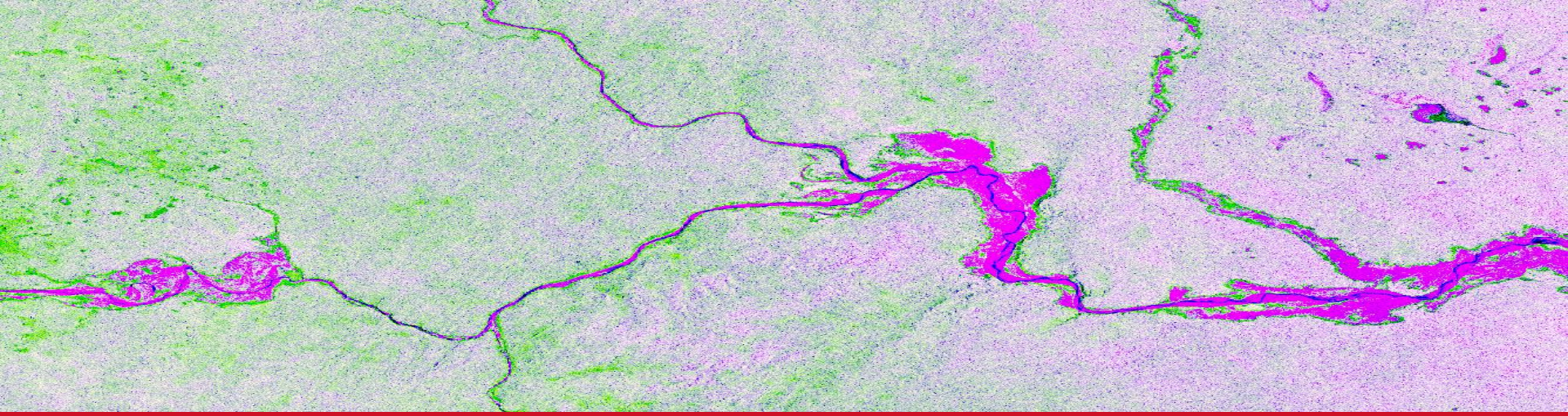


A DEEPER DIVE INTO SAR: AGRICULTURE AND LAND SURFACE DEFORMATION

MEGAN GALLAGHER

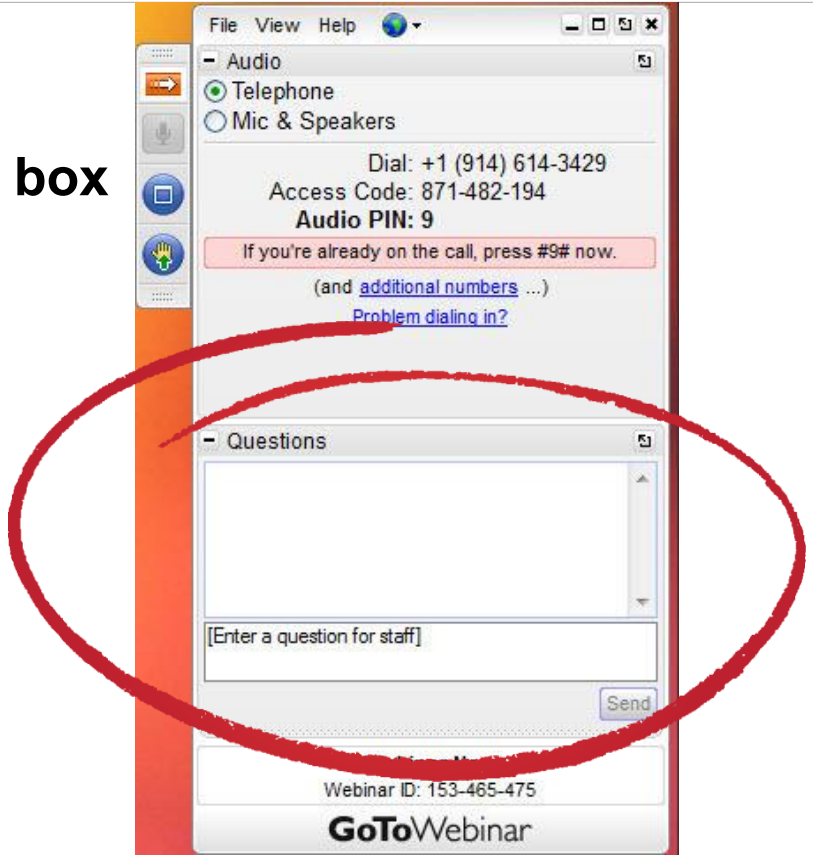
Solutions Engineer

sarmap
your information gateway

HARRIS® TECHNOLOGY TO CONNECT, INFORM AND PROTECT™

Housekeeping

- **All attendees are muted**
- **Ask your questions in the Questions box**
- **Check out the Handouts box for the slides and related content**
- **We'd love your feedback –**
  Fill out the survey after the webinar
- **We are recording the webinar**



Today's Speaker

Megan Gallagher

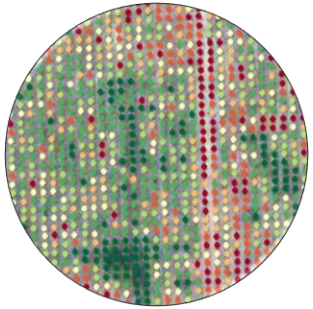
Solutions Engineer

megan.gallagher@harris.com

Harris Geospatial

www.harrisgeospatial.com
geospatialinfo@harris.com
303-786-9900

Geospatial Portfolio



Precision Ag

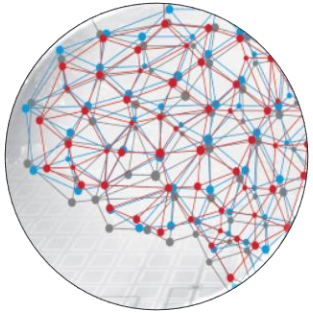
ENVI

SARscape

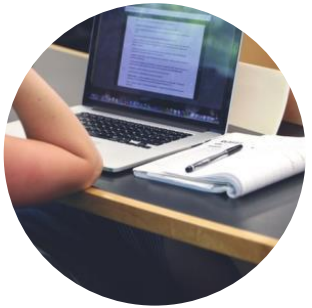
Damage Assessment

Data Management and Dissemination

Disaster Response

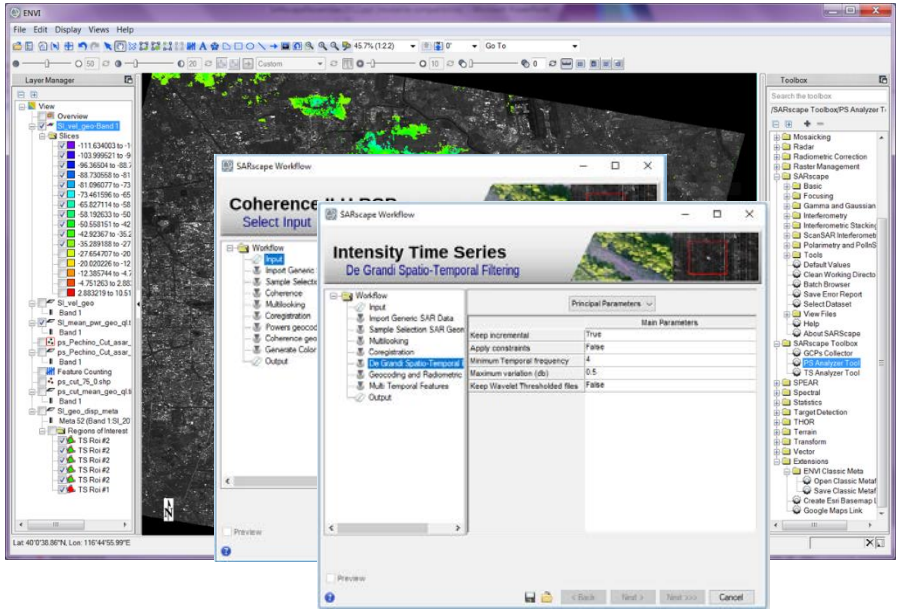


Feature Extraction with Deep Learning



Training & Consulting

SAR Processing Where You Need It



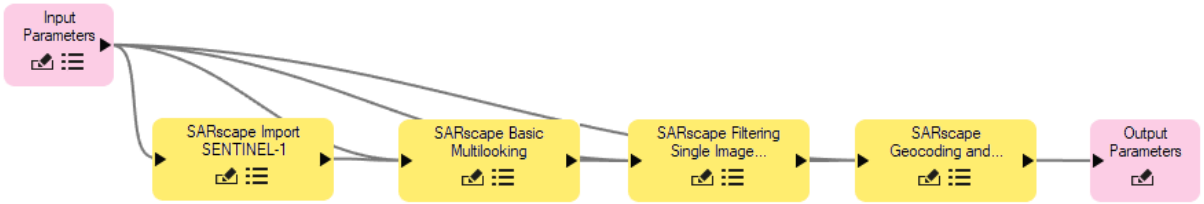
ENVI UI

ENVI Workflows

ENVI Modeler

ArcGIS Pro

Desktop-Enterprise-Cloud



Desktop, Enterprise, and Cloud Solutions

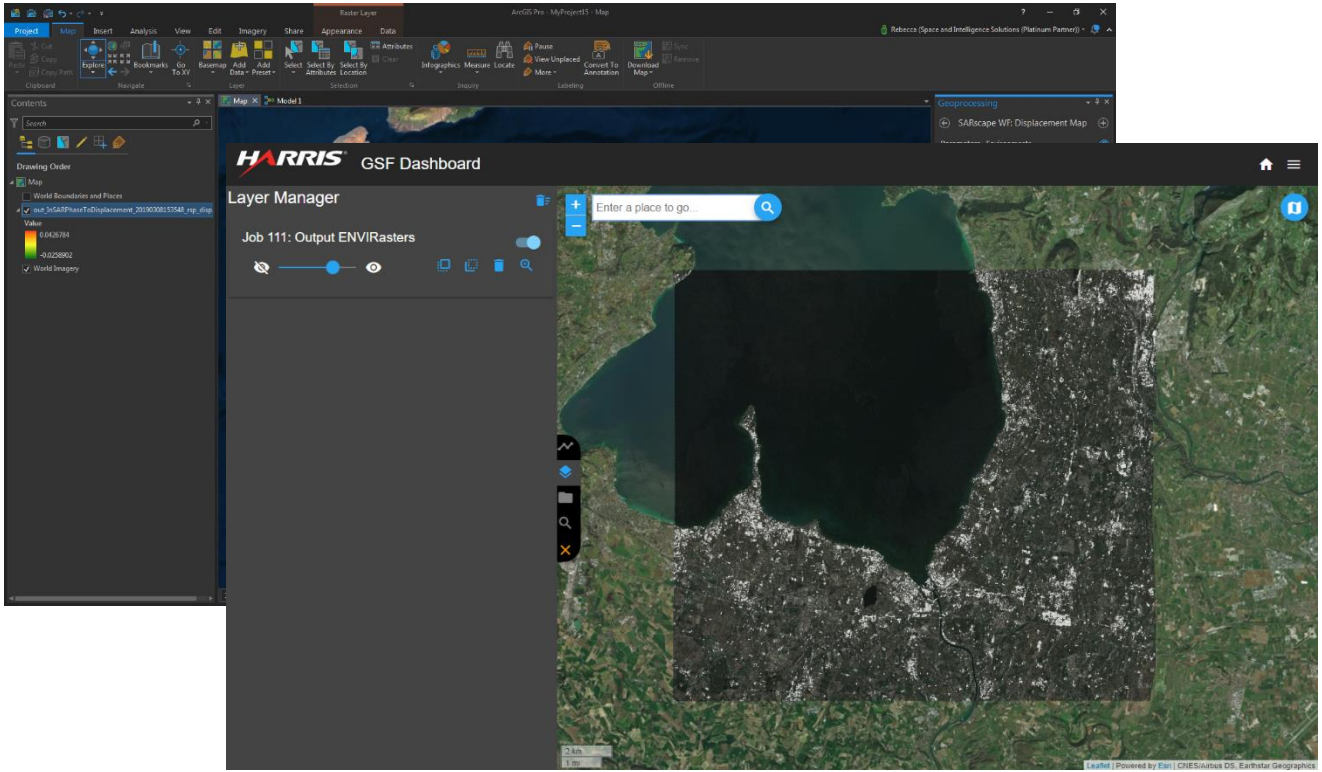
ENVI UI

ENVI Workflows

ENVI Modeler

ArcGIS Pro

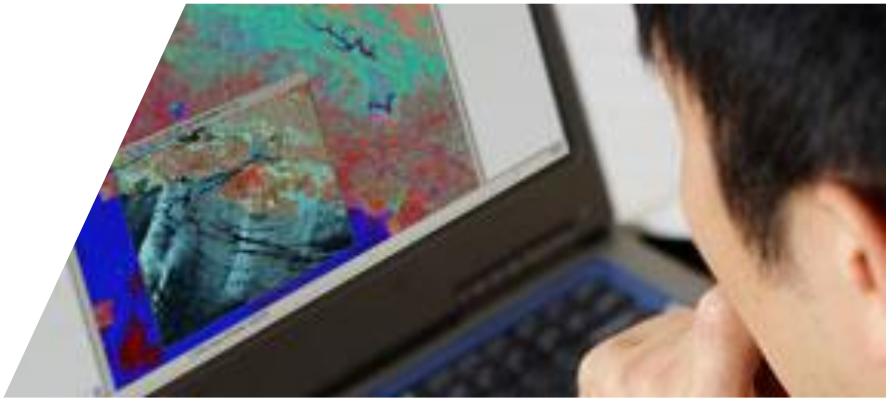
Desktop-Enterprise-Cloud



Example Web App with SAR Analytics

Upcoming SAR Training

- **Date:** May 6 – 9, 2019 (4 days)
- **Location:** Broomfield, Colorado USA
- **Prerequisites:** A basic level of remote sensing knowledge as well as ENVI operations are necessary to take this course



REGISTER TODAY!

https://sar_may_2019.eventbrite.com

SARscape Fast Start

To ensure your success using ENVI SARscape, Harris Geospatial is offering a free, limited-time Fast Start support bundle with the purchase of a license.

This limited-time offer includes:

- A 4-day training class
- Up to four hours of remote consultation
- Silver Support

ENVI SARscape Training Schedule

Broomfield: *May 6-9*
Gilching, Germany: *May 7-10*
Paris, France: *(Taught in French) May 14-17*
Broomfield: *Sept 3-6*
Berkshire, UK: *June 25-28*
Purasca, Switzerland: *July 2-5*
Gilching, Germany: *Nov 12-15*

Agenda

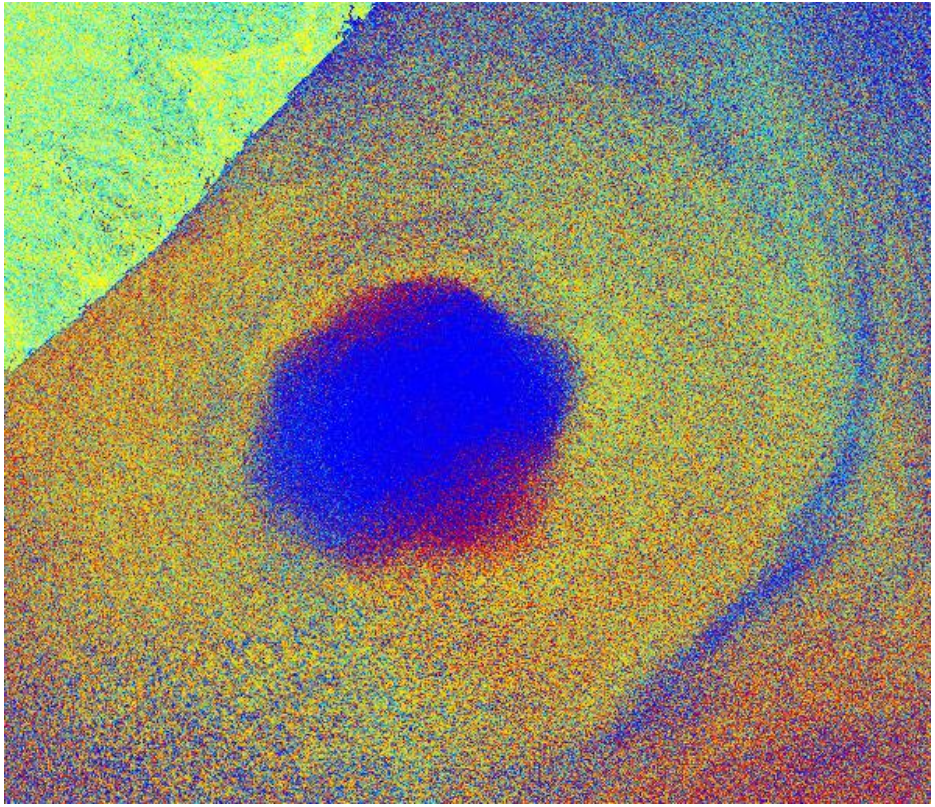
Agriculture Monitoring

- **Background**
- **Time Series Analysis**
- **Classification**

Land Surface Deformation

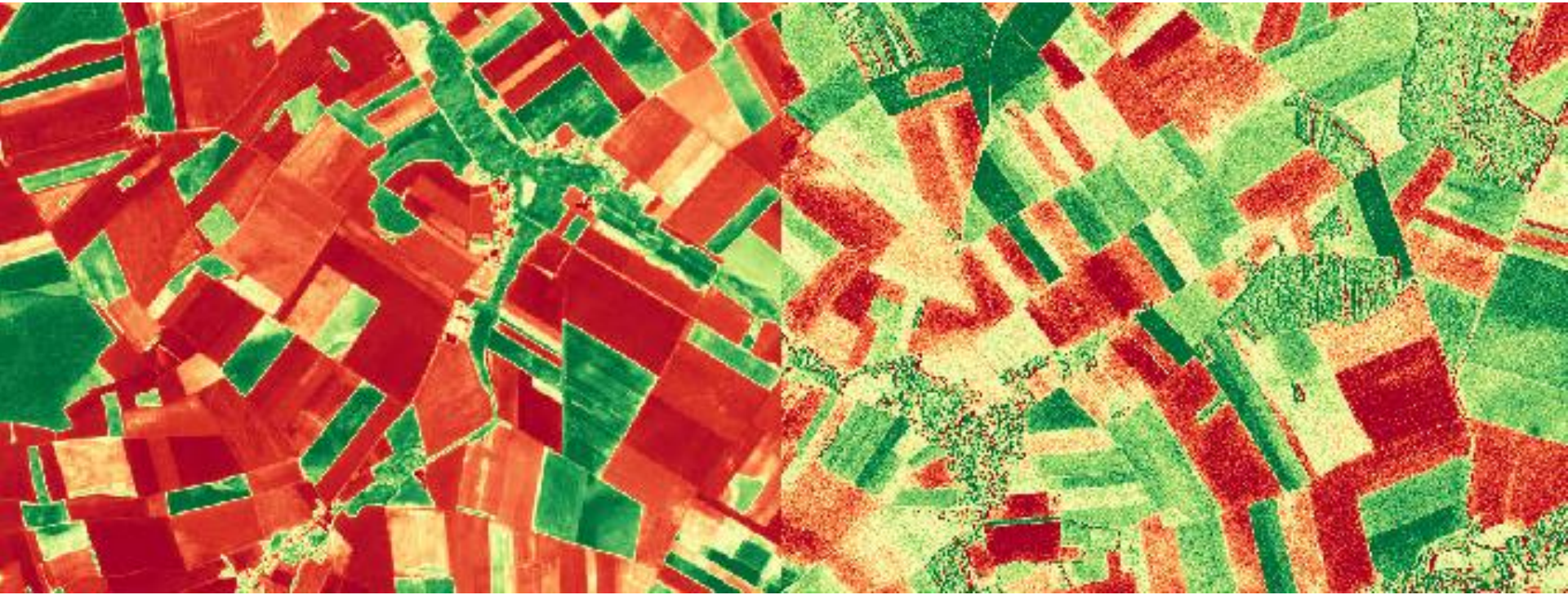
- **Background**
- **Example Case with SBAS**

Questions



Cyclone Idai making landfall

Introduction to Agriculture

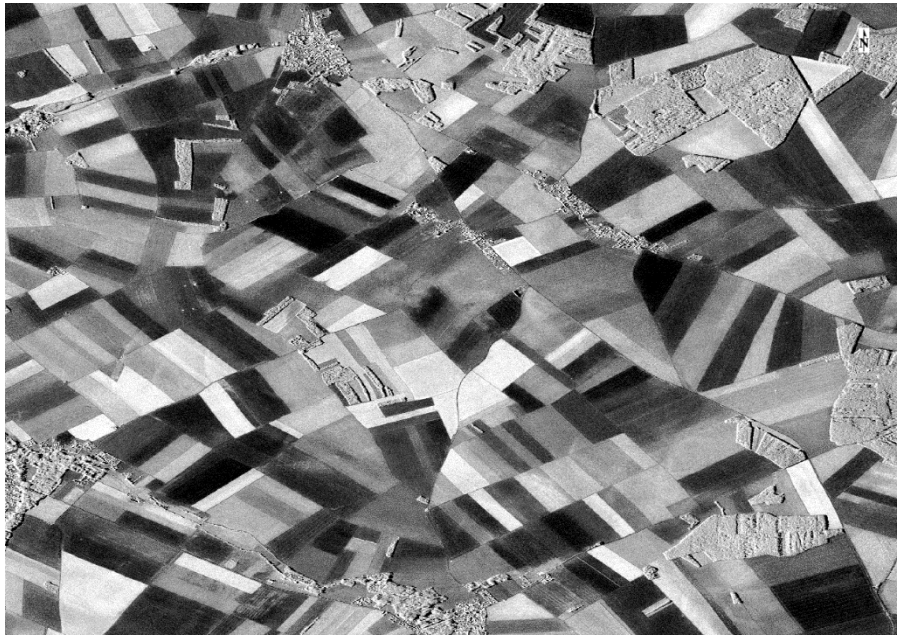


Sentinel-2 NDVI

TerraSAR-X Intensity

Optical and SAR

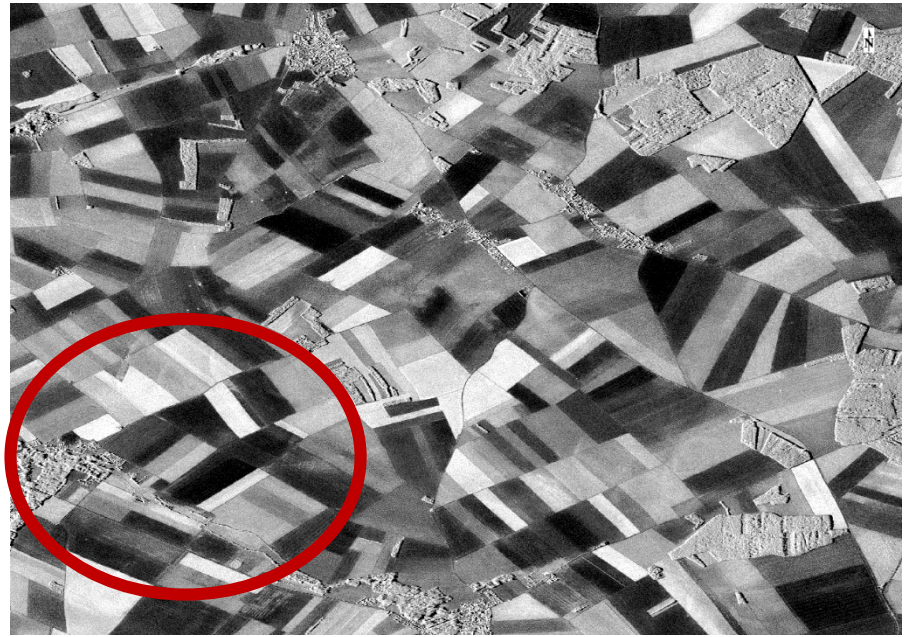
Sentinel-2, June 20, 2018



TerraSAR-X, June 18, 2018

Optical and SAR

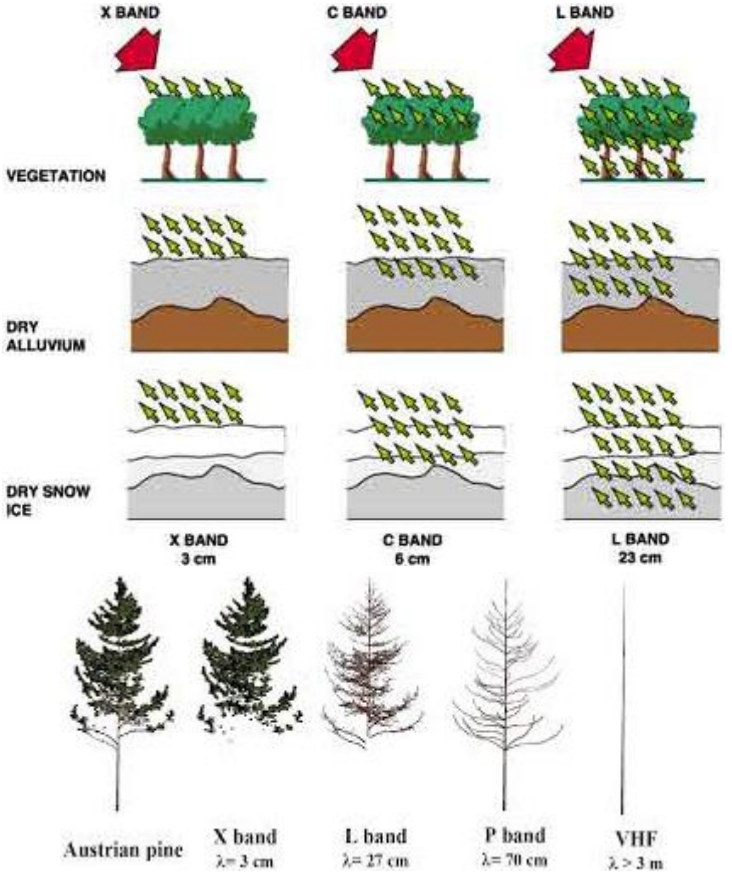
Sentinel-2, June 20, 2018



TerraSAR-X, June 18, 2018

Radar Band Frequency

Band	Frequency	Applications
VHF	300 kHz - 300 MHz	Foliage/ground penetration, biomass
P	300 MHz - 1 GHz	Biomass, soil moisture, ground penetration
L	1 - 2 GHz	Agriculture/forestry, soil moisture, ground penetration
S	3-4 GHZ	Agriculture, biomass, ocean
C	4 - 8 GHz	Ocean, agriculture, general surface investigation
X	8 - 12 GHz	Ocean, agriculture, general surface investigation (high resolution)
Ku	14 - 18 GHz	Glacial/ice, snow cover
Ka	27 - 47 GHz	Glacial/ice, very high resolution imagery

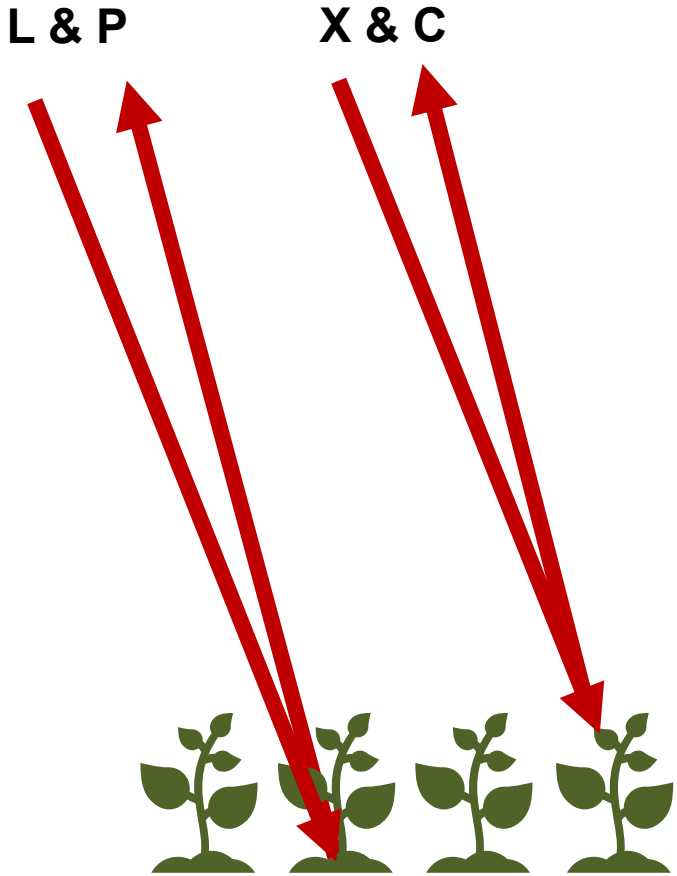


Band Effects

L and P band have longer wavelengths, and are dominated by soil backscatter. They are used mainly for soil moisture and information on thicker vegetation.

C and X band interact mainly with the canopy.

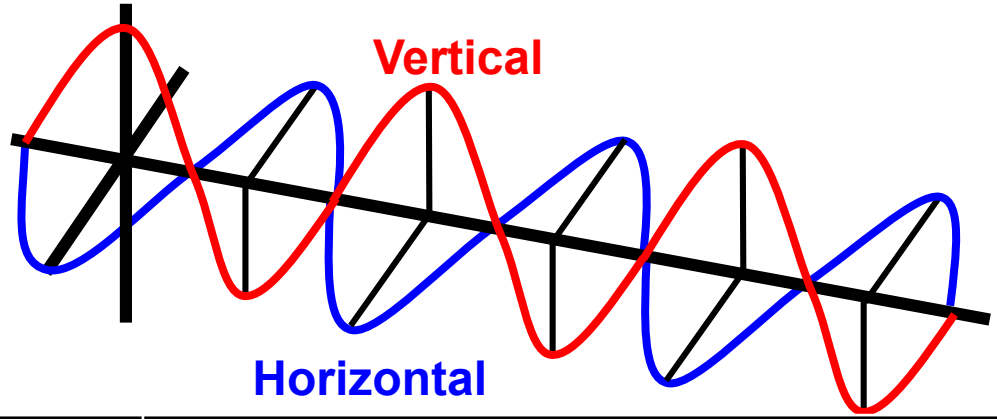
X band works well with broad leafed plants (e.g. Corn and soybeans) while both X and C work well with narrow leafed plants (most grains)



Polarization Choices

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

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



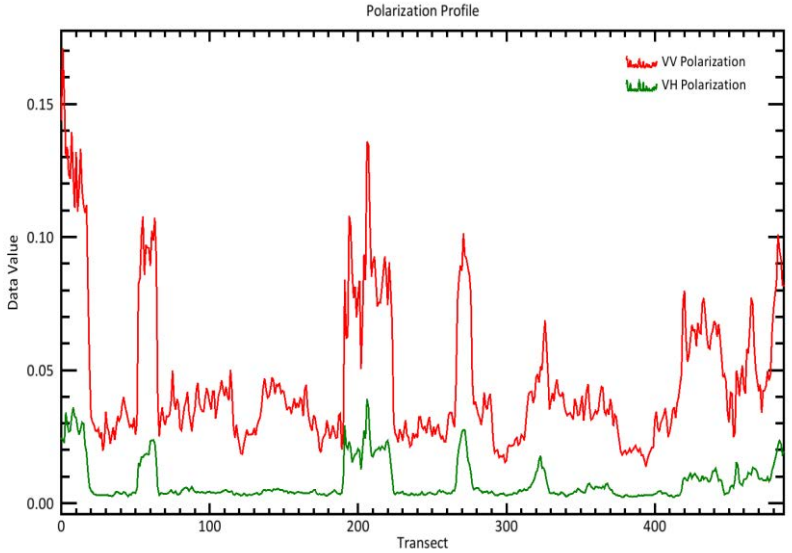
Polarization	Physical Meaning
VV	Vertical wave, outgoing and incoming
HH	Horizontal wave, outgoing and incoming
VH	Vertical Wave outgoing, Horizontal Wave incoming
HV	Horizontal Wave outgoing, Vertical Wave incoming

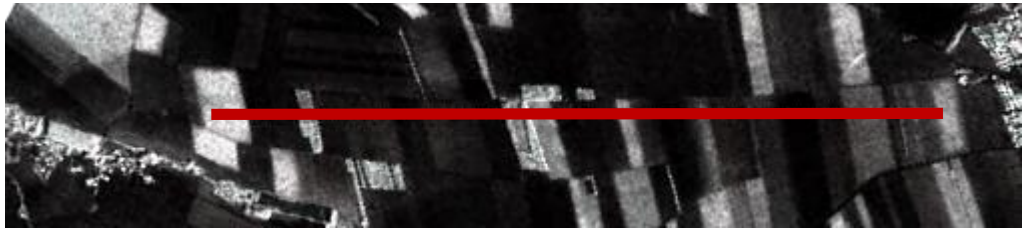
Polarization Effects

Quad Polarized (VV, HH, VH, and HV) has the most information for full understanding of vegetation.

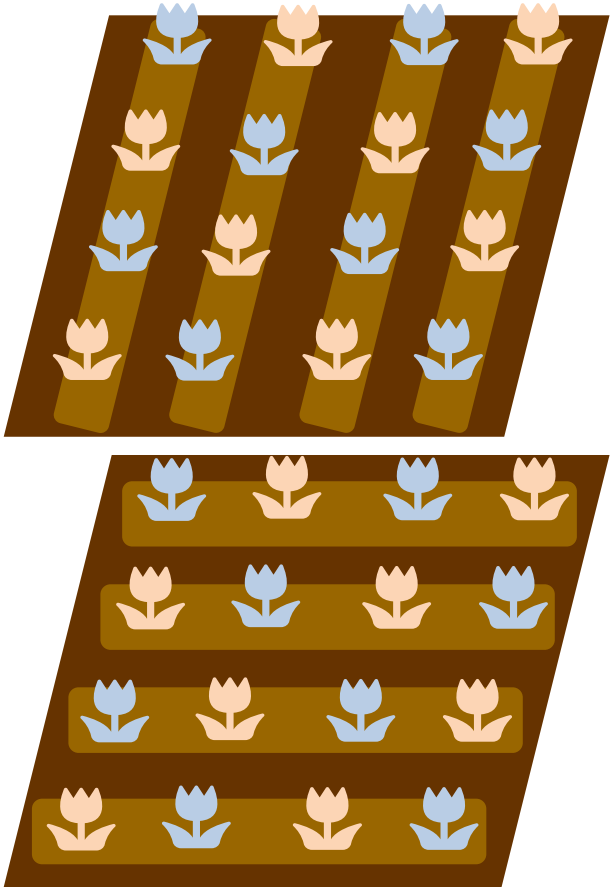
Dual Pol (VV & VH or HH & HV) is still able to discern major differences.

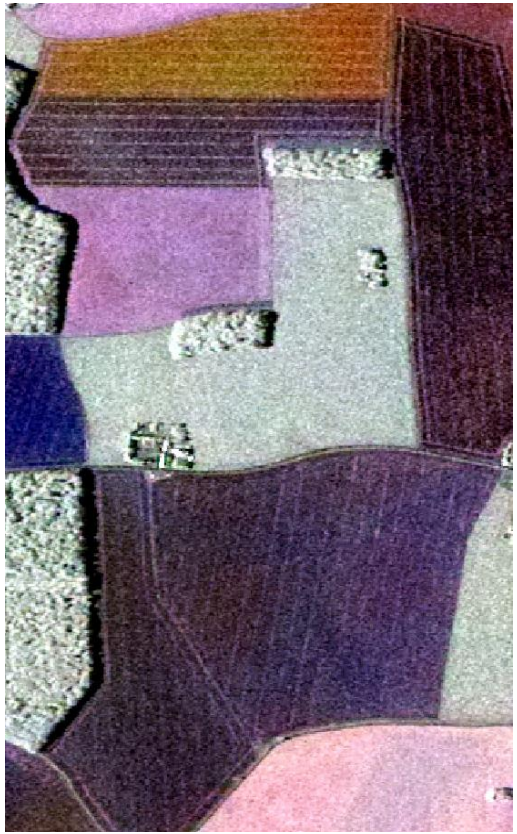
Polarization	Mainly impacted by
HH	Surface Scattering* very small roughness
HV/VH	Volume Scatter
VV	Vegetation Structure





Geometric Effects

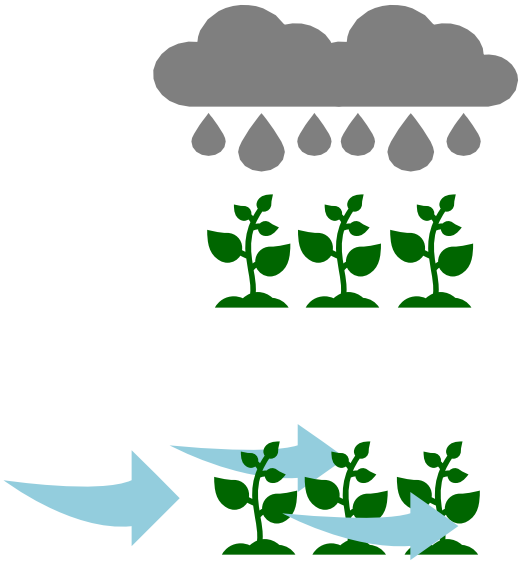




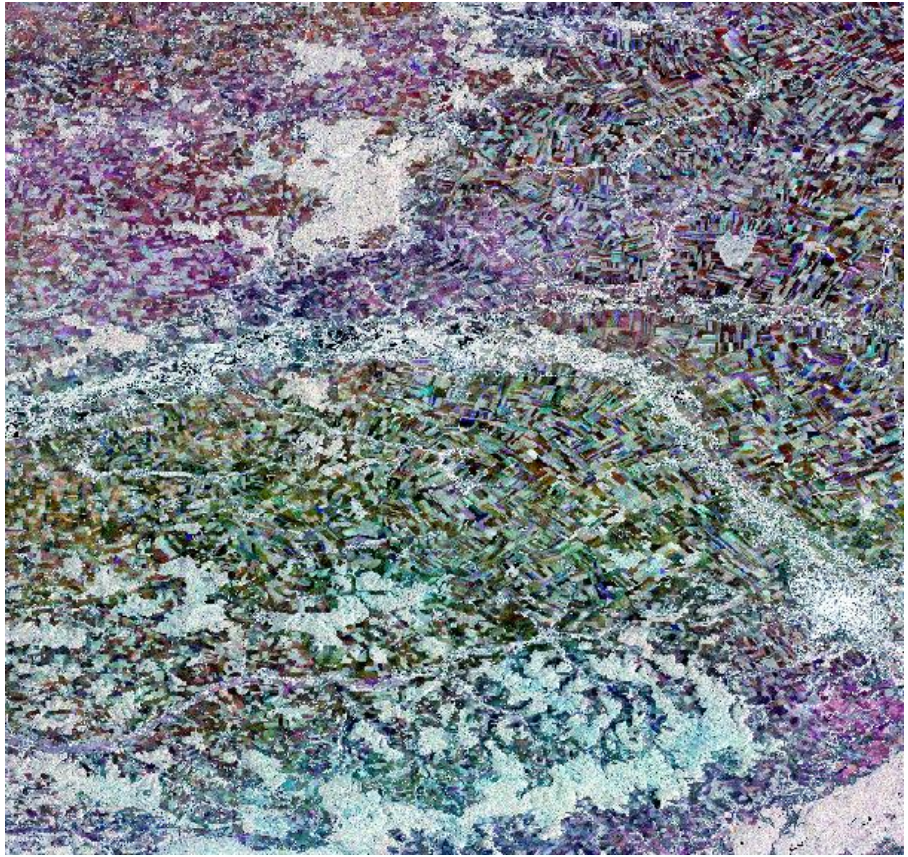
Weather Effects

Rain/Snow – Causes noise and moisture will collect in soil and on the crop surface

Wind – Changes the structure of the plants with their movements

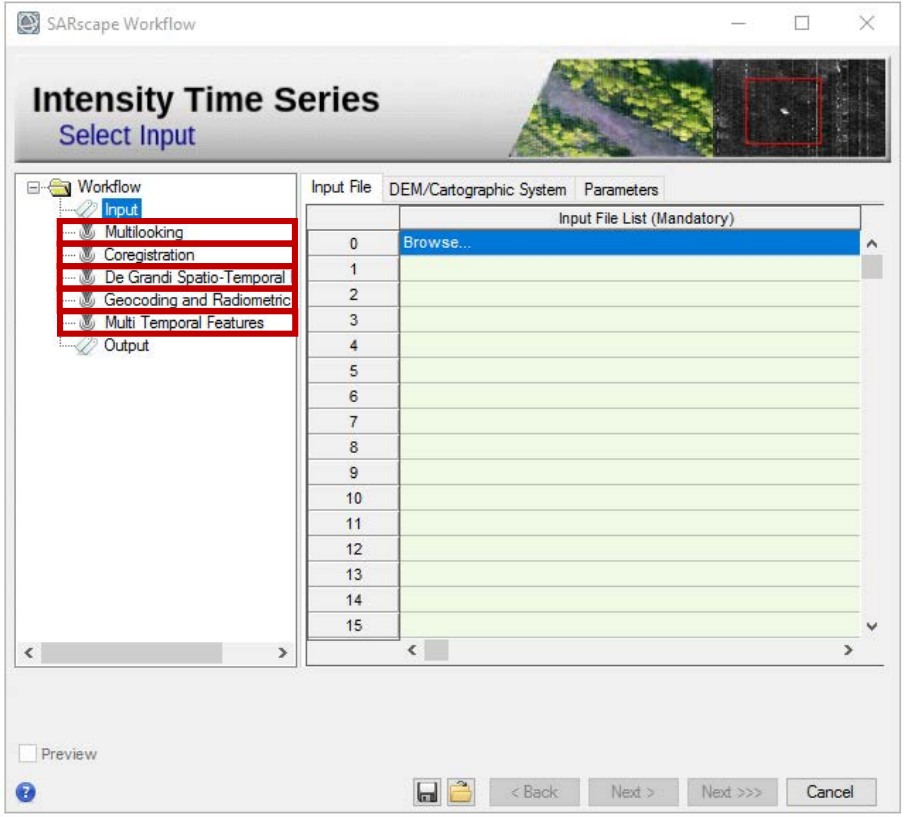


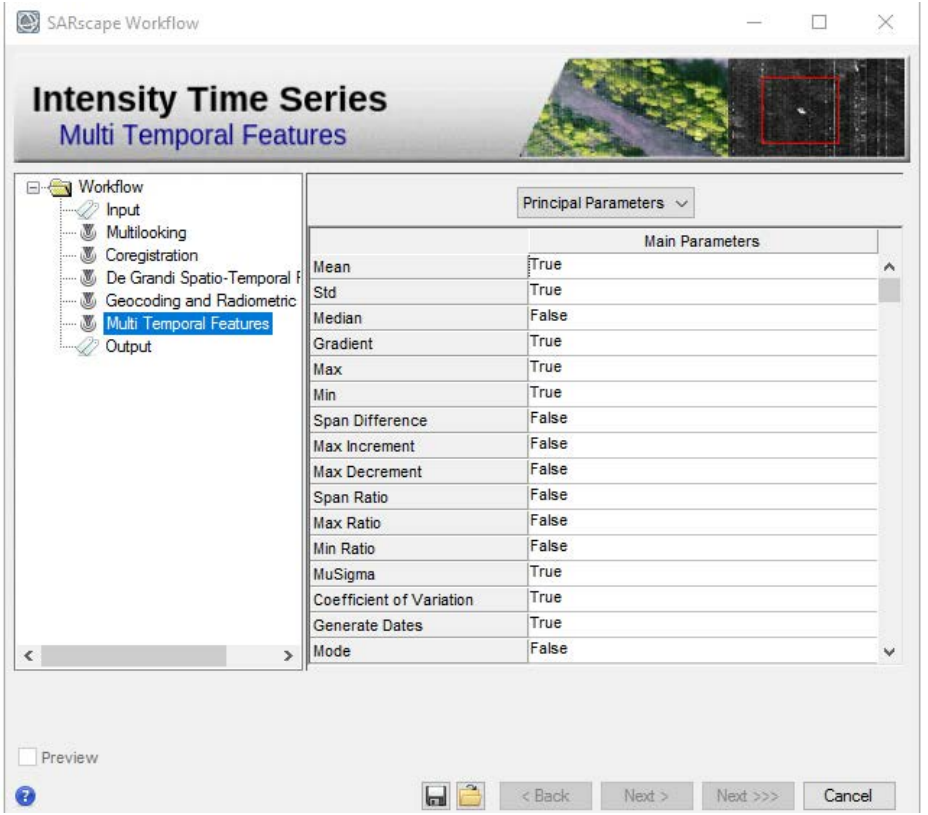
Area of Interest



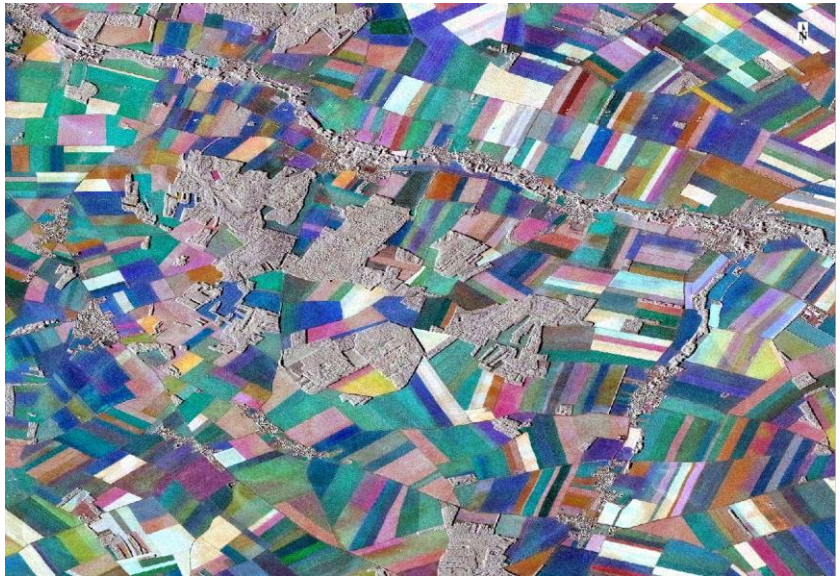
Time Series: Sentinel-2

Intensity Time Series

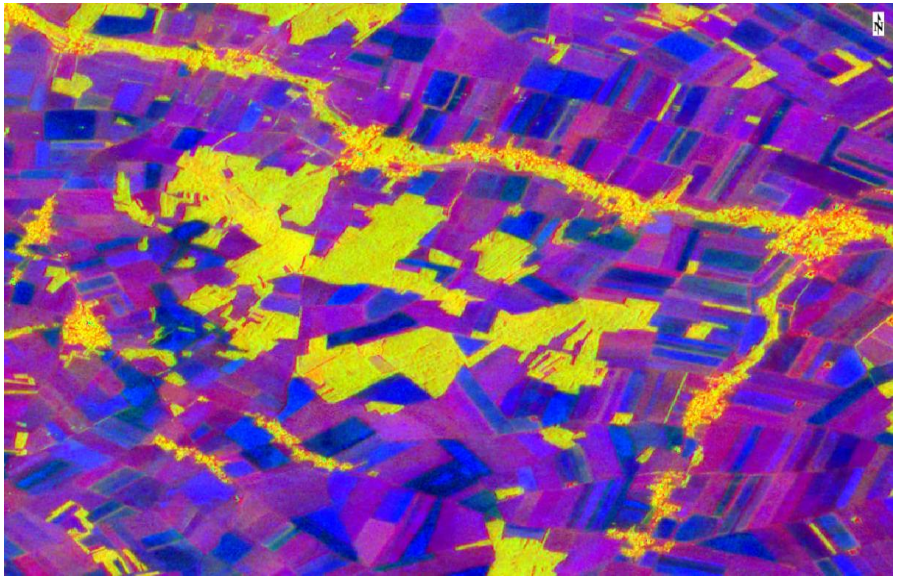




Intensity Time Series Outputs

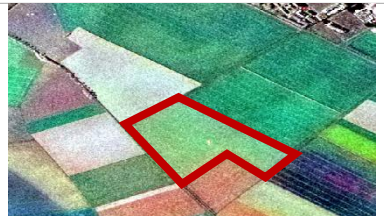


Every processed date is a separate band, highlighting change over time

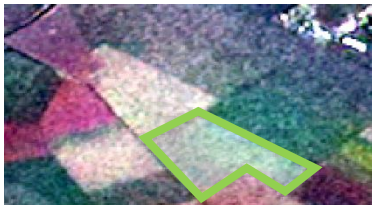


Statistical information such as covariance, minimum, mean, maximum, gradient, etc.

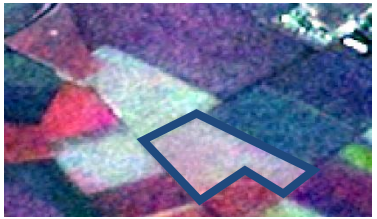
Time Series: SAR



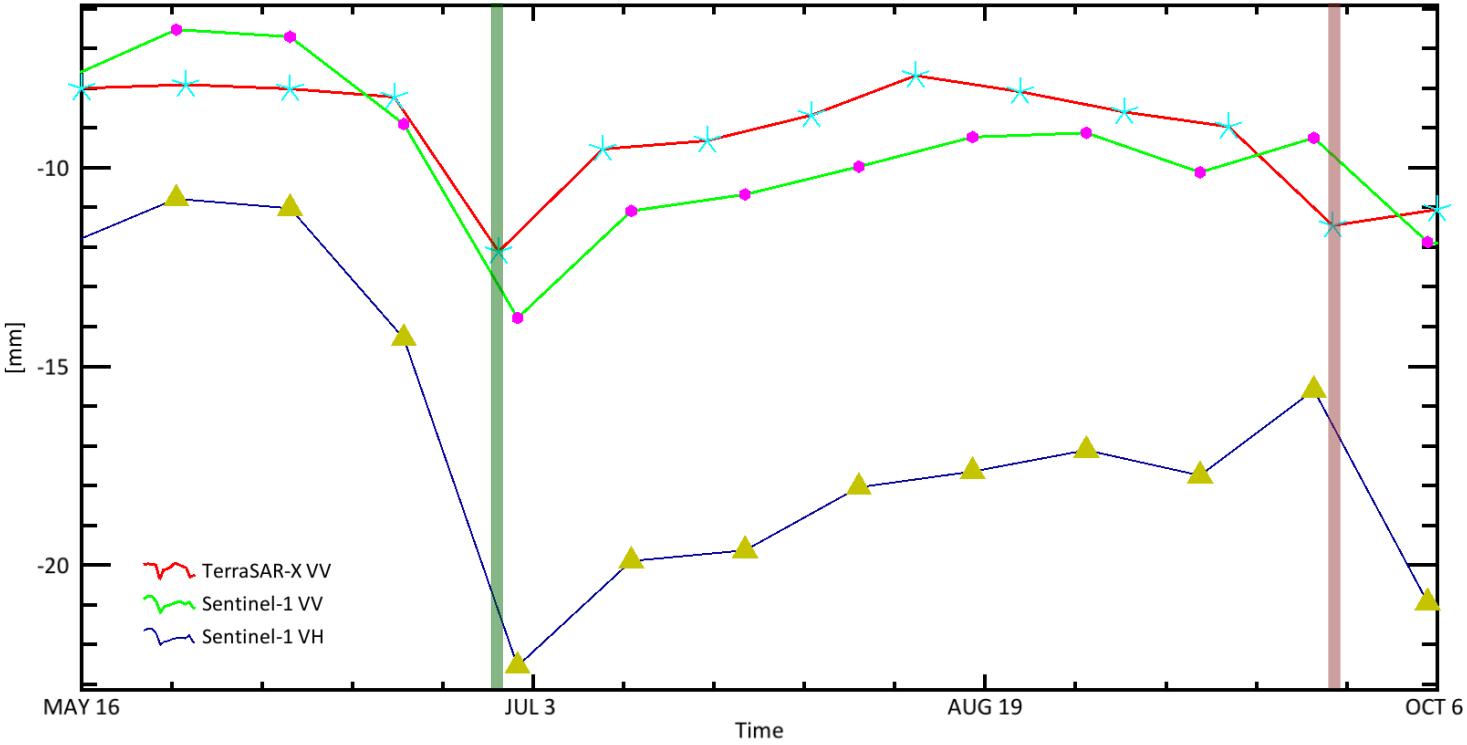
TerraSAR-X VV



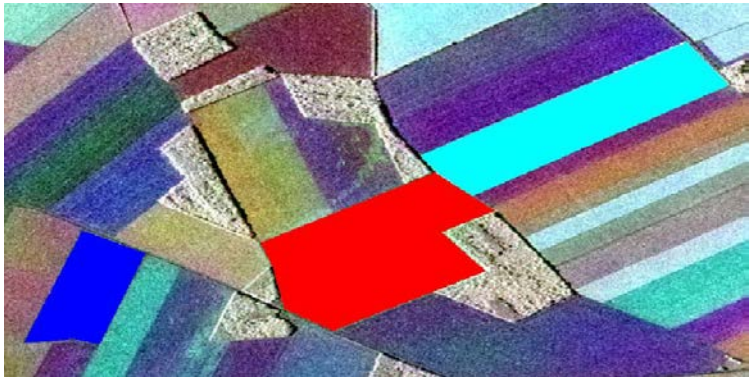
Sentinel-1 VV

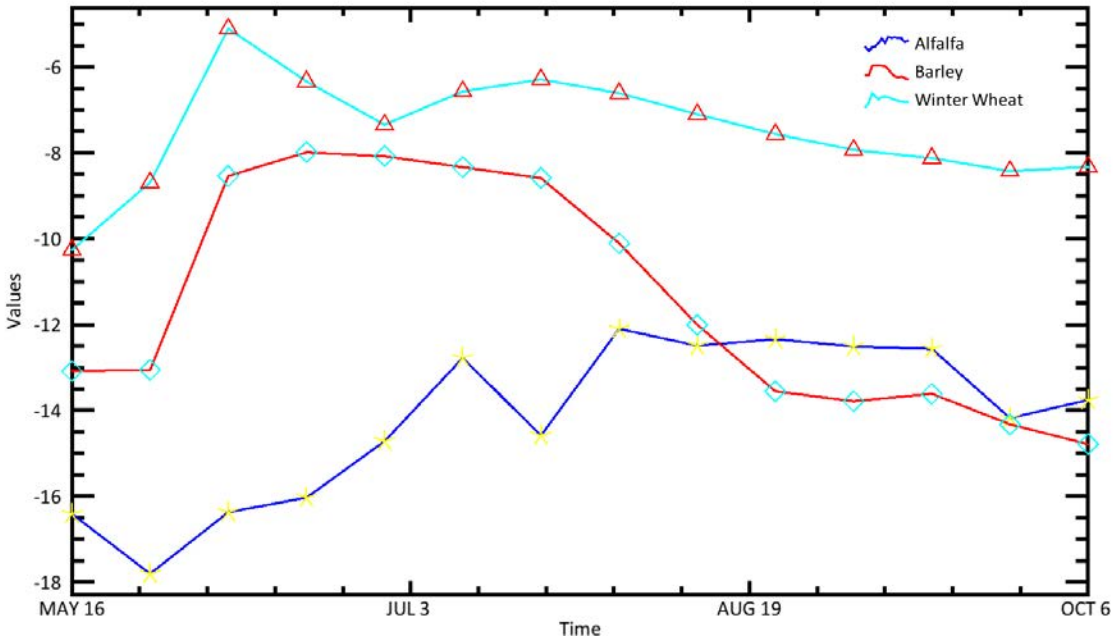


Sentinel-1 VH



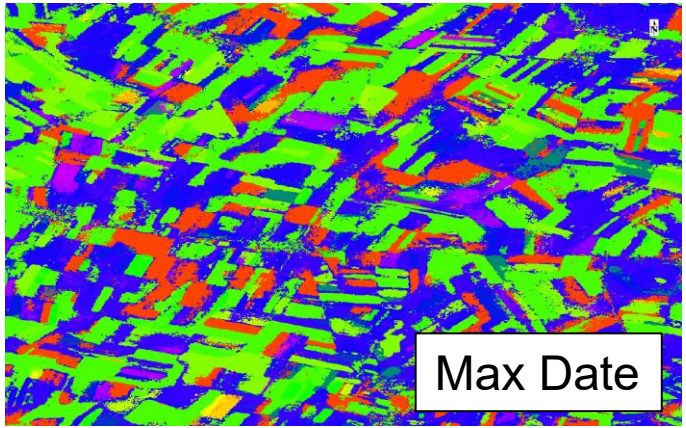
Time Series over Fields

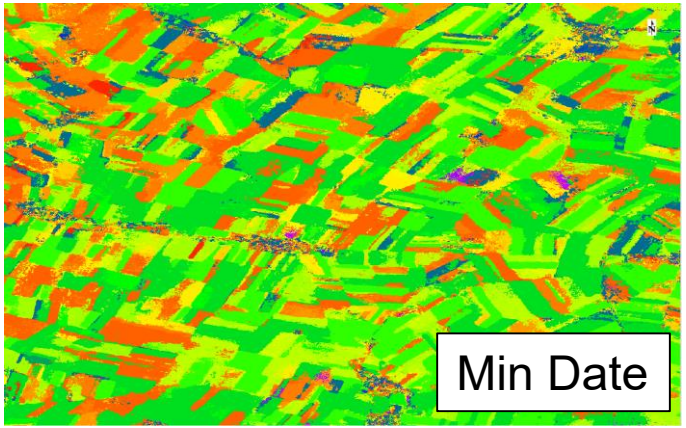


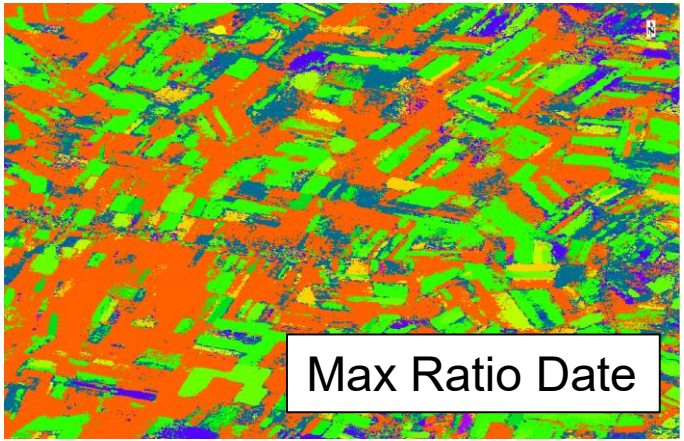


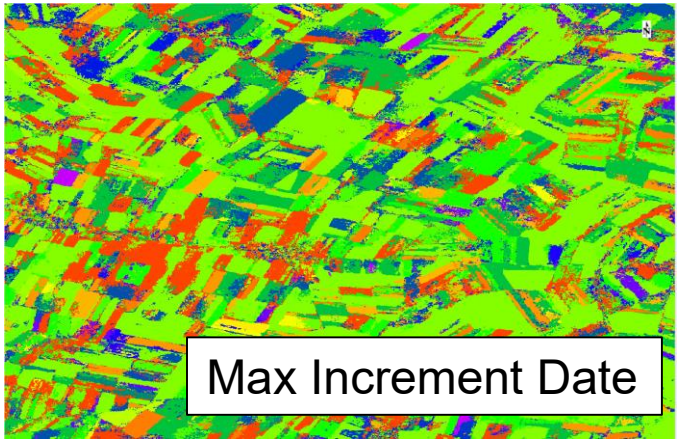
Different fields have different temporal signatures, allowing for discrimination and classification.

Date Information



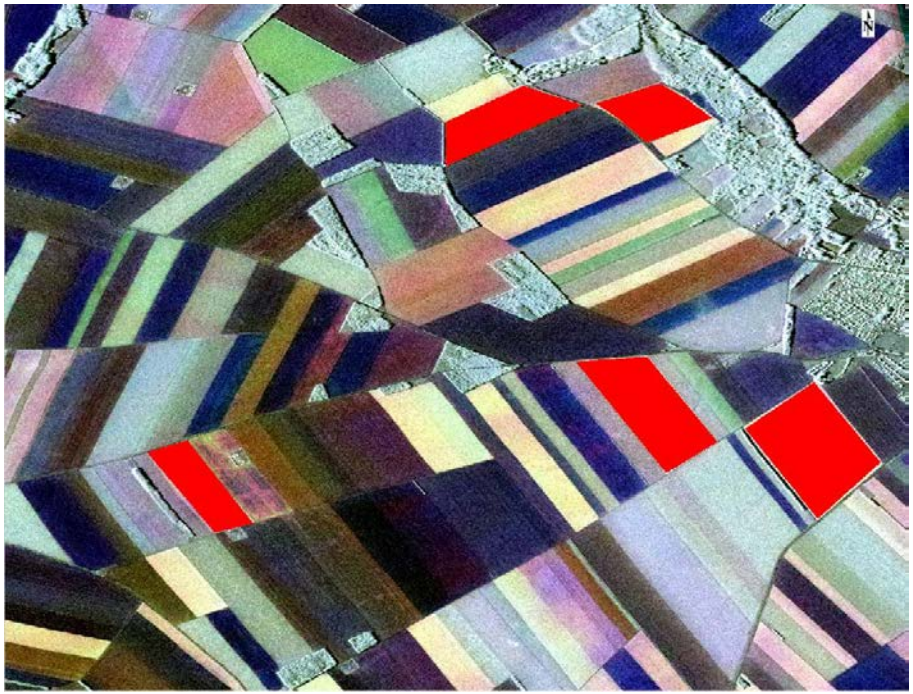




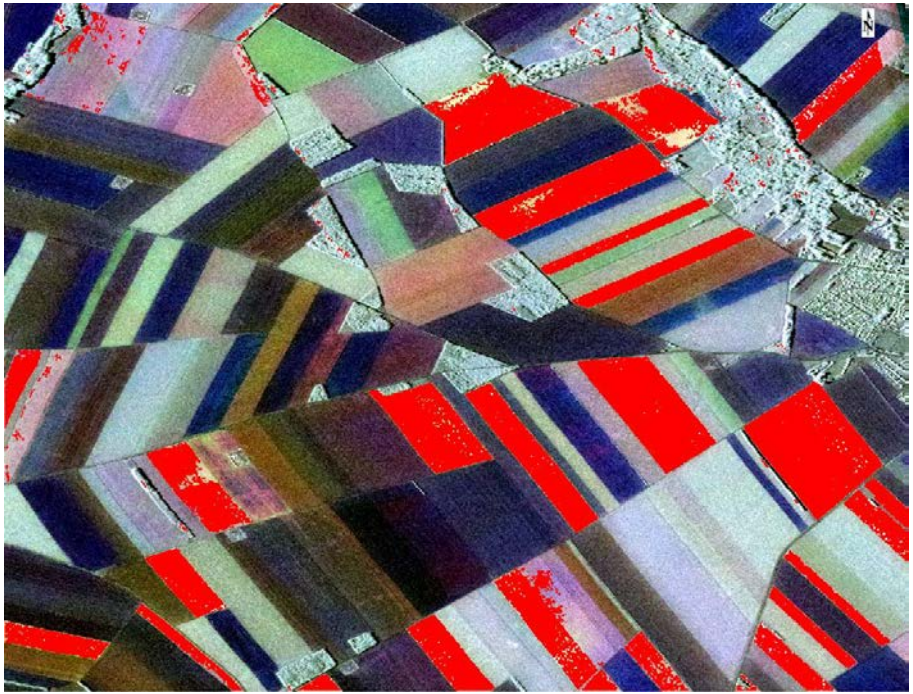


- Unclassified
- October 22, 2017
- November 3, 2017
- November 15, 2017
- December 9, 2017
- December 21, 2017
- January 2, 2018
- January 14, 2018
- January 26, 2018
- February 7, 2018
- February 19, 2018
- March 3, 2018
- March 15, 2018
- March 27, 2018
- April 8, 2018
- April 20, 2018
- May 2, 2018
- May 14, 2018
- May 26, 2018
- June 7, 2018
- June 19, 2018
- July 1, 2018
- July 13, 2018
- July 25, 2018
- August 6, 2018
- August 18, 2018
- August 30, 2018
- September 11, 2018
- September 23, 2018
- October 5, 2018
- October 29, 2018
- November 10, 2018
- November 22, 2018

Classification



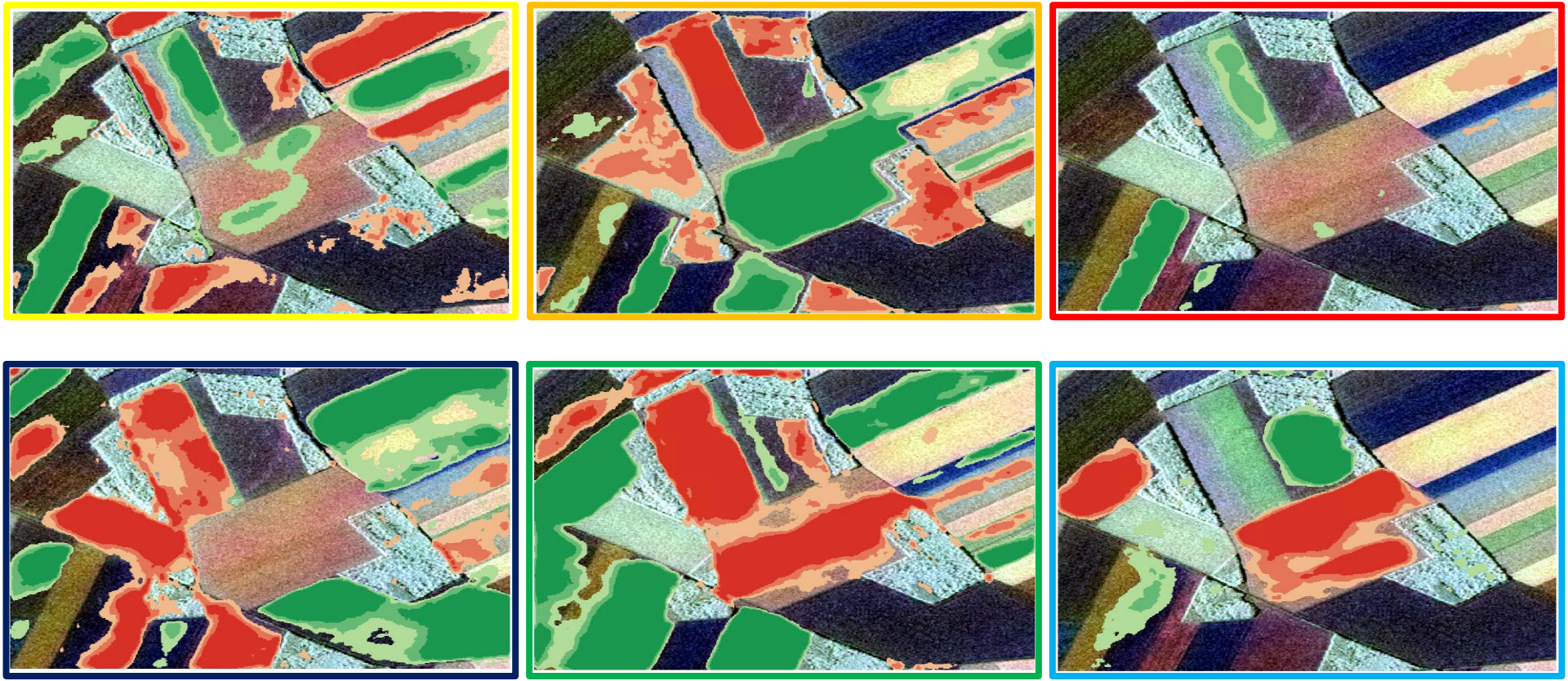
Training Data



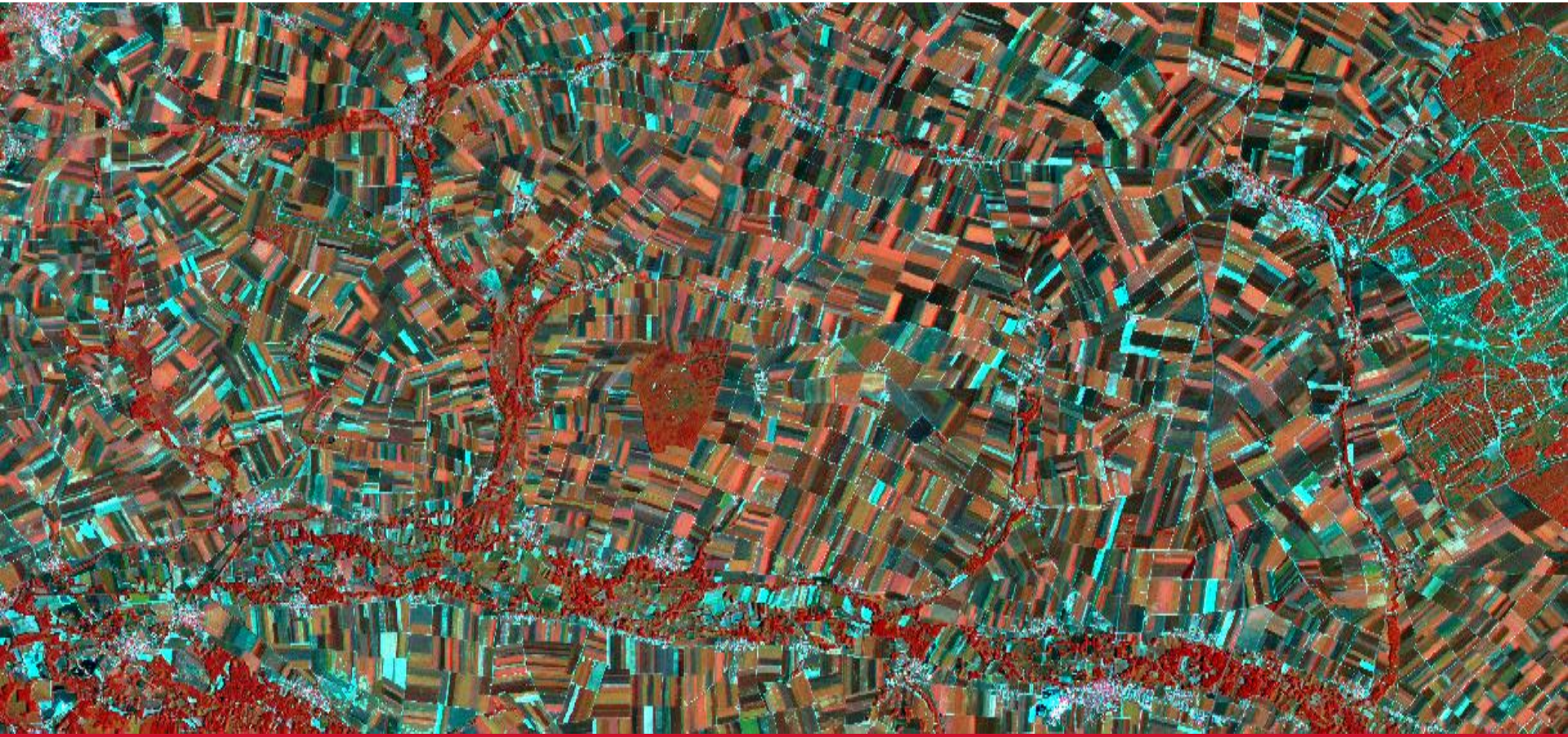
Classification Results

Minimum Distance Classification for Wheat

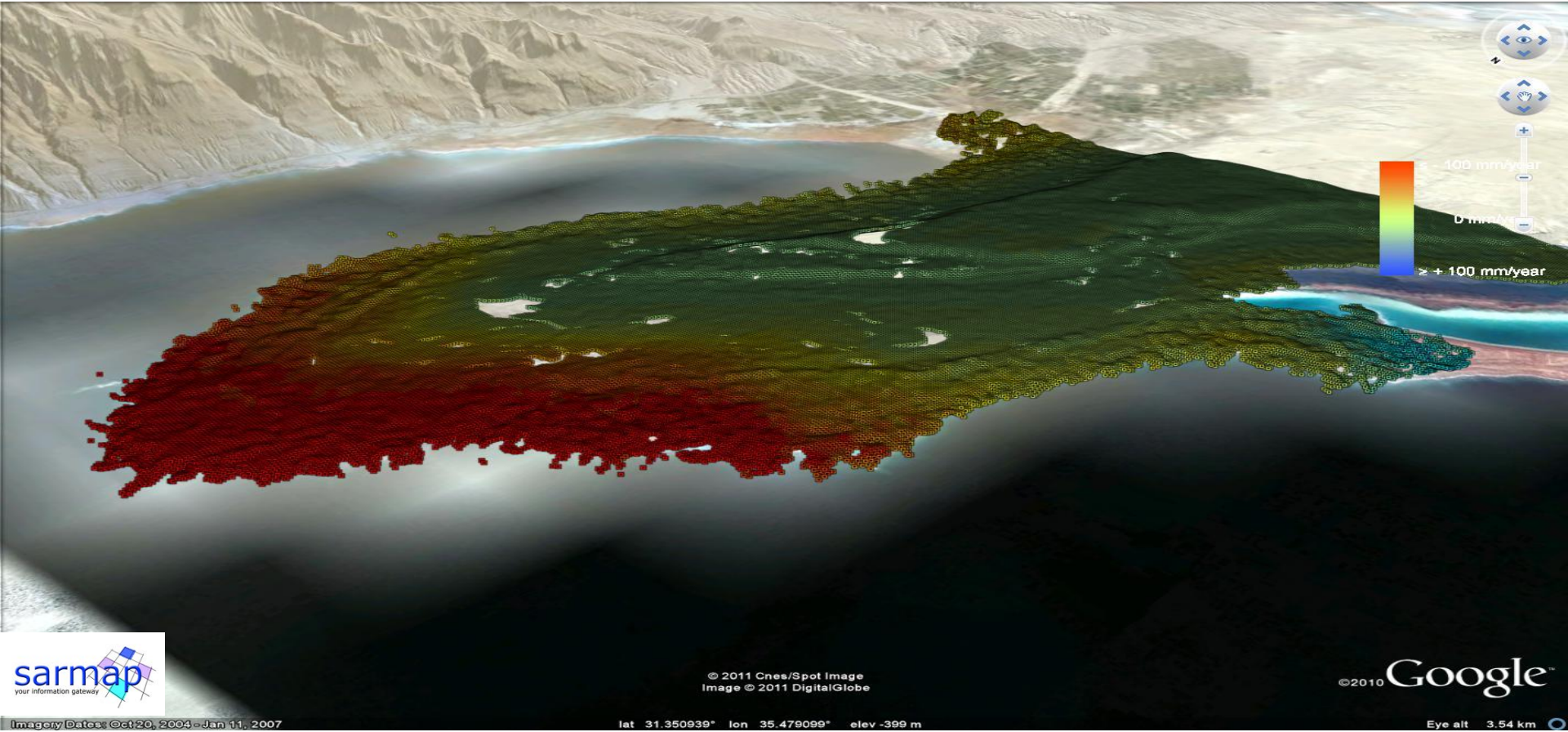
Developing Hotspots with SAR



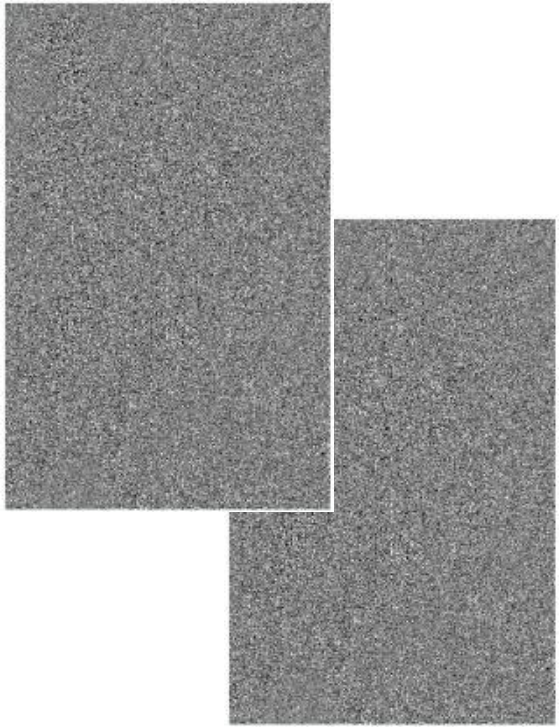
Agriculture Overview



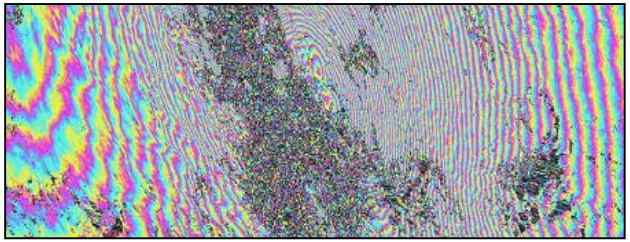
Land Surface Deformation



Intro to Interferometry

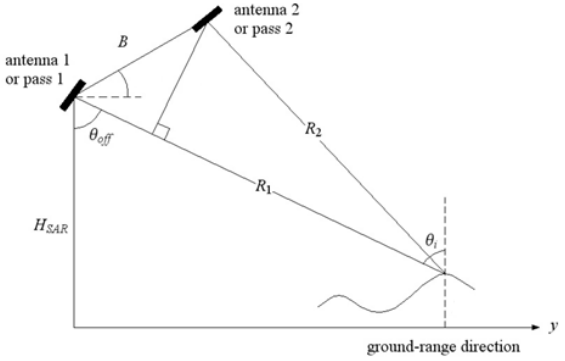


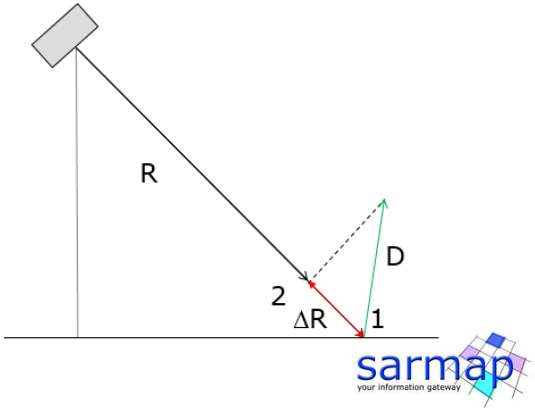
SAR Phase



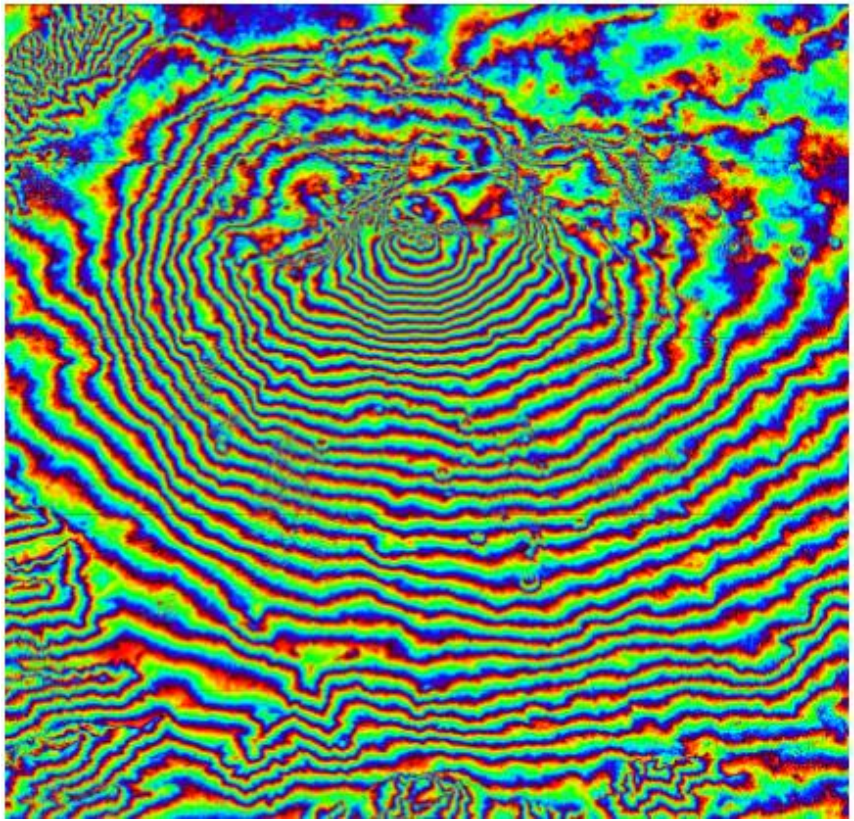
SAR Interferometry

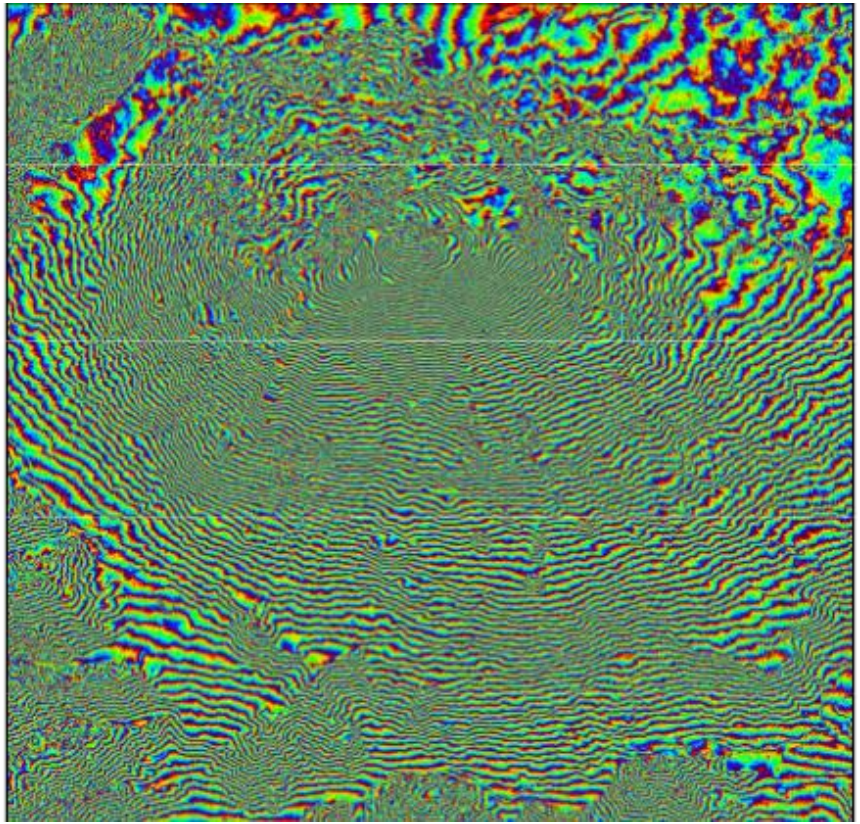
$$\phi_{Int} = \phi_{Topography} + \phi_{Movement} + \phi_{Noise} + \phi_{Atmosphere}$$





Importance of Baselines





Intro to Interferometry Part 2

$$\phi_{Int} = \phi_{Topography} + \phi_{Movement} + \phi_{Noise} + \phi_{Atmosphere}$$

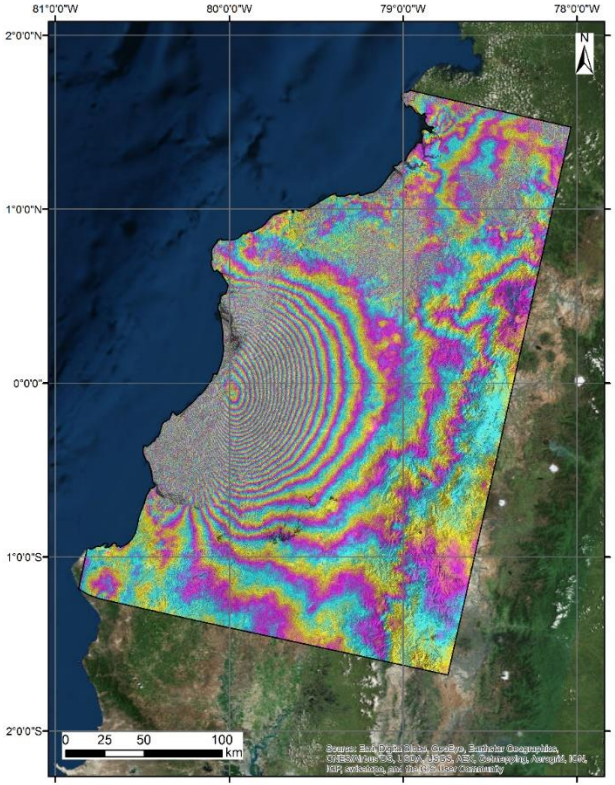
DEM GENERATION

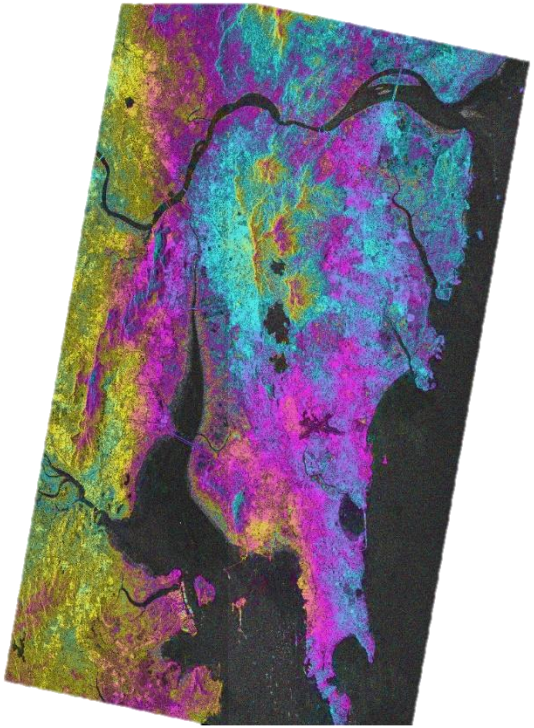
$$\phi_{Int} = \phi_{Topography} + \phi_{Noise}$$

DISPLACEMENT GENERATION

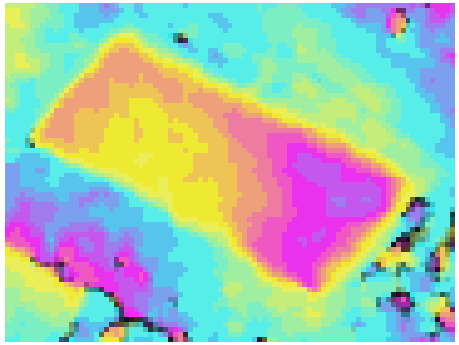
$$\phi_{Int} = \phi_{Movement} + \phi_{Noise}$$

Pair vs. Time Series

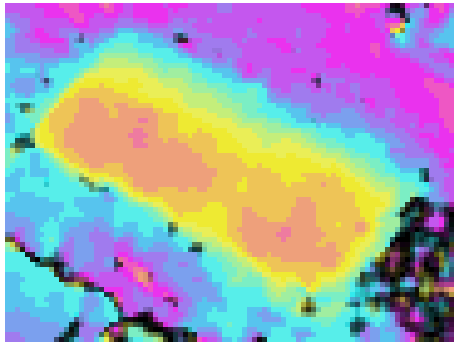




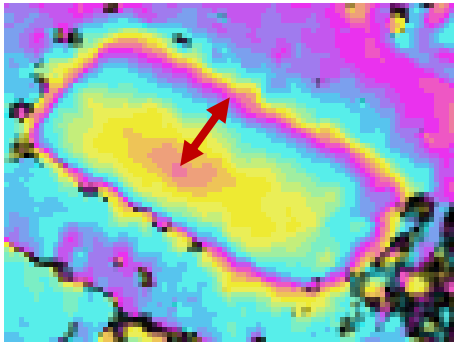
Land Displacement



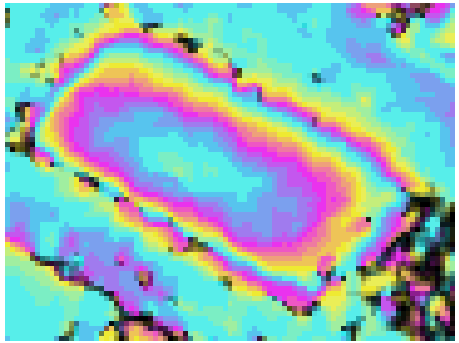
11 Days



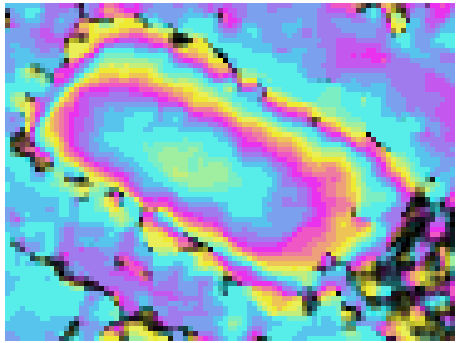
22 Days



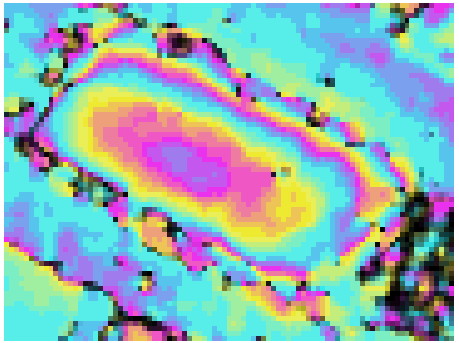
33 Days



44 Days



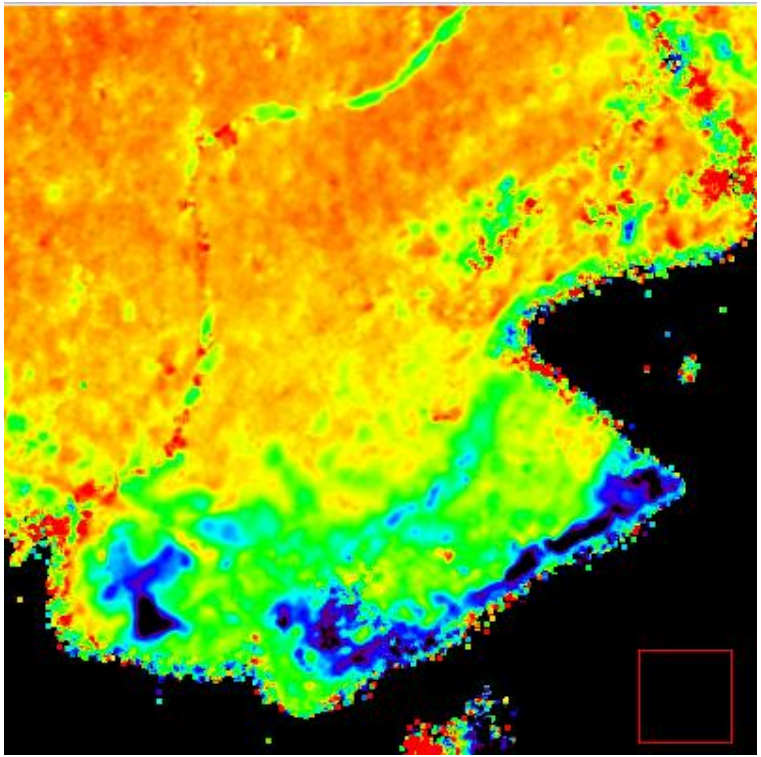
55 Days



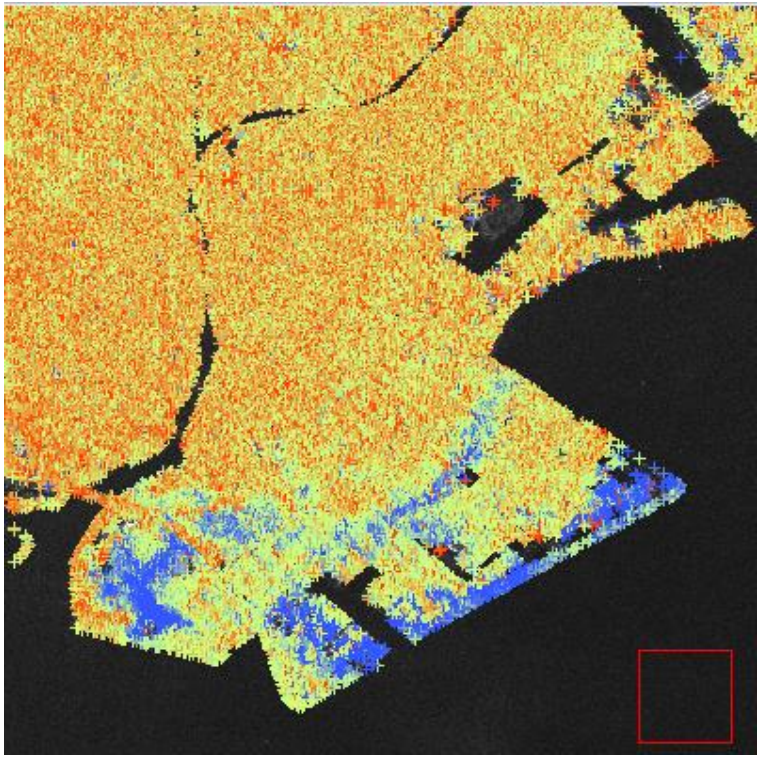
66 Days

1 color cycle ≈ 1.55 cm of displacement

Interferometric Stacking Types

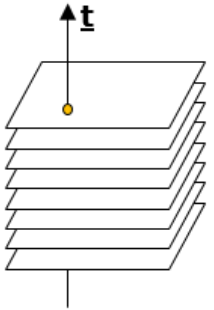


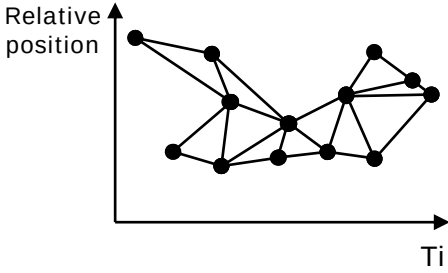
Small BAseline Subsets

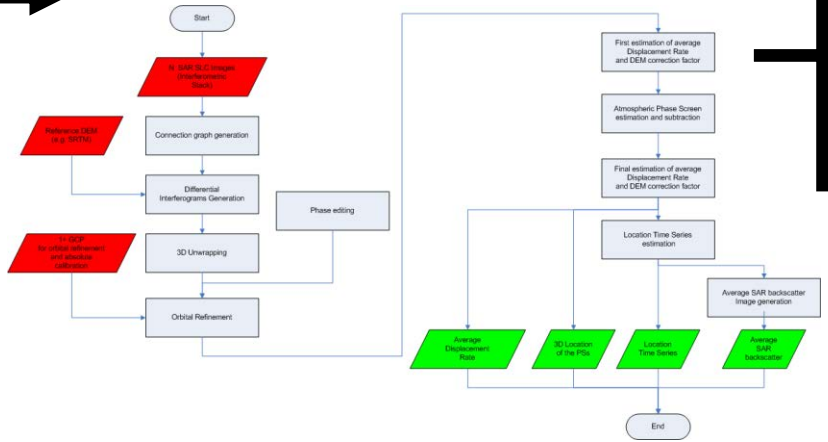


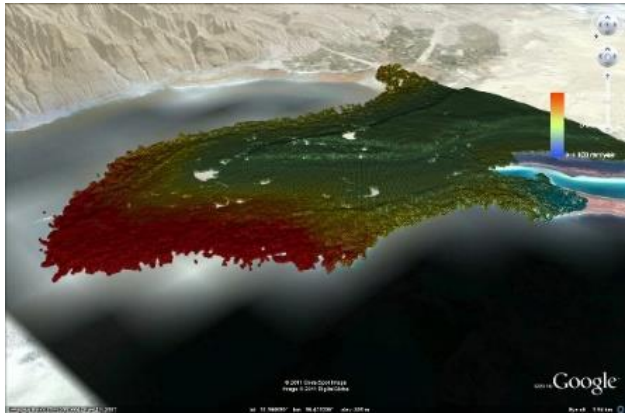
Persistent Scatterers

Small BAseline Subsets

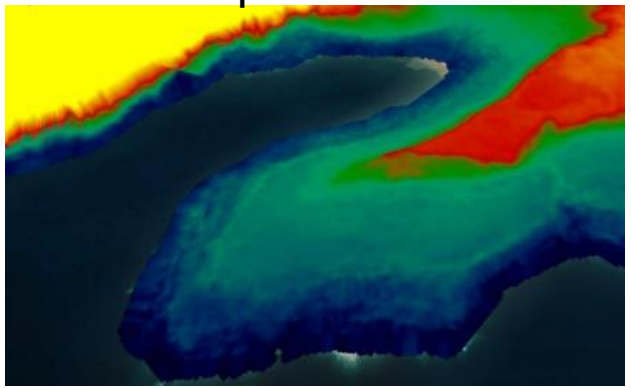








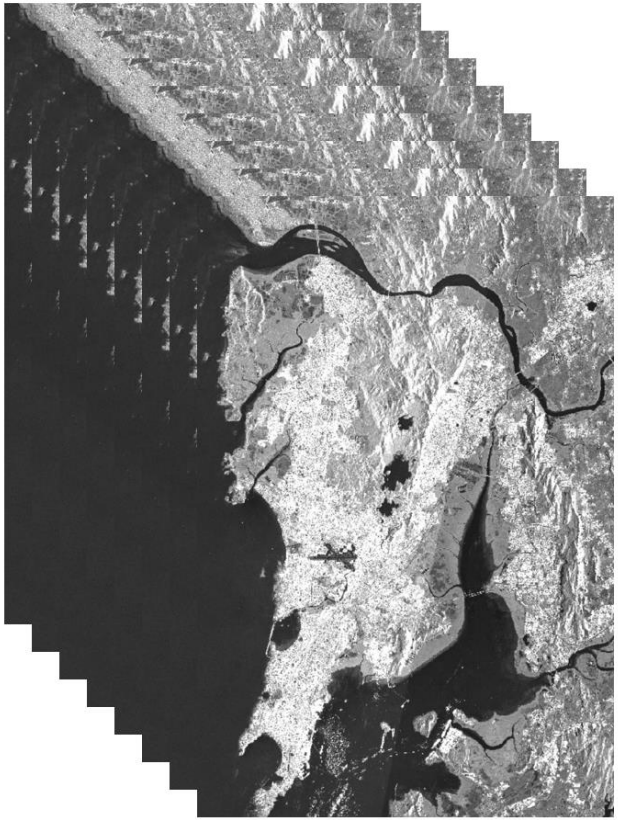
Displacement



Topography

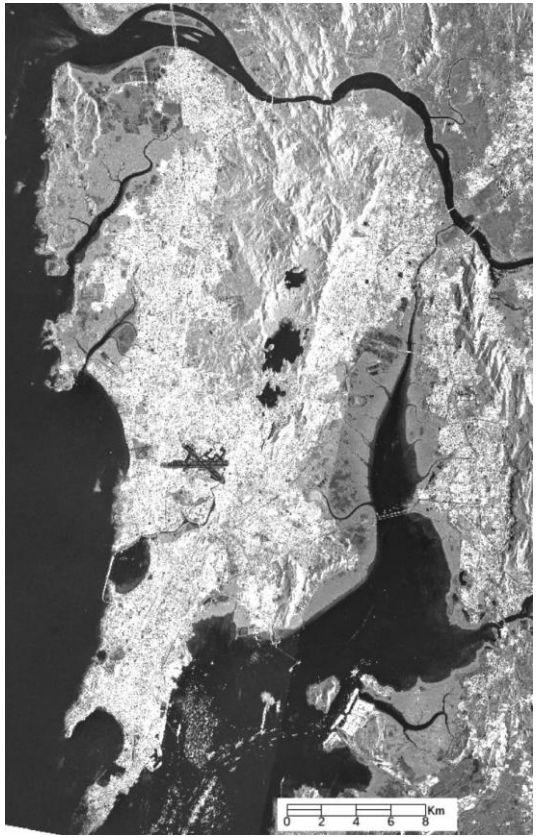
Area of Interest: Mumbai Airport

Data

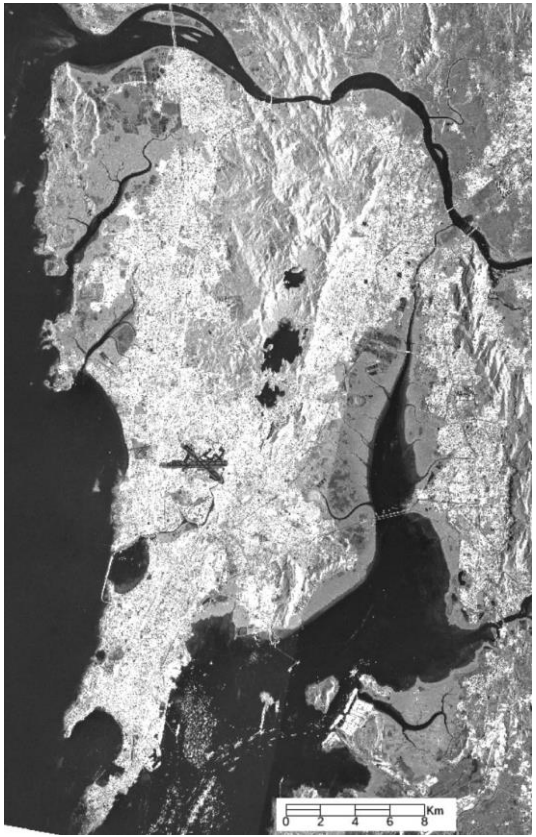


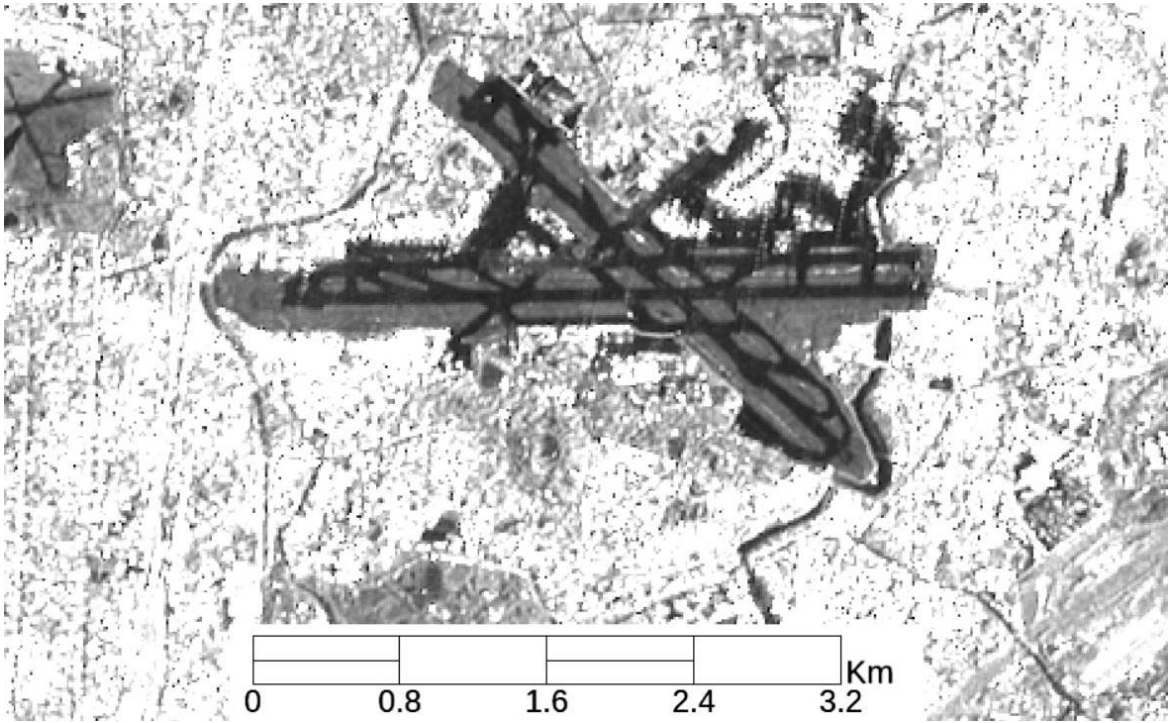
54 Sentinel-1 VV images
Ground Resolution: 15 m
Relative Orbit: 54
Acquisition Geometry: Descending
Time interval:
September 2016 – July 2018
Revisiting time: 12 days

Quick View of Sentinel-1 Imagery



Quick View of Sentinel-1 Imagery





Overview of Steps: Tips and Tricks

SBAS Connection Graph

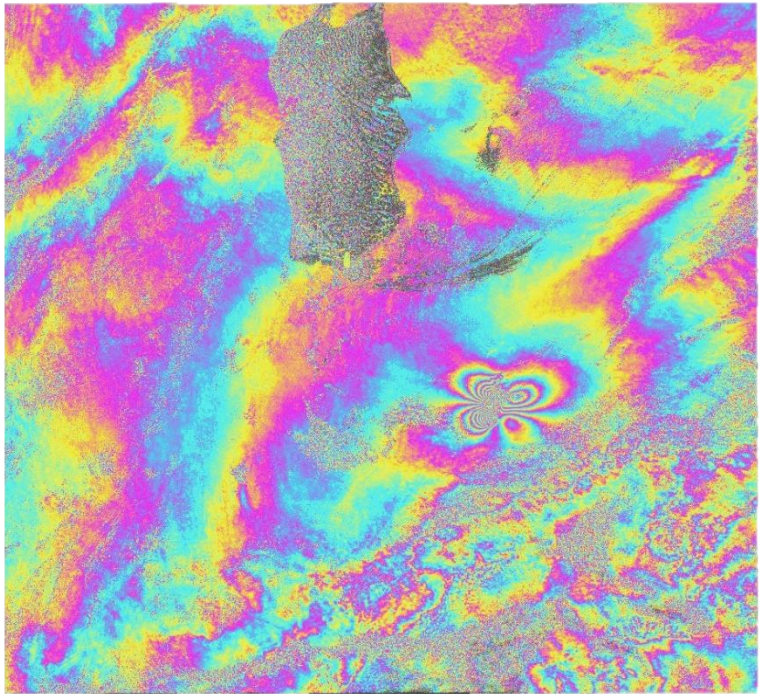
Interferogram Generation

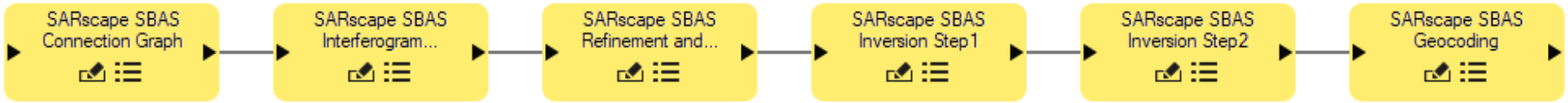
Refinement and Re-flattening

First Inversion

Second Inversion

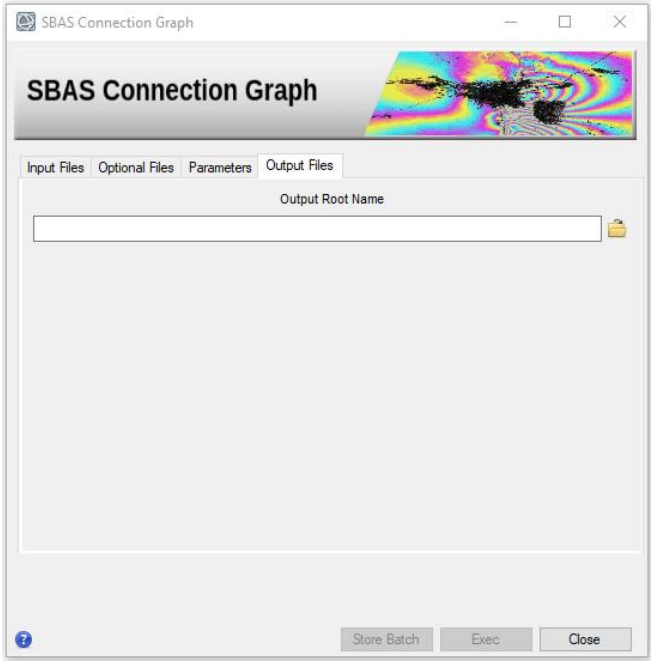
Geocoding

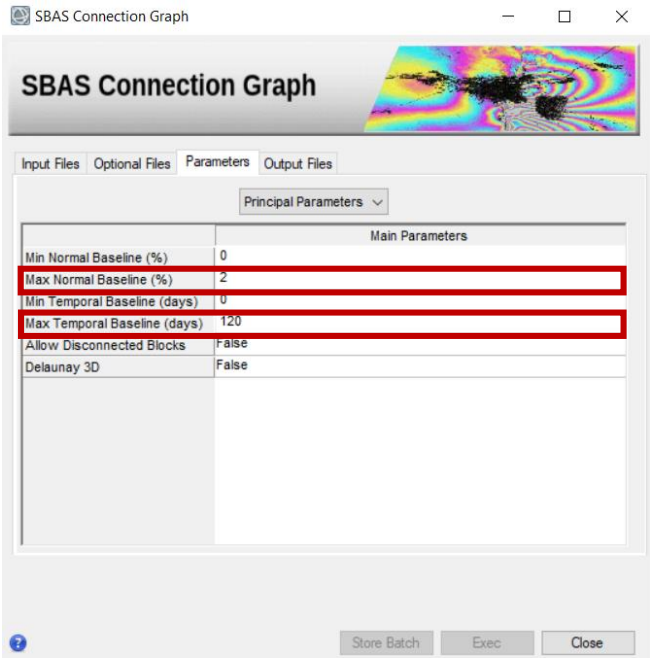


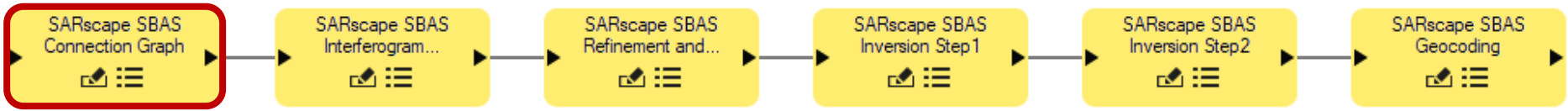


Connection Graph

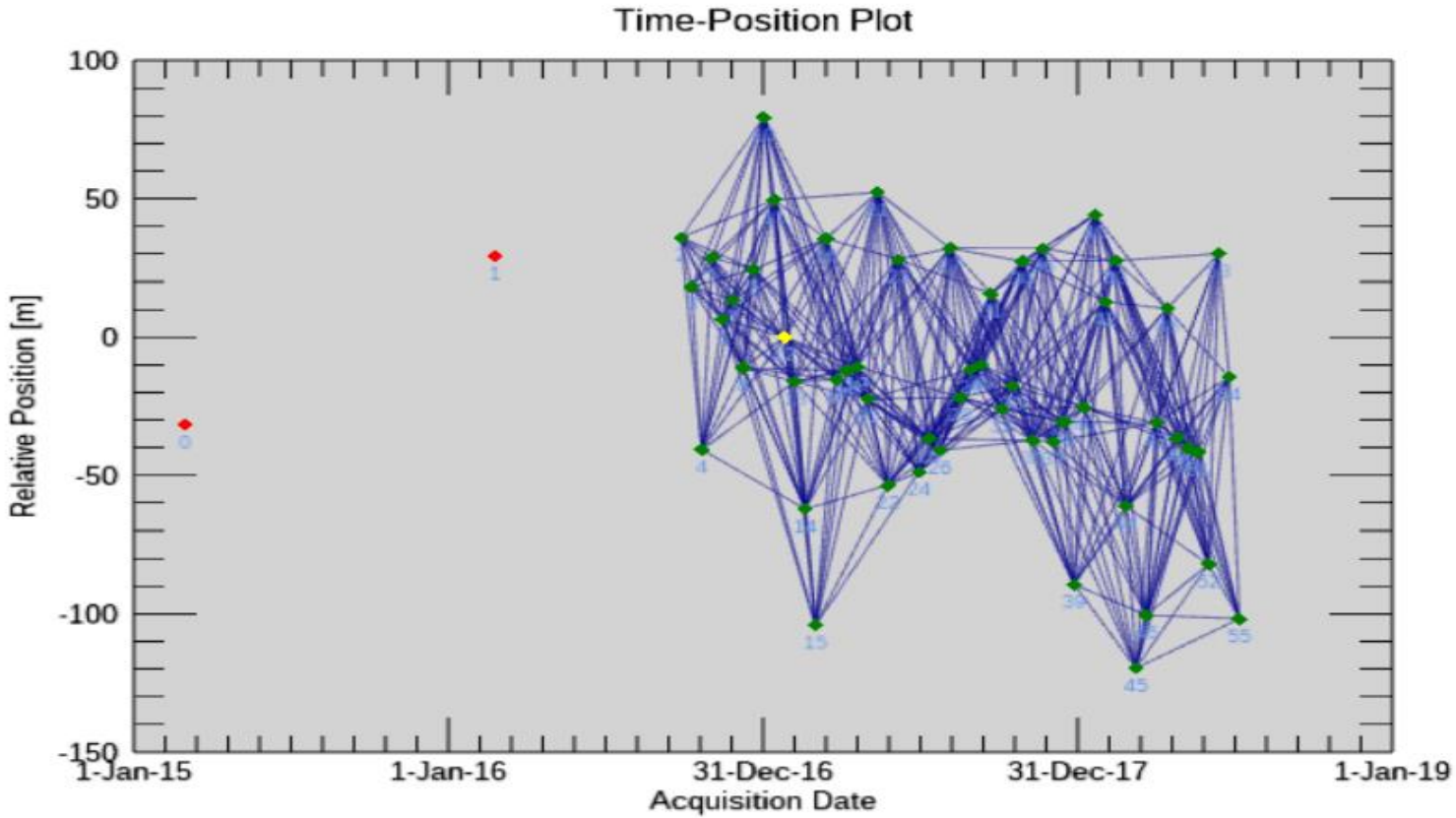
Builds a graph to show the relations of the imagery using the temporal and positional baseline



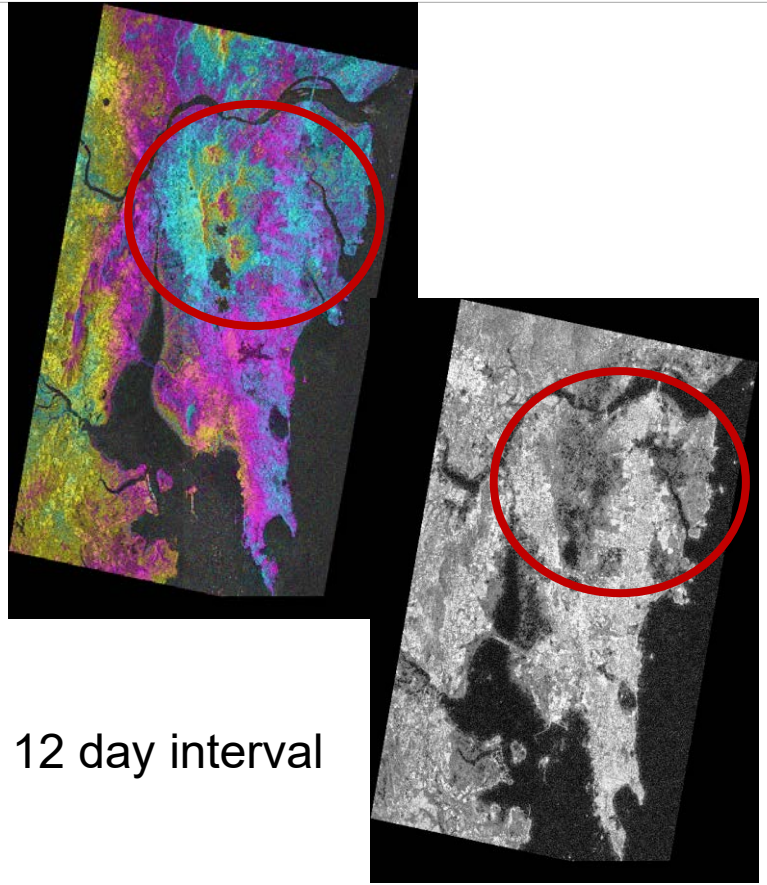




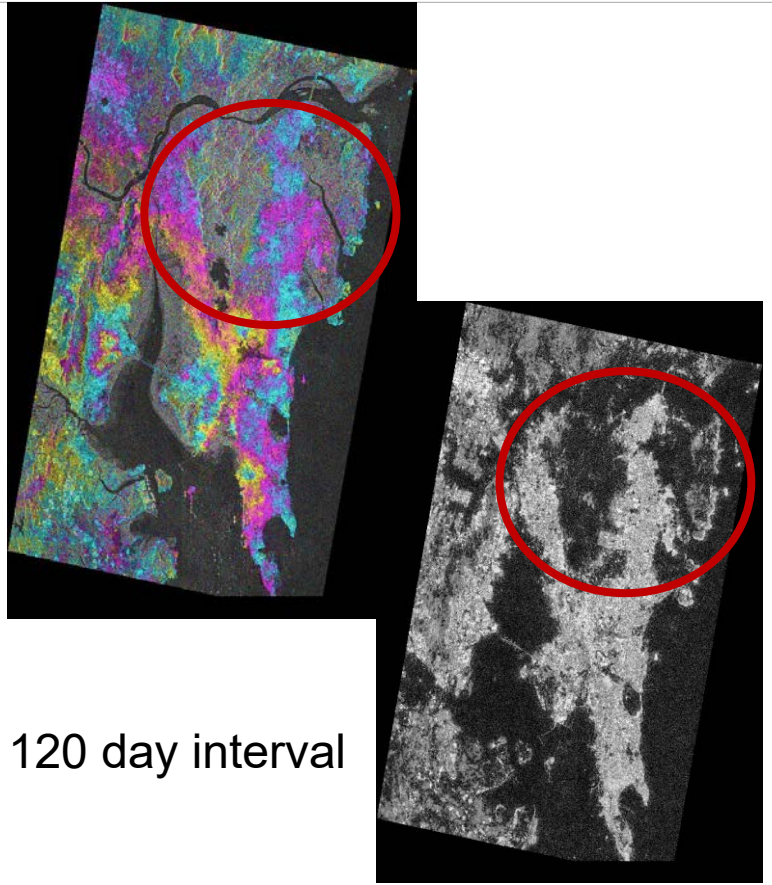
Connection Graph



Temporal Decorrelation



12 day interval

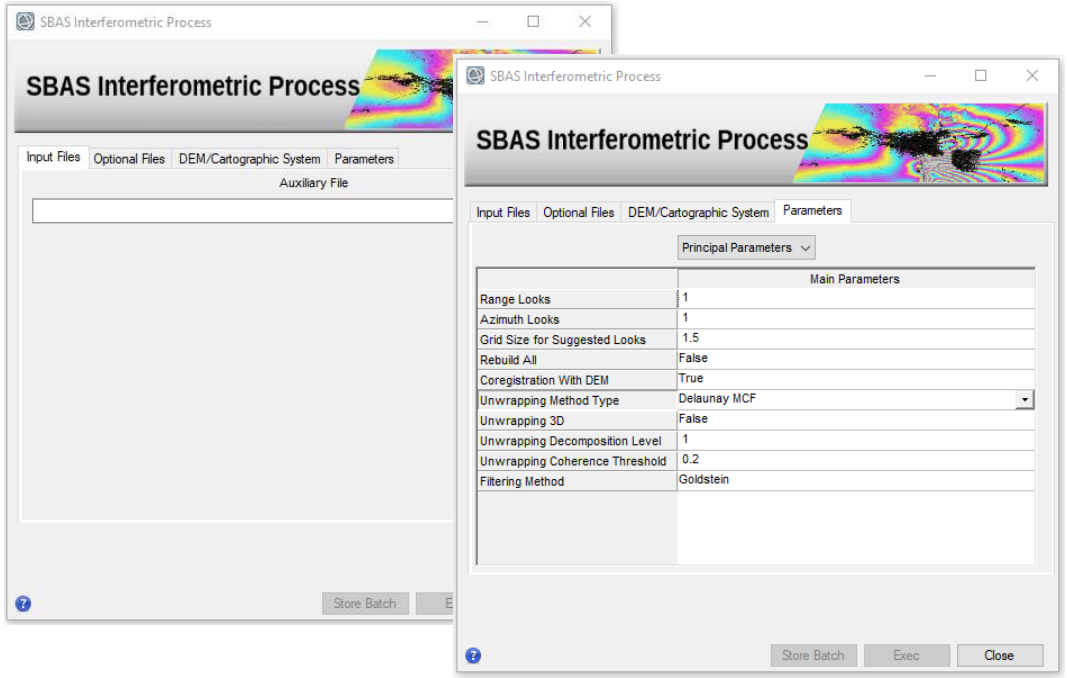


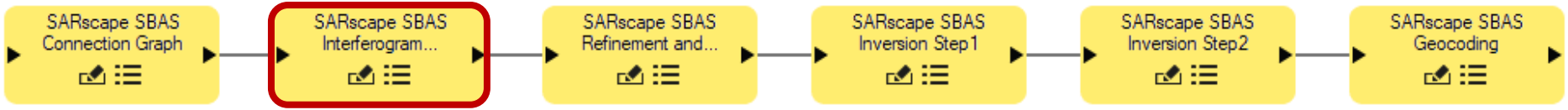
120 day interval

Interferogram Generation

Creates interferograms for every pair.

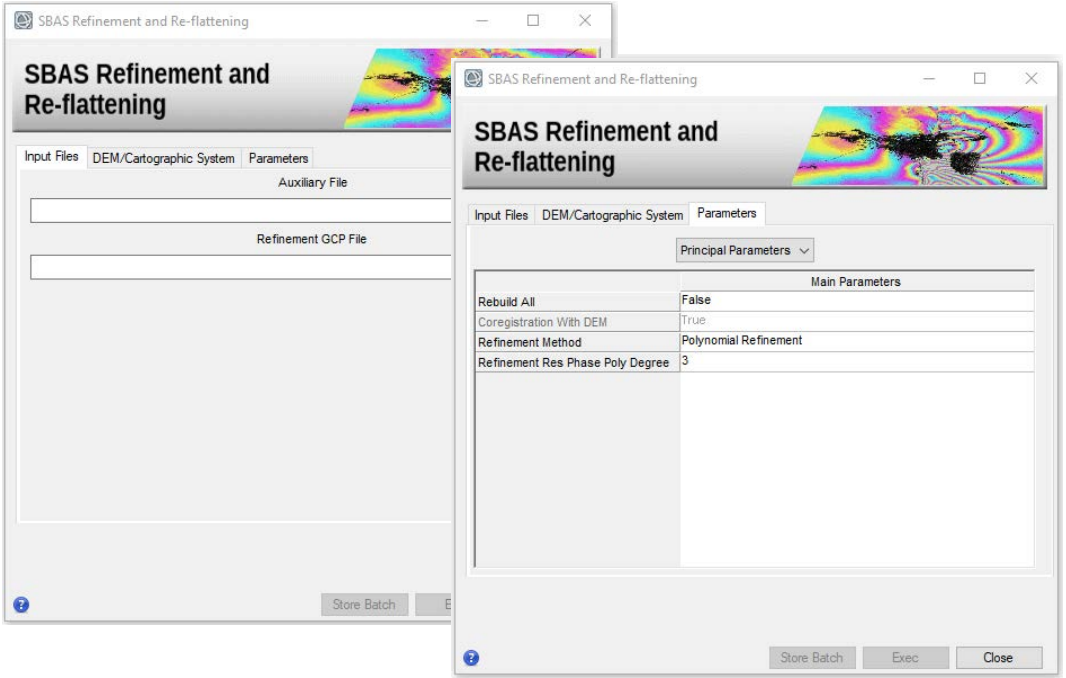
Make sure to check on the outputs!

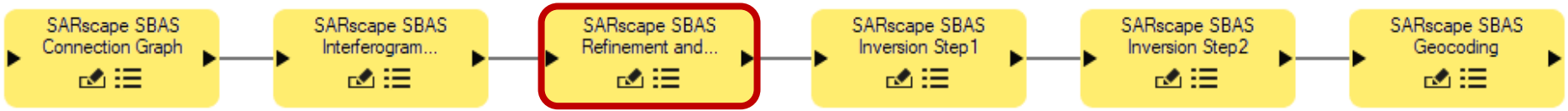




Refinement and Re-flattening

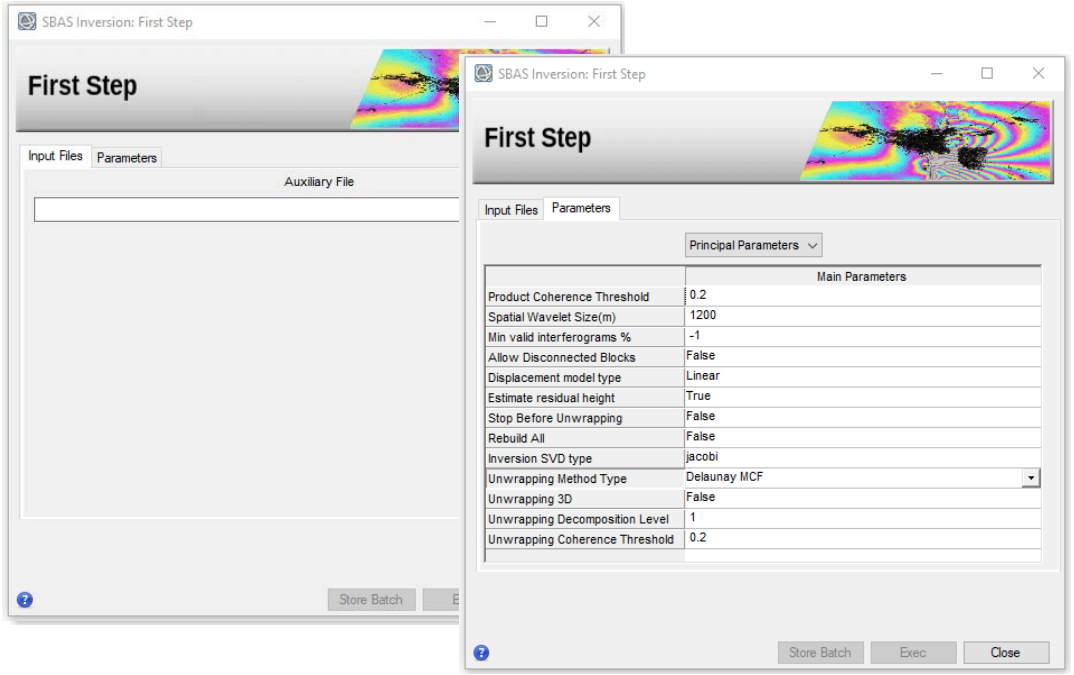
Uses a Ground Control Point file to refine orbit and flatten the phase response

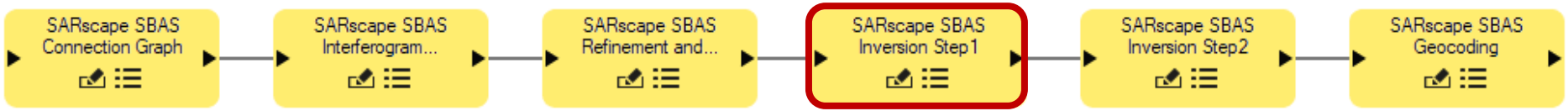




First Inversion

Calculates residual phase and displacement to re-flatten phase and generate better products.

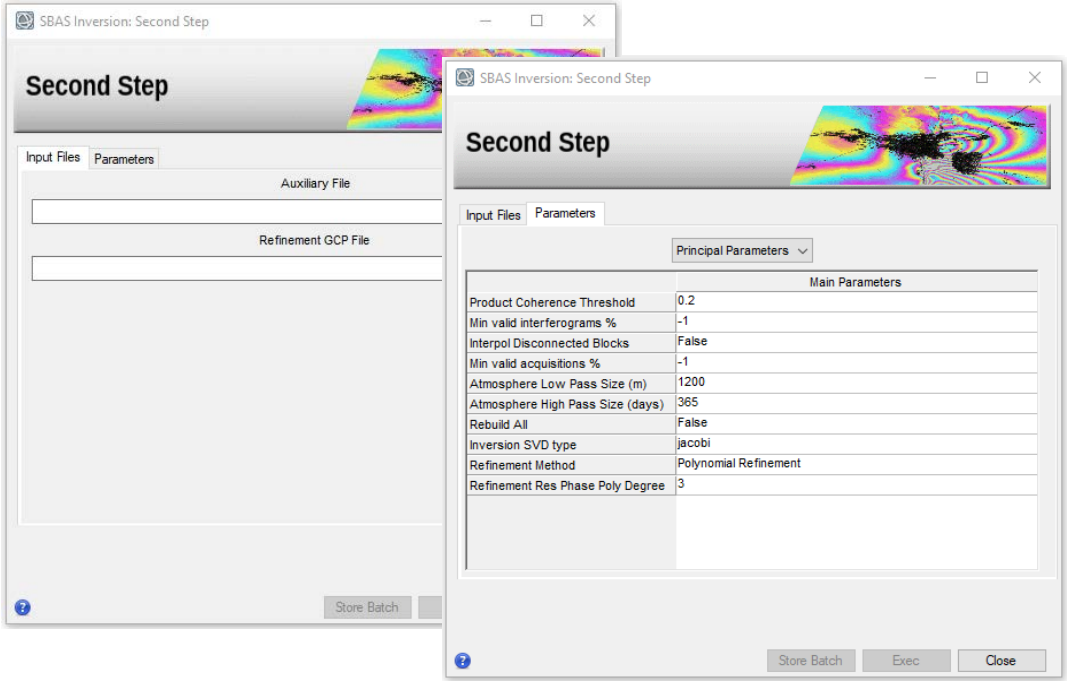


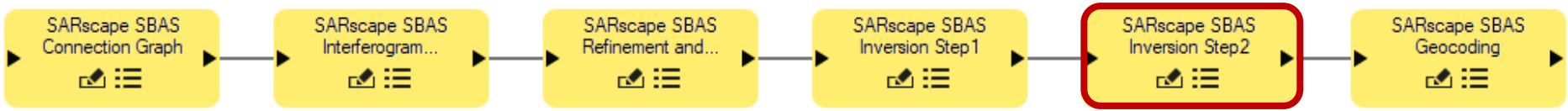


Second Inversion

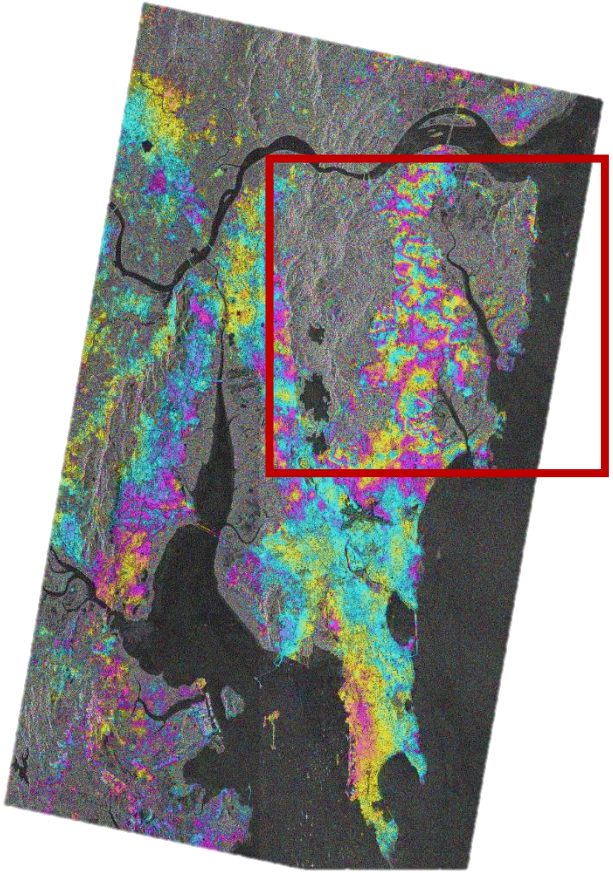
Removes atmospheric effects

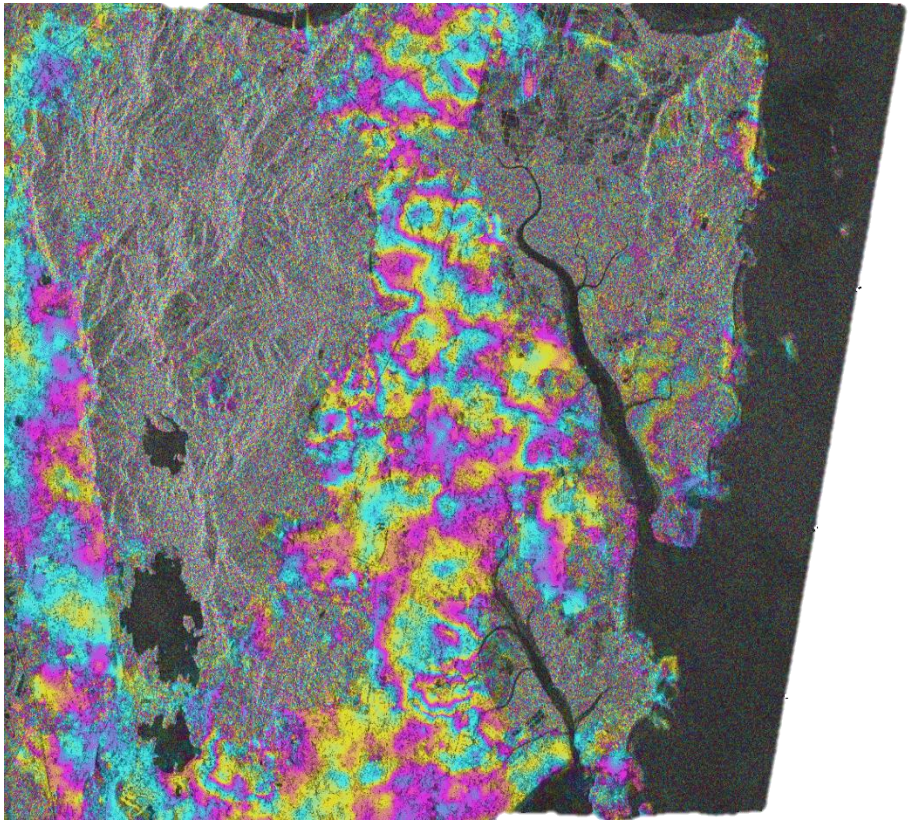
Fits the outputs to the displacement velocity model



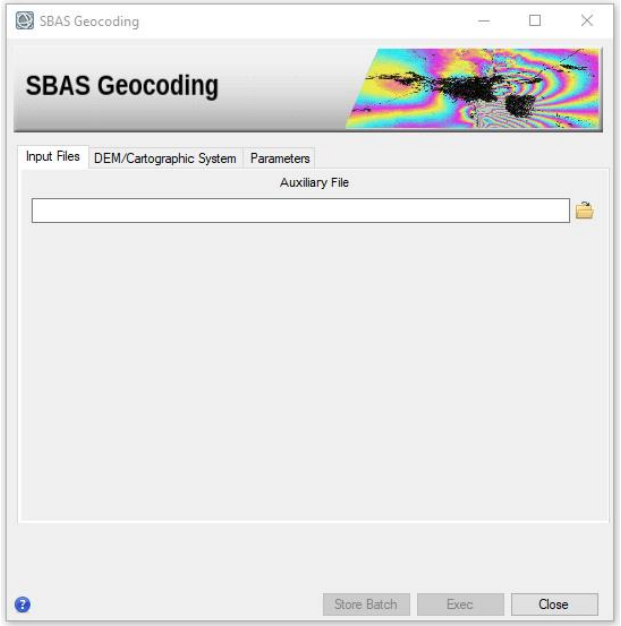


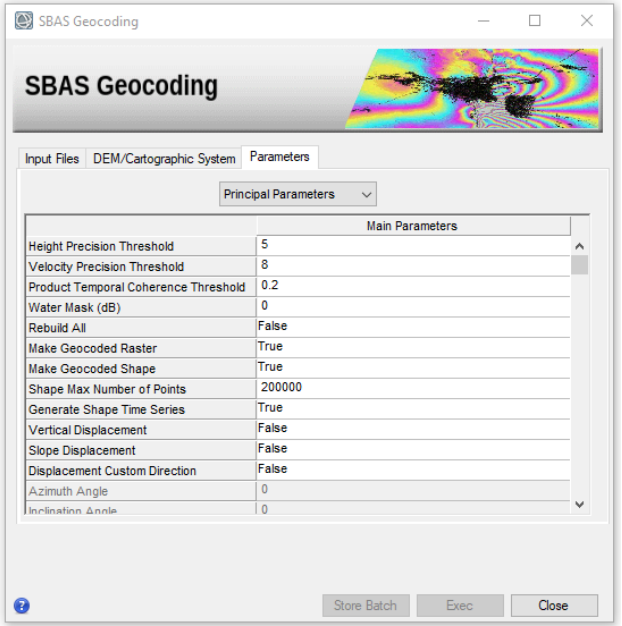
Atmospheric Effects

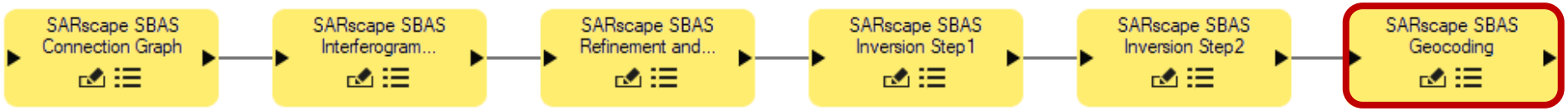




Geocoding


SBAS Geocoding
SBAS Geocoding
Input Files
DEM/Cartographic System
Parameters
Auxiliary File
Store Batch
Exec
Close

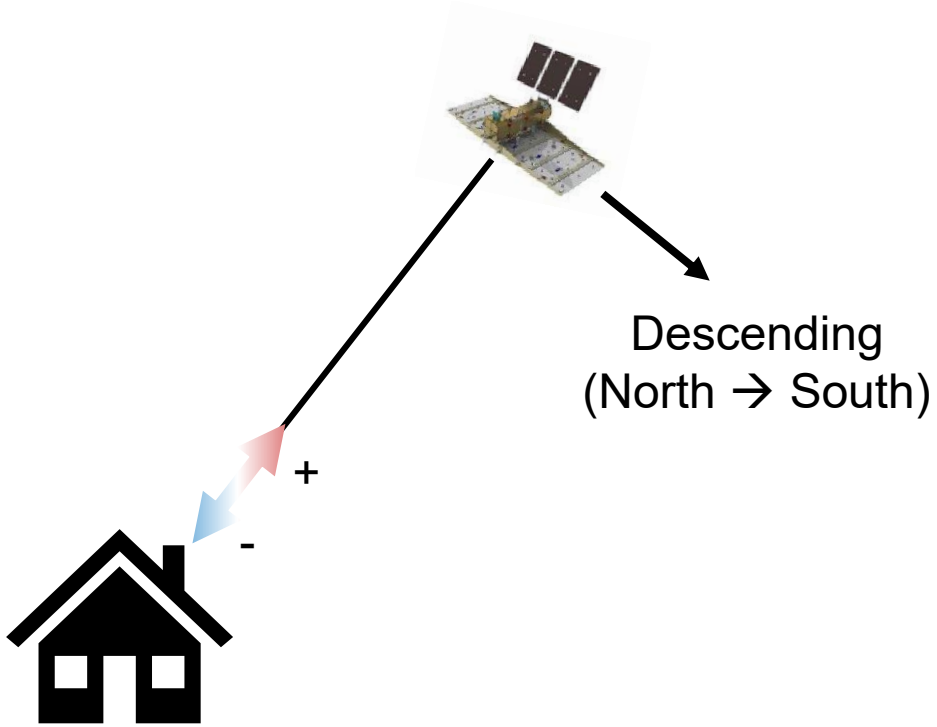

SBAS Geocoding
SBAS Geocoding
Input Files
DEM/Cartographic System
Parameters
Principal Parameters
Main Parameters
Height Precision Threshold 5
Velocity Precision Threshold 8
Product Temporal Coherence Threshold 0.2
Water Mask (dB) 0
Rebuild All False
Make Geocoded Raster True
Make Geocoded Shape True
Shape Max Number of Points 200000
Generate Shape Time Series True
Vertical Displacement False
Slope Displacement False
Displacement Custom Direction False
Azimuth Angle 0
Inclination Angle 0
Store Batch
Exec
Close


SARscape SBAS Connection Graph
SARscape SBAS Interferogram...
SARscape SBAS Refinement and...
SARscape SBAS Inversion Step1
SARscape SBAS Inversion Step2
SARscape SBAS Geocoding

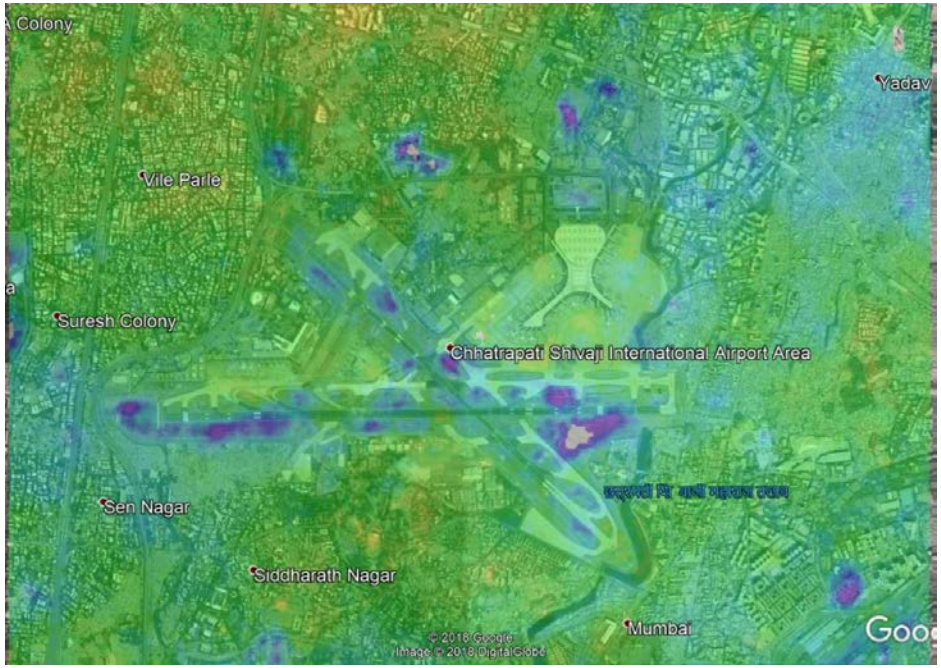
Line of Sight

Displacement with one acquisition geometry is not TRUE vertical and horizontal displacement.

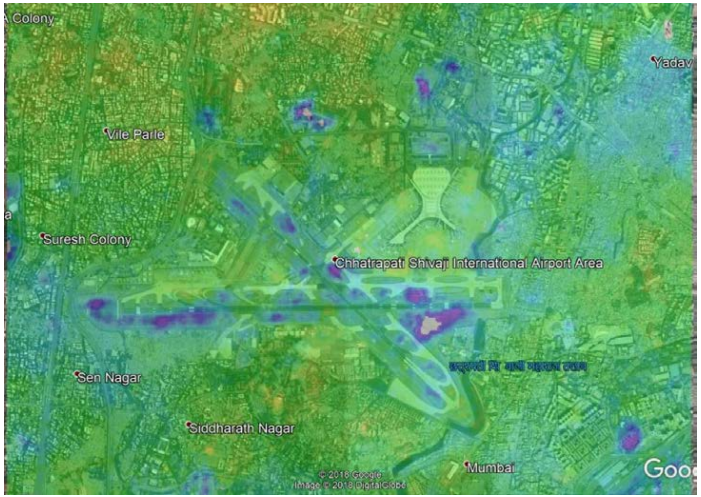
It is relative to the viewing angle of the satellite

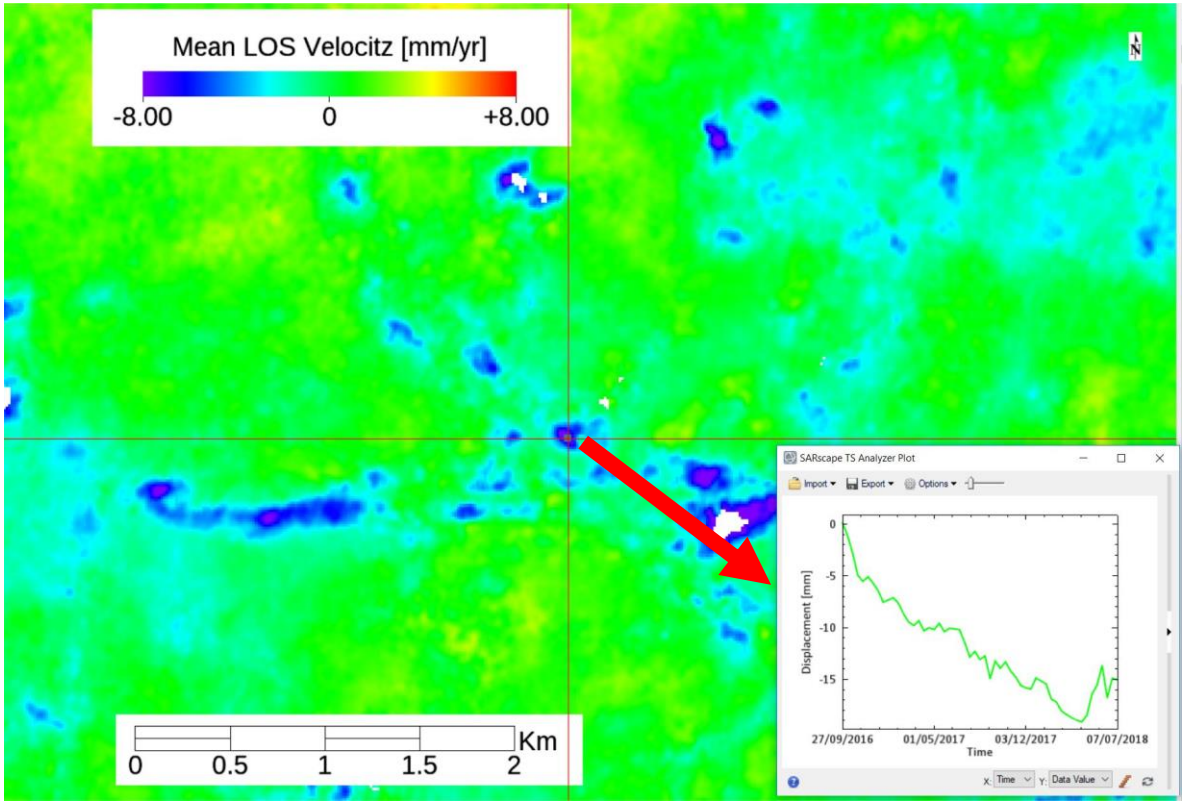


Final Outputs

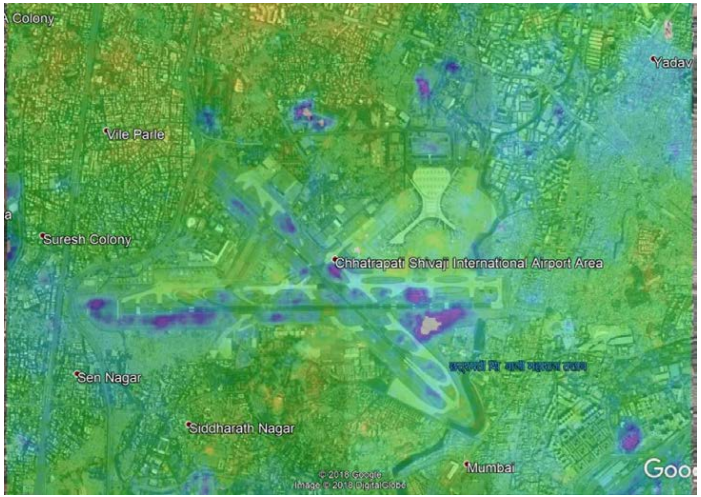


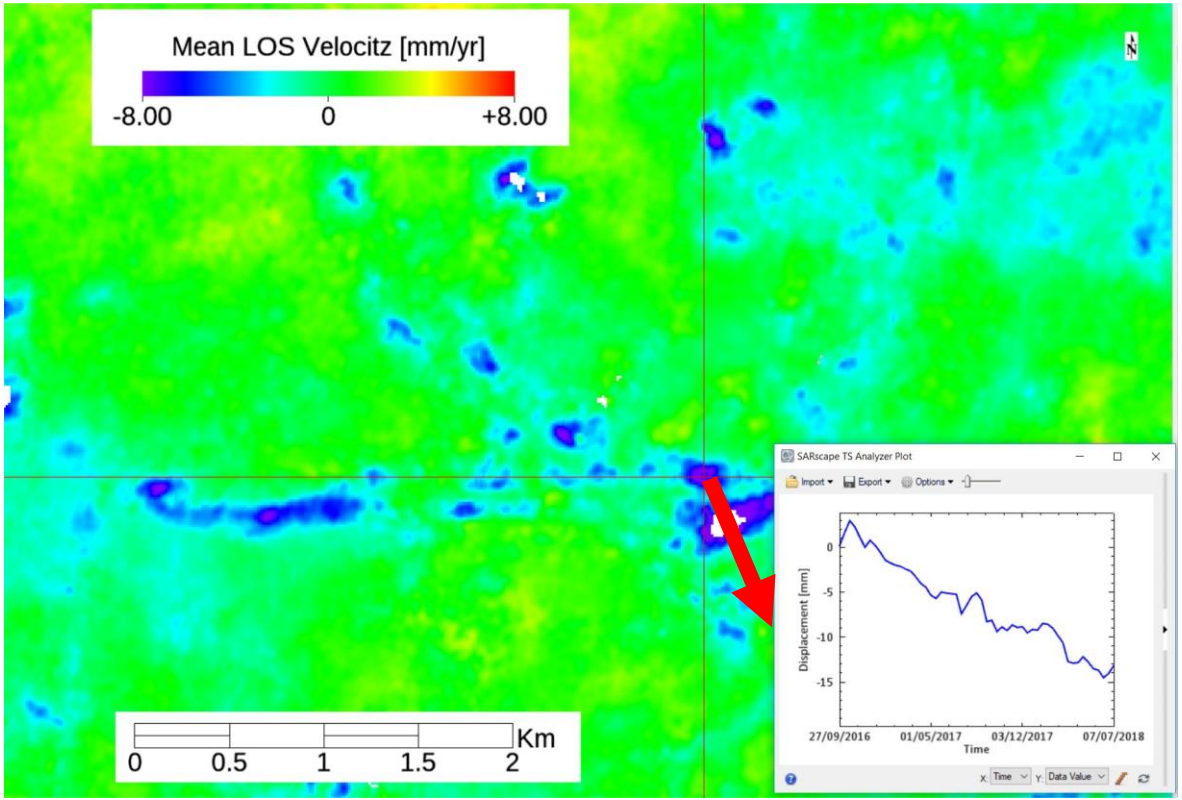
Final Outputs



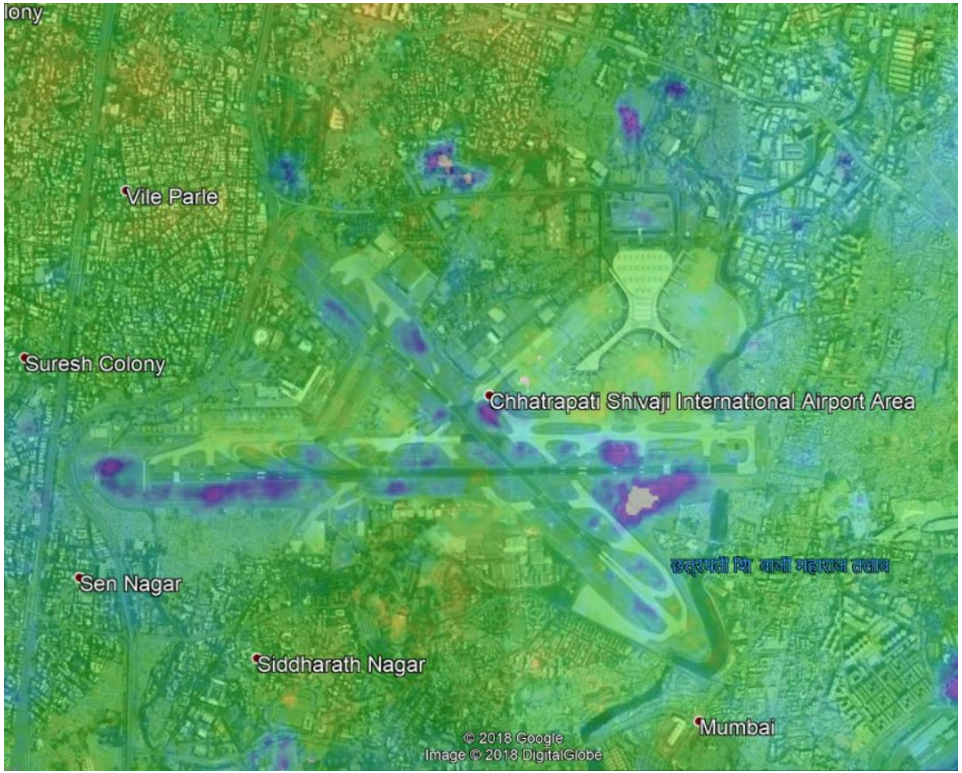


Final Outputs





Conclusion



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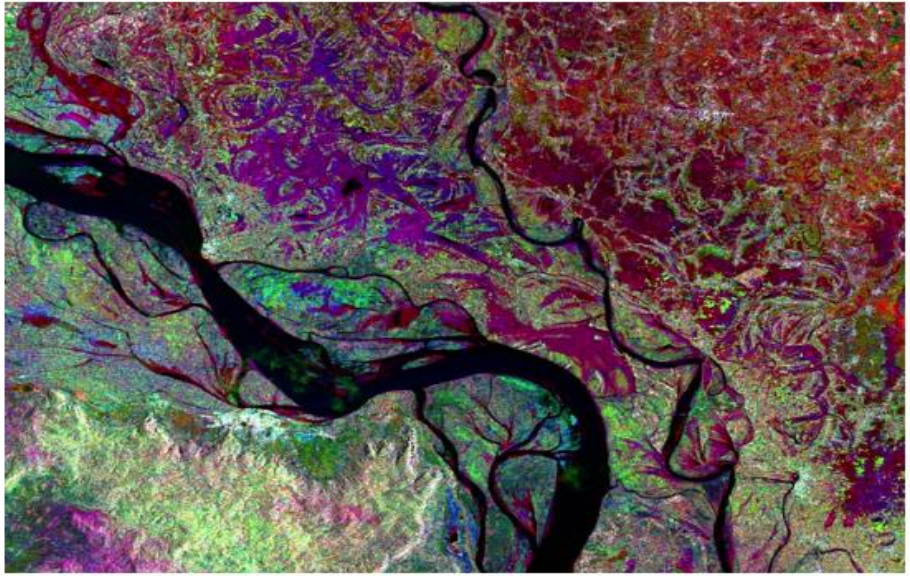
Attendees will glean knowledge and ideas from other successful real-world analytical applications, all while sitting in the beautiful surroundings of Europe's capital of History and Heritage, Rome. Attendance for the symposium is limited to 120 people in order to provide high-quality interaction and participation. All the programme will be presented in English language.



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