the temporary folder.

ERRMSG
Set this keyword to a named variable that will contain any error message issued during execution of the SARscape Module. If no error occurs, the ERROR variable will be set to a null string ('').

SARscapeBatch::ExecuteProgress

This method executes the SARscape module that has been defined. Before the executing it performs a sanity check on the parameters defined and after the validation it starts the process. Unlike the method Execute during the process a progress bar is visualized.

Note: The progress bar is visualized only if an ENVI batch session is open.

Example

This example shows how to initialize a SARscapeBatch object inside an ENVI session and its execution.

```
; Launch ENVI
ENVI, /RESTORE_BASE_SAVE_FILES
ENVI_BATCH_INIT
oSB = SARscapeBatch(Module='ImportCskFormat')
FileIn = 'MyCosmoScene'
FileOut = 'MyFileout'
ok = oSB.SetParam('input_file_list',FileIn)
ok = oSB.SetParam('output_file_list',FileOut)
oK =oSB.ExecuteProgress(ErrMgs=err)
```

Syntax

Result = SARscapeBatch.Execute(WORKING_DIRECTORY=varIn, ERRMSG=varOut)

Return Value

Returns a 1 if successful in executing the module, 0 otherwise

Arguments

None

Keywords

WORKING_DIRECTORY

Set this keyword to a valid directory to supersede the default directory of the temporary folder.

ERRMSG

Set this keyword to a named variable that will contain any error message issued during execution of the SARscape Module. If no error occurs, the ERROR variable will be set to a null string ('').

SARscapeBatch::GetParam

The GetParam method retrieves the values of the parameters associated with the selected SARscape module. To print the names and values of each parameters associated with the SARscape module the method ListParams can be used.

Example

This example shows how to retrieve the values of parameters from a SARscape module

```
; Launch ENVI

ENVI, /RESTORE_BASE_SAVE_FILES

ENVI_BATCH_INIT, /NO_STATUS_WINDOW

oSB = SARscapeBatch()

ok = oSB.SetupModule(Module='BaseMultilooking')

oSB.ListParams

 MAIN_BASIC_MULTILOOKING
       sarscapeenvironment:              IDL_ENVI_ENV
         input_file_list:          USER_PARAMETER_TO_FILL
         output_file_list:         USER_PARAMETER_TO_FILL
        azimuth_multilook:               5.0000000
         range_multilook:                1.0000000
        output_root_name:          USER_OPTIONAL_PARAMETER
       cut_dummy_min_pixel:              -1.0000000
  grid_size_for_suggested_looks:         -1.0000000
      delete_temporary_files:                OK
            make_tiff:                  NotOK
        saturation_default:              0.33330000

ok = oSB.GetParam('azimuth_multilook',value)

print,value
```

Syntax

Result = SARscapeBatch.GetParam(NameParam,Value)

Return Value

Returns a 1 if successful, 0 otherwise

Arguments

NAMEPARAM

A scalar string that is a fully-qualified parameter name

VALUE

Name of an IDL variable that will contain the value of the parameter

Output

USER_PARAMETER_TO_FILL indicates that the corresponding parameter value is not initialized from the defaults, and that it shall mandatorily set by the user before executing the module.

USER_OPTIONAL_PARAMETER indicates that the corresponding parameter value is not initialized from the defaults, but it shall not necessarily set by the user before executing the module.

SARscapeBatch::ListParams

Use the ListParams method to print the parameters and their values defined for a module

Example

This example shows how to print the names and values of parameters.

```
; Launch ENVI

ENVI, /RESTORE_BASE_SAVE_FILES

ENVI_BATCH_INIT, /NO_STATUS_WINDOW

oSB = SARscapeBatch()

ok = oSB.SetupModule(Module='BaseMultilooking')

oSB.ListParams

  MAIN_BASIC_MULTILOOKING
            sarscapeenvironment:                IDL_ENVI_ENV
                input_file_list:          USER_PARAMETER_TO_FILL
               output_file_list:          USER_PARAMETER_TO_FILL
              azimuth_multilook:                 5.0000000
                range_multilook:                 1.0000000
               output_root_name:          USER_OPTIONAL_PARAMETER
             cut_dummy_min_pixel:                -1.0000000
   grid_size_for_suggested_looks:                -1.0000000
          delete_temporary_files:                OK
                      make_tiff:                 NotOK
             saturation_default:                 0.33330000
```

Syntax

SARscapeBatch.ListParams

Arguments

None

Output

USER_PARAMETER_TO_FILL indicates that the corresponding parameter value is not initialized from the defaults, and that it shall mandatorily set by the user before executing the module.

USER_OPTIONAL_PARAMETER indicates that the corresponding parameter value is not initialized from the defaults, but it shall not necessarily set by the user before executing the module.

SARscapeBatch::Manifest

Use the Manifest method to list all the names of the SARscape modules available and a brief description.

Example

This example shows how to list all the names of the SARscape modules.

; Launch ENVI

ENVI, /RESTORE_BASE_SAVE_FILES

ENVI_BATCH_INIT, /NO_STATUS_WINDOW

oSB = SARscapeBatch()

oSB.Manifest

```
-----------------------------------------------------------------------------------------
 Description of the modules available for SARscape Batch
-----------------------------------------------------------------------------------------
Module Name..: BASEMULTILOOKING
Description..: BaseMultilooking
**************************************************************************
*****************
Module Name..: BASICCOREGISTRATION
Description..: Coregistration
**************************************************************************
*****************
Module Name..: BASICFECOEFFOFVAR
Description..: Coefficient of Variation
**************************************************************************
*****************
Module Name..: BASICFECOHERENCE
Description..: Coherence Generation
**************************************************************************
*****************
Module Name..: BASICFEMULTITEMPORALFEATURES
Description..: Multitemporal Features
**************************************************************************
*****************
Module Name..: BASICFERATIO
Description..: Ratio
...............
```

Syntax

SARscapeBatch.Manifest,/FULL,SEARCH=SEED

Arguments

None

Keywords

FULL

Set this keyword to list also the xml Schema name associated with each module.

SEED

A scalar string that contains the seed research

SARscapeBatch::SearchModule

This method allows searching for the name of a specific module.

Example

This example shows how to search for the modules that execute the multilooking functionality.

```
; Launch ENVI

ENVI, /RESTORE_BASE_SAVE_FILES

ENVI_BATCH_INIT, /NO_STATUS_WINDOW

oSB = SARscapeBatch()

oSB.SearchModule,'Multilooking'

-----------------------------------------------------------------------------------------
 Description of the modules available for SARscape Batch
 seed: "Multilooking"
-----------------------------------------------------------------------------------------
Module Name..: BASEMULTILOOKING
Description..: BaseMultilooking
*************************************************************************
*****************
Module Name..: INSARCOMPLEXDATAMULTILOOKING
Description..: Complex Data Multilooking
*************************************************************************
*****************

ok = oSB.SetUpModule(Module='BASEMULTILOOKING')

oSB.ListParams

  MAIN_BASIC_MULTILOOKING
          sarscapeenvironment:                    IDL_ENVI_ENV
             input_file_list:              USER_PARAMETER_TO_FILL
            output_file_list:              USER_PARAMETER_TO_FILL
           azimuth_multilook:                      5.0000000
             range_multilook:                     1.0000000
            output_root_name:              USER_OPTIONAL_PARAMETER
          cut_dummy_min_pixel:                      -1.0000000
  grid_size_for_suggested_looks:                     -1.0000000
       delete_temporary_files:                        OK
                 make_tiff:                       NotOK
          saturation_default:                     0.33330000
```

Syntax

SARscapeBatch.SearchModule,SEED

Arguments

SEED

A scalar string that contains the seed research

SARscapeBatch::SetParam

The SetParam method enables the assignment of values at parameters associated with the selected SARscape module.

Example

This example shows how to search for the modules that execute the multilooking functionality and defines some parameters

```
; Launch ENVI

ENVI, /RESTORE_BASE_SAVE_FILES

ENVI_BATCH_INIT, /NO_STATUS_WINDOW

oSB = SARscapeBatch()

ok = oSB.SetUpModule(Module='BASEMULTILOOKING')

oSB.ListParams

 MAIN_BASIC_MULTILOOKING
        sarscapeenvironment:            IDL_ENVI_ENV
        input_file_list:                USER_PARAMETER_TO_FILL
        output_file_list:               USER_PARAMETER_TO_FILL
        azimuth_multilook:              5.0000000
        range_multilook:                1.0000000
        output_root_name:               USER_OPTIONAL_PARAMETER
        cut_dummy_min_pixel:            -1.0000000
        grid_size_for_suggested_looks:  -1.0000000
        delete_temporary_files:         OK
        make_tiff:                      NotOK
        saturation_default:             0.33330000

ok = oSB.SetParam('azimuth_multilook','4.0')

ok = oSB.SetParam('range_multilook,'2.0')

ok = oSB.SetParam('input_file_list','c:\temp\SARData')

oSB.ListParams

 MAIN_BASIC_MULTILOOKING
        sarscapeenvironment:            IDL_ENVI_ENV
        input_file_list (001):          c:\temp\SARdata
        output_file_list:               USER_PARAMETER_TO_FILL
        azimuth_multilook:              4.0000000
        range_multilook:                2.0000000
        output_root_name:               USER_OPTIONAL_PARAMETER
        cut_dummy_min_pixel:            -1.0000000
        grid_size_for_suggested_looks:  -1.0000000
        delete_temporary_files:         OK
        make_tiff:                      NotOK
        saturation_default:             0.33330000
ok = oSB.Setparam('input_file_list',['c:\temp\SARdata1','c:\temp\SARdata2'])
```

oSB.ListParams

MAIN_BASIC_MULTILOOKING	
sarscapeenvironment:	IDL_ENVI_ENV
input_file_list (001):	c:\temp\SARdata1
input_file_list (002):	c:\temp\SARdata2
output_file_list:	USER_PARAMETER_TO_FILL
azimuth_multilook:	4.0000000
range_multilook:	2.0000000
output_root_name:	USER_OPTIONAL_PARAMETER
cut_dummy_min_pixel:	-1.0000000
grid_size_for_suggested_looks:	-1.0000000
delete_temporary_files:	OK
make_tiff:	NotOK
saturation_default:	0.33330000

Syntax

Result = SARscapeBatch.SetParam(NameParam,Value)

Return Value

Returns a 1 if successful, 0 otherwise

Arguments

NAMEPARAM

A scalar string that is a fully-qualified parameter name

VALUE

A scalar string or an array of strings.
Note: Array of strings can be assigned only to the parameters containing the string “list” inside the name.

SARscapeBatch::SetUpModule

The method SetUpModule allows selecting the SARscape module that needs to be executed.

Example

This example shows to select the module that performs the geocoding.

```
; Launch ENVI
ENVI, /RESTORE_BASE_SAVE_FILES
ENVI_BATCH_INIT, /NO_STATUS_WINDOW
oSB = SARscapeBatch()
ok = oSB.SetUpModule(Module='BASICGEOCODING')
```

Syntax

Result = SARscapeBatch.SetUpModule(Module=ModuleName)

Return Value

Returns a 1 if successful, 0 otherwise

Arguments

None

Keywords

MODULE

A scalar string with the name of a valid SARscape Module.

SARscapeBatch::VerifyParams

The VerifyParams method verifies that all the mandatory parameters are filled and in case some parameters have not been filled it sends a notification. This method is also used by the methods Execute and ExecuteProgress before the start of the computational process.

Example

This example shows how to use the method VerifyParams.

```
; Launch ENVI

ENVI, /RESTORE_BASE_SAVE_FILES

ENVI_BATCH_INIT, /NO_STATUS_WINDOW

oSB = SARscapeBatch()

ok = oSB.SetUpModule(Module='BASEMULTILOOKING')

ok = oSB.SetParam('azimuth_multilook','4.0')

ok = oSB.SetParam('range_multilook','2.0')

ok = oSB.SetParam('input_file_list','c:\temp\SARData')

ok = oSB.VerifyParams()

Parameter: ***OUTPUT_FILE_LIST*** needs to be filled before exec

 Optional Parameter: ***OUTPUT_ROOT_NAME*** not filled

ok = oSB.SetParam('input_file_list','c:\temp\SARData')

ok = oSB.SetParam('output_file_list','c:\temp\OutData')

ok = oSB.VerifyParams()

Print,ok

       1
```

Syntax

Result = SARscapeBatch.VerifyParams(/Silent,/Optional)

Return Value

Returns a 1 if successful, 0 otherwise

Arguments

None

Keywords

SILENT

The keyword disables the print of messages

OPTIONAL

The keyword enables the control also on optional parameters.

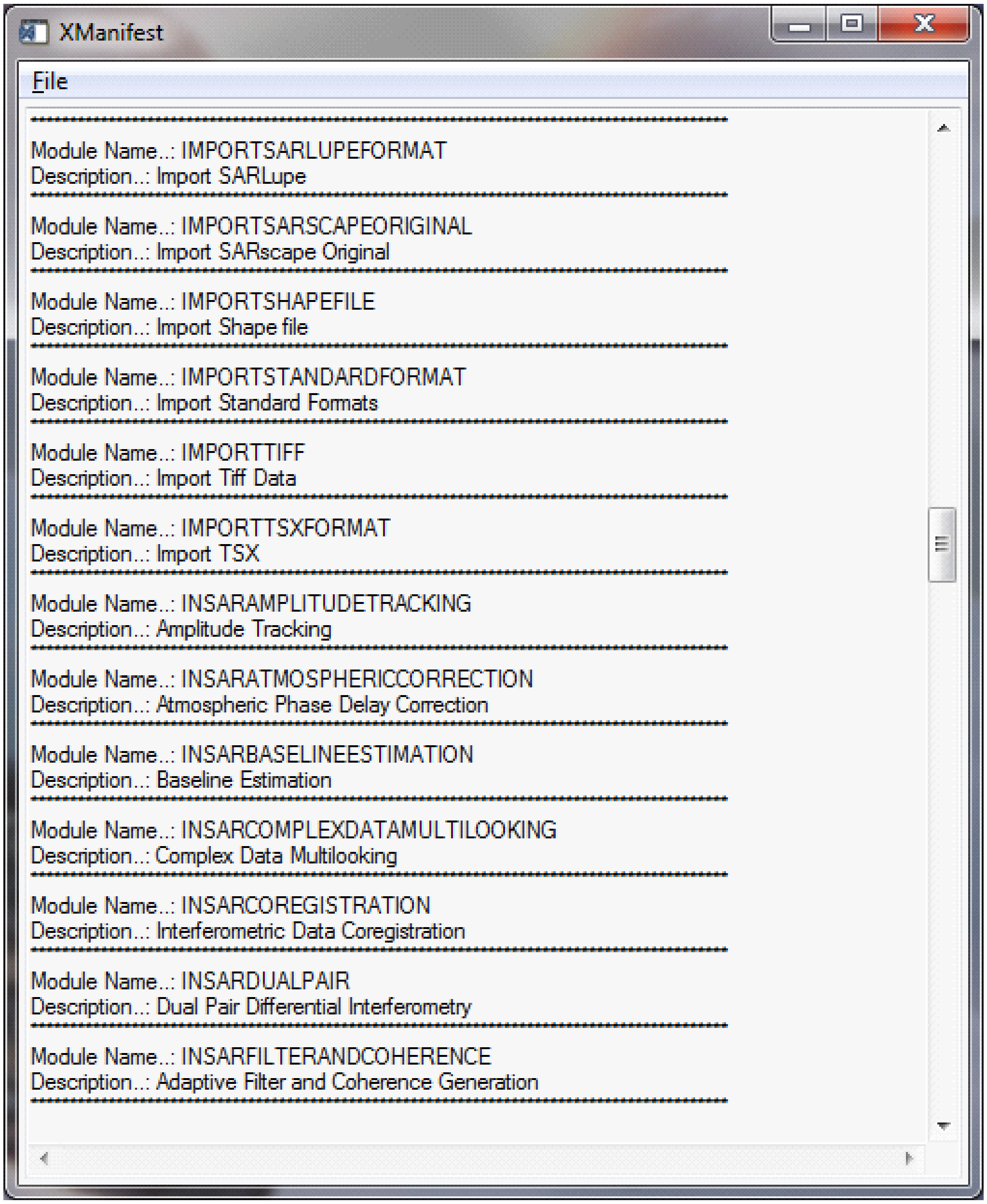
SARscapeBatch::xManifest

Use the xManifest method to list all the names of the SARscape modules available in a GUI.

Example

This example shows how to list all the names of the SARscape modules.

```
; Launch ENVI
ENVI, /RESTORE_BASE_SAVE_FILES
ENVI_BATCH_INIT, /NO_STATUS_WINDOW
oSB = SARscapeBatch()
oSB.xManifest
```



Syntax

SARscapeBatch.xManifest,/FULL,SEARCH=SEED

Arguments

None

Keywords

FULL

Set this keyword to list also the xml Schema name associated with each module.

SEED

A scalar string that contains the seed research

1.17 Save Error Report

Purpose

When a processing error is reported, the relevant information is stored by clicking this button.

It must be noted that, once an error is reported, the program automatically initiate a procedure to save the "Error Report".

This functionality can also be used to store the processing information (Log + Trace files), which are relevant to the last step executed.

Technical Note

When saving the "Error Report" be sure that other SARscape processes have not been executed.

The "Error Report" has to be sent to your distributor for a further investigation and solution of the problem.

1.18 Select Dataset

Purpose

The specific Test Dataset (one for each SARscape module) can be executed using a predefined batch processing 802 sequence.

Technical Note

The following steps must be carried out:

1. Decompress the original official SARscape dataset, which have been provided by your software distributor, on a local folder.
2. Double click on the "Select Dataset" button to initiate the TDS execution procedure.
3. Identify the local folder where the relevant SARscape dataset has been previously decompressed.
4. Identify the local folder where the output products, coming from the TDS execution, must be stored.
5. Run the batch processing.

It is possible to modify the processing parameters by editing the relevant fields in the right side of the batch processing panel, which pops up after the selection of the input/output TDS folders (refer to the batch processing 802 for details).

1.19 View Files

Section Content

1.19.1 Header File

Purpose

The file related information in the SARscape header file (.sml, _hdr) can be visualised.

Technical Note

The SARscape header file provides information relevant to the data specific characteristics as well as information concerning previous processing steps executed on that file. This file is mandatory to run any SARscape functionality.

General Functions

Delete
The Log file content is removed.

Cancel
The window will be closed.

Help
Specific help document section.

1.19.2 Log File

Purpose

The log viewer allows viewing processing related information. Note that since the information is continuously stored in the Log file, this file can become very large unless its content is removed from time to time using the delete button.

Technical Note

None.

General Functions

Delete
The Log file content is removed.

Cancel
The window will be closed.

Help
Specific help document section.

1.19.3 Trace File

Purpose

The trace viewer provides detailed information about the latest process executed. Note this file is overwritten any time a new process is launched.

Technical Note

None.

General Functions

Cancel
The window will be closed.

Help
Specific help document section.

Keyword Index

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