

LAND & SEA APPLICATIONS USING SAR



Meet the Presenters



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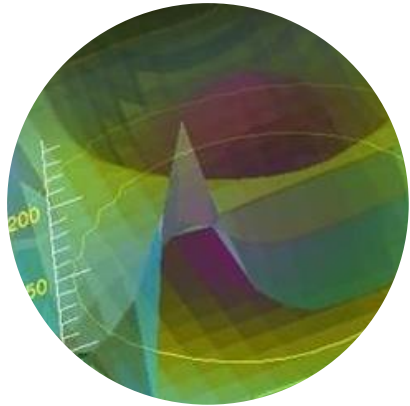
- **Introductions**
- **Background on SAR**
- **Ocean Applications**
 - Ship Detection
 - Oil Spills
- **Land Applications**
 - Burn Area Analysis
 - Land Surface Deformation



Poll Question #1



Harris Geospatial Solutions – SW Portfolio



IDL



ENVI



Geospatial Services
Framework



SARscape



An integrated software platform for operational processing of SAR data



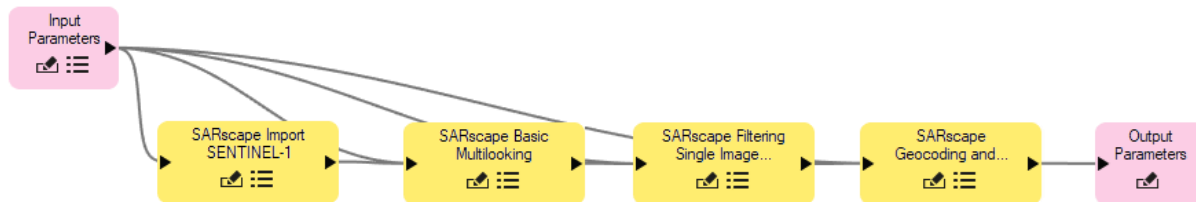
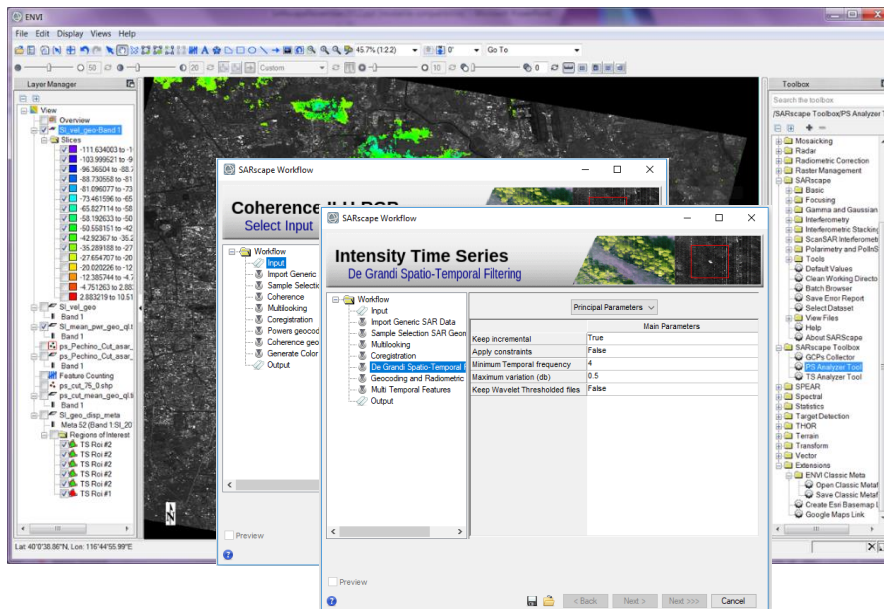
ENVI UI

ENVI Workflows

ENVI Modeler

ArcGIS Pro

Desktop-Enterprise-Cloud



Run SARscape where you are most comfortable.



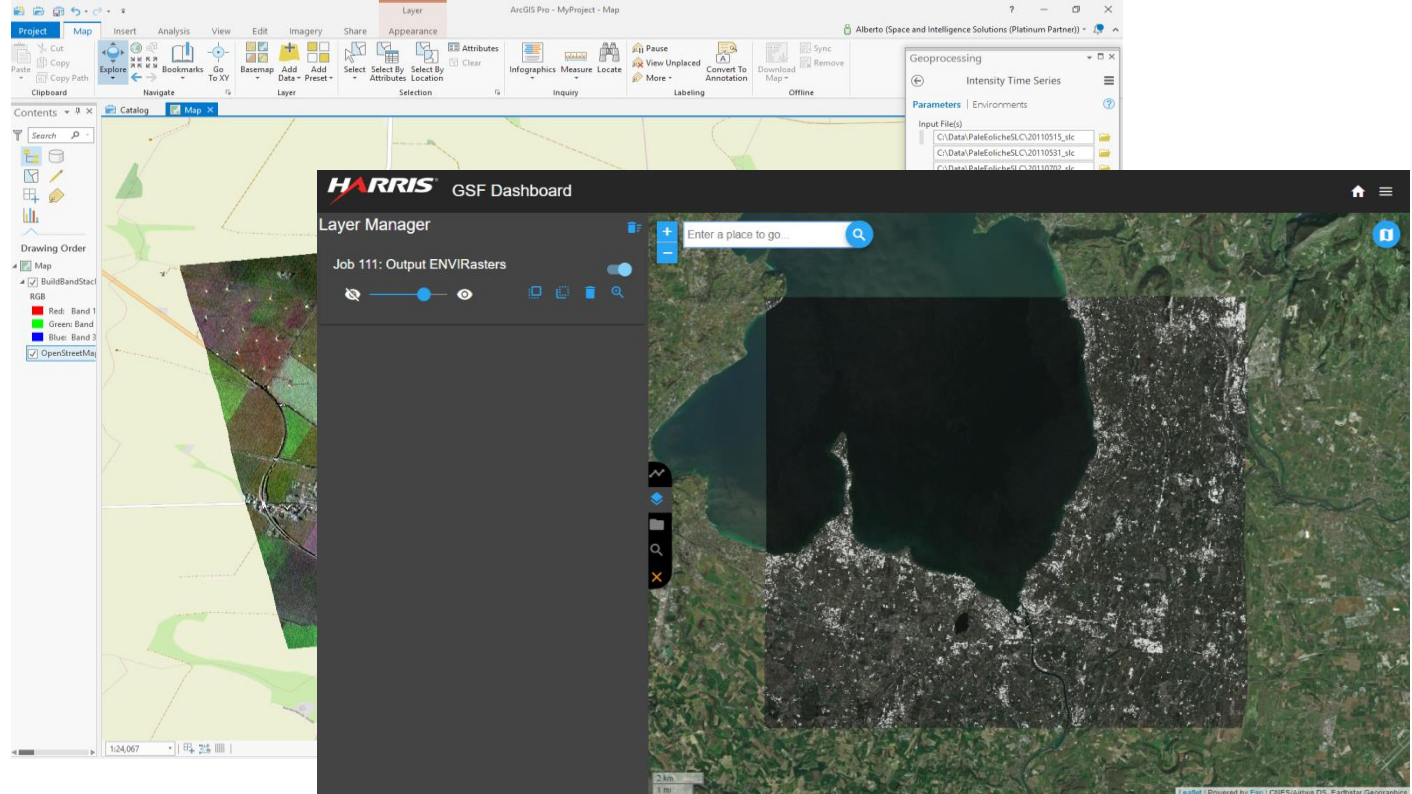
ENVI UI

ENVI Workflows

ENVI Modeler

ArcGIS Pro

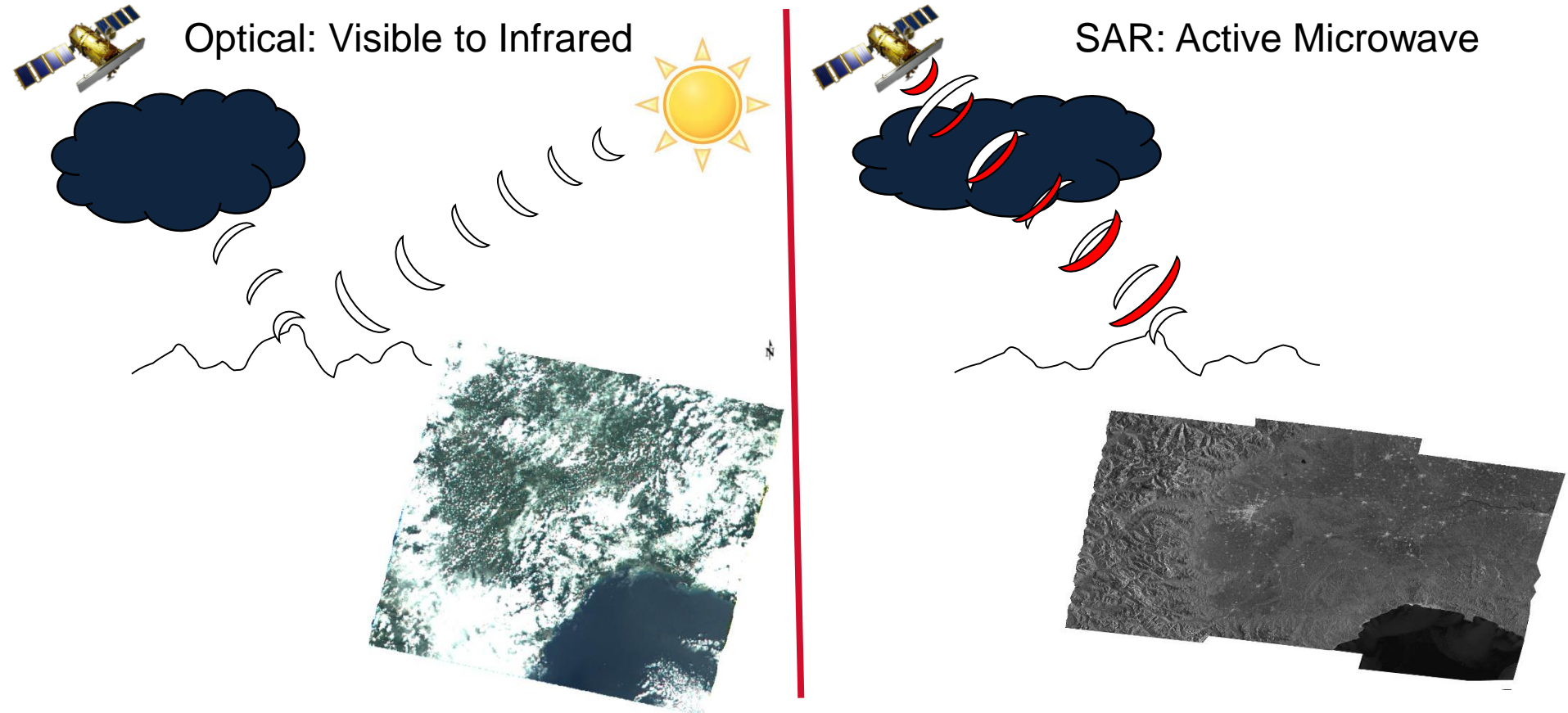
Desktop-Enterprise-Cloud



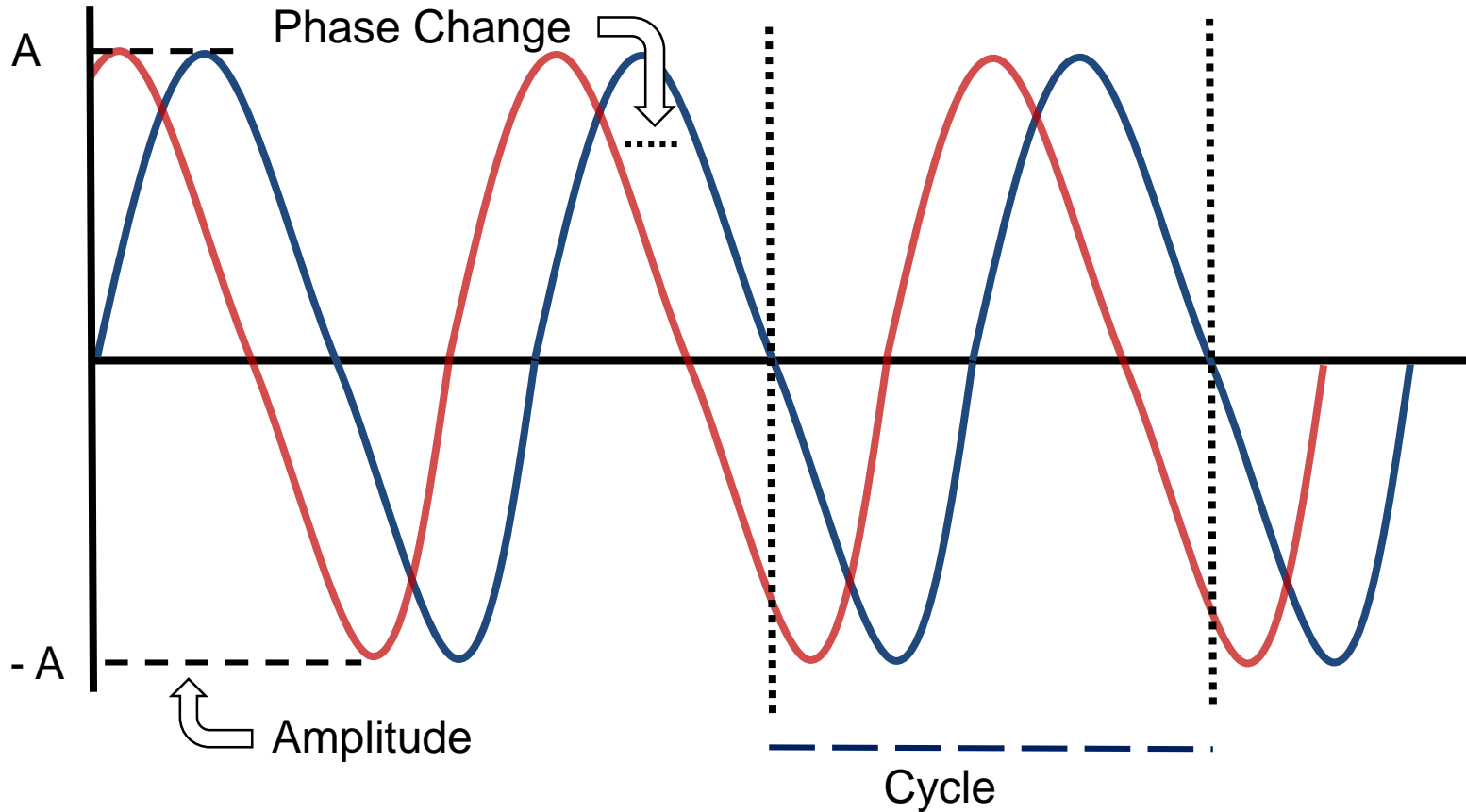
Poll Question #2



Why SAR?



Backscatter Results: Amplitude and Phase

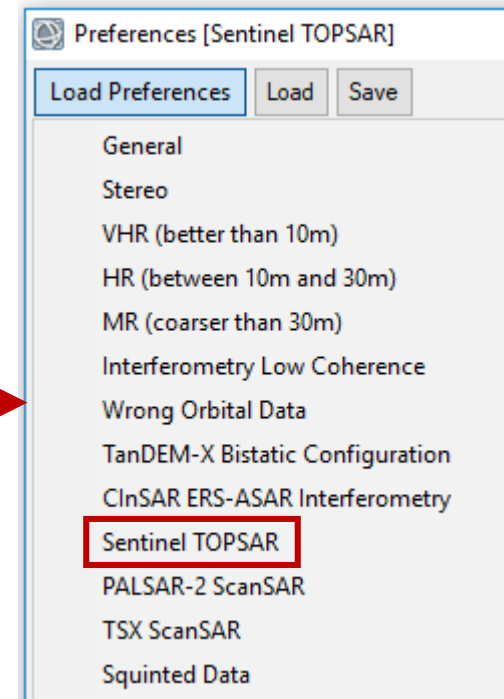
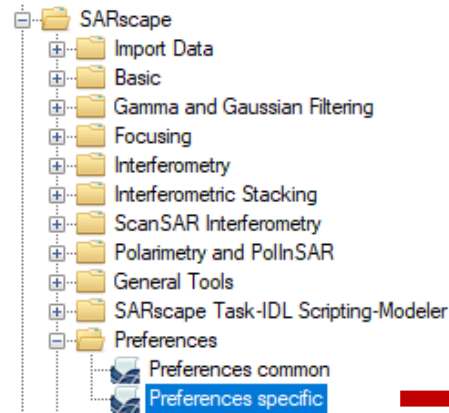
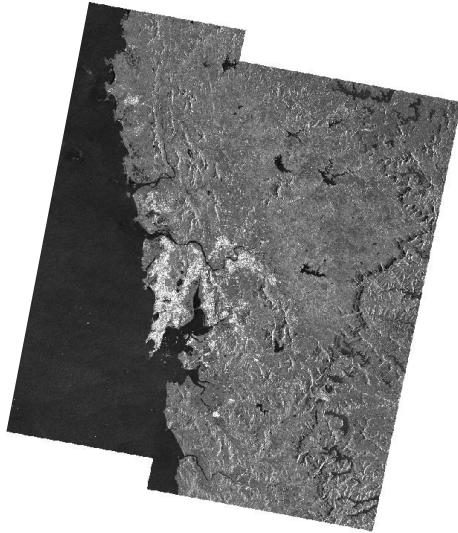
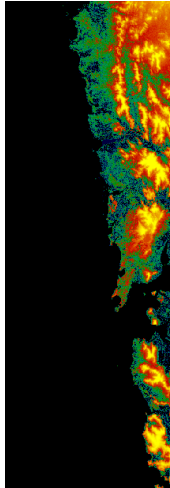


Before you get started



SAR data
DEM

Set format-specific preferences



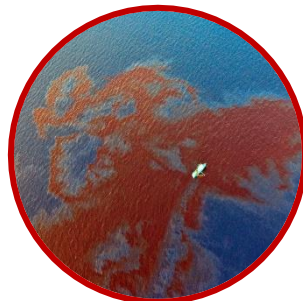
Synthetic Aperture Radar Applications



Landslides



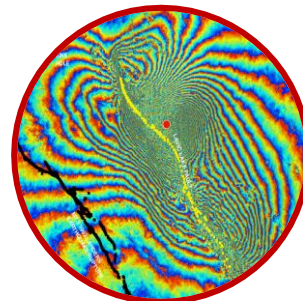
Glaciers and
permafrost



Oil spills



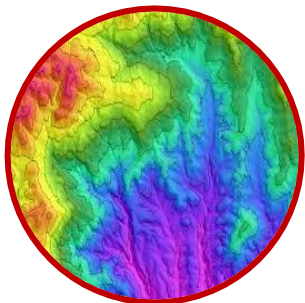
Subsidence



Earthquakes



Shipping



DEM
generation



Burn Area
Analysis



Deforestation



Flooding



Volcano
monitoring



Activity
monitoring

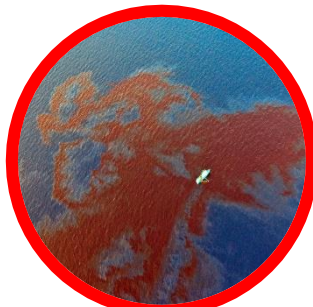
Synthetic Aperture Radar Applications



Landslides



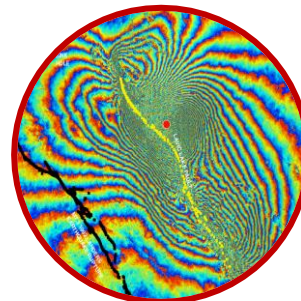
Glaciers and
permafrost



Oil spills



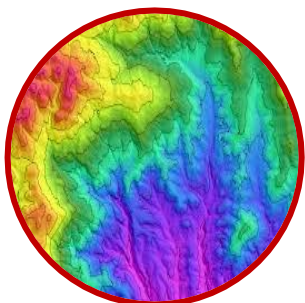
Subsidence



Earthquakes



Shipping



DEM
generation



**Burn Area
Analysis**



Deforestation



Flooding



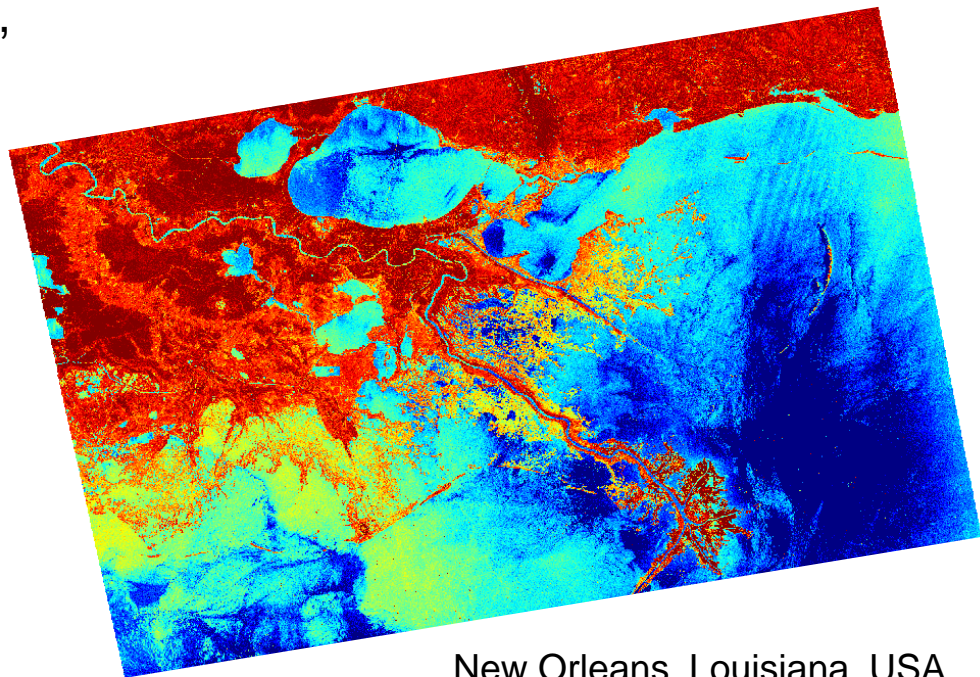
**Volcano
monitoring**



Activity
monitoring

SAR views the surface water conditions, allowing us to view important features such as:

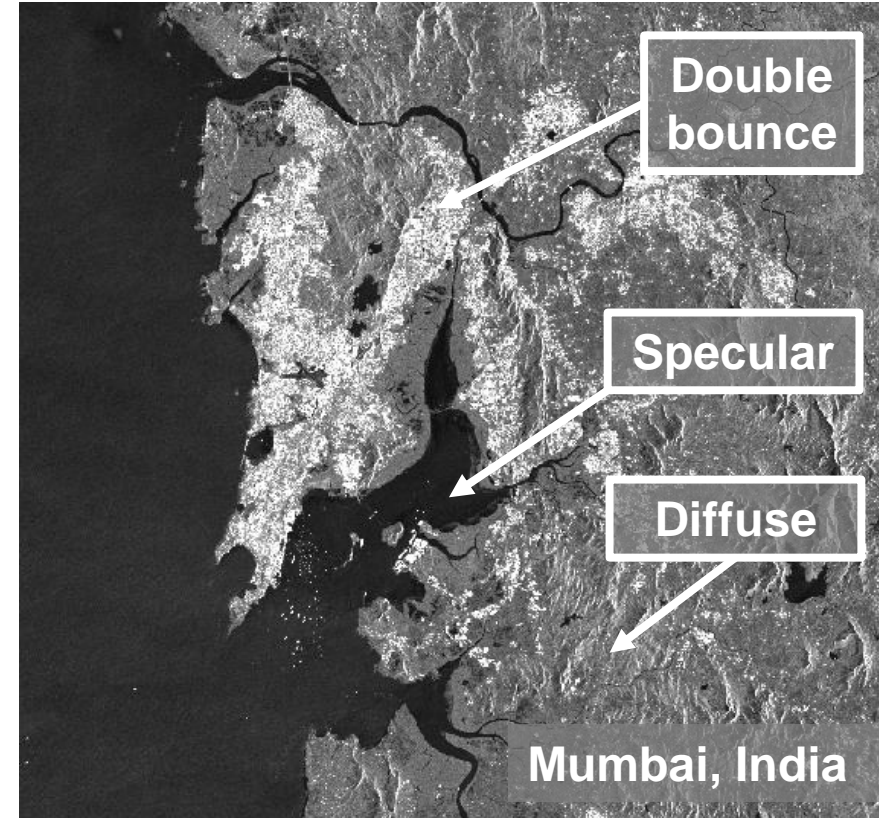
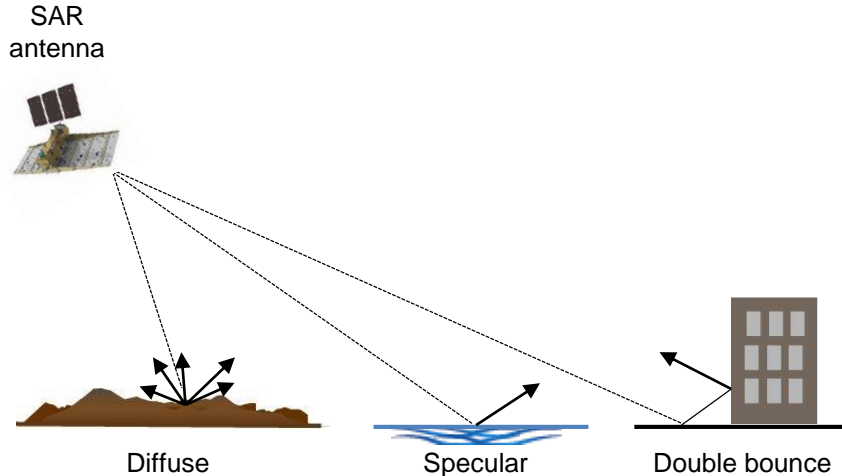
- Waves
- Tides and Currents
- Shallow Bathymetry
- Wind effects
- Oils or other surface coverings



New Orleans, Louisiana, USA
and the Gulf of Mexico
May 15, 2016 – Sentinel-1

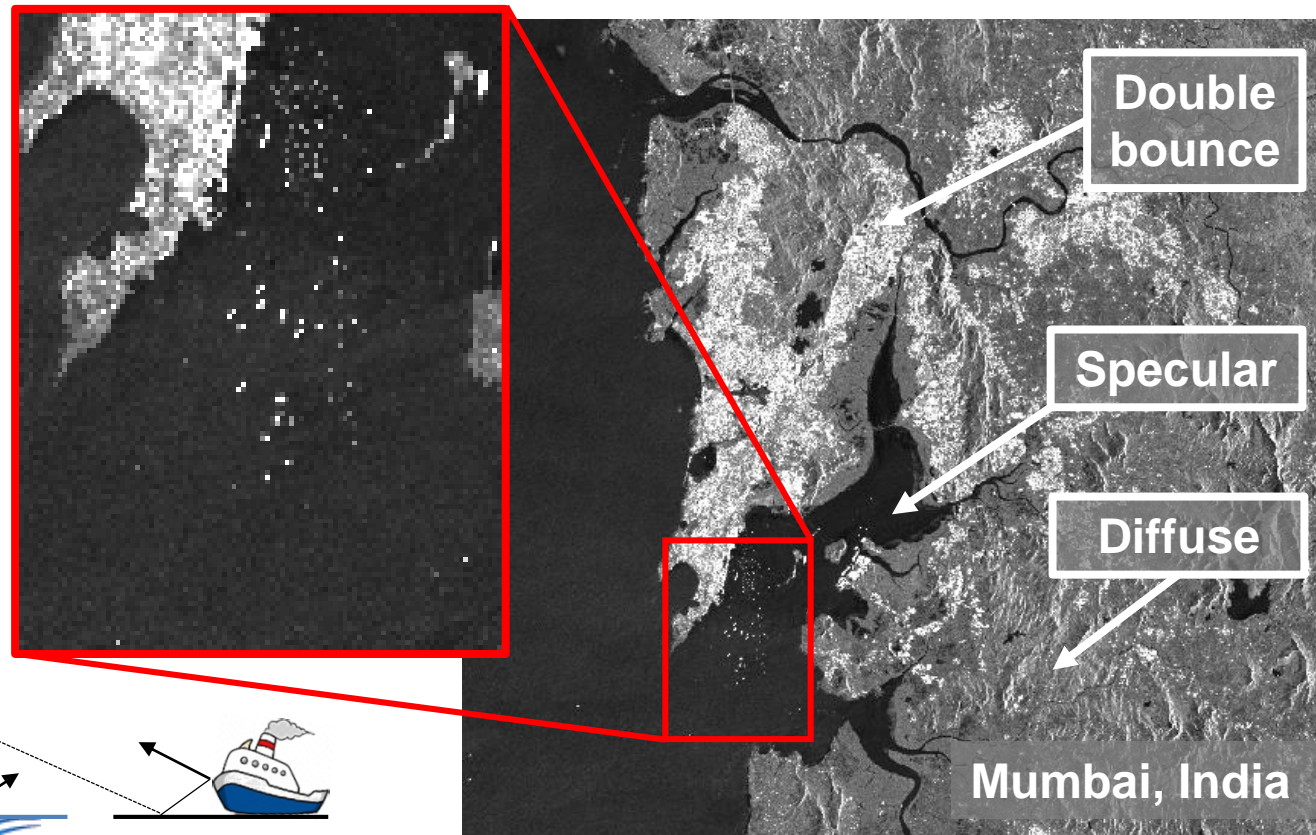
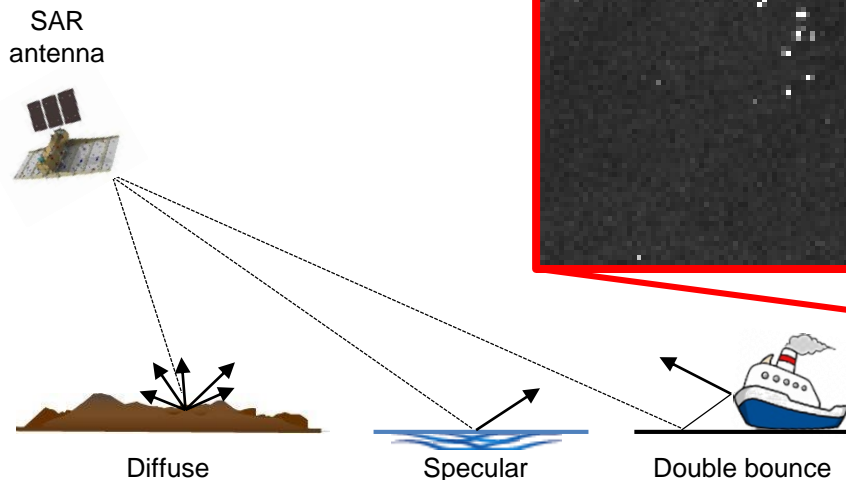
Ship Detection

Differences in radar backscatter highlight ships against water



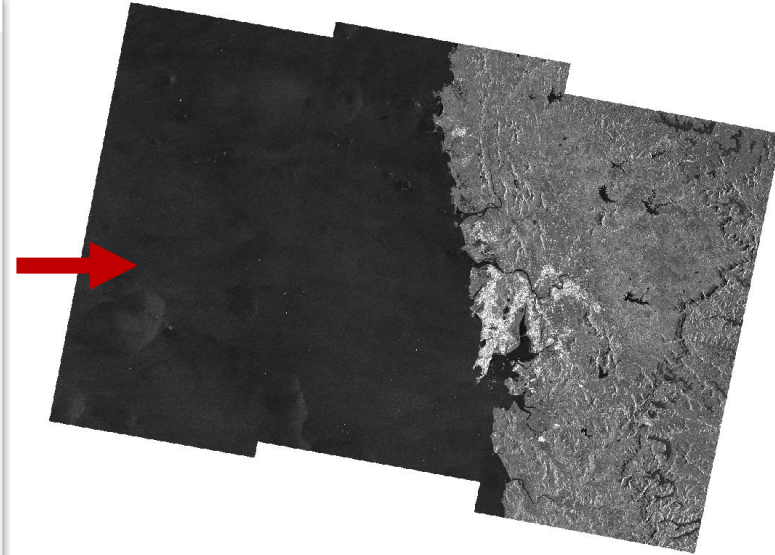
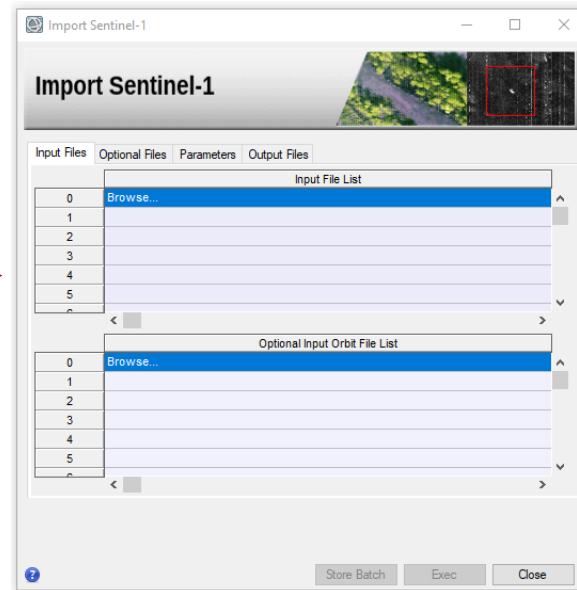
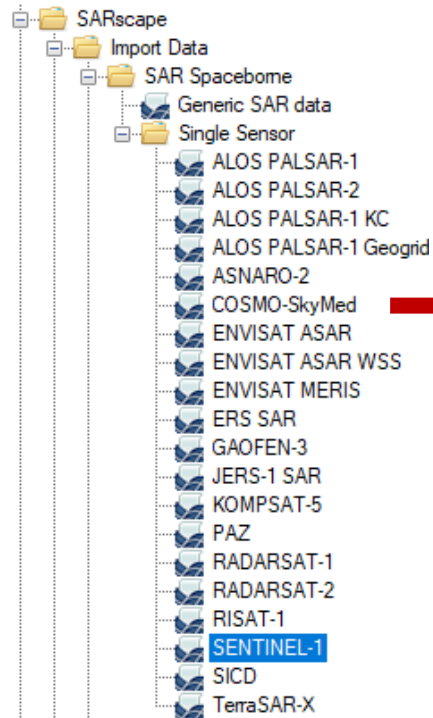
Ship Detection

Differences in radar backscatter highlight ships against water



Ship Detection – Step 1: Data Import

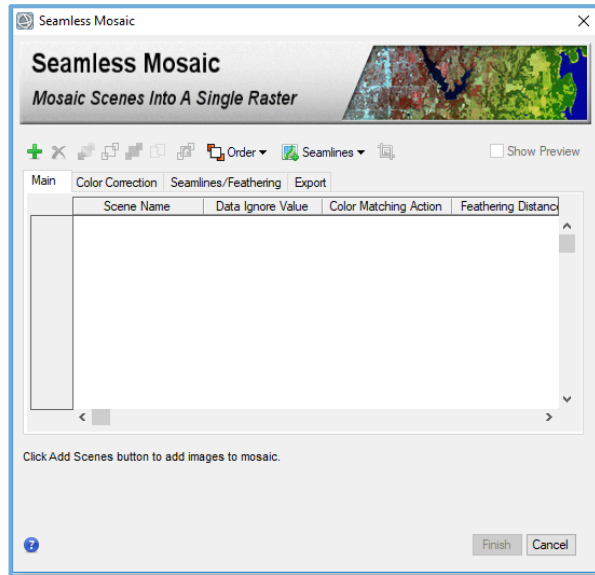
Import Sentinel-1 GRD Data



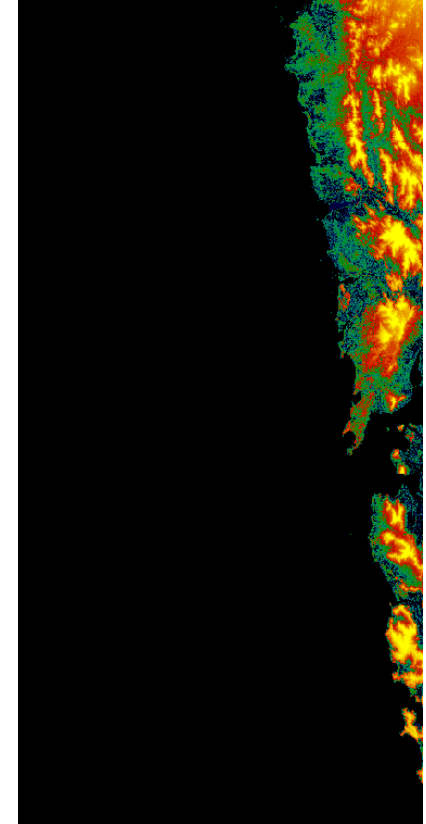
GRD data is already converted to ground range

Ship Detection – Step 2: DEM Import

ASTER DEM: allows for simple land mask creation

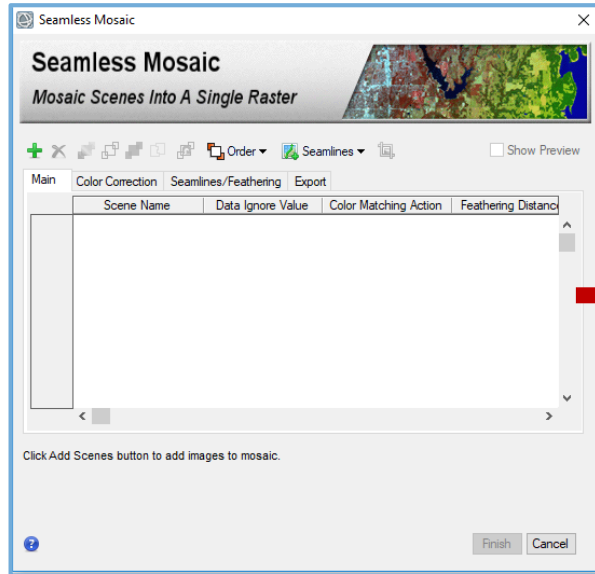


Mosaic DEM tiles
(if needed)

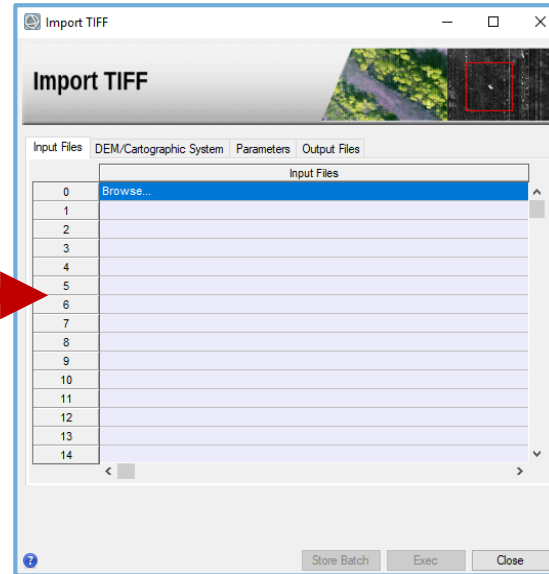


Ship Detection – Step 2: DEM Import

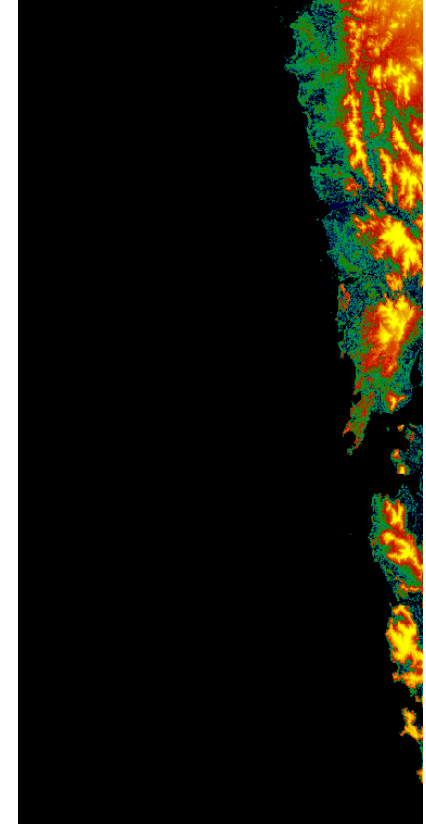
ASTER DEM: allows for simple land mask creation



Mosaic DEM tiles
(if needed)

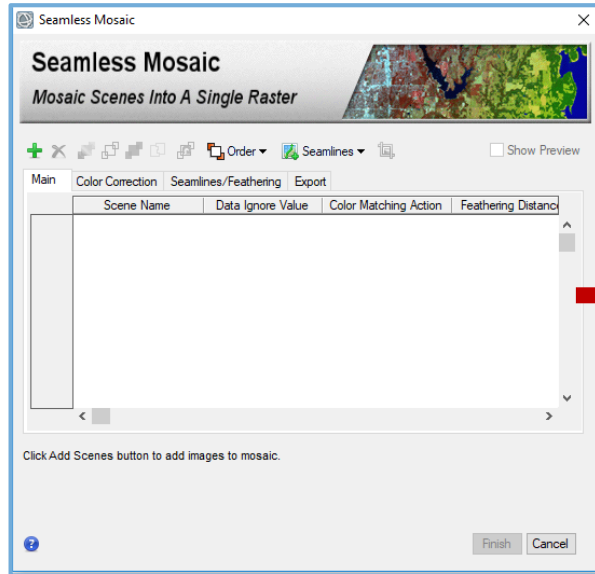


SARscape import Generic tiff

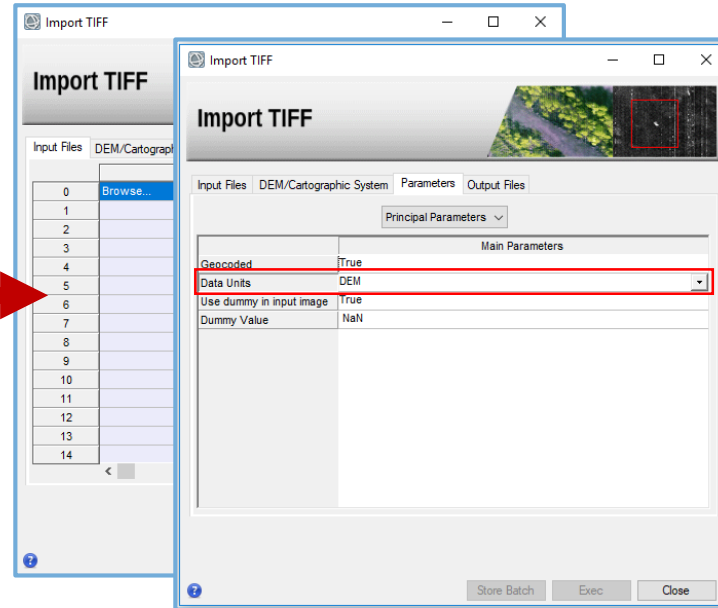


Ship Detection – Step 2: DEM Import

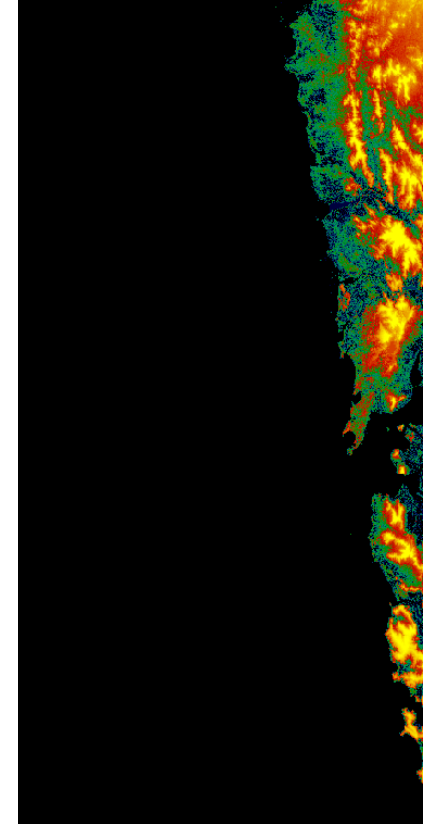
ASTER DEM: allows for simple land mask creation



Mosaic ASTER DEM tiles
(if needed)

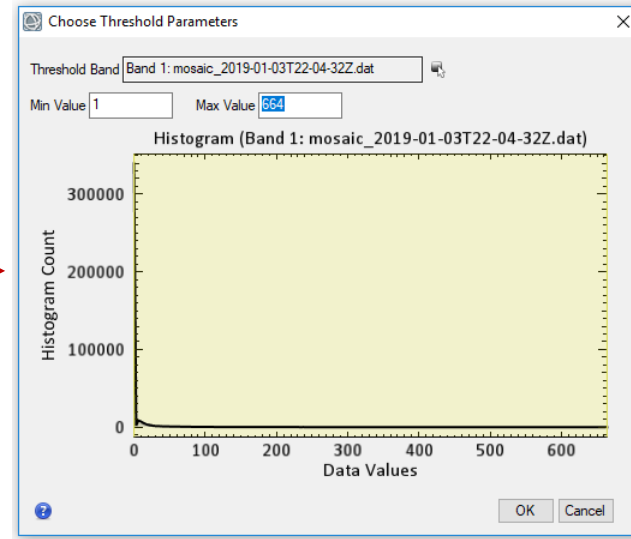
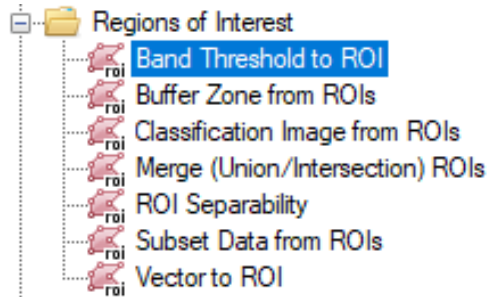


SARscape import Generic tiff



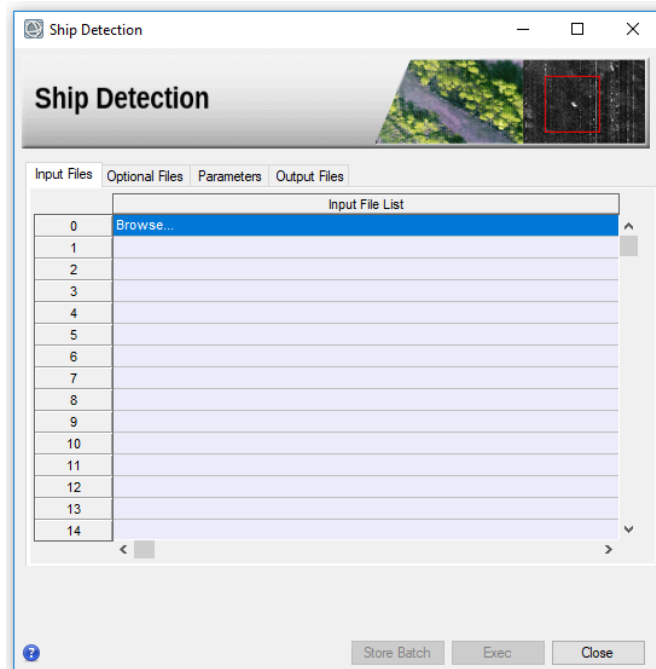
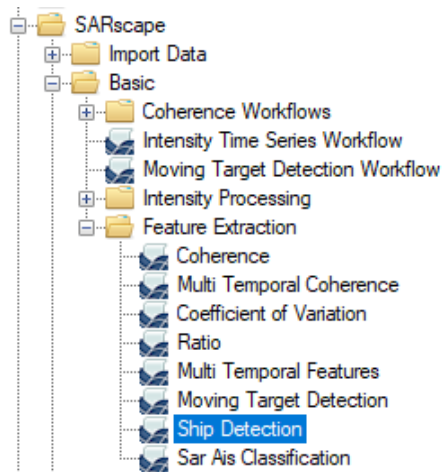
Ship Detection – Step 3: Land Mask

Threshold DEM to ROI

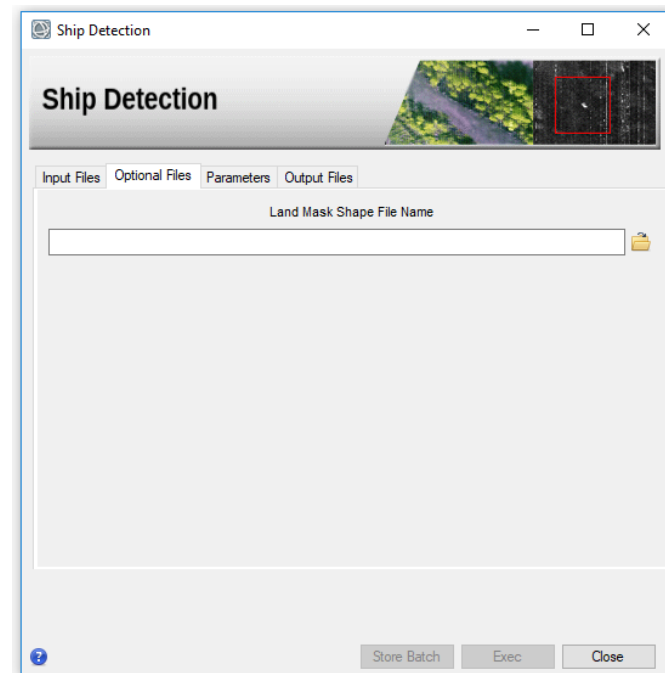


Min value = 1

Ship Detection – Step 4: Ship Detection Tool



SAR Data input



Mask from DEM

Ship Detection – Step 4: Ship Detection Tool



Parameter	Significance
Target window	Size of target
Guard window size	Buffer around target
Background window size	Background value calculation
Land mask buffer size	Buffer around land mask to reduce noise

Ship Detection

Ship Detection

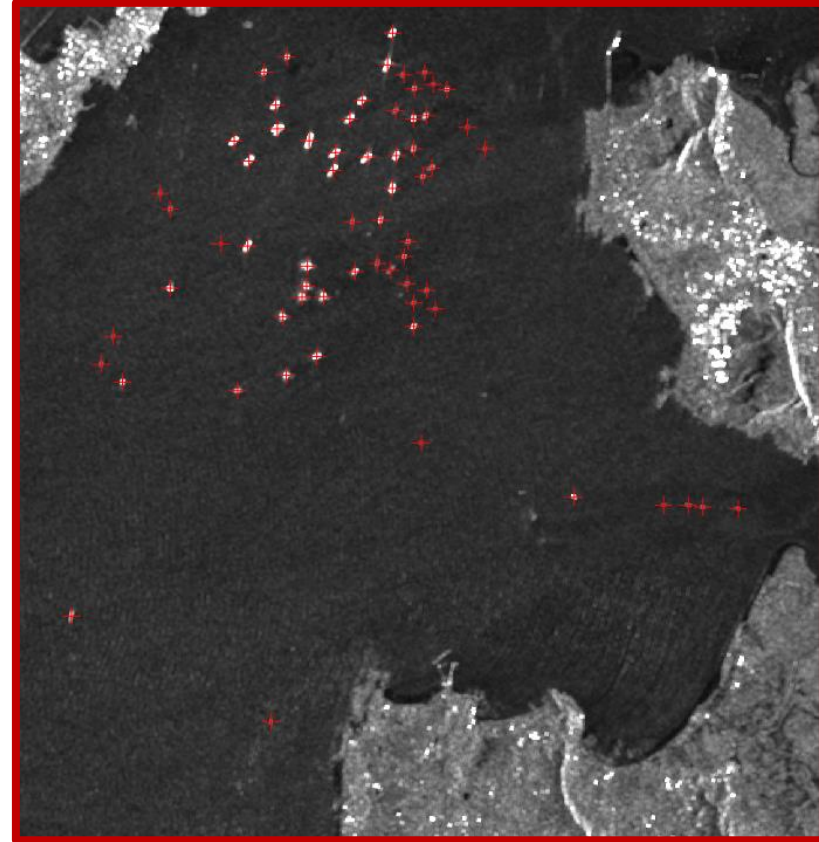
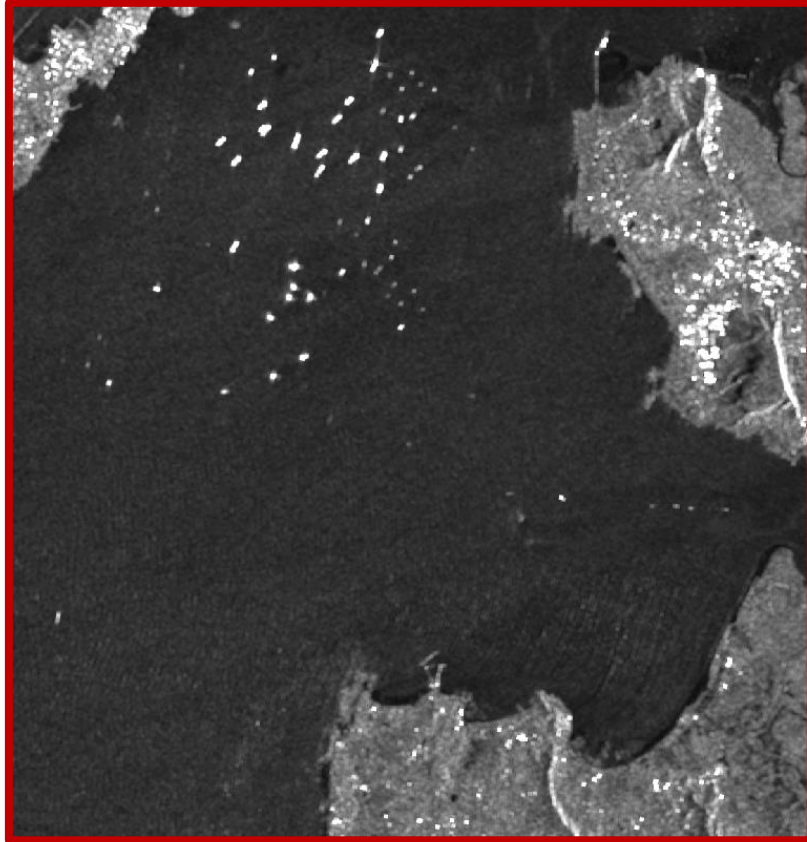
Input Files Optional Files Parameters Output Files

Principal Parameters

Main Parameters	
Target Window Size [m]	75
Guard Window Size [m]	400
Background Window Size [m]	1000
Probability Of False Alarm [0-1]	0.001
Minimum Mean Sigma0 [dB]	-10
Minimum Ship Size [pixels]	1
Generate KML	True
Land Mask Buffer Size [m]	0

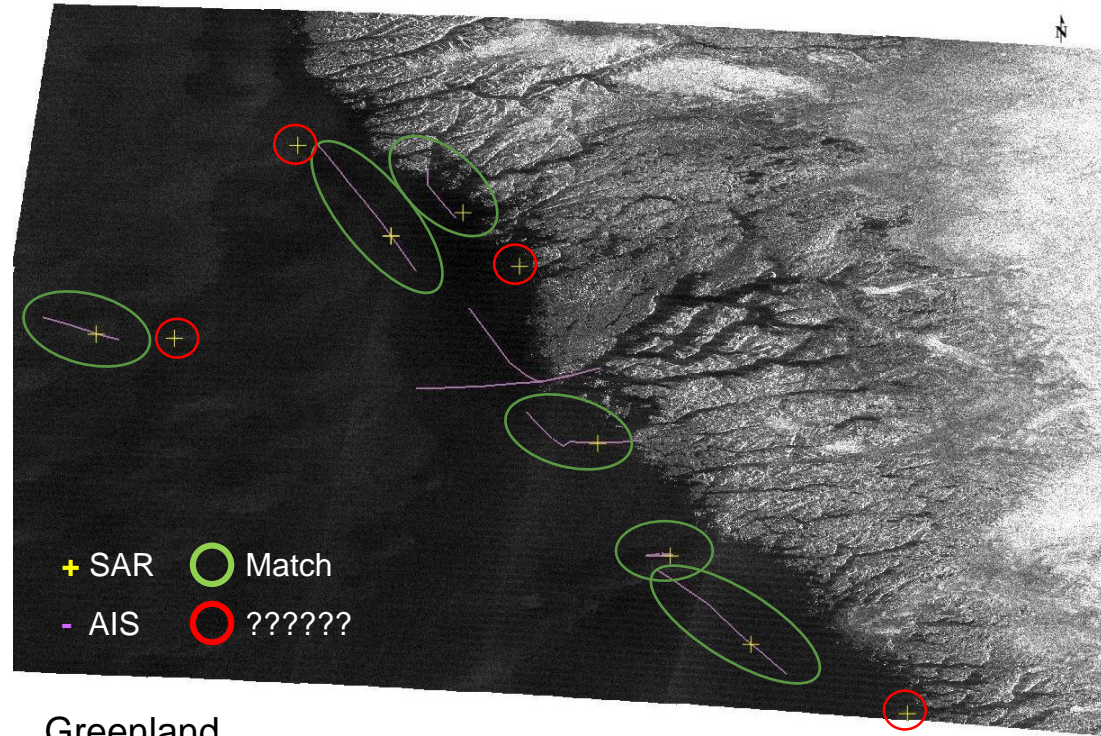
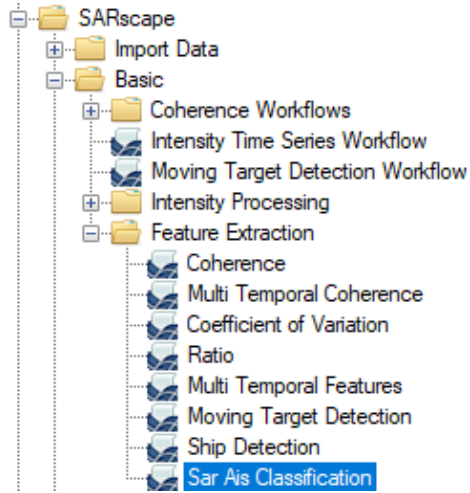
Store Batch Exec Close

Ship Detection: Output



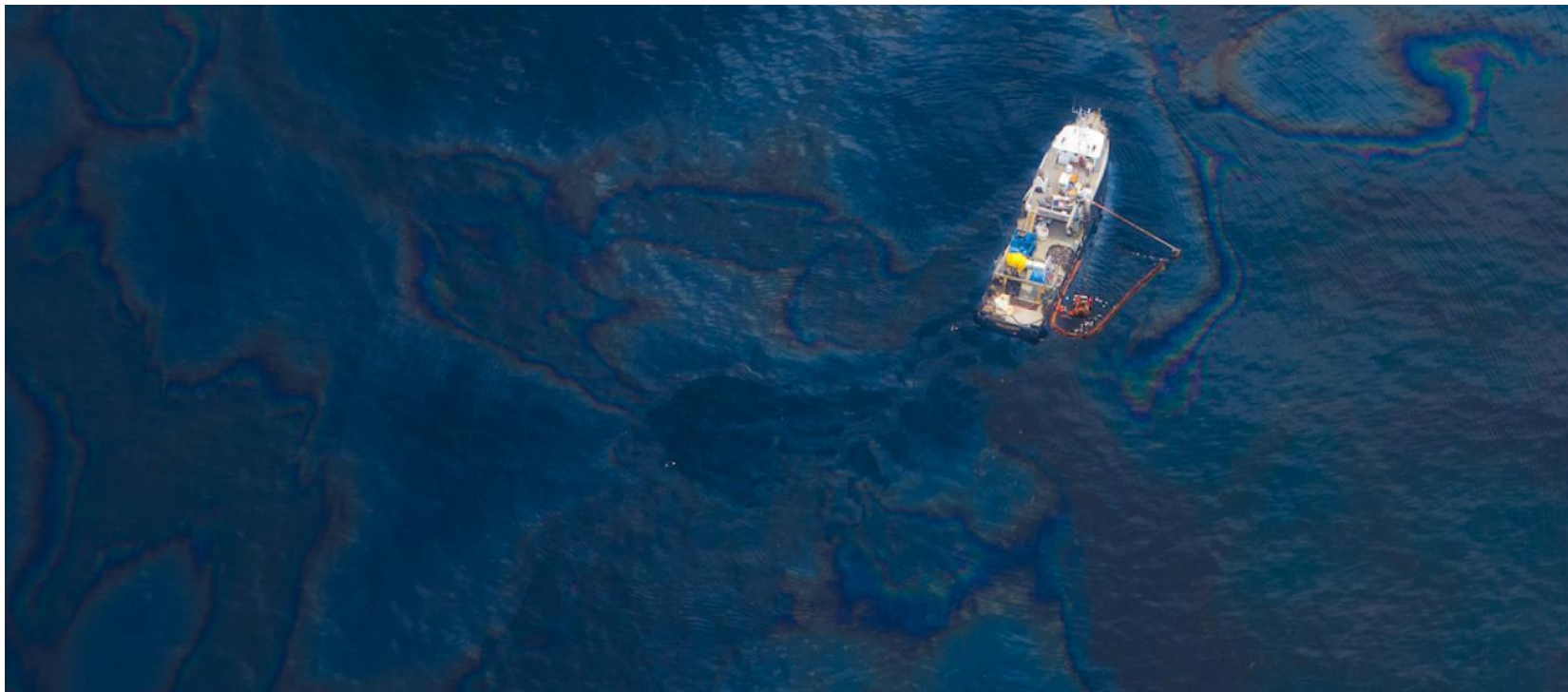
Ship Detection with AIS

AIS (Automatic Identification Systems) documentation for ships can be used with the ship detection tool



Greenland
Radarsat-2 data
SAR & AIS matching

Oil creates a heavy sheen on the water surface, differentiating it from surrounding water.



Background – Ennore and Gotland Island

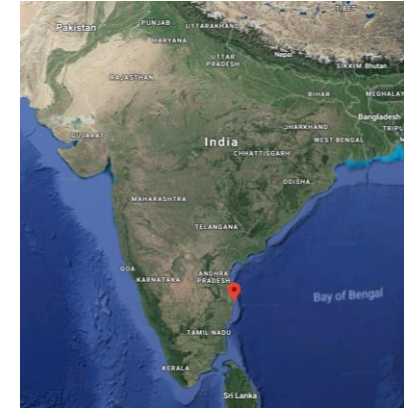


Ennore Oil Spill

Date: 28 January 2017

Cause: BW Maple collided with Dawn Kanchipuram

Where: Kamarajar Port, Ennore India



Gotland Island

Date: May 2005

Cause: Unknown

Where: Gotland Island, Sweden



Data:

Sentinel-1 SLC

Process:

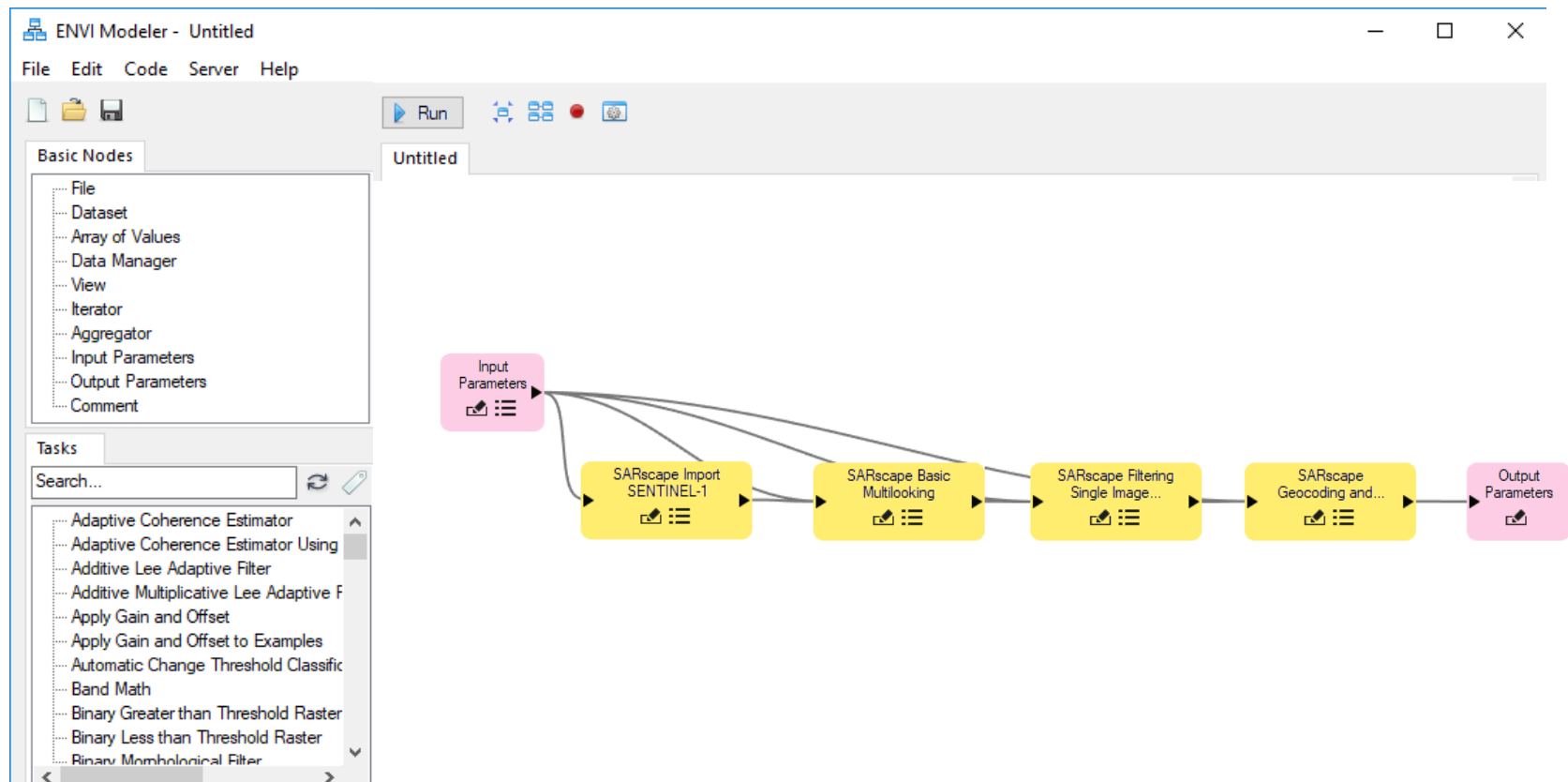
Import Sentinel-1 SLC

Preprocess

Create ROI



Oil Spills Workflow



Multilook

Filter

Geocode



Multilook

Filter

Geocode



Multilook

Filter

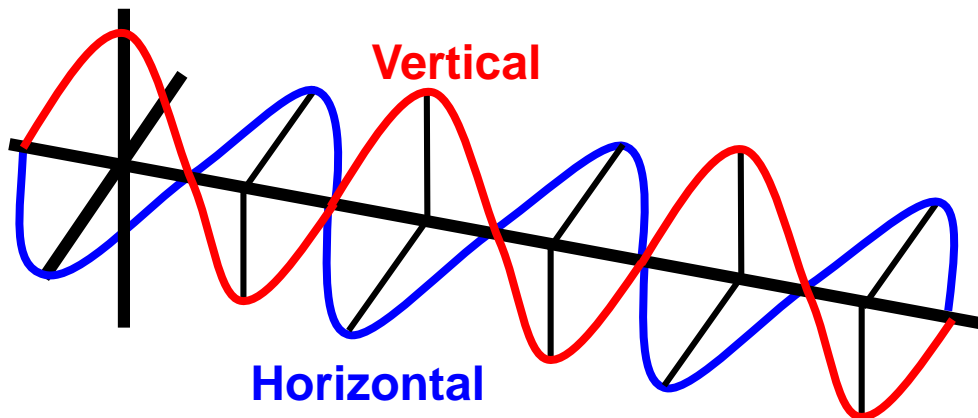
Geocode



Polarization Choices

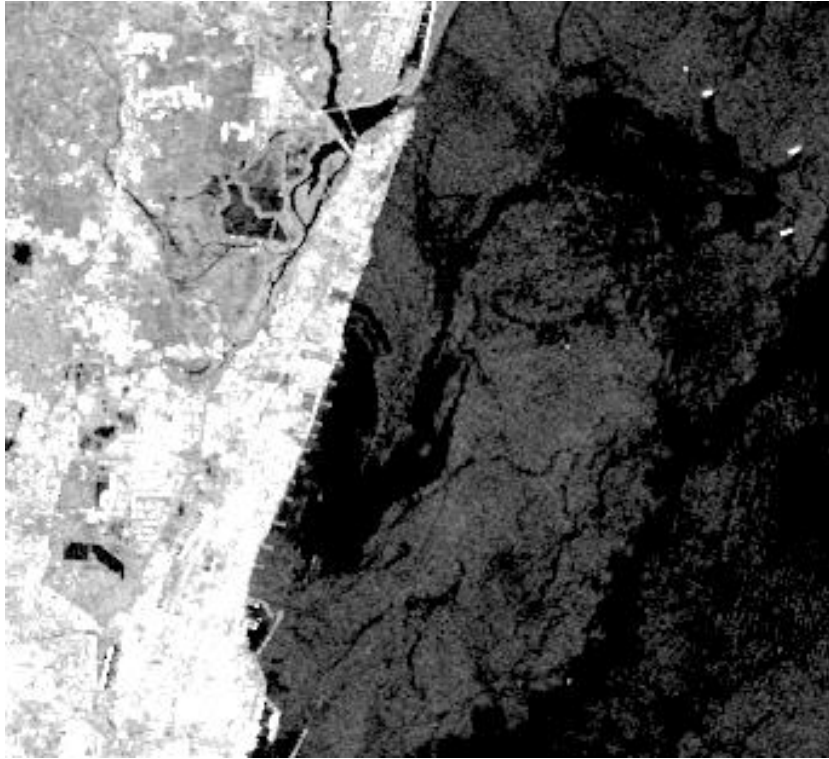
SAR satellites have multiple polarizations, from single pole (such as only VV or HH) to quad-pole (which returns all variations)

Each polarization interacts differently with the surface it hits, adding information to the scene



Polarization	Physical Meaning
VV	Vertical wave, outgoing and incoming
HH	Horizontal wave, outgoing and incoming
VH	Vertical Wave outgoing, Horizontal Wave incoming
HV	Horizontal Wave outgoing, Vertical Wave incoming

Oil Spill – Why Polarization is Important

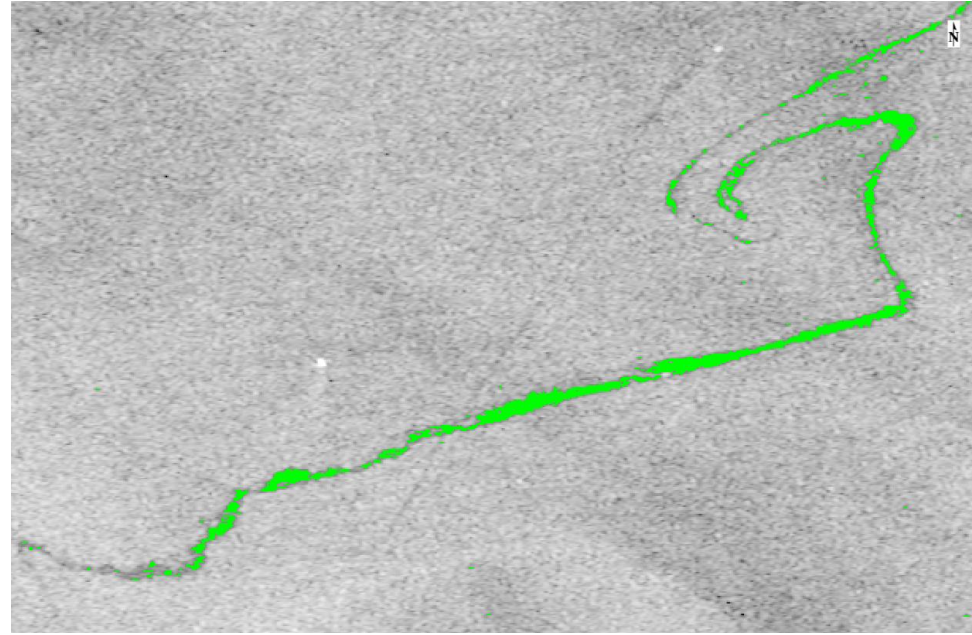
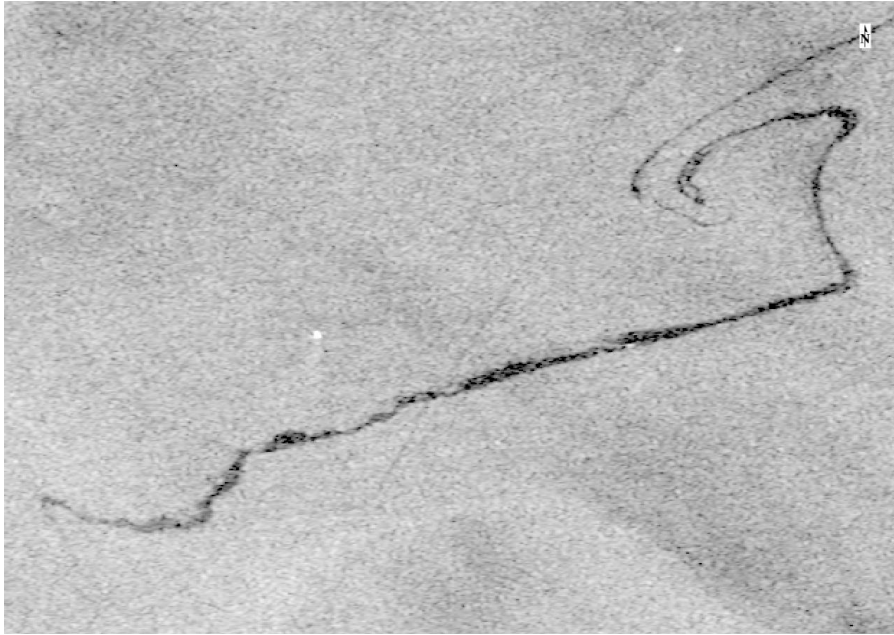


VV

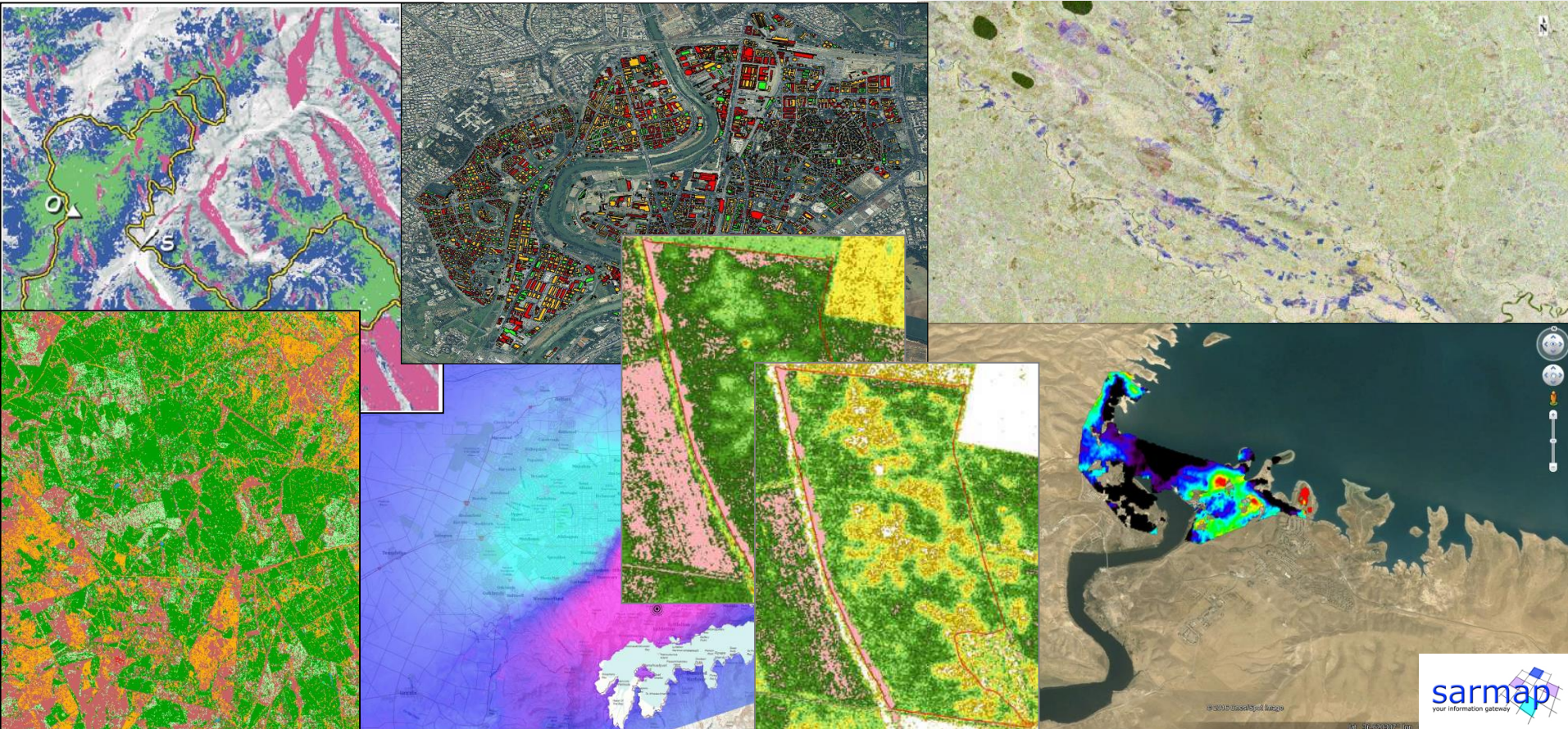


VH

Oil Spills – Area with ROI/Classification



Land Applications

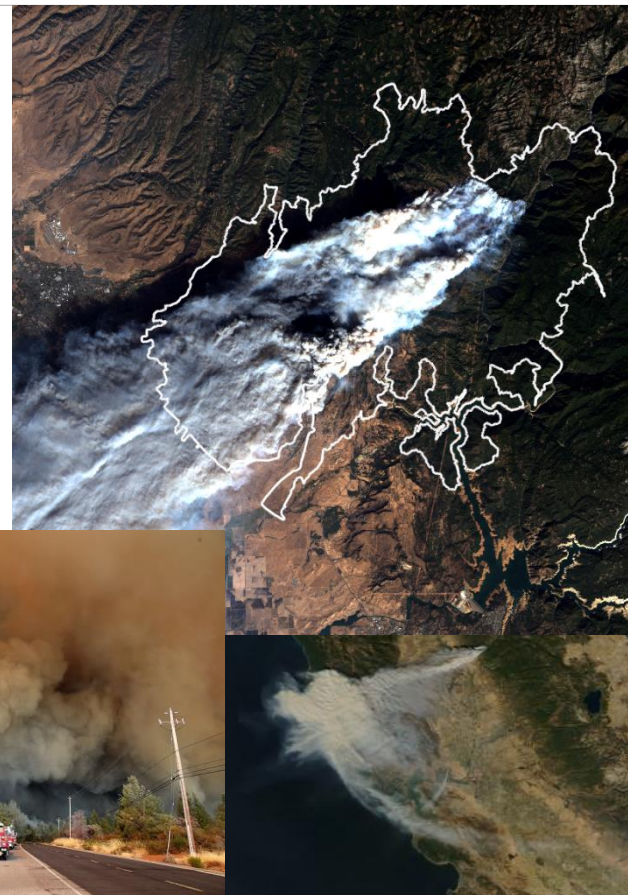


Burn Area Analysis – Camp Fire

Camp Fire, Butte County California USA
November 8th – November 25th

The Camp fire is the deadliest wildfire that has ever occurred in California, with 88 people were killed, and 18,000 buildings were destroyed.

The smoke of the Camp Fire inundated the Bay Area of California, causing the worst air pollution globally for days.



Data:

Sentinel-1 SLC scenes

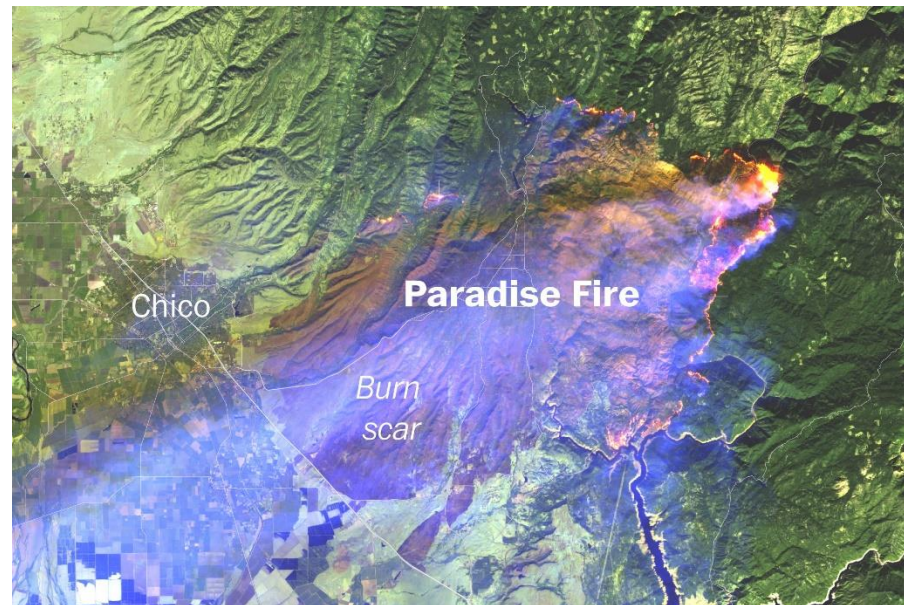
DEM GTOPO 30

Camp Fire Shapefile

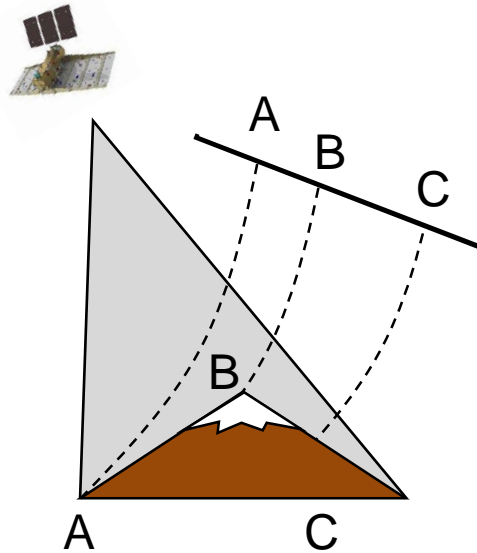
Process:

Import SAR SLC data

Run Coherent Change Detection Timeline Workflow

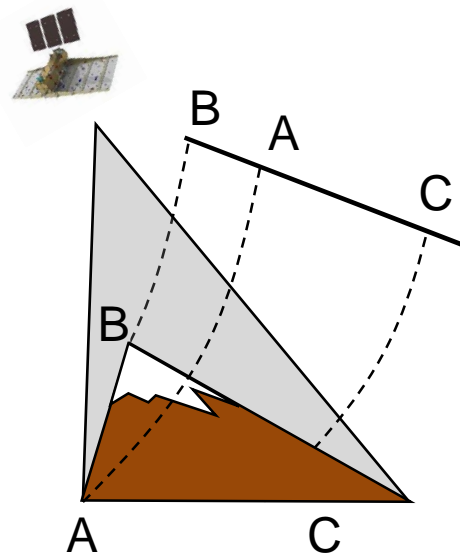


Geometric Effects in SAR Imagery



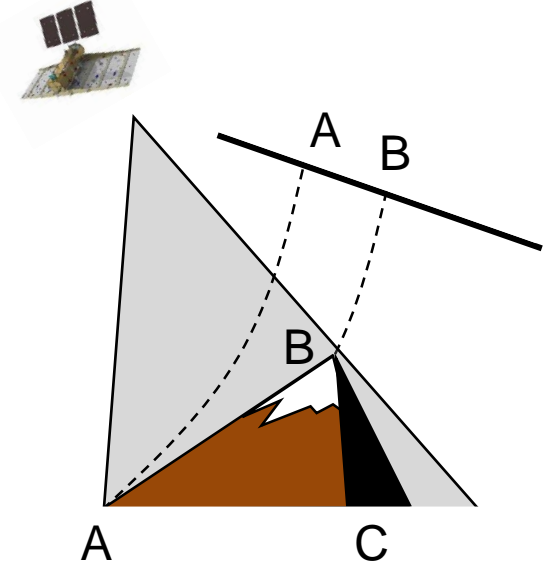
Foreshortening:

When an area is “squished” caused by change in vertical and horizontal placement emphasized by imaging angle



Layover:

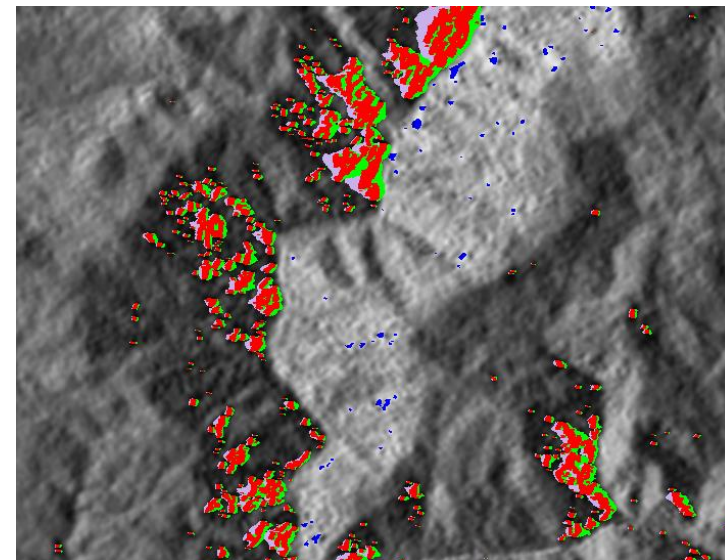
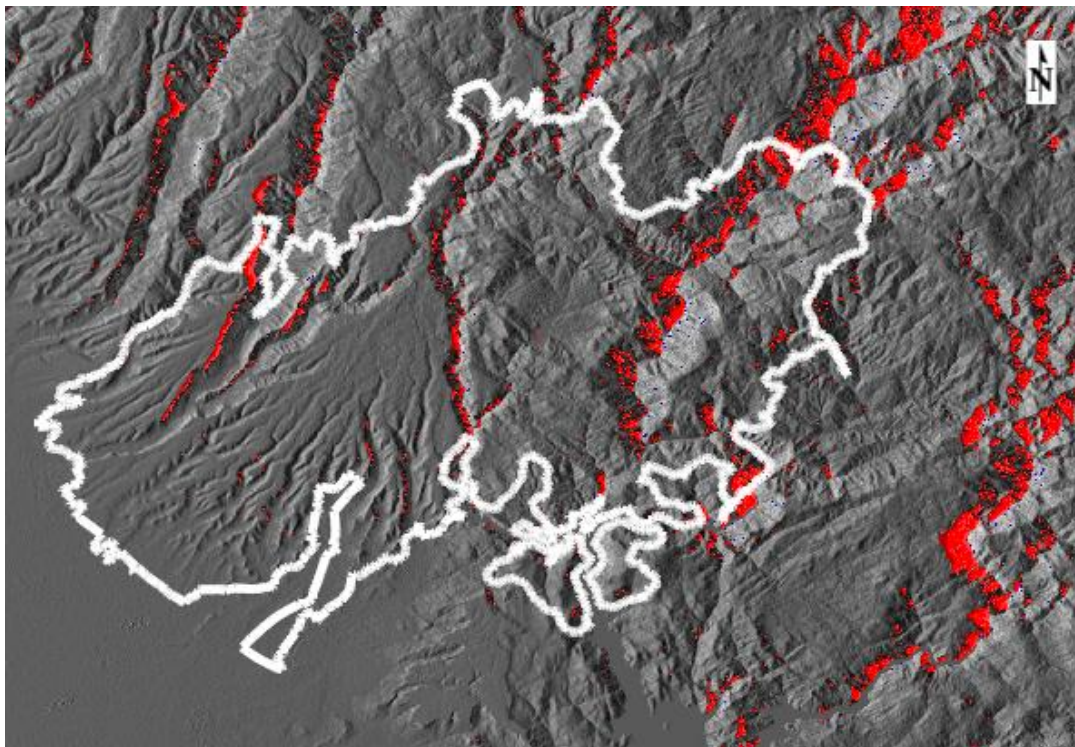
Extreme foreshortening, when a point is seen as occurring before another point



Shadowing:

When an area is covered by other areas

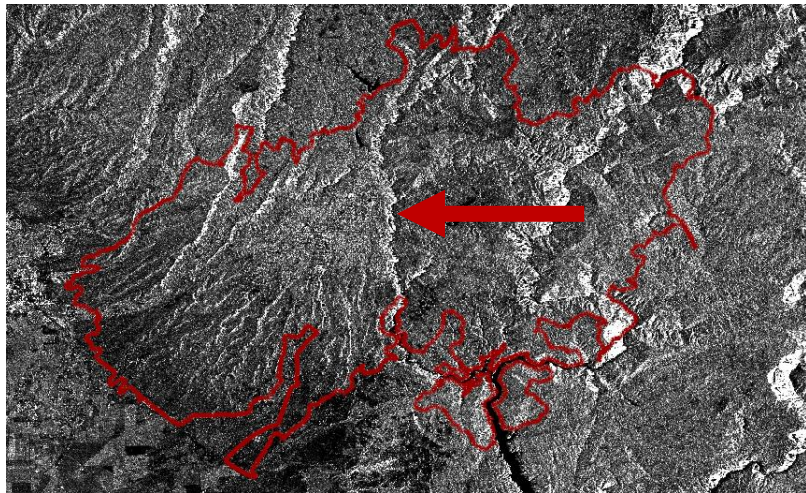
Layover and Shadow



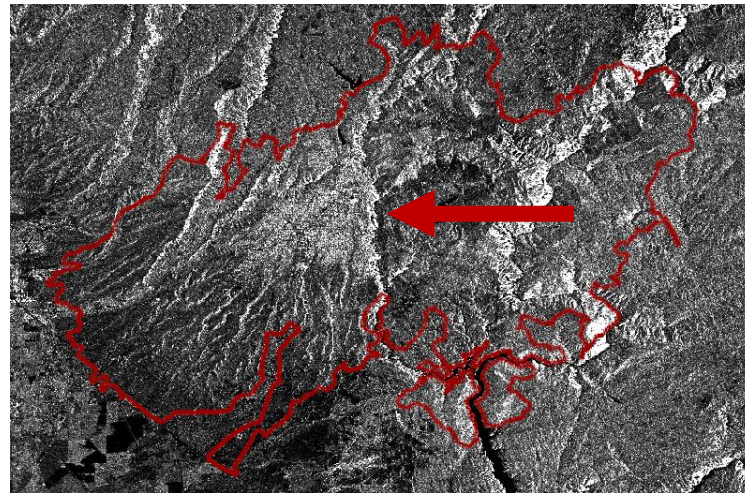
- Layover Active
- Layover Near Passive
- Layover Far Passive
- Shadow Active
- Shadow Passive
- Layover Shadow

Coherence Change Detection uses the similarities between the phase responses of multiple images.

The phase is influenced greatly by surface roughness and changes in surface features.

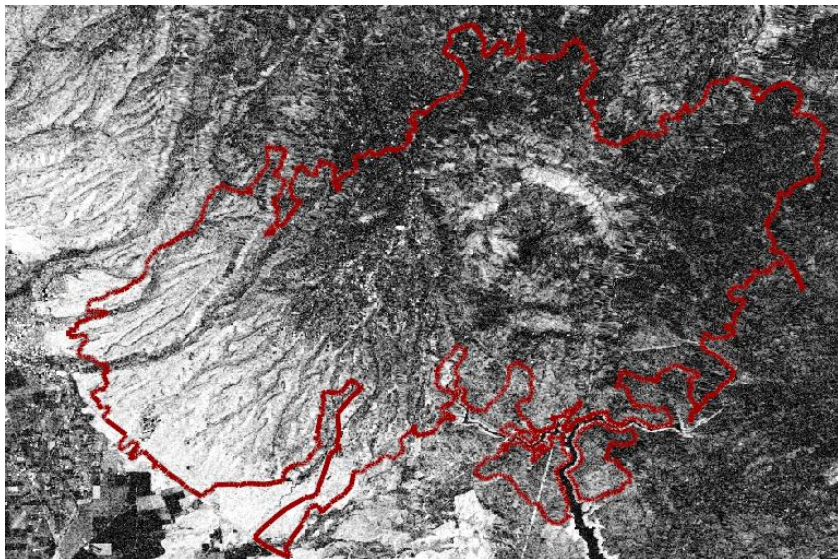


Pre-Fire Intensity

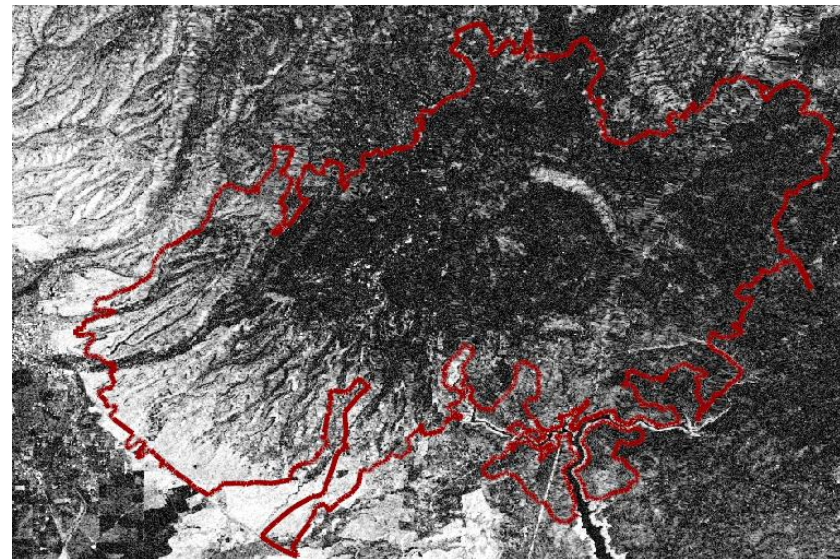


Co-Fire Intensity

Burn Area Analysis- CCD



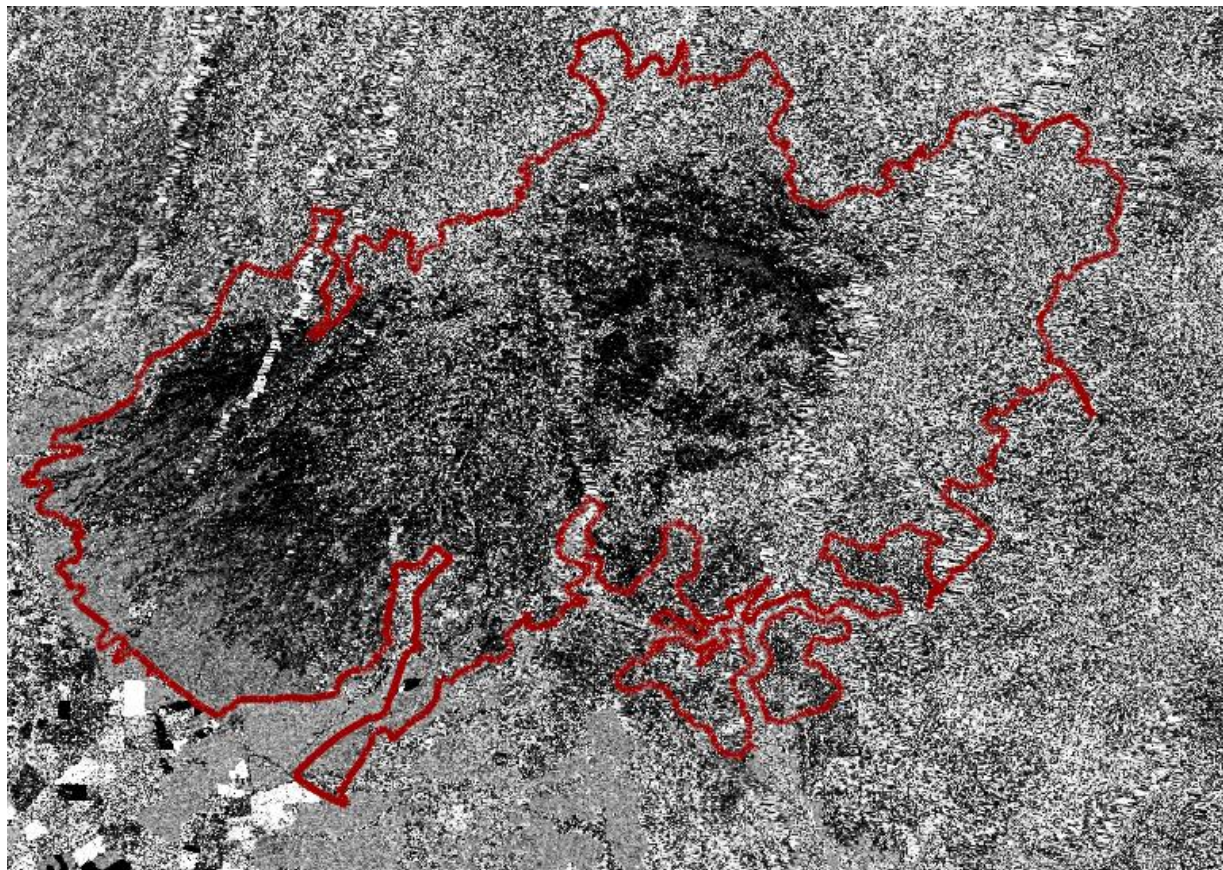
—



Pre-Fire Coherence:
October 16th and 28th

Co-Fire Coherence:
October 28th and November 9th

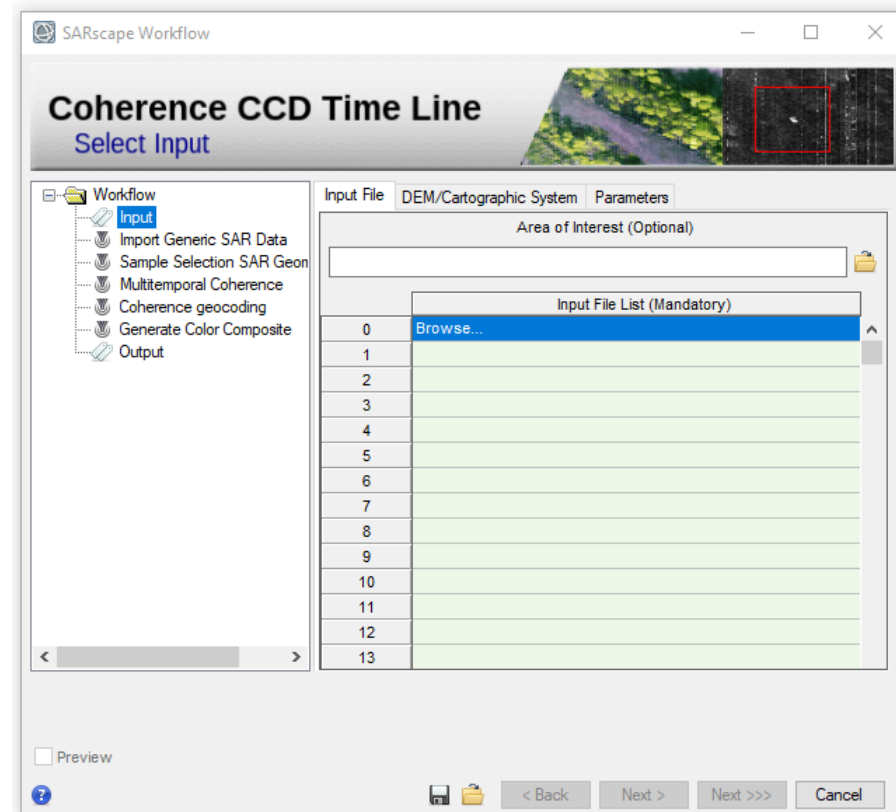
Coherence change between
pre- and co-fire pairs



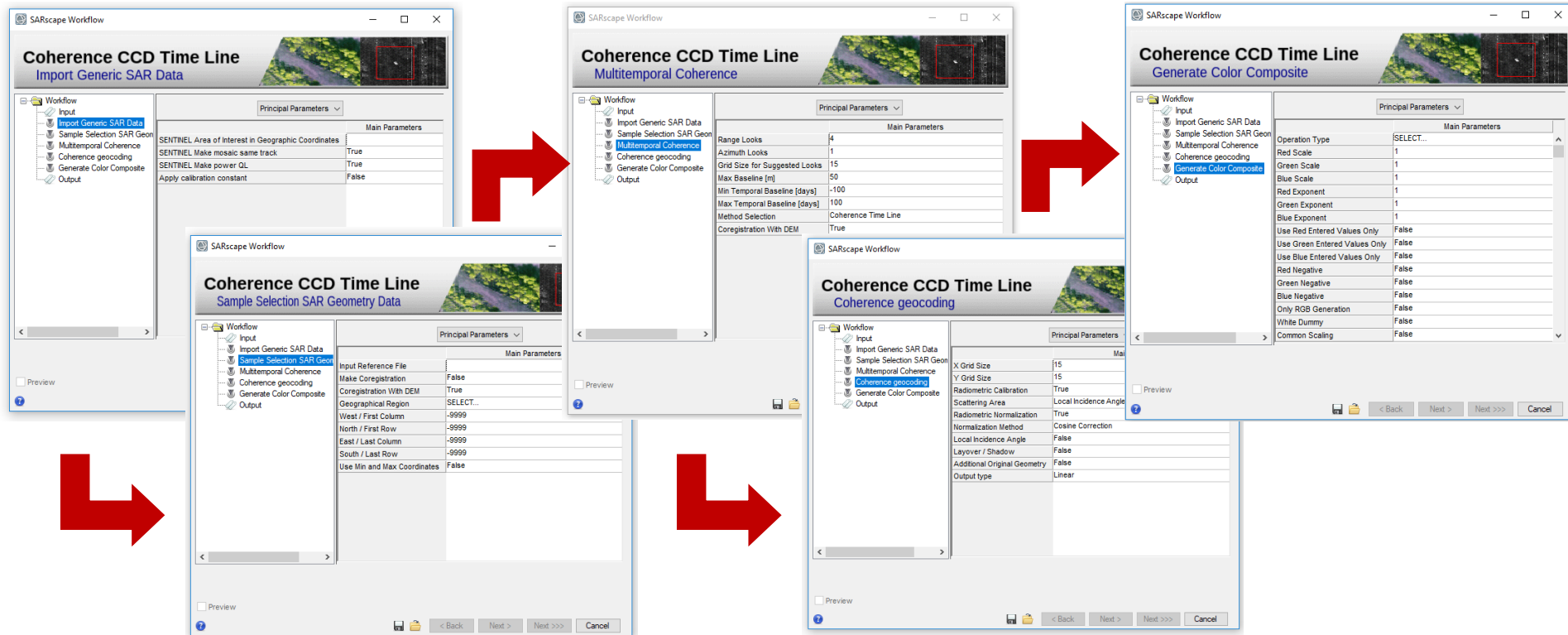
Burn Area Analysis Workflow



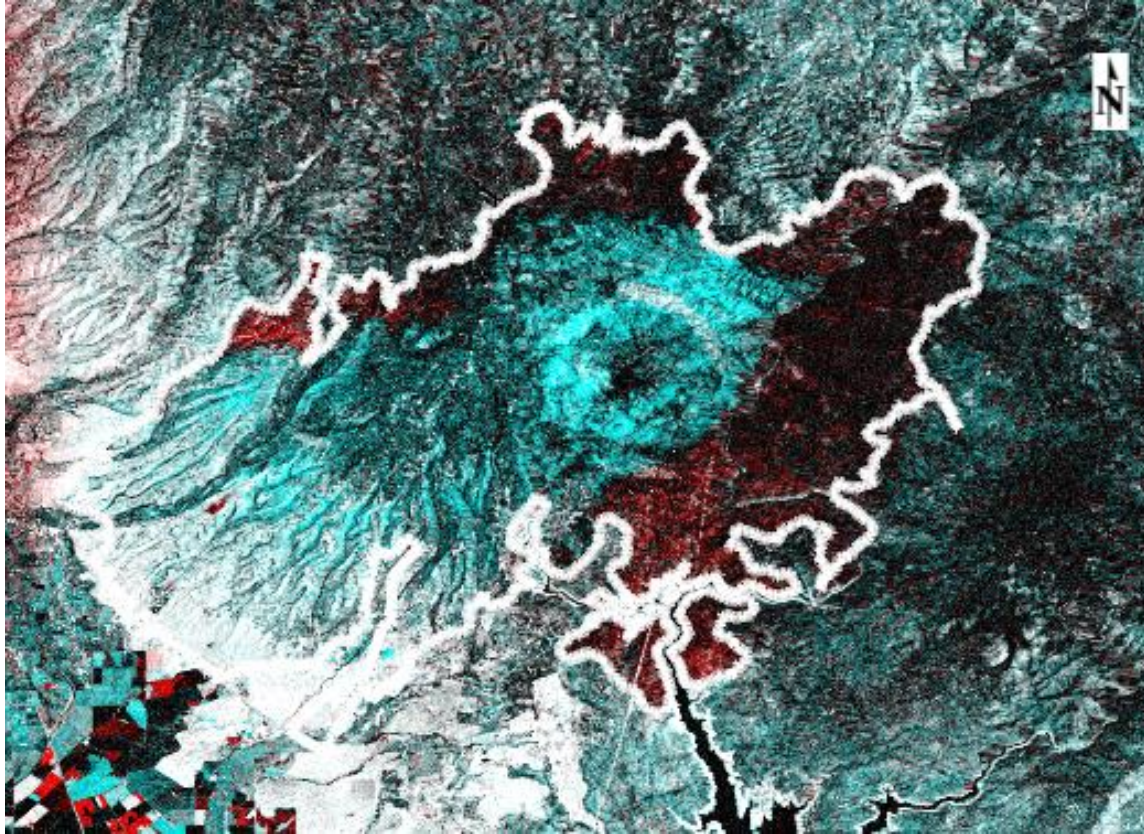
ILU	Coherence Map Average Backscatter Absolute Value of the Difference
MTC	Master Backscatter Slave Backscatter Coherence
MICCD	First Coherence Second Coherence Second Coherence
COV-PWR-CC	Spatial-Coefficient of Variation of average backscatter Average Backscatter of Master/Slave Coherence



Burn Area Analysis Workflow



Camp Fire, California, USA



3 Sentinel-1 scenes

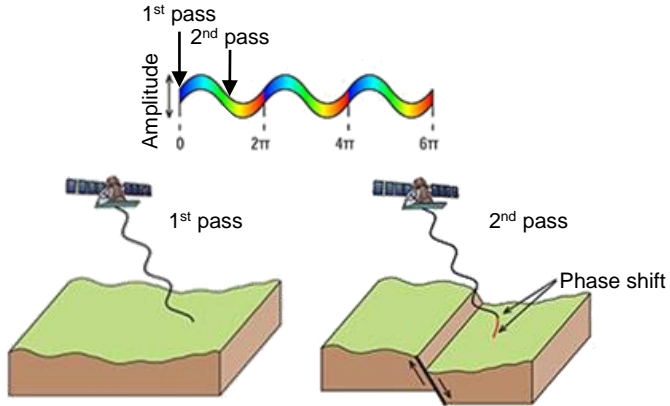
Blue/Green is large change
between October 28 and
November 9

Red is change between
November 9 and November
21

DInSAR Displacement

- Detect mm displacement
- Volcanoes & Earthquakes
- Ongoing subsidence

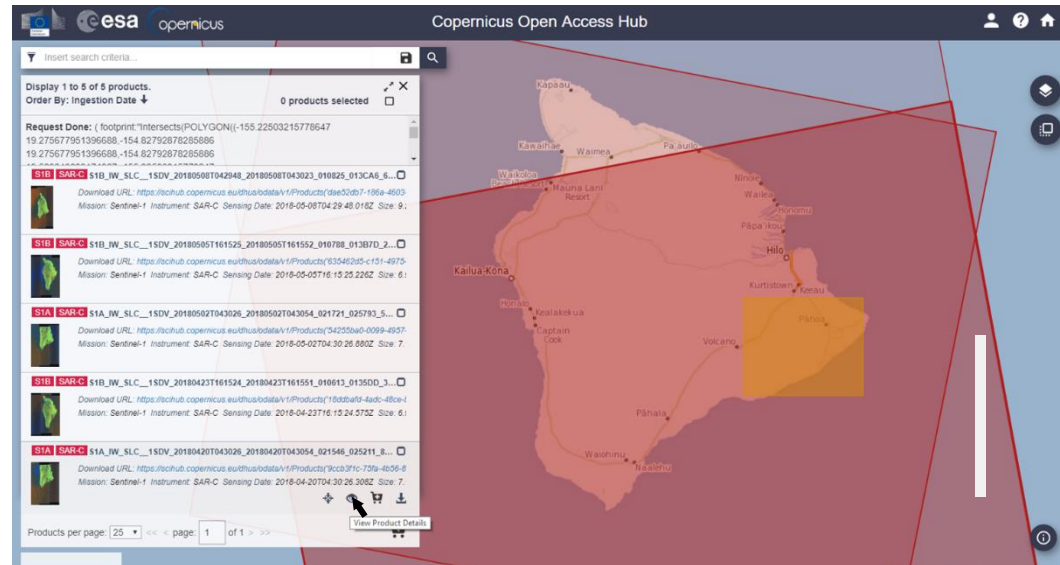
Change in phase from T1 to T2



Hawaii, USA – 2018

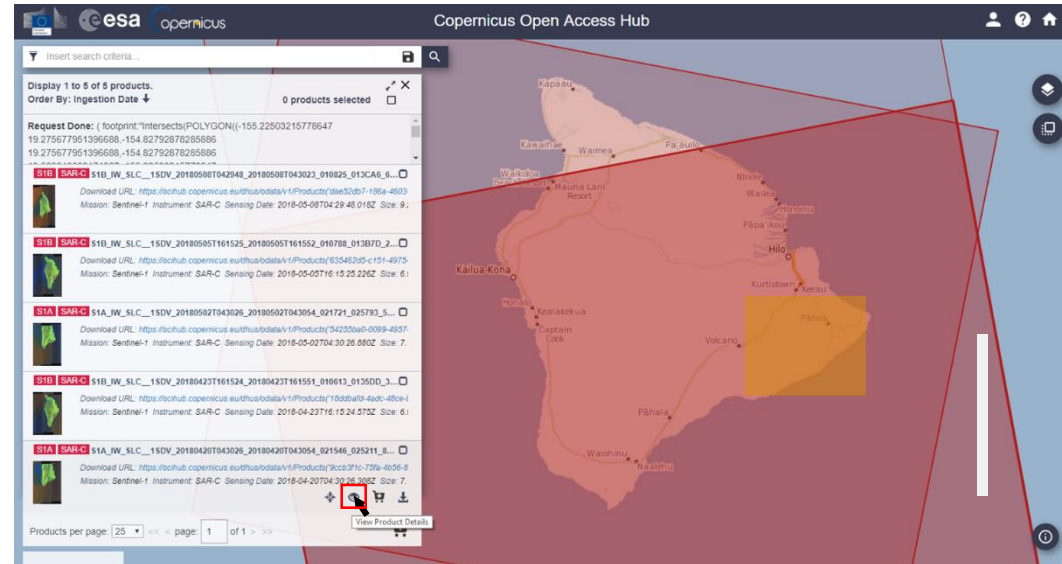
Important things to consider when preparing your data:

- Don't mix
 - satellites
 - relative orbit numbers
 - acquisition geometries
- Only use co-polarized data for interferometry
- Low coherence = trouble



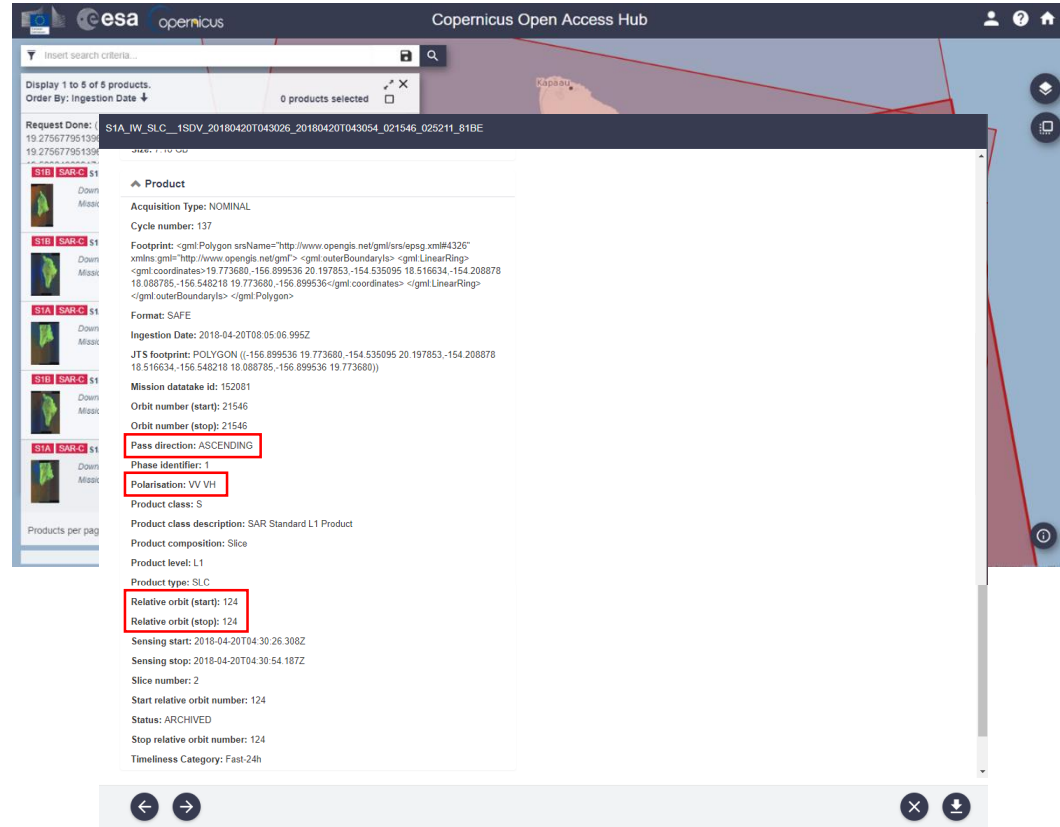
Important things to consider when preparing your data:

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- Don't mix
 - satellites
 - relative orbit numbers
 - acquisition geometries
- Only use co-polarized data for interferometry
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The screenshot displays the Copernicus Open Access Hub interface. The top navigation bar includes the ESA and Copernicus logos, a search bar, and user account icons. The main content area shows a list of products on the left and detailed metadata for a selected product on the right. The product ID is S1A_IW_SLC__1SDV_20180420T043026_20180420T043054_021546_025211_81BE. The metadata includes acquisition type (NOMINAL), cycle number (137), footprint (GML Polygon), format (SAFE), ingestion date (2018-04-20T08:05:06.996Z), JTS footprint, mission data ID (152081), orbit number (21546), pass direction (ASCENDING), phase identifier (1), polarisation (VV VH), product class (S), product class description (SAR Standard L1 Product), product composition (Slice), product level (L1), product type (SLC), relative orbit (124), sensing start and stop times, slice number (2), start relative orbit number (124), status (ARCHIVED), stop relative orbit number (124), and timeliness category (Fast-24h).

Request Done: 19 27567795139
19 27567795139

Product

Acquisition Type: NOMINAL
Cycle number: 137

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18.088785,-156.548218 19.773680,-156.899536</gml:coordinates> </gml:LinearRing>
</gml:outerBoundaryIs> </gml:Polygon>

Format: SAFE
Ingestion Date: 2018-04-20T08:05:06.996Z
JTS footprint: POLYGON ((-156.899536 19.773680,-154.535095 20.197853,-154.208878
18.516634,-156.548218 18.088785,-156.899536 19.773680))

Mission data ID: 152081
Orbit number (start): 21546
Orbit number (stop): 21546

Pass direction: ASCENDING

Phase Identifier: 1

Polarisation: VV VH

Product class: S
Product class description: SAR Standard L1 Product
Product composition: Slice
Product level: L1
Product type: SLC

Relative orbit (start): 124
Relative orbit (stop): 124

Sensing start: 2018-04-20T04:30:26.308Z
Sensing stop: 2018-04-20T04:30:54.187Z
Slice number: 2
Start relative orbit number: 124
Status: ARCHIVED
Stop relative orbit number: 124
Timeliness Category: Fast-24h

DInSAR Displacement Workflow



The image shows the SARscape software interface. On the left is a hierarchical tree view of workflows. A red arrow points from the 'DInSAR Displacement Workflow' item in this tree to the main workflow configuration window on the right.

SARscape Workflow Tree:

- SARscape
 - Import Data
 - Basic
 - Gamma and Gaussian Filtering
 - Focusing
 - Interferometry
 - Coherence Workflows
 - Interferometry Without GCP Workflows
 - InSAR DEM Workflow
 - InSAR Tandem-X bistatic Dem Workflc
 - Stereo DEM Workflow
 - DInSAR Displacement Workflow**

DInSAR Displacement Workflow Configuration Window:

Select Input

Workflow:

- Input
- Import Generic SAR Data
- Sample Selection SAR Geon
- Interferogram Generation
- Adaptive Filter and Coherenc
- Phase Unwrapping
- GCP Selection
- Refinement and Re-flattening
- Phase to Displacement Conv
- Output

Input File:

- DEM/Cartographic System
- Parameters

Input Master File (Mandatory):

sentinel1_124_20180420_043026308_IW_SIW1_A_VV_slc_list

Input Slave File (Mandatory):

sentinel1_124_20180502_043026880_IW_SIW1_A_VV_slc_list

Area of Interest (Optional):

Hawaii_ROI.shp

Preview: ☐

Navigation: < Back, Next >, Next >>>, Cancel

DInSAR Displacement Workflow



The image displays the SARscape software interface. On the left, a project tree shows the 'DInSAR Displacement Workflow' selected under the 'Interferometry' folder. A red arrow points from this workflow to the main window. The main window, titled 'DInSAR Displacement', shows the 'Select Input' step. The workflow list on the right includes: Input, Import Generic SAR Data, Sample Selection SAR Geon, Interferogram Generation, Adaptive Filter and Coherenc, Phase Unwrapping, GCP Selection, Refinement and Re-flattening, Phase to Displacement Conv, and Output. The 'Parameters' tab is active, showing 'Input File' set to 'DEM/Cartographic System' and 'Reference Type' set to 'Input DEM'. The 'Input DEM' field contains the text 'Hawaii_ASTER_DEM'. At the bottom, there are navigation buttons: '< Back', 'Next >', 'Next >>', and 'Cancel'.

DInSAR Displacement Workflow



The image displays the SARscape software interface, illustrating the selection of the DInSAR Displacement Workflow. On the left, a hierarchical tree structure lists various workflows under the 'Interferometry' folder. The 'DInSAR Displacement Workflow' is highlighted in blue. A red arrow points from this workflow to the main window, which shows the 'DInSAR Displacement' workflow selected. The main window is titled 'DInSAR Displacement' and 'Select Input'. It features a 'Workflow' pane on the left with a list of steps: 'Input', 'Import Generic SAR Data', 'Sample Selection SAR Geon', 'Interferogram Generation', 'Adaptive Filter and Coherenc', 'Phase Unwrapping', 'GCP Selection', 'Refinement and Re-flattening', 'Phase to Displacement Conv', and 'Output'. The 'Input' step is selected. The right pane shows the 'Parameters' tab with settings for 'Skip Import SAR Data' (True), 'Skip Sample Selection' (True), and 'Grid Size' (H5.00). The bottom of the window includes a 'Preview' checkbox and navigation buttons: '< Back', 'Next >', 'Next >>', and 'Cancel'.

SARscape Workflow

DInSAR Displacement
Select Input

Workflow

- Input
- Import Generic SAR Data
- Sample Selection SAR Geon
- Interferogram Generation
- Adaptive Filter and Coherenc
- Phase Unwrapping
- GCP Selection
- Refinement and Re-flattening
- Phase to Displacement Conv
- Output

Preview

SARscape Workflow

DInSAR Displacement
Select Input

Workflow

- Input
- Import Generic SAR Data
- Sample Selection SAR Geon
- Interferogram Generation
- Adaptive Filter and Coherenc
- Phase Unwrapping
- GCP Selection
- Refinement and Re-flattening
- Phase to Displacement Conv
- Output

Preview

SARscape Workflow

DInSAR Displacement
Select Input

Workflow

- Input
- Import Generic SAR Data
- Sample Selection SAR Geon
- Interferogram Generation
- Adaptive Filter and Coherenc
- Phase Unwrapping
- GCP Selection
- Refinement and Re-flattening
- Phase to Displacement Conv
- Output

Preview

Parameters

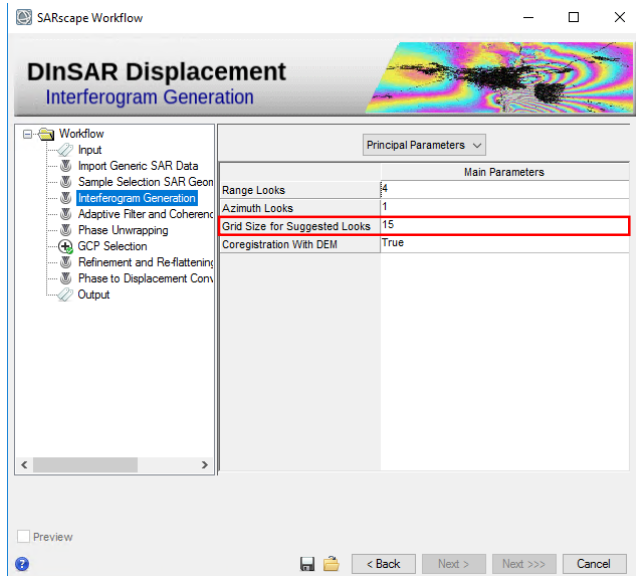
Skip Import SAR Data True

Skip Sample Selection True

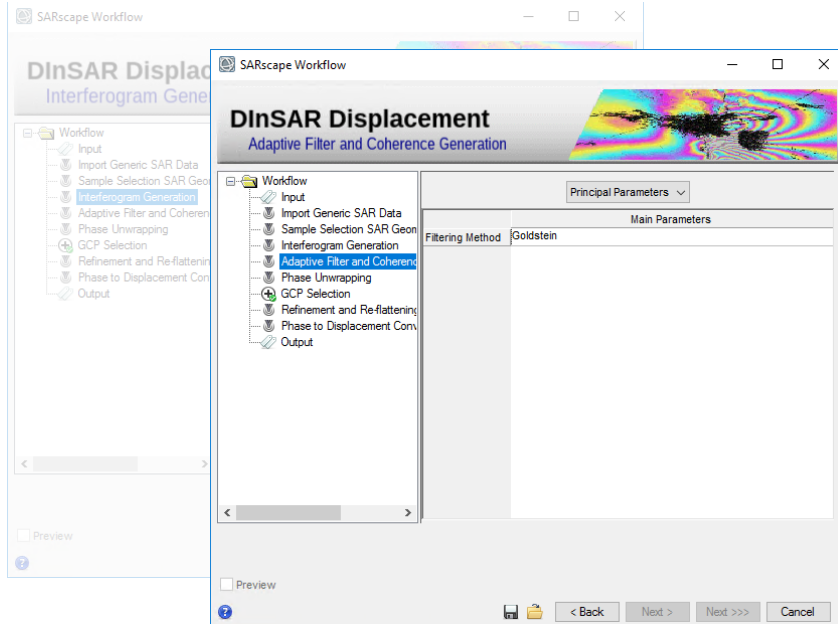
Grid Size: H5.00

< Back Next > Next >> Cancel

DInSAR Displacement Workflow



DInSAR Displacement Workflow



DInSAR Displacement Workflow

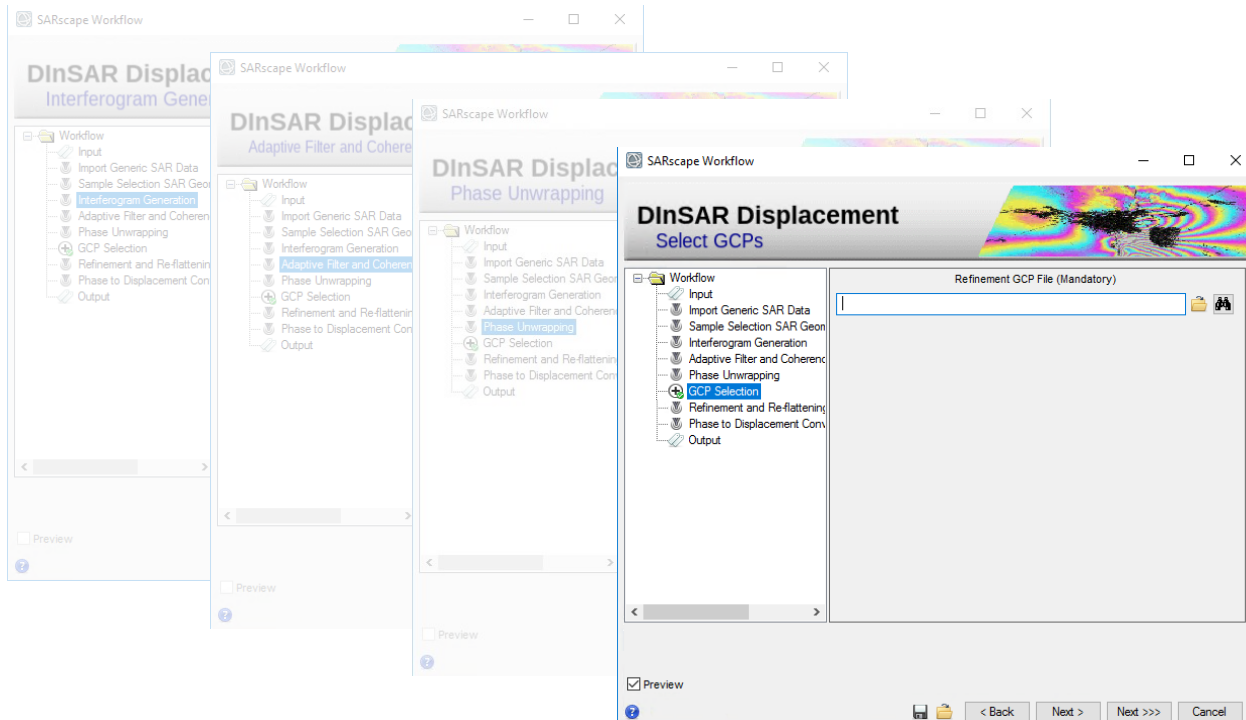


The screenshot displays the SARscape Workflow software interface. The main window is titled "DInSAR Displacement Phase Unwrapping" and features a workflow tree on the left and a parameter table on the right. The workflow tree includes steps such as "Input", "Import Generic SAR Data", "Sample Selection SAR Geom", "Interferogram Generation", "Adaptive Filter and Coherence", "Phase Unwrapping", "GCP Selection", "Refinement and Re-flattening", "Phase to Displacement Conversion", and "Output". The "Phase Unwrapping" step is currently selected. The parameter table, titled "Main Parameters", lists the following settings:

Main Parameters	
Unwrapping Method Type	DeLaunay MCF
Unwrapping Decomposition Level	1
Unwrapping Coherence Threshold	0.3

The interface also includes a "Preview" checkbox and a "Next >>>" button at the bottom right.

DInSAR Displacement Workflow



DInSAR Displacement Workflow



DInSAR Displacement Refinement and Re-flattening

Principal Parameters

Main Parameters	
Refinement Method	Polynomial Refinement
Refinement Res Phase Poly Degree	3
Coregistration With DEM	True

Workflow steps: Input, Import Generic SAR Data, Sample Selection SAR Geom, Interferogram Generation, Adaptive Filter and Coherence, Phase Unwrapping, GCP Selection, Refinement and Re-flattening, Phase to Displacement Conversion, Output.

DInSAR Displacement Workflow



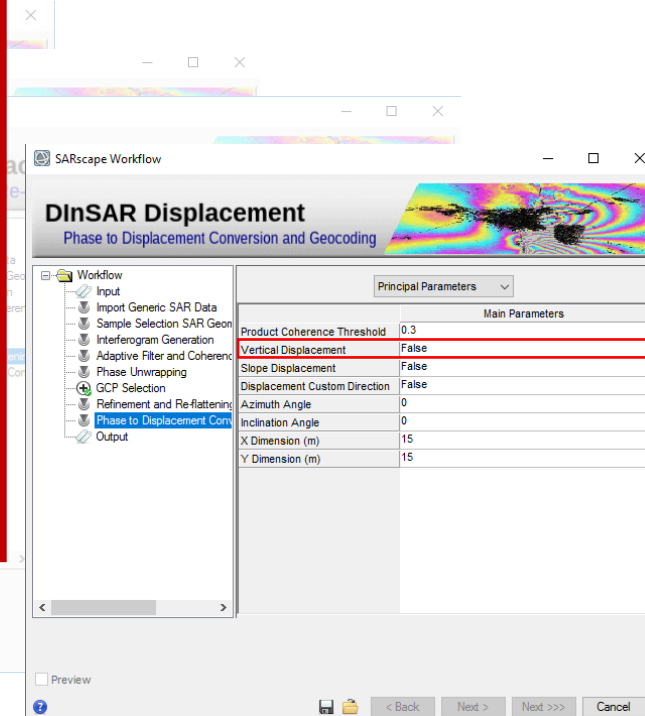
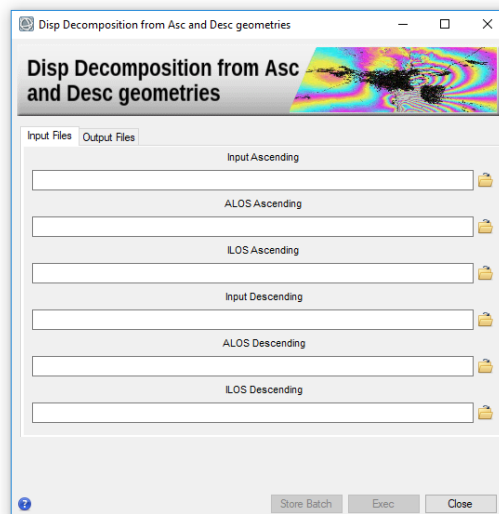
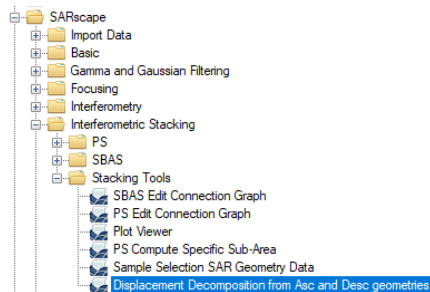
DInSAR Displacement Phase to Displacement Conversion and Geocoding

Principal Parameters	
Main Parameters	
Product Coherence Threshold	0.3
Vertical Displacement	False
Slope Displacement	False
Displacement Custom Direction	False
Azimuth Angle	0
Inclination Angle	0
X Dimension (m)	15
Y Dimension (m)	15

DInSAR Displacement Workflow



Vertical displacement



DInSAR Displacement Workflow

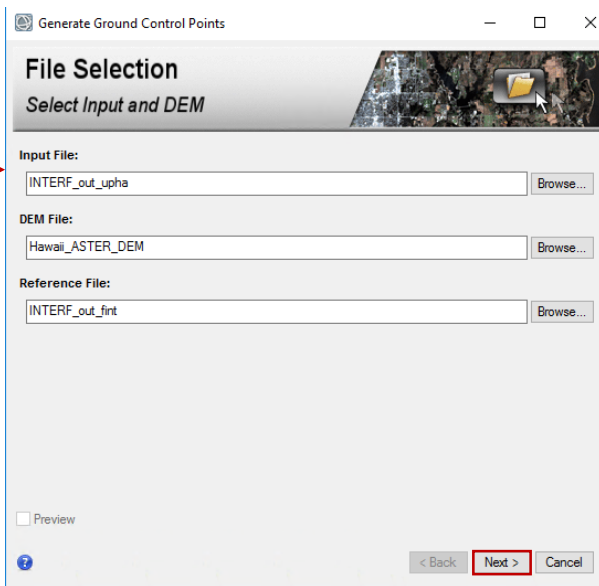
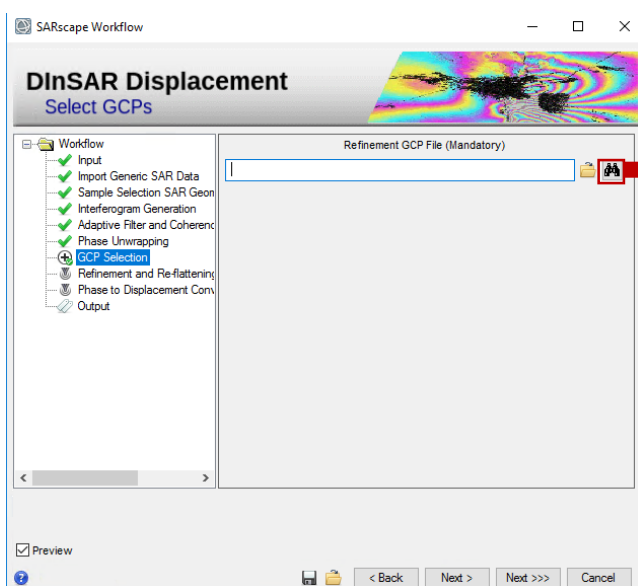


The image displays a series of overlapping screenshots of the SARscape Workflow software interface, illustrating the DInSAR Displacement Workflow. The workflow steps shown are:

- DInSAR Displacement Interferogram Generation**
- DInSAR Displacement Adaptive Filter and Coherence**
- DInSAR Displacement Phase Unwrapping**
- DInSAR Displacement Select GCPs**
- DInSAR Displacement Refinement and Re-flattening**
- DInSAR Displacement Select Output**

The **Select Output** window is highlighted, showing the **Output Root Name (Mandatory)** field with the path `S:\Sarah\DInSAR\Hawaii_2018\DInSAR_output\Hawaii_2018`. A red box highlights the **Delete Temporary Files** checkbox, which is currently unchecked. The **Next >>** button is also highlighted with a red box.

DInSAR Displacement Workflow



DInSAR Displacement Workflow



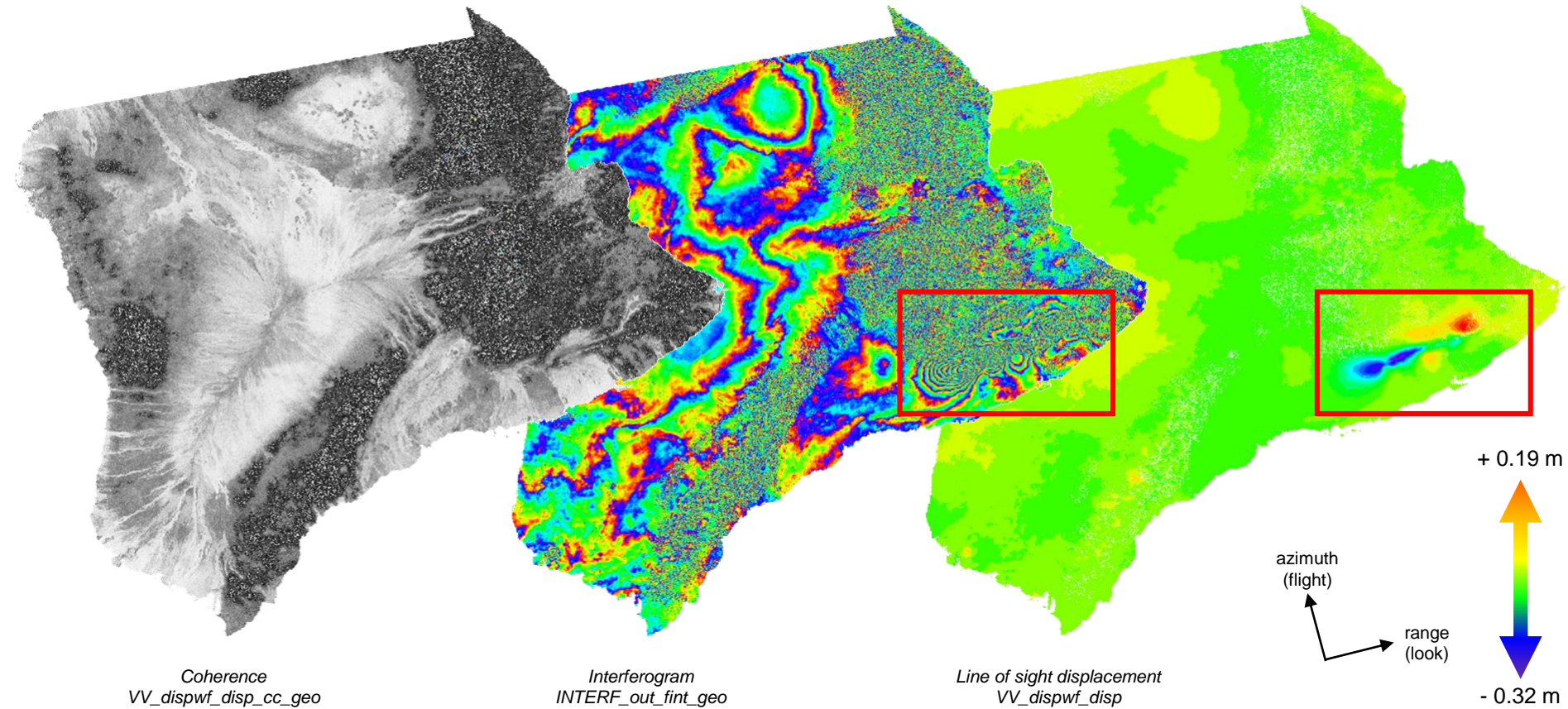
The image displays the DInSAR Displacement Workflow software interface, showing the process of selecting Ground Control Points (GCPs) for displacement analysis.

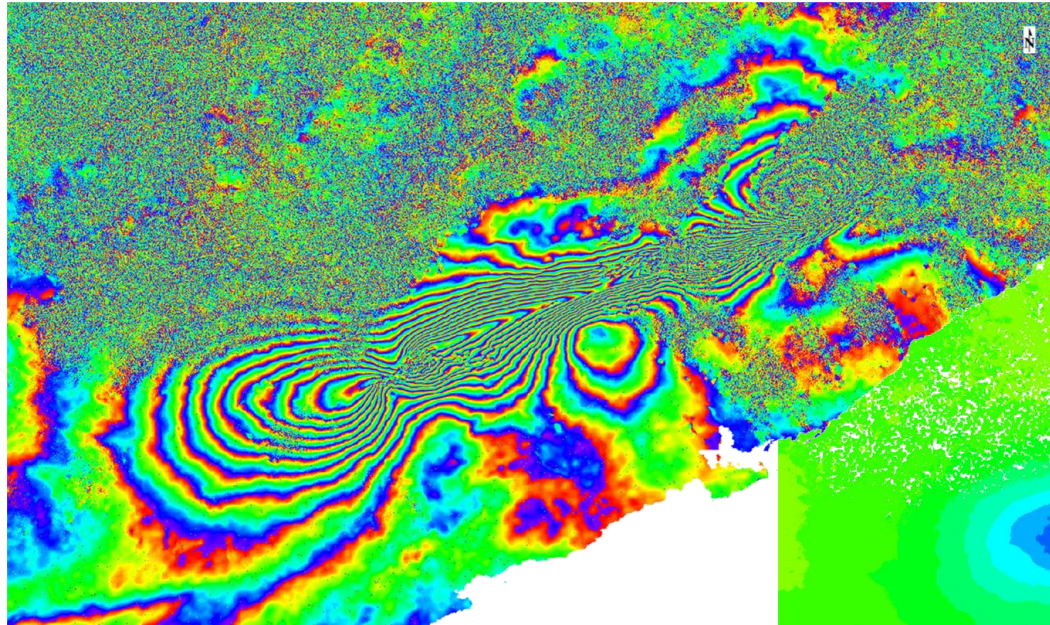
Workflow Overview:

- DInSAR Displacement Select GCPs:** The main workflow window. The **Workflow** pane on the left lists steps: Input, Import Generic SAR Data, Sample Selection SAR Geon, Interferogram Generation, Adaptive Filter and Coherence, Phase Unwrapping, **GCP Selection** (highlighted), Refinement and Re-flattening, Phase to Displacement Conv, and Output. The **Refinement GCP File (Mandatory)** field is empty.
- Generate Ground Control Points File Selection:** A sub-window titled "Select Input and DEM". It shows the **Input File:** `INTERF_out_upha` and the **DEM File:** field. A red arrow points from the **Refinement GCP File (Mandatory)** field in the main workflow to this sub-window.
- DInSAR Main View:** The central map area displays a grayscale SAR image. A red dashed line outlines a large area of interest. A red rectangle highlights a specific region within this area. A yellow rectangle highlights another region. The **Layer Manager** on the left shows the loaded files: `INTERF_out_upha` and `INTERF_out_dem`.
- Select GCPs... Import GCPs...:** A sub-window titled "Select GCPs...". It shows a table of **Ground Control Points: 41**. The table lists the Name, Map X, Map Y, Height, Image X, Image Y, Vert. X (mmy), Vert. Y (mmy), and Date for each GCP. The **GCP Properties** table is shown below the main list.

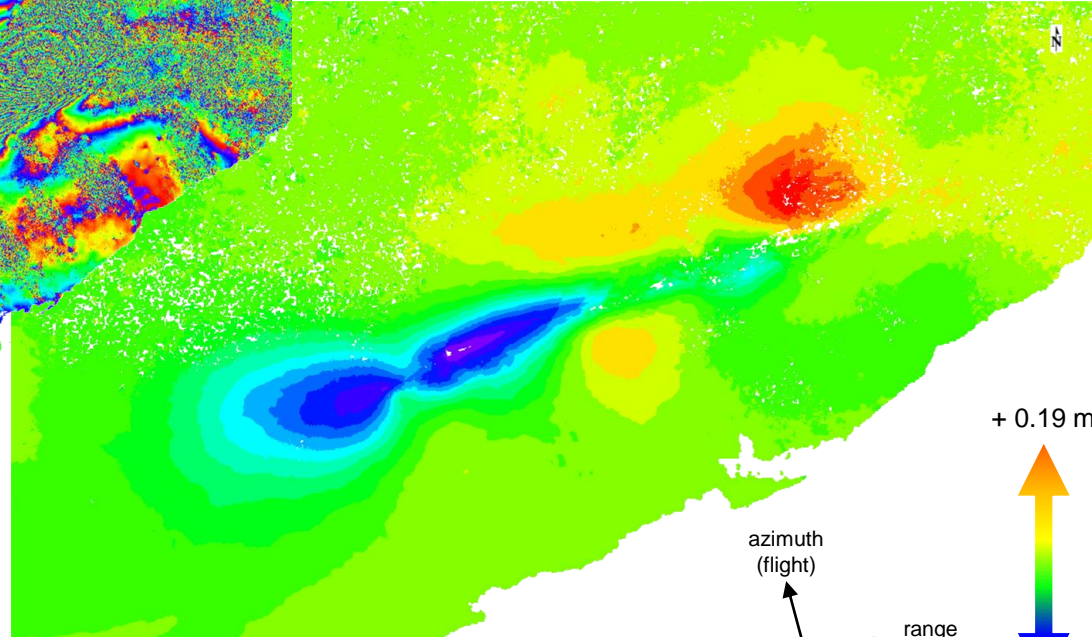
Name	GCP_41
Map X	0
Map Y	0
Height	0
Image X	3658.851015156
Image Y	2010.4822998047
Vert. X (mmy)	0
Vert. Y (mmy)	0
Vert. Height (mmy)	0
Date	

The **Select GCPs...** window also includes a **Preview** section at the bottom, showing a list of files and a **Preview** button.





Interferogram
INTERF_out_fint_geo



Line of sight displacement
VV_dispwf_disp

Poll Question #3

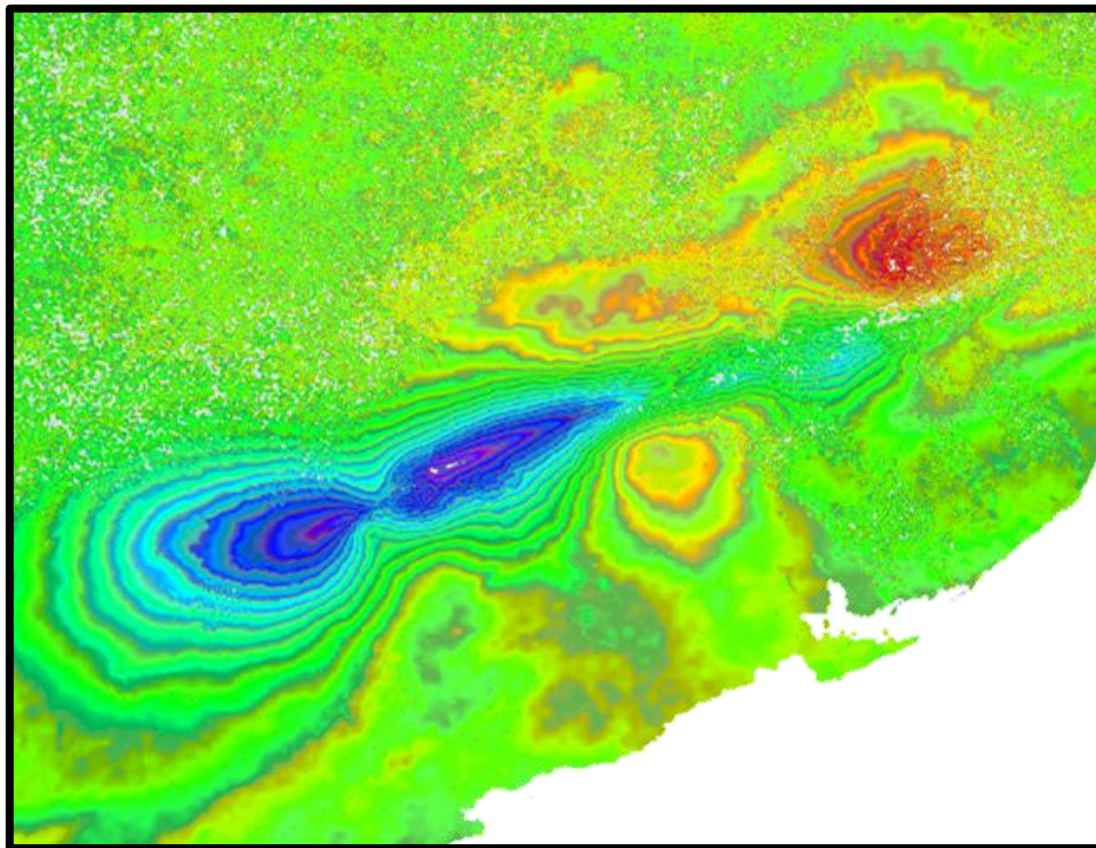


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