HOMEWORK III

PREPARED BY

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COURSE NAME :3D MODELING WITH REMOTE SENSING DATA

LECTURER :PROF. DR. ESRA ERTEN

Information About the Data

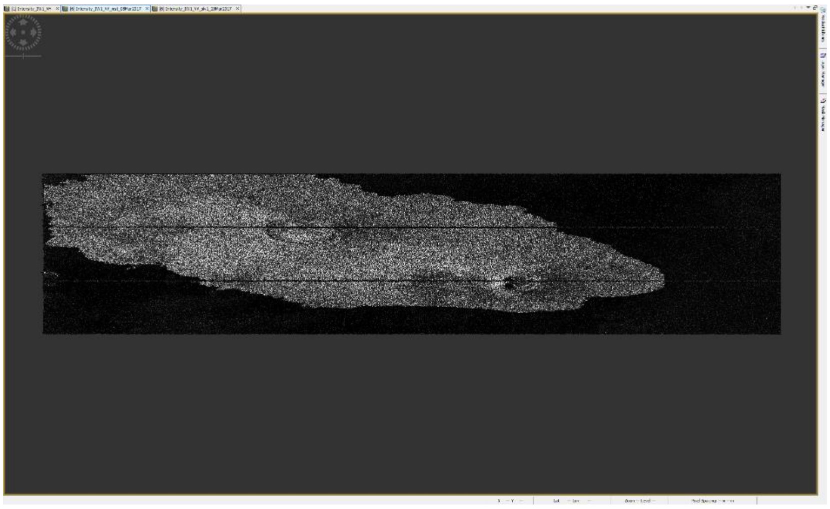
The primary acquisition mode across the Earth's surface is one of the modes of the Seninel IW swath mode. A 250 km swath is covered with a resolution of 5 x 20 m (Range X Azimuth) in a single look. Three sub-swaths are acquired using the Terrain Observation with Progressive Scans SAR (TOPSAR) technique. Large sweep widths and improved radiometric performance are provided by this option.

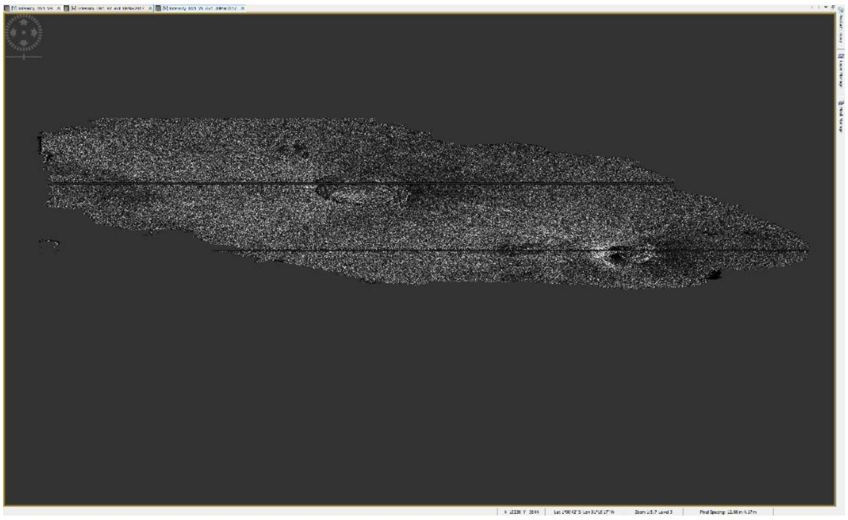
With one or two polarizations, one picture per sub-swath, one image per polarization channel, and a total of three (single polarization) or six (dual polarization) images in an IW product, Single Look Complex (SLC) products in IW mode. Each sub-swath has also been divided into a number of bursts.

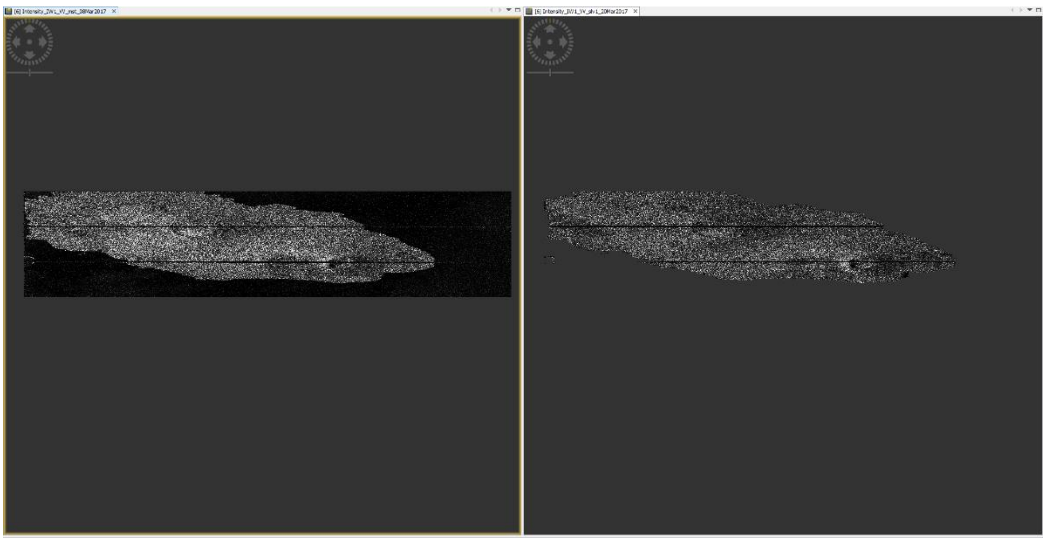
The Copernicus website (scihub.copernicus.eu) allowed for the download of two separate Sentinel-1 satellite data sets.

Data Set Attribute	*Attribute Value*	*Data Set Attribute*	*Attribute Value*
Identifier	S1A_IW_SLC_1SDV_20170319T002614_20170319T002644_015753_019EFB_FA12	Date	2017-03-19T00:26:14.981Z
Instrument	SAR-C	IMode	IW
Polarisation	VV VH	Product class description	SAR Standard L1 Product
Instrument name	Synthetic Aperture Radar (C-band)	Instrument swath	IW1 IW2 IW3

Data Set Attribute	*Attribute Value*	*Data Set Attribute*	*Attribute Value*
Identifier	S1A_IW_SLC_1SDV_20170308T114955_20170308T115025_015600_019A6E_6CE8	Date	2017-20-19T00:26:14.981Z
Instrument	SAR-C	IMode	IW
Polarisation	VV VH	Product class description	SAR Standard L1 Product
Instrument name	Synthetic Aperture Radar (C-band)	Instrument swath	IW1 IW2 IW3

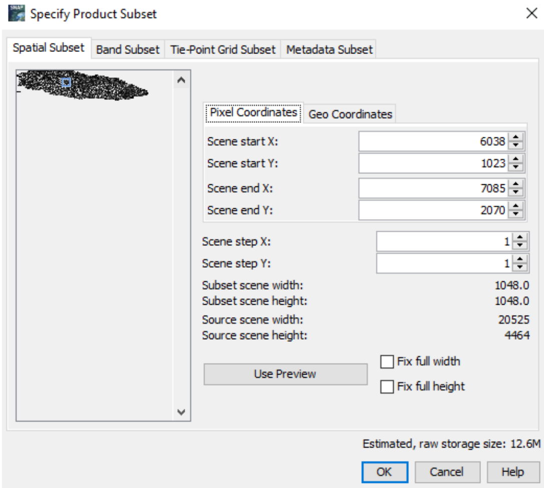






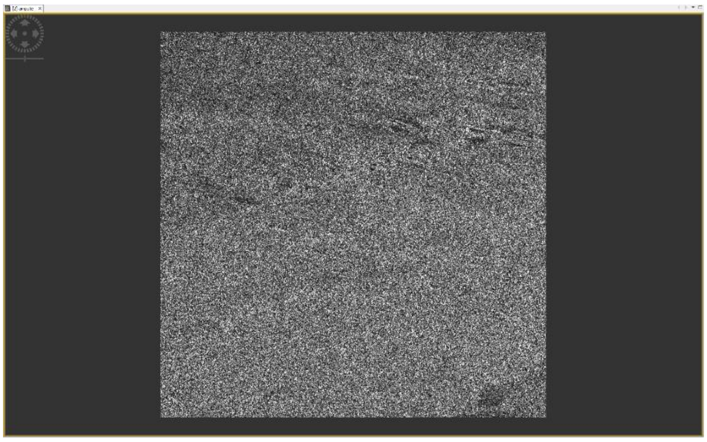
I. Exercise one: Visualize data

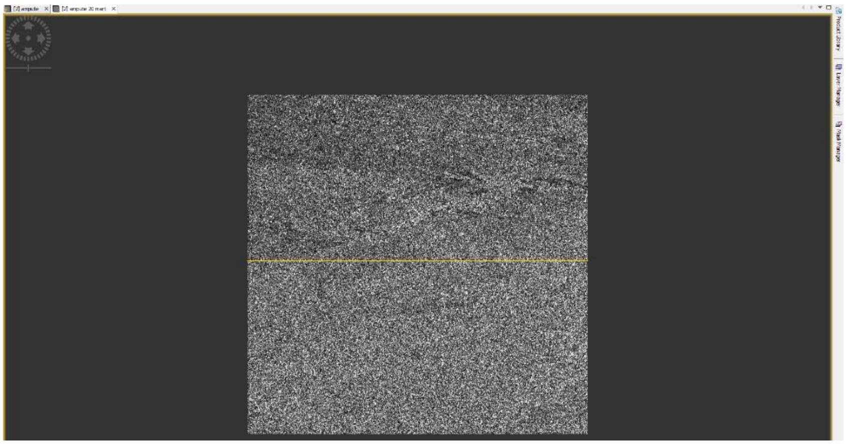
Subsetting



The subsetting of Sentinel-1 satellite data to a dimension of 1048 X 1048 was performed using the ESA SNAP application. The subsetting process involved selecting the desired region of interest from the original Sentinel-1 dataset and specifying the desired dimensions. The SNAP application provided an intuitive graphical user interface (GUI) that facilitated the subsetting operation, allowing for precise control over the subset dimensions. By extracting a sub-image of 1048 X 1048 pixels, the data was effectively cropped to a specific area of interest, enabling further analysis and visualization at a localized level. The first subset image seen above is from March 8, 2017, while the second image is from March 20, 2017.

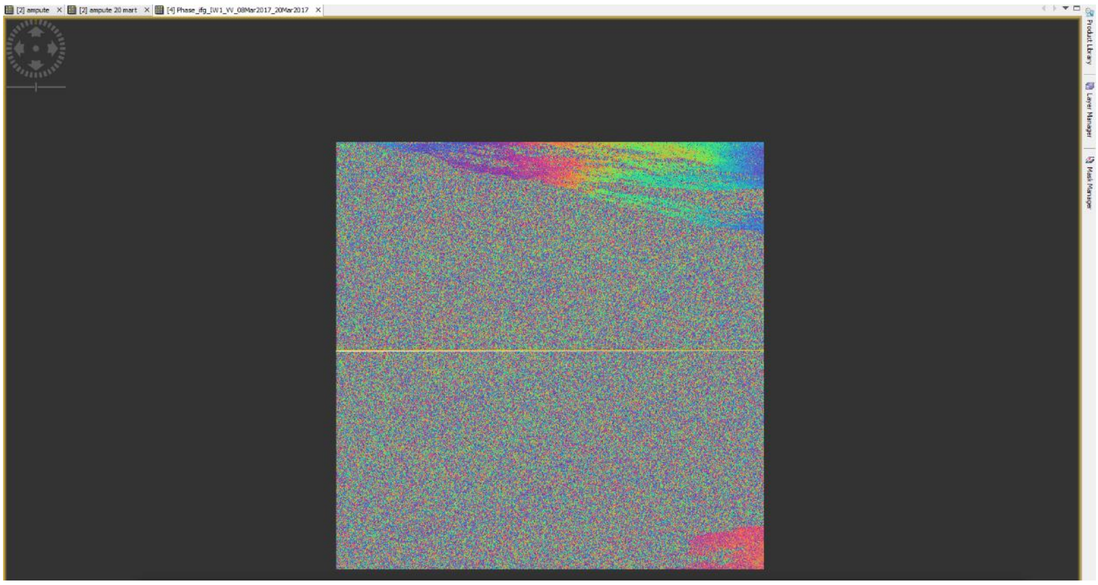
Displaying The Amplitude Of The Data





The amplitude of the subseted Sentinel-1 satellite data, which had been cropped to a resolution of 1048 X 1048 pixels, was displayed using the ESA SNAP tool. The data's magnitude or intensity over the subsegmented region of interest had to be visualized in this stage. The SNAP program produced a clear and useful depiction of the distribution and variation of the amplitude throughout the subseted data by adding a suitable color map to the amplitude values. This visualization provided crucial insights for further research and interpretation by enabling a thorough knowledge of the amplitude characteristics within the particular area of interest. The first amplitude image seen above is from March 8, 2017, while the second image is from March 20, 2017.

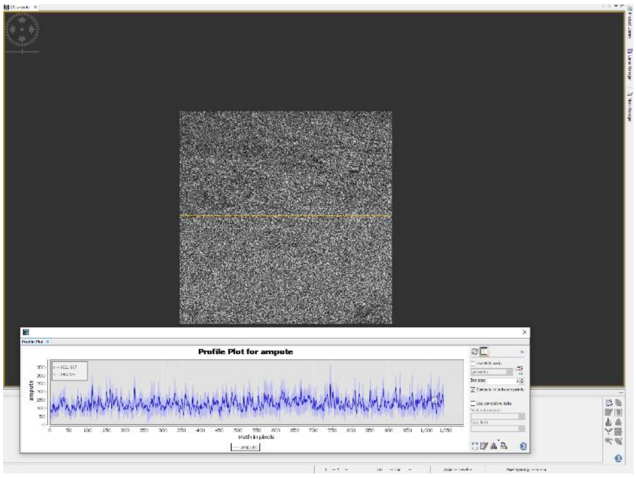
Displaying The Phase Of The Data

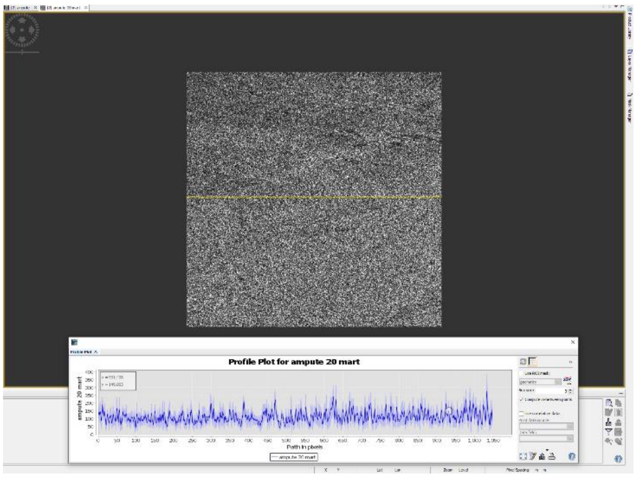


The phase of subseted Sentinel-1 satellite data, which had been cropped to a resolution of 1048 X 1048 pixels, was displayed using the ESA SNAP tool. The phase angles connected to the data points within the subsequent region of interest had to be visualized in this step. The SNAP application created a visual representation of the spatial variation of the phase information throughout the subseted data by assigning an appropriate color map to the phase values. This representation made it easier to spot patterns and phase shifts in the region of interest, allowing for more in-depth examination and interpretation of the observed scene. The phase display contributed to a thorough understanding of the data by offering insightful information about the relationships between the radar signals and by highlighting regions with notable phase deviations.

Profiling Row 512 Of Amplitude Data

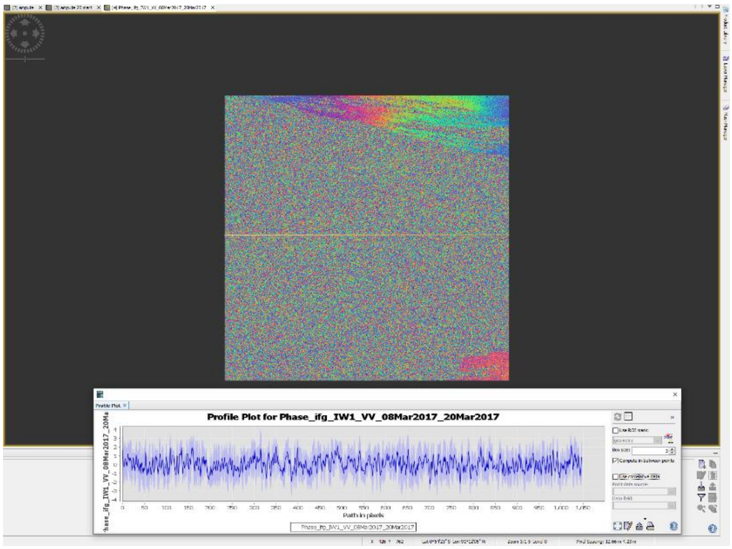
In the images of March 8, 2017 and March 20, 2017, from which we extracted the Amplitude data, a line was drawn through all the pixels with the Y:512 pixel location, and the Profile Plot data of the values on this line was extracted and shown in a graphic.





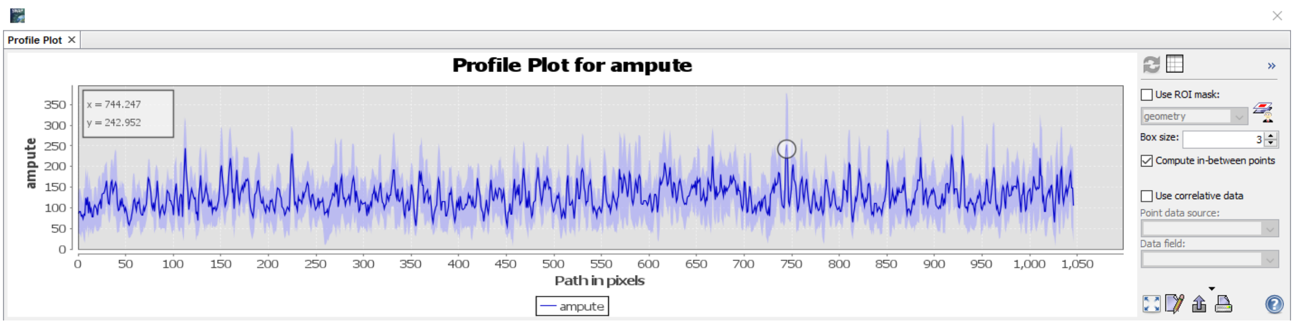
Profiling Row 512 Of Phase Data

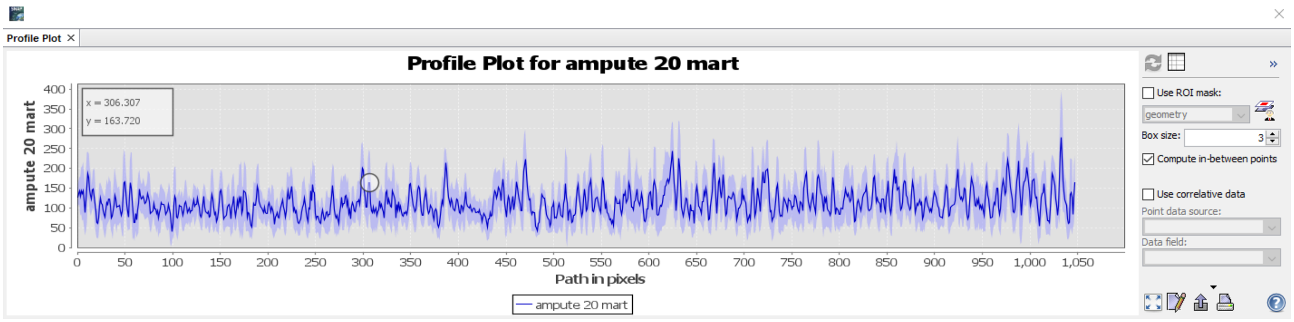
From the combined image of the images dated "March 8, 2017 and March 20, 2017", from which we extracted the phase data, a line was drawn through all the pixels with the Y:512 pixel location, and the Profile Plot data of the values remaining on this line was extracted and shown as a graph.



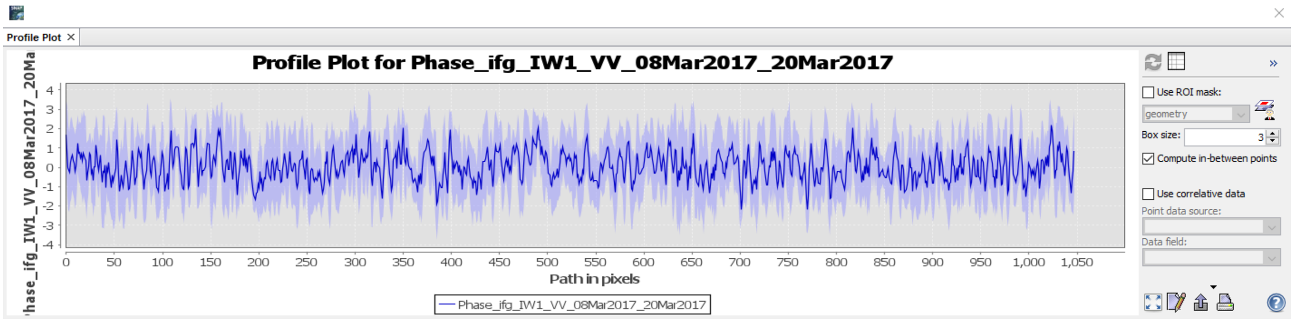
Comparison Of Profile Plots

Path pixel values of all profile plots are between 0-1,050. When we look at the amplitude values, a graph has emerged according to the absence differences in the image. The maximum value of March 8 data is 243. Here, the change in the image is clearly visible. It generally consists of instantaneous rises and falls.





In the phase plot, if the range is between (-4)-(4), where there are sudden ascents and descents, the color difference is more visible. After the disaster, the differences in value in these areas increased.



II. Exercise two: After interferometric process

Interferometric processing employs the process of co-registering various images to form a stack. In this stack, one image is selected as the principal, and the rest are termed "subordinate" images. The aim is to precisely match the pixels in the subordinate images with those in the principal image at sub-pixel accuracy.

The purpose of the co-registration process is to ensure that each terrestrial object is attributed to the same pixel coordinates regarding range and azimuth in both principal and subordinate images. Such alignment is crucial for accurate interferometric assessment.

When working with TOPSAR (Terrain Observation with Progressive Scans) InSAR, the S-1 TOPS Co-registration method is employed. This technique is specific to co-registering Sentinel-1 Synthetic Aperture Radar (SAR) images obtained using the TOPS imaging mode.

The Sentinel Application Platform (SNAP) software provides a functionality for TOPS co-registration, offering a unique approach to the precise alignment of Sentinel-1 SAR images recorded in TOPS mode. This technique plays a vital role in the subsequent interferometric processing and analysis.

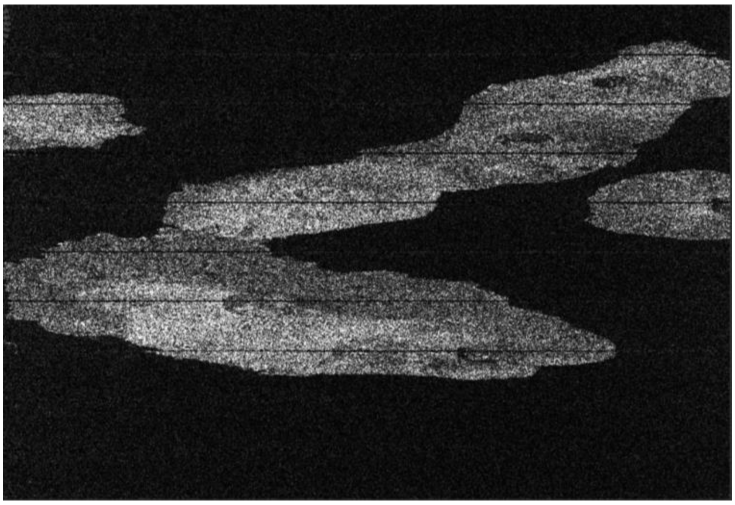
The TOPS co-registration function in SNAP is particularly designed to tackle geometric distortions and to enable the alignment of multiple TOPS images onto a common reference system. It calculates and implements the necessary geometric transformations to assure proper alignment, taking into account the specific acquisition geometry related to TOPS mode.

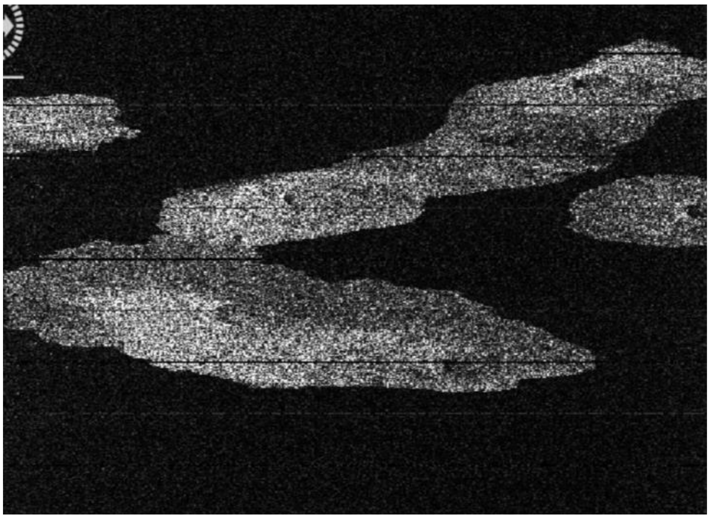
The implementation of TOPS co-registration allows for the precise and correct alignment of TOPS SAR images. Such alignment is extremely important for various applications, such as change detection, interferometry, and time-series analysis. The co-registration process facilitates reliable and uniform comparisons between images, allowing for the extraction of significant information and the investigation of temporal changes and spatial associations within the data.

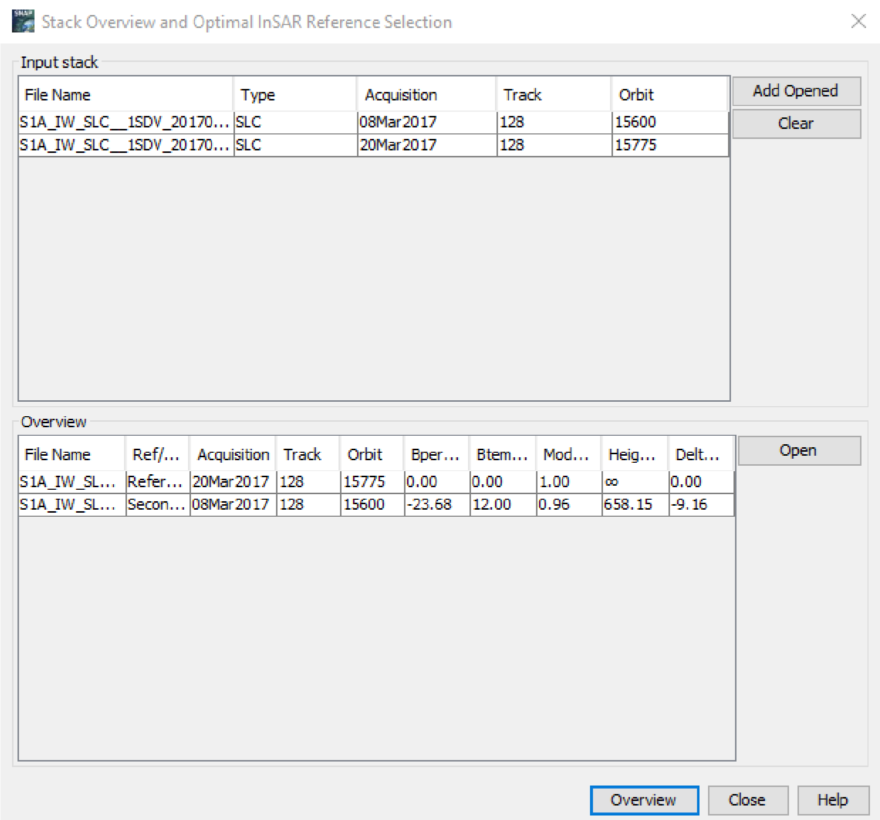
The process of TOPS Coregistration in SNAP involves a series of automated steps performed during the processing.

Displaying The Coherence And Interpreting The Scene

The data is shown in the product navigator in the two figures below for SLC data for March 8 and March 20. The images Intensity_IW1_VH from March 8, 2017, and Intensity_IW1_VH from March 20, 2017, are shown in the first and second figures, respectively.





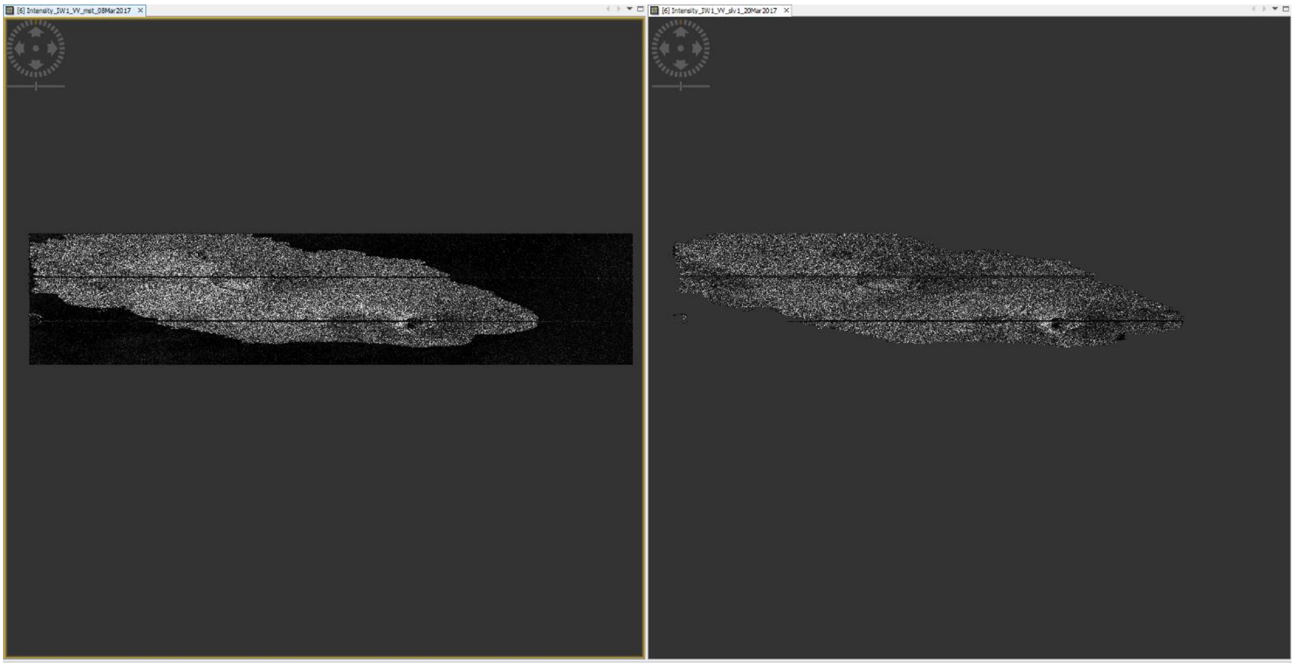


"Evaluation of the baseline" refers to the SAR (Sentinel-1 Synthetic Aperture Radar) system's baseline evaluation. The geometric difference between two different satellite passes is represented by baseline. Bperp and Btempt, two significant metrics, are used in this evaluation.

Perpendicular Baseline (Bperp): The horizontal separation between two various picture transitions that the SAR system has received is represented by Bperp. The satellite's position has changed, which has caused this gap. According to the image above, the horizontal distance between the two photographs is 23.68 m.

The time difference between two separate image transitions collected from the same position is represented by Btempt (Temporal Baseline). In applications where objects may change over time, the btempt value is crucial. According to the above image, there are 12 days between the two photographs.

Coregistration



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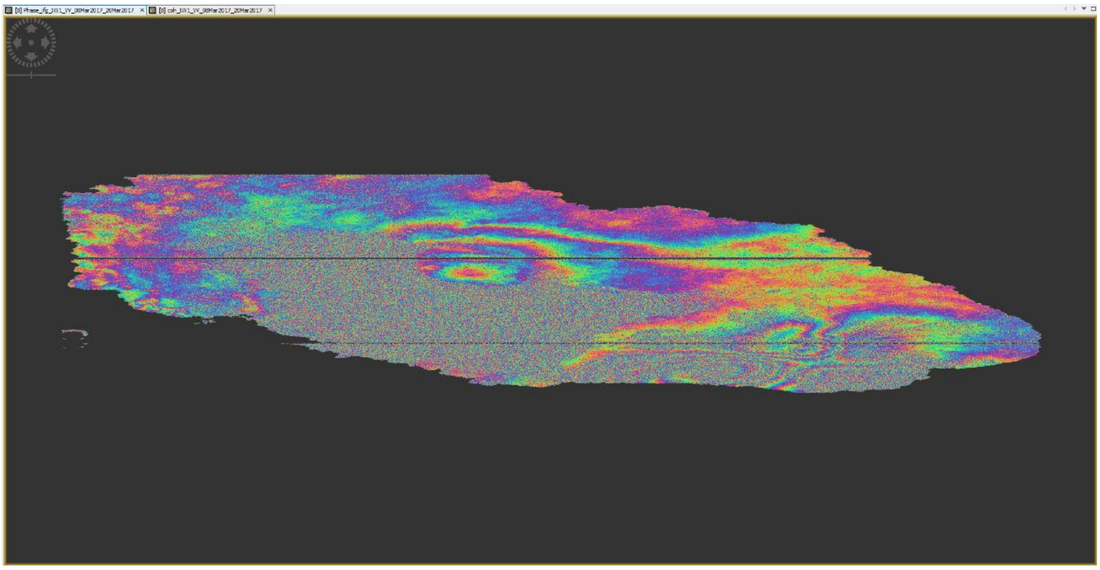
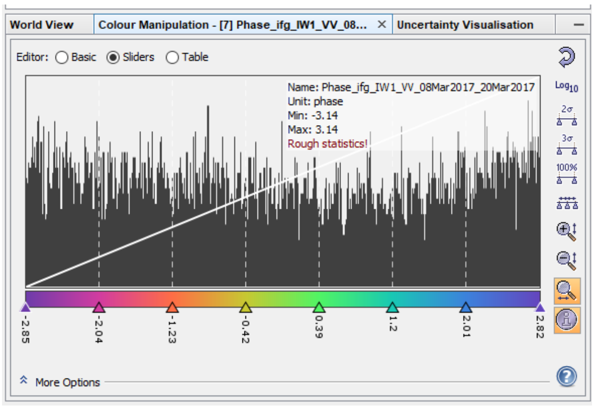
Geometric alignment of SAR pictures taken on several dates in the same region is provided by the coregistration procedure. This procedure ensured that the satellite photos from March 8 and March 20 were taken from the same geographic location and viewpoint. This will be displayed in the top image. As a result, it offers a solid foundation for applications like change detection and time series analysis. For tracking the time-varying characteristics of objects and detecting changes, more precise results can be obtained as the aligned photos are in the same geographic location and perspective.

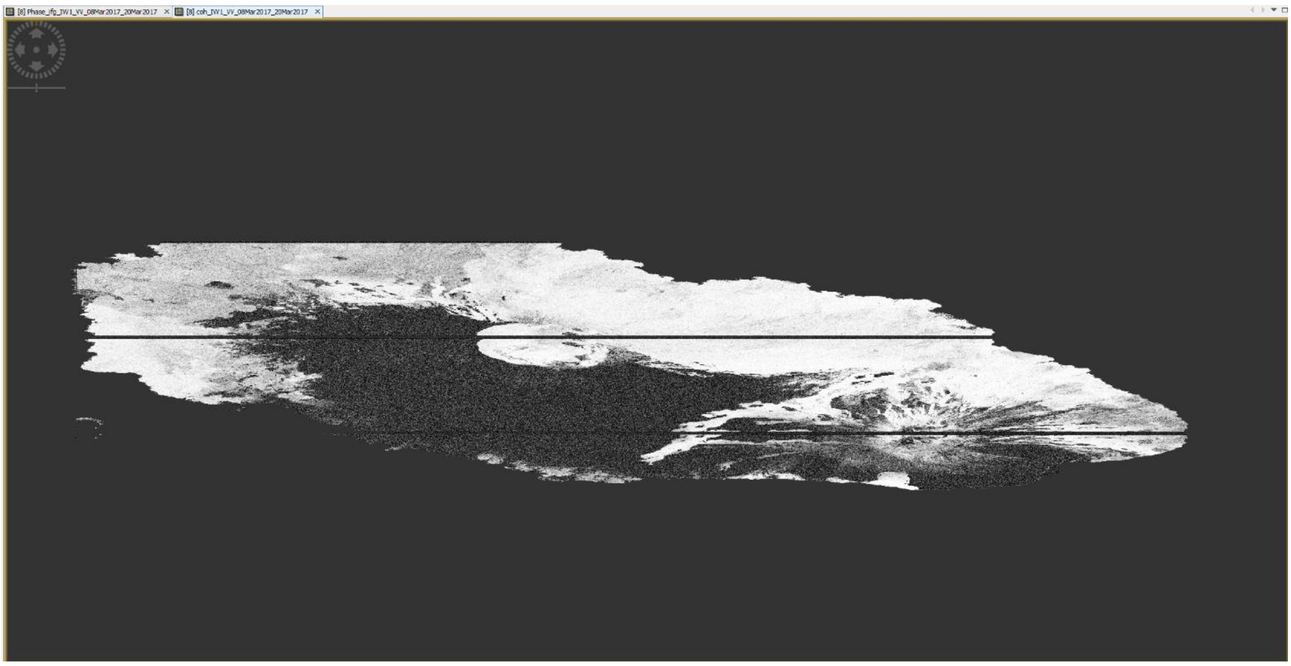
Interferogram Formation

At this point, the Interferogram and the Coherence bands are the two main outputs of the operation. The interferogram, a product that shows phase differences and depicts changes in the earth, is the result. The coherence band shows how consistently and logically the images relate to one another. Analysis of the surface changes can be done by combining the two methods.

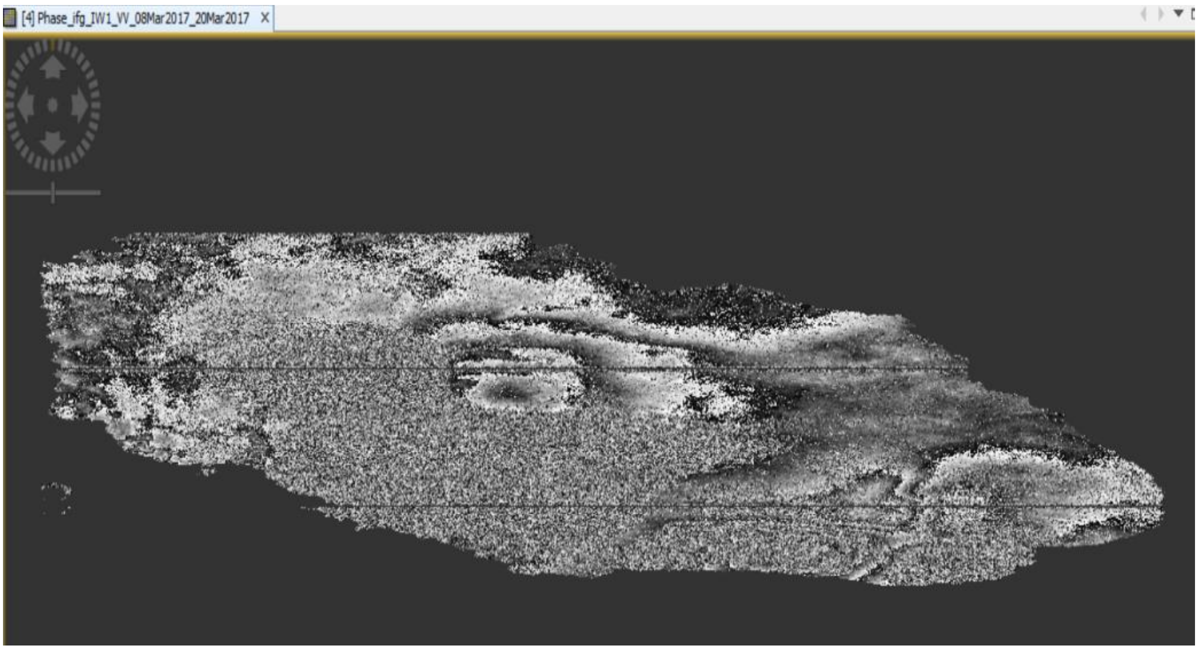




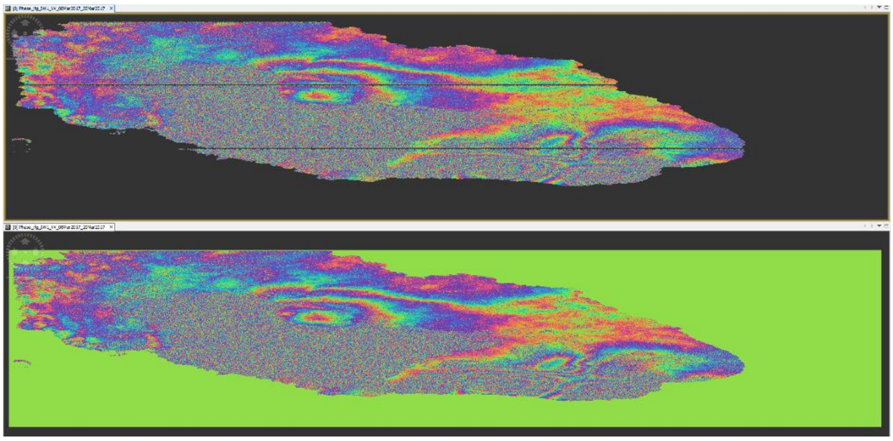
In March 2017, the Cerro Azul Volcano in the Galápagos Islands of South America experienced disturbance that caused extensive surface deformation on the southern Isabela Island but no eruption or surface breach. A SAR image of two separate dates that has undergone interferometric processing to create an interferogram. By comparing the phase differences of two pictures, interferometry enables the detection of changes in the earth. The phase changes in color displayed in the second image above are represented by the interferogram. Phase difference between the two dated images is measured at each pixel, and based on this difference, the color or brightness of the pixel is determined. Changes can be observed in the interferogram as fractal patterns or interference lines correlating to various colors or brightness levels. The phase difference in the interferogram ranges between -3.14 and 3.14, as can be seen in the second image up top. Positive or negative phase differences, such as negative peak displacement and positive peak displacement, might indicate distinct directions of motion or deformation between pictures. The green and yellow toned pixels in the first image above had the fewest surface alterations.



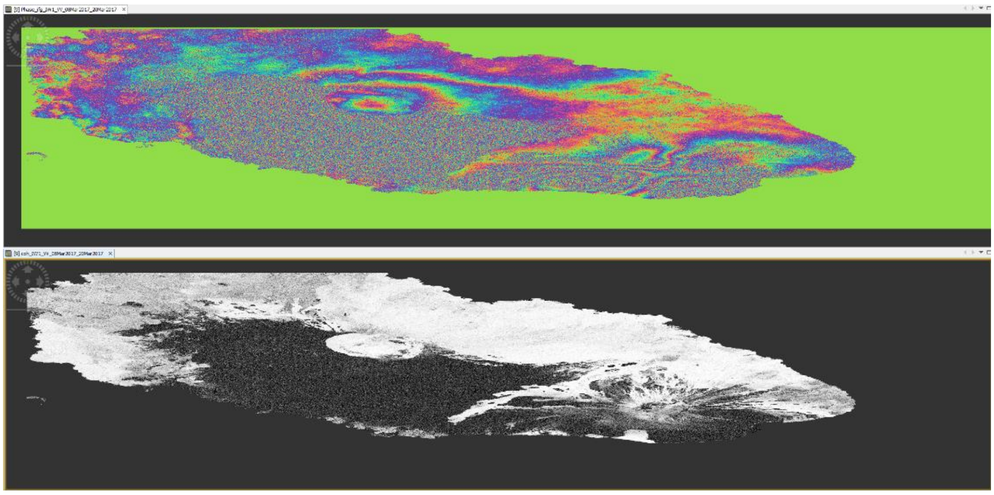
Another outcome of the interferometric process is the coherence band. The degree of consistency and correlation between photographs taken on two different dates is referred to as coherence. A more trustworthy interferogram is produced when the two pictures have high coherence values, which show that they have similar characteristics. The uniformity between photos is highest in the white parts. Where the uniformity is weakest is in the black parts.



Deburst

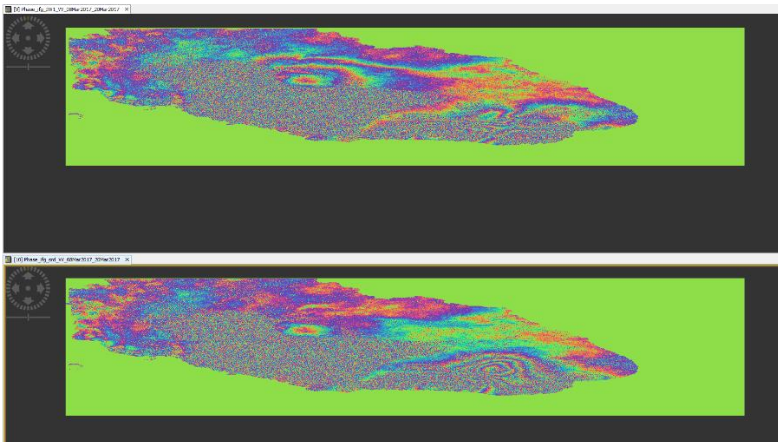


Combining these burst-based data as shown in the image above, debursting is done to create a continuous presentation. Using this technique, a high resolution synthetic aperture radar (SAR) image is produced by combining successive pulses. A data collecting method called TOPSAR combines Sentinel-1's high-resolution and extensive coverage capability. The production of a smooth image and proper processing of the data acquired in this operating mode are both guaranteed by TOPS debursting.

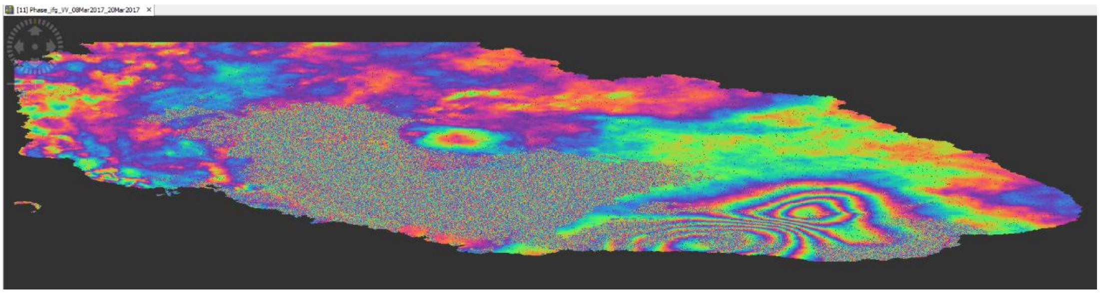


Topographic Phase Removing

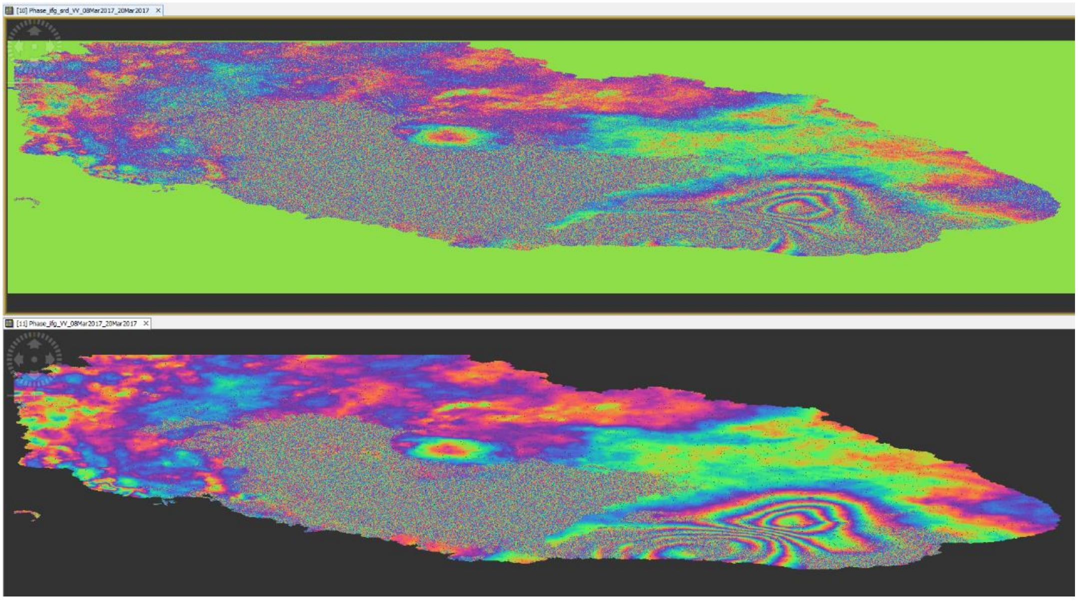
To eliminate the topographic influences of the surface in Sentinel-1 SAR images, topographic phase removal is carried out following TOPS Deburst. These unfavorable topographic effects are eliminated by topographic phase reduction, which enables a more precise surface deformation analysis. The photos below have been smoothed to produce more precise findings for surface deformation analysis and other applications, shown in the image below.

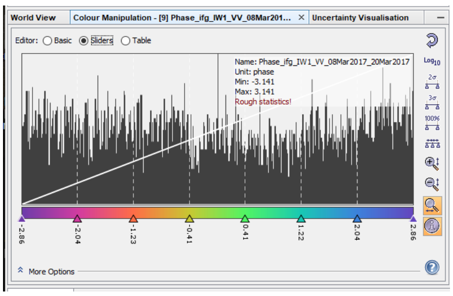


Filtering



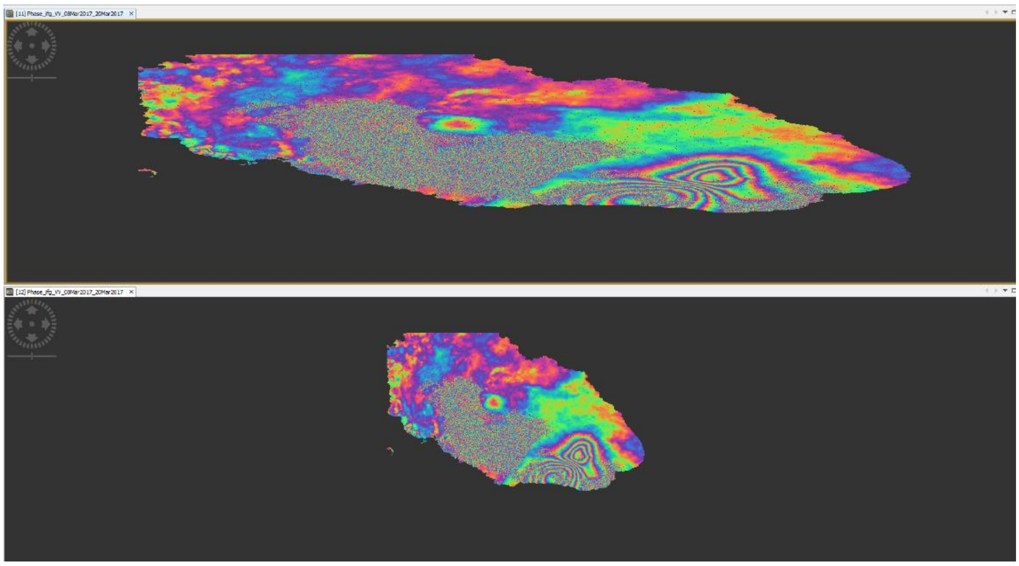
Using Goldstein Phase Filtering, noisy SAR interferograms can have their unpredictable phase components reduced. Two SAR pictures' phase discrepancies are what make up interferograms. In addition to random ambient noise and highly resonant signals, surface deformations and topography can affect these phase differences and can result in phase noise. Using a recognized Digital Elevation Model (DEM), topographic phase reduction removes the topographic phase from interferograms. The phase that remains is caused by phase noise and surface deformations. This phase noise is lessened via Goldstein phase filtering. enables the filter to more effectively keep low-noise zones while filtering out loud areas.





As a result of this process, when the filter was applied, a much more consistent graphic emerged as seen above.

Multilooking



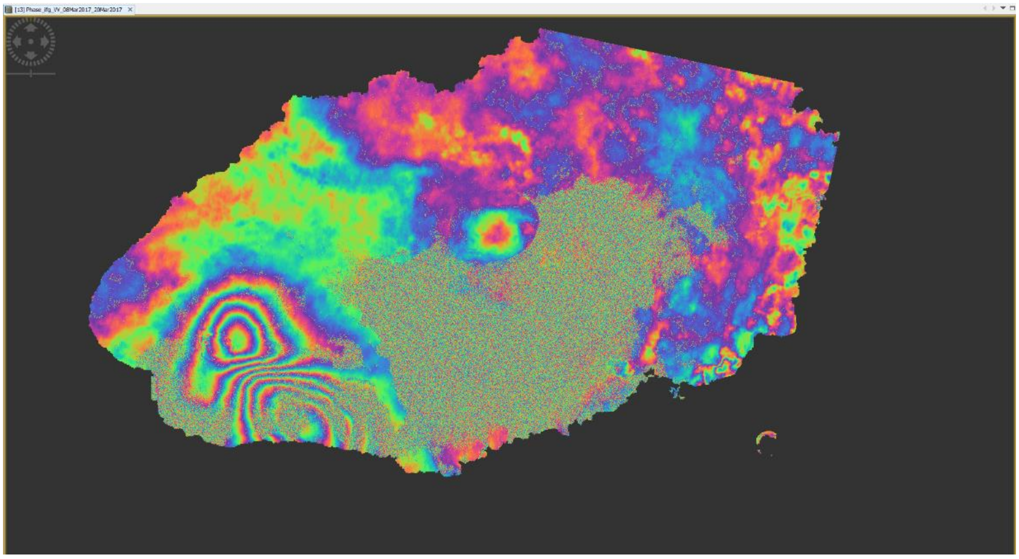
The multilooking method seeks to lessen the speckle noise typically seen in SAR photos like those captured by Sentinel-1. When comparing the output image following the multilooking procedure, the following modifications take place.

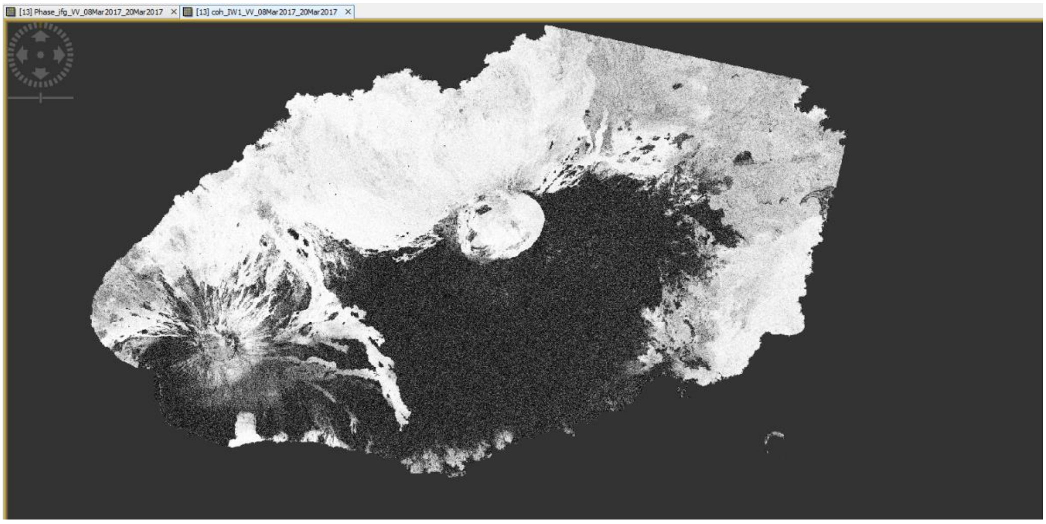
Noise reduction: As seen in the image above, the image quality has increased overall as a result of the Multilooking process, making it easier to distinguish surface features.

Reduced Resolution: Multilooking decreases noise, although it typically results in a slight loss of spatial resolution.

Geometry Modifications: Multilooking also modifies the image's geometry slightly.

Terrain Correction





To fix a SAR image's geographic flaws, employ terrain correction. The processing and analysis of a SAR image often end with this stage. The geometry used to acquire SAR pictures is known as slant range geometry (also known as inclined range geometry). Due to elevation differences and ground tilt, this is based on the radar's slope distance from objects and frequently affects the radar image. These flaws are fixed during the terrain correction process, which also translates a SAR image to the real-world coordinates seen in the image below.

SAR Image To Real-World Coordinates