Introduction to Synthetic Aperture Radar (SAR) technology and spaceborne SAR data analysis

Masters Homework: Differential Interferometry

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Differential Interferometry

Introduction

Differential Interferomerty technique relies on the processing of two SAR images of the same portion of the Earth's surface by taking the two images and removing their phase to produce an Interferogram.

For this homework, two Single Look Complex (SLC) products over the same area acquired at different times for Muenster i.e. 26th February 2018 and 22nd March 2018 from the availed data were used to complete the task:

S1B_IW_SLC__1SDV_20180226T054101_20180226T054128_009790_011B17_93F8.SAFE – Master Image

S1B_IW_SLC__1SDV_20180322T054101_20180322T054128_010140_0126A7_99A0.SAFE – Slave Image.

The choice of these two dates was to assess change over a month in vegetation in Muenster.

The differential Interferomerty was carried out using the SNAP (v6.0)desktop software

Stepwise Analysis Outline for the work included:

Subsetting and Applying Orbit File

Co-Registration

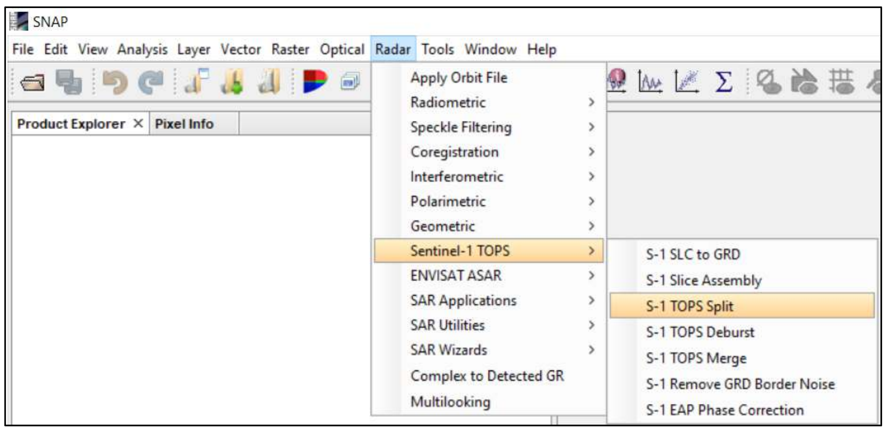
Interferogram Formation and Coherence Estimation

Terrain Correction and Export to Google earth .kmz

- Conclusion

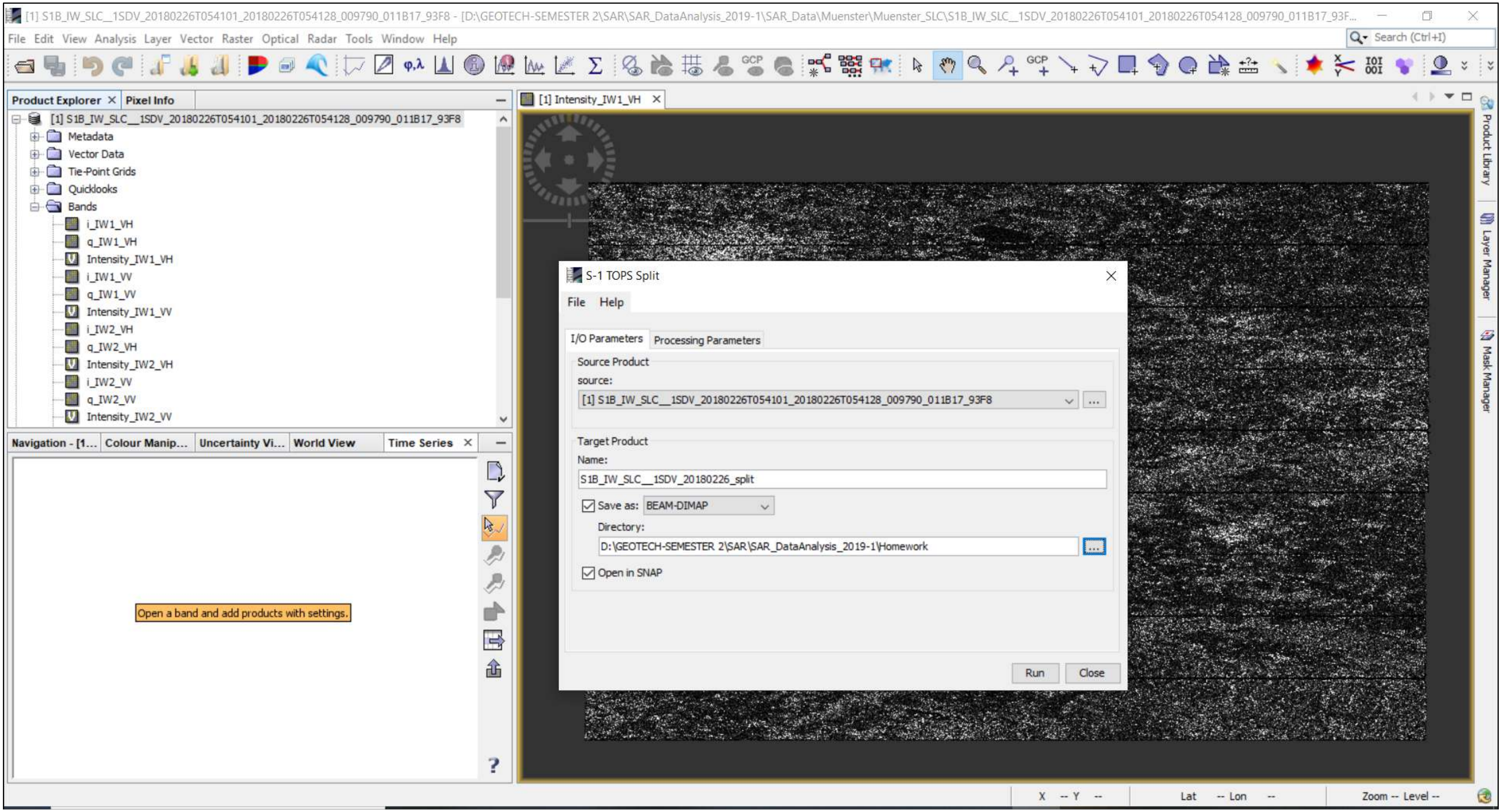
Image Subset using Topsplit

- Subsetting the image helps to reduce the processing time needed to execute the steps and to focus the analysis to a specific area only of the whole SLC Image.
- I first visualized the image to asses location of study area. Muenster is located in the second subwath and included in Bursts 4, 5 and 6.
- Then, Navigate to S-1 TOPS Split Subswath then IW2 where the POI is and Burst 4-6.
- Steps followed in SNAP are



NB: Please Refer To Screenshots Below

Image Subset: 1



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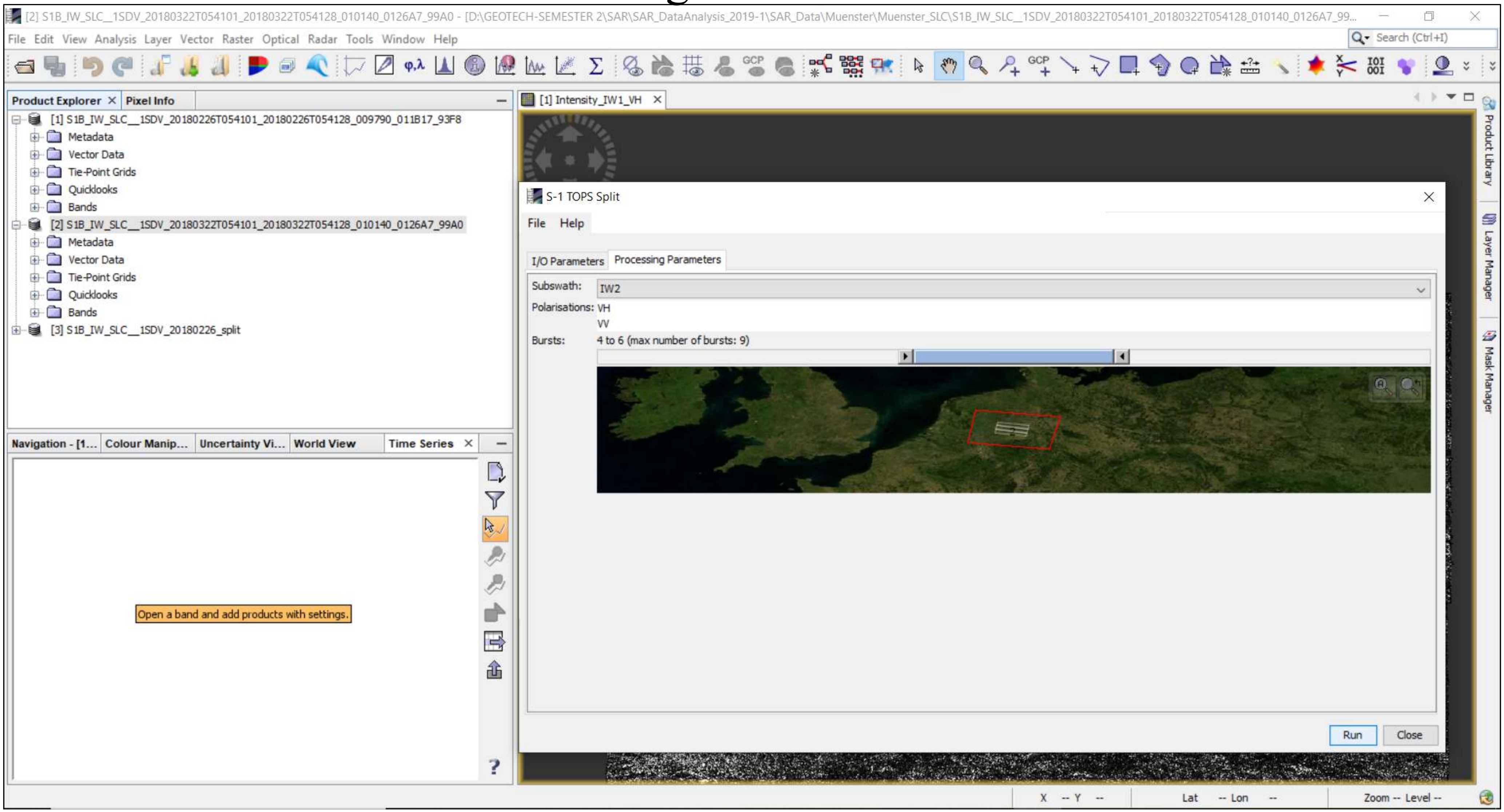
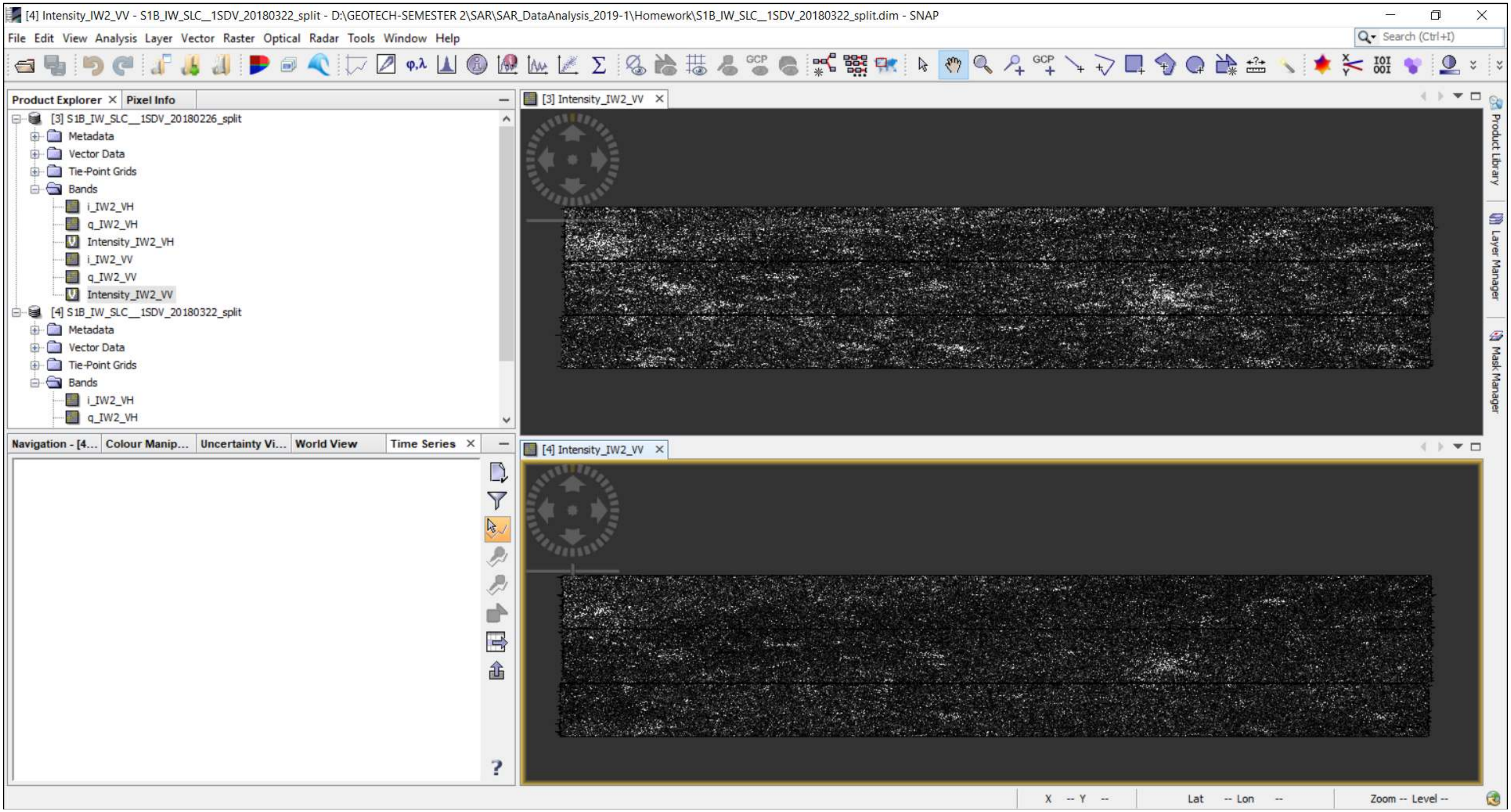
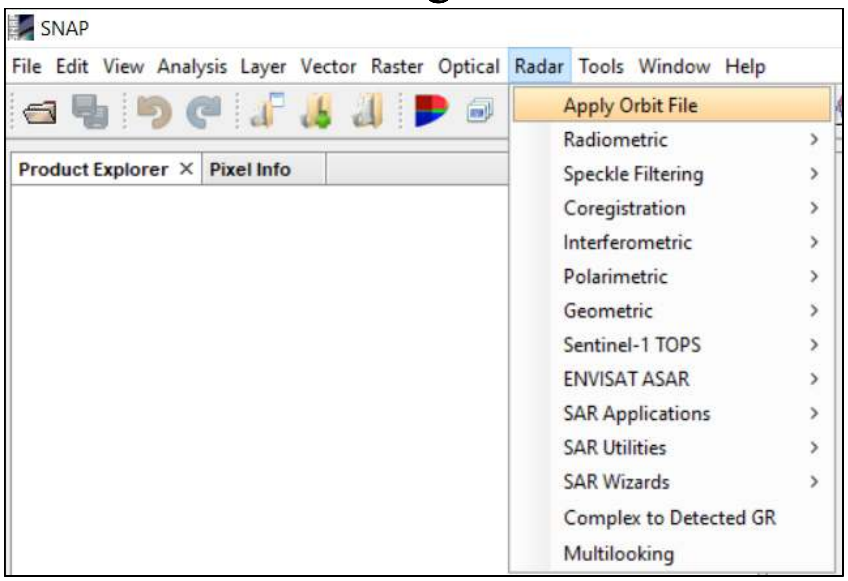


Image Subset: 3



Apply Orbit File

- I applied an orbit file in order to provide accurate satellite position and velocity information to the images.



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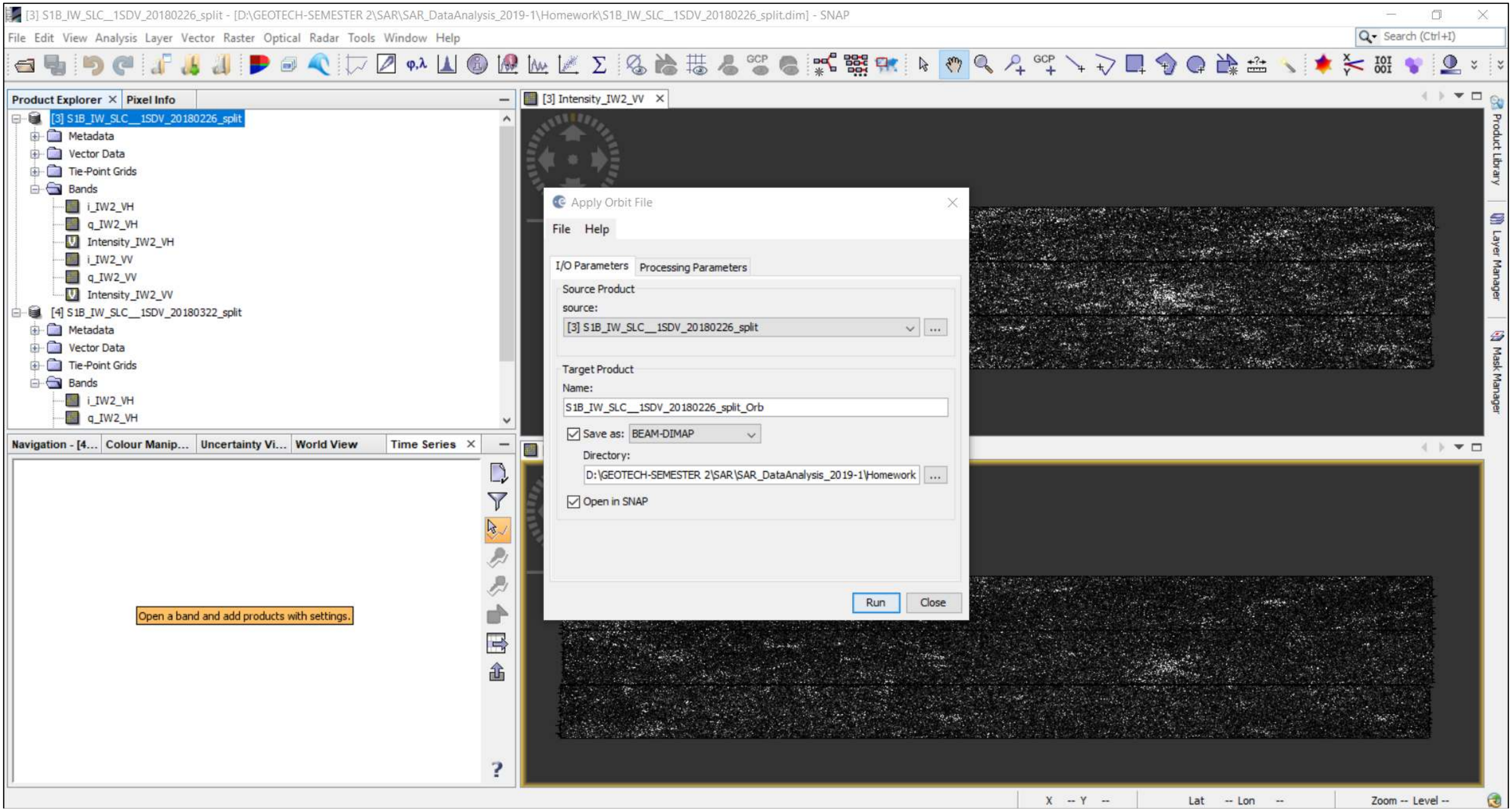
Apply orbit file



Co-Registration

Co-Registration step is carried out so that corresponding pixels the two images perfectly match. It ensures that each ground target contributes to the same pixel in range and azimuth for both the master (26^{th} feb) and the slave (22 march) images. The slave images will be co-registered with respect to the master image i.e. Back-geocoding.

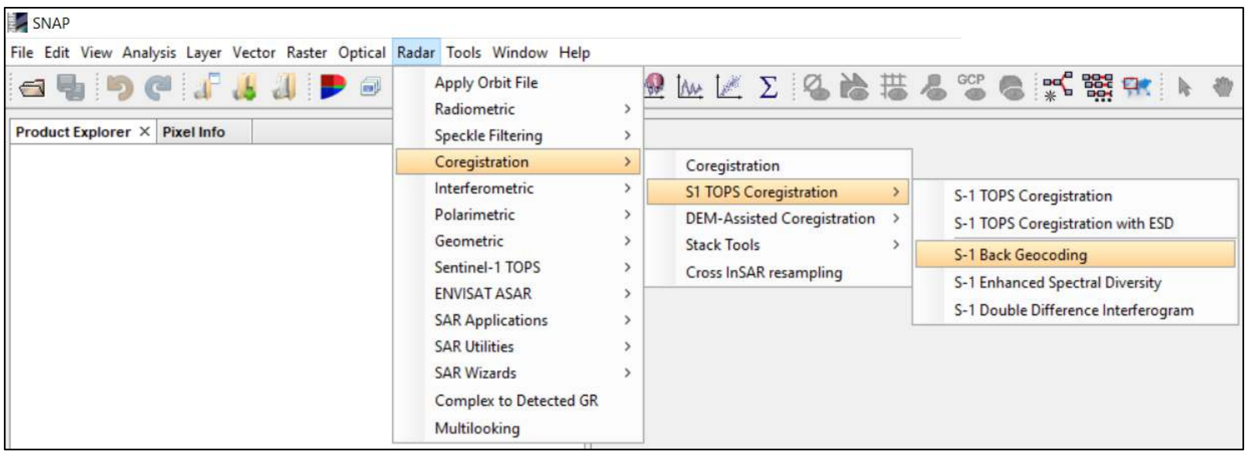
- Co-Registration procedure involved two steps:

  Back Geocoding

  Enhanced Spectral Diversity.

Back Geocoding

- Back-Geocoding performs a DEM assisted co-registration to two split products of the same sub-swath using the orbit parameters of the two products and a DEM. Change DEM resampling method and resampling type to cubic convolution
- The Digital Elevation Model (DEM) to use SRTM 3Sec (Auto Download); the DEM resampling method and type used was cubic convolution.
- "Output Deramp and Demod Phase" was selected since Enhanced Spectral Diversity was to be used to improve the co-registration .



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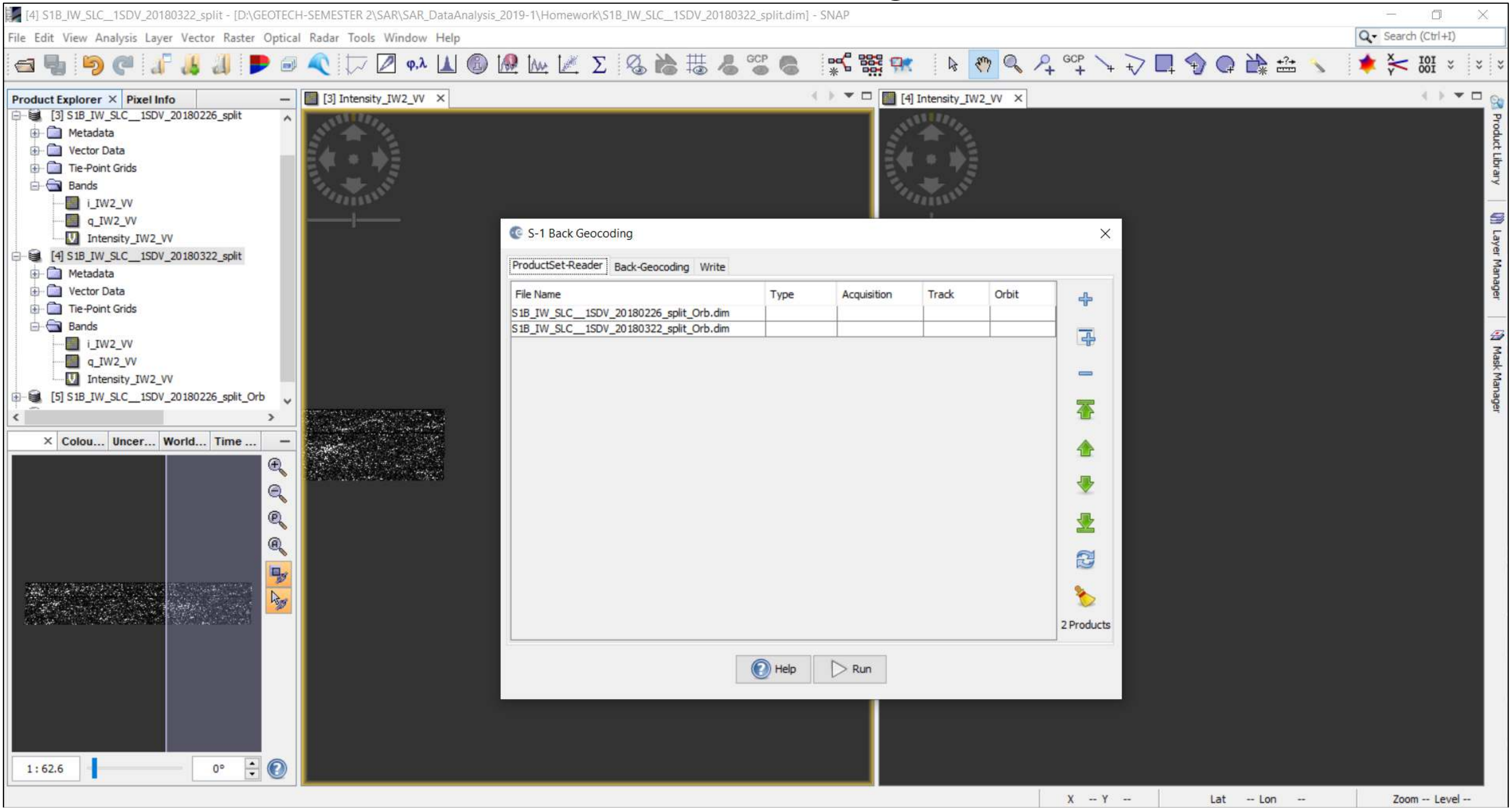
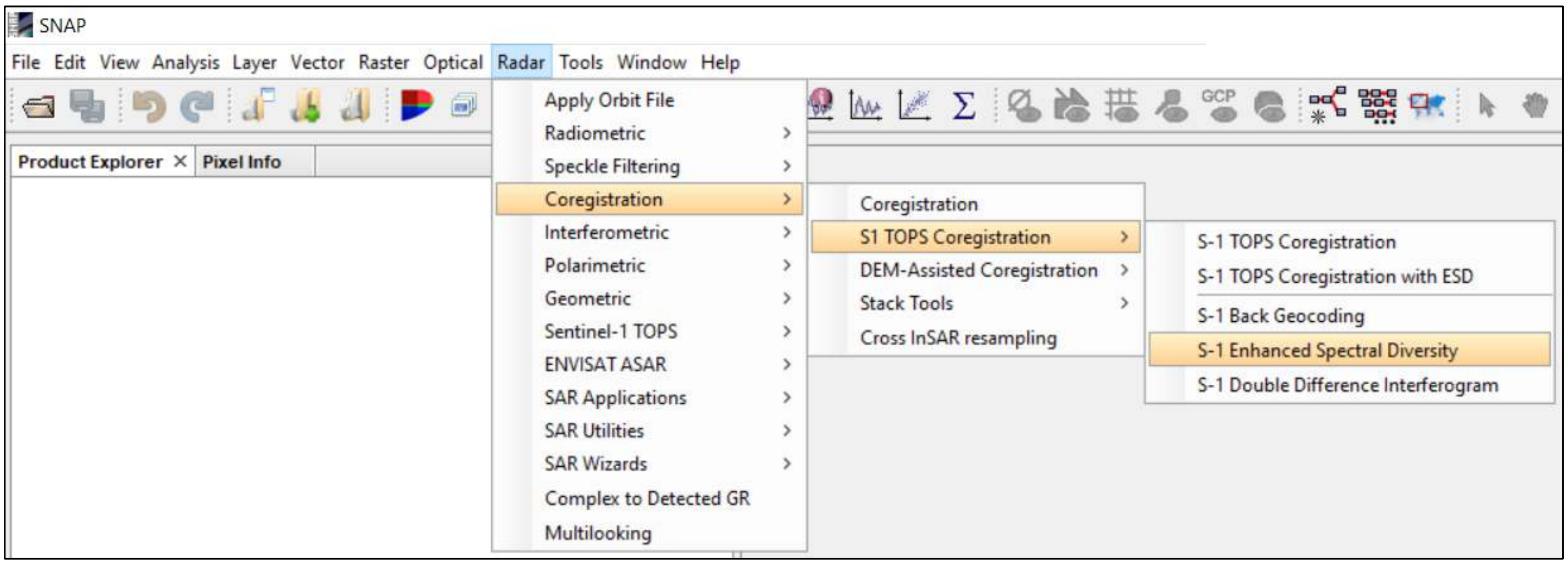
Back Geocoding



Enhanced Spectral Diversity

- Enhanced Spectral Diversity follows the geocoding and exploits the data of the overlapped areas in the adjacent bursts and perform range and azimuth corrections.



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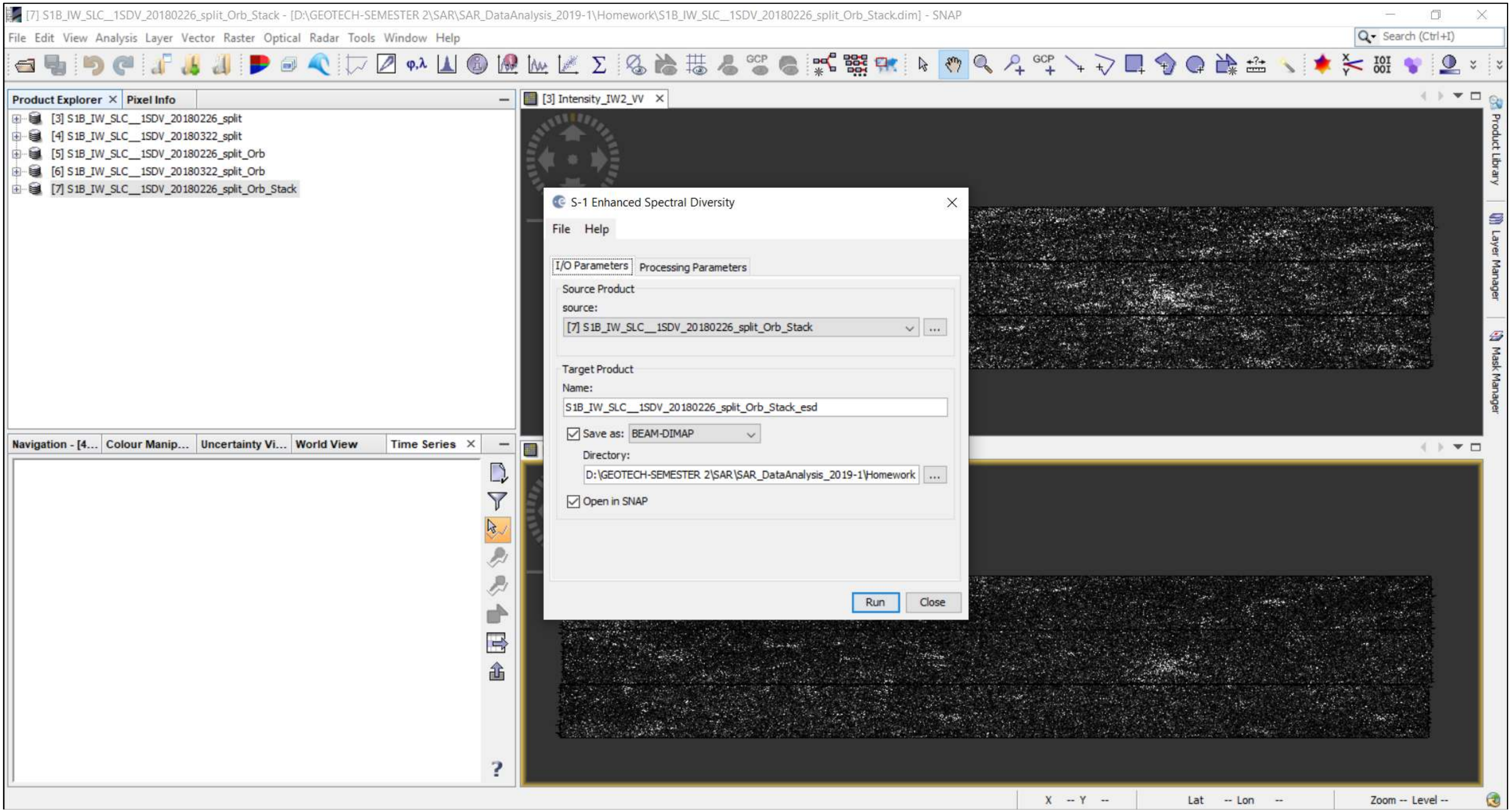
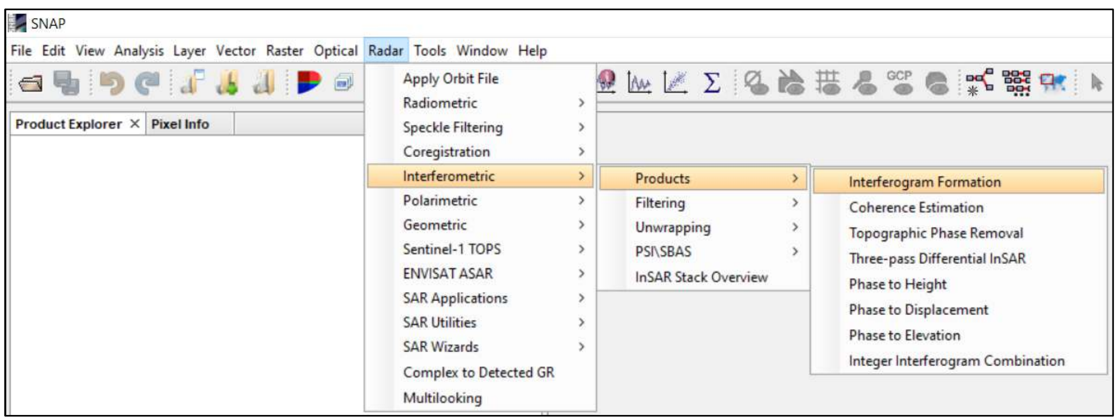
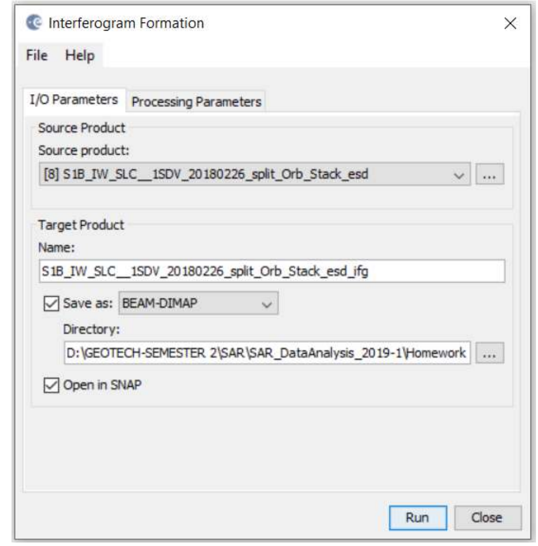
Enhanced Spectral Diversity

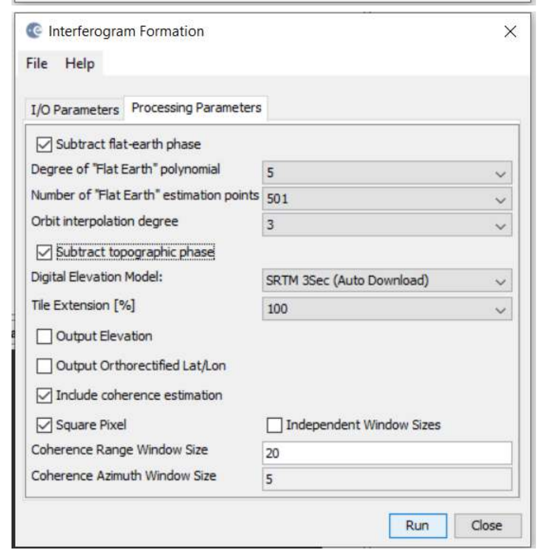


Interferogram Formation and Coherence Estimation

- The Interferogram is formed by cross multiplying the master image with the complex conjugate of the slave. The amplitude of both images is multiplied while the phase represents the phase difference between the two images.
- The Interferogram formation step involves also removing the flat-Earth phase which is present in the interferometric signal due to the curvature of the reference surface.

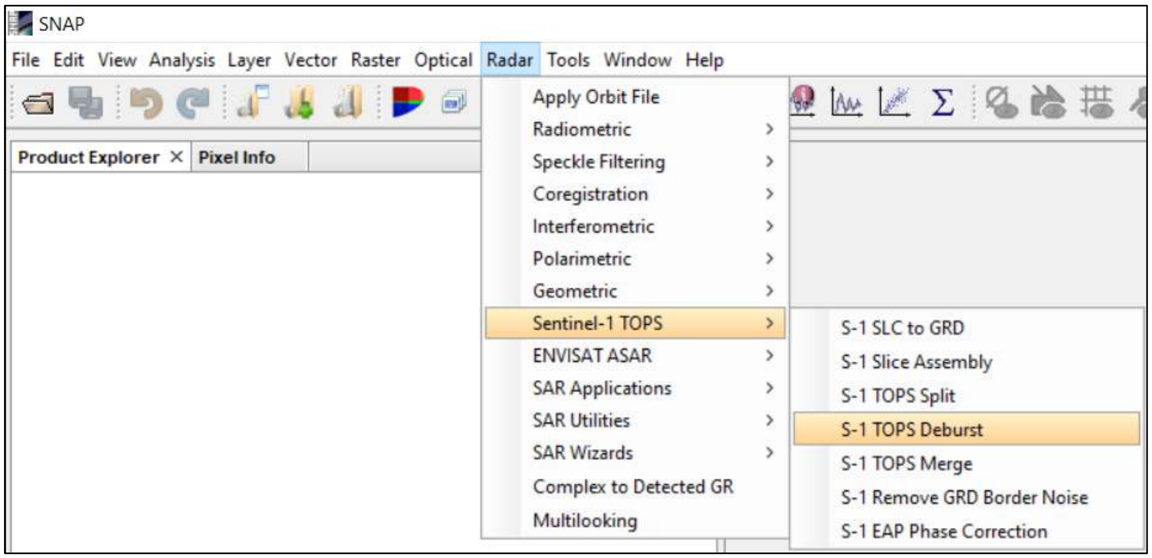






Deburst

- The Interferogram formation product will contain a band for the interferometric phase which contains bursts. The bursts will be removed using the TOPS Deburst tool in order to produce a continuous coverage of the ground.



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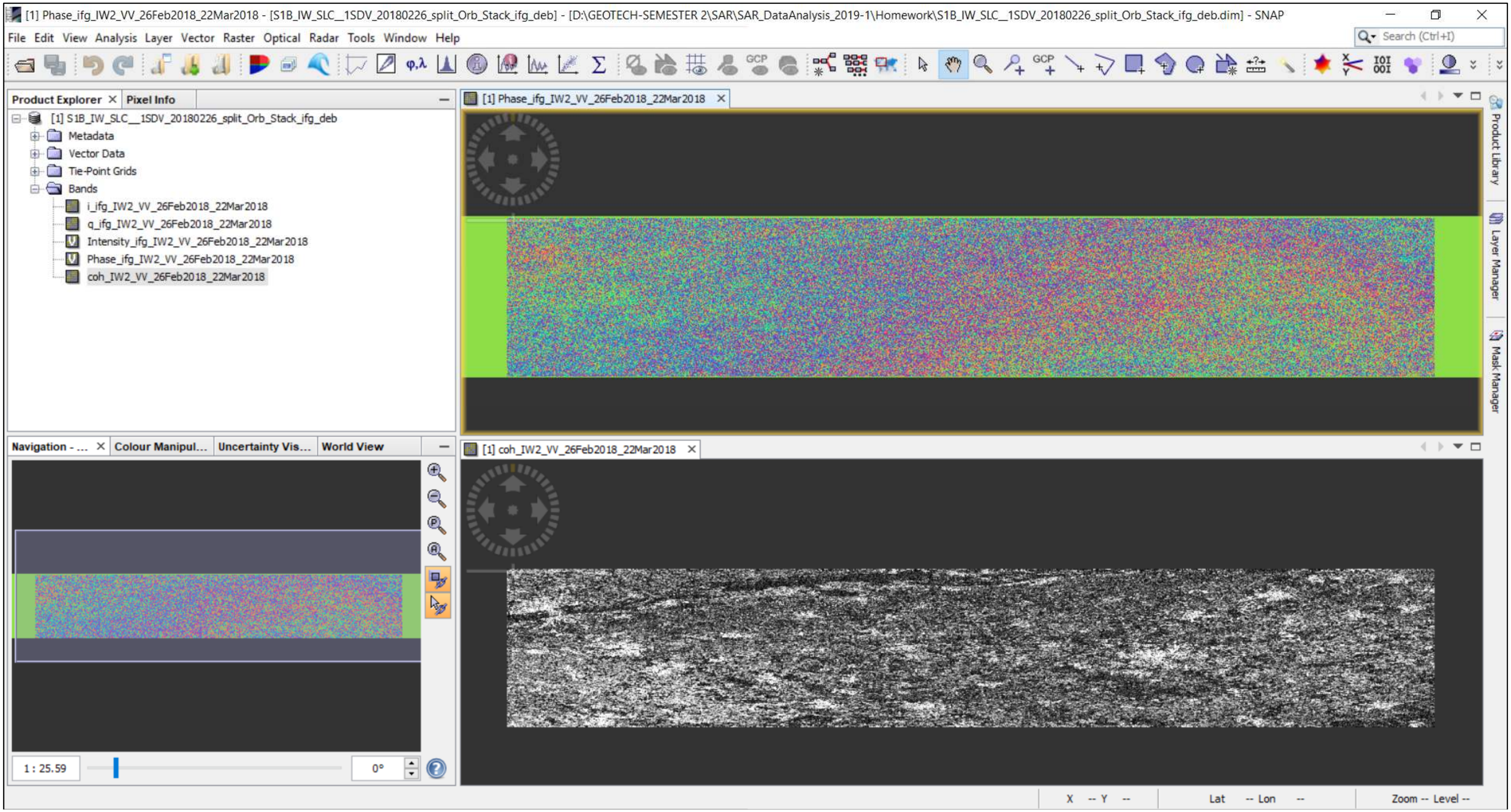
Deburst



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Product Explorer
Pixel Info
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Metadata
Vector Data
Tie-Point Grids
Bands
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q_ifg_IW2_VV_26Feb2018_22Mar2018
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Product Library
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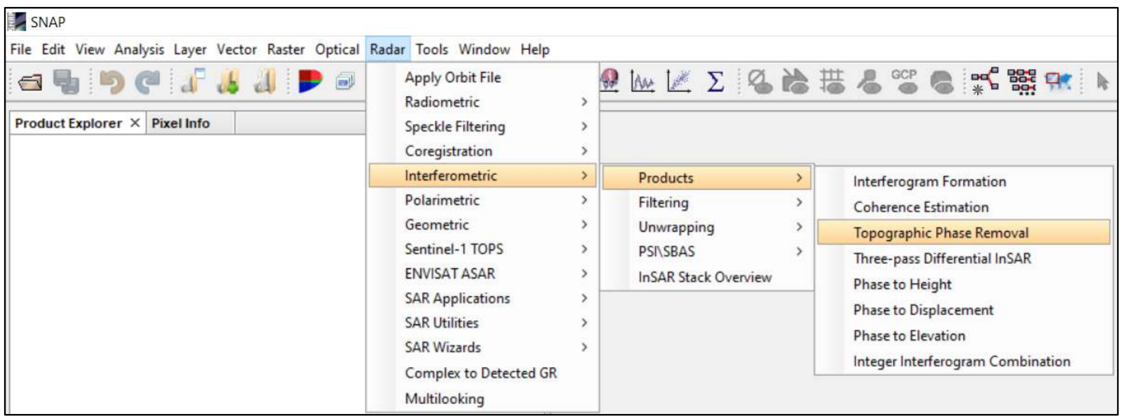
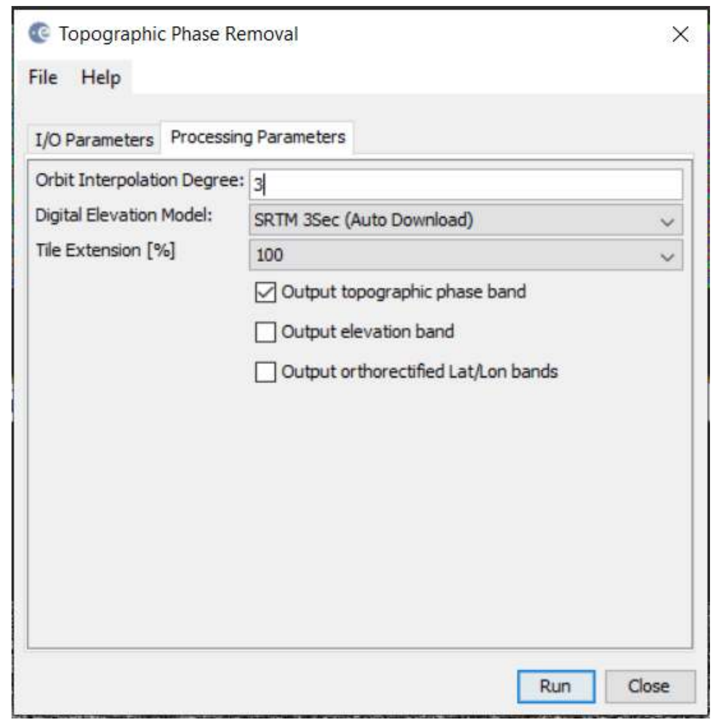
Deburst Results

- The result of the deburst is the interferometric phase band and deburst coherence band. The phase band represents the phase difference in the 3 images and the 3 burst have been combined to one. The coherence band which is an indirect measure of the quality of the Interferogram, shows how similar each pixel is between the master and slave images. Areas of high coherence appear bright and areas of poor coherence appear dark.

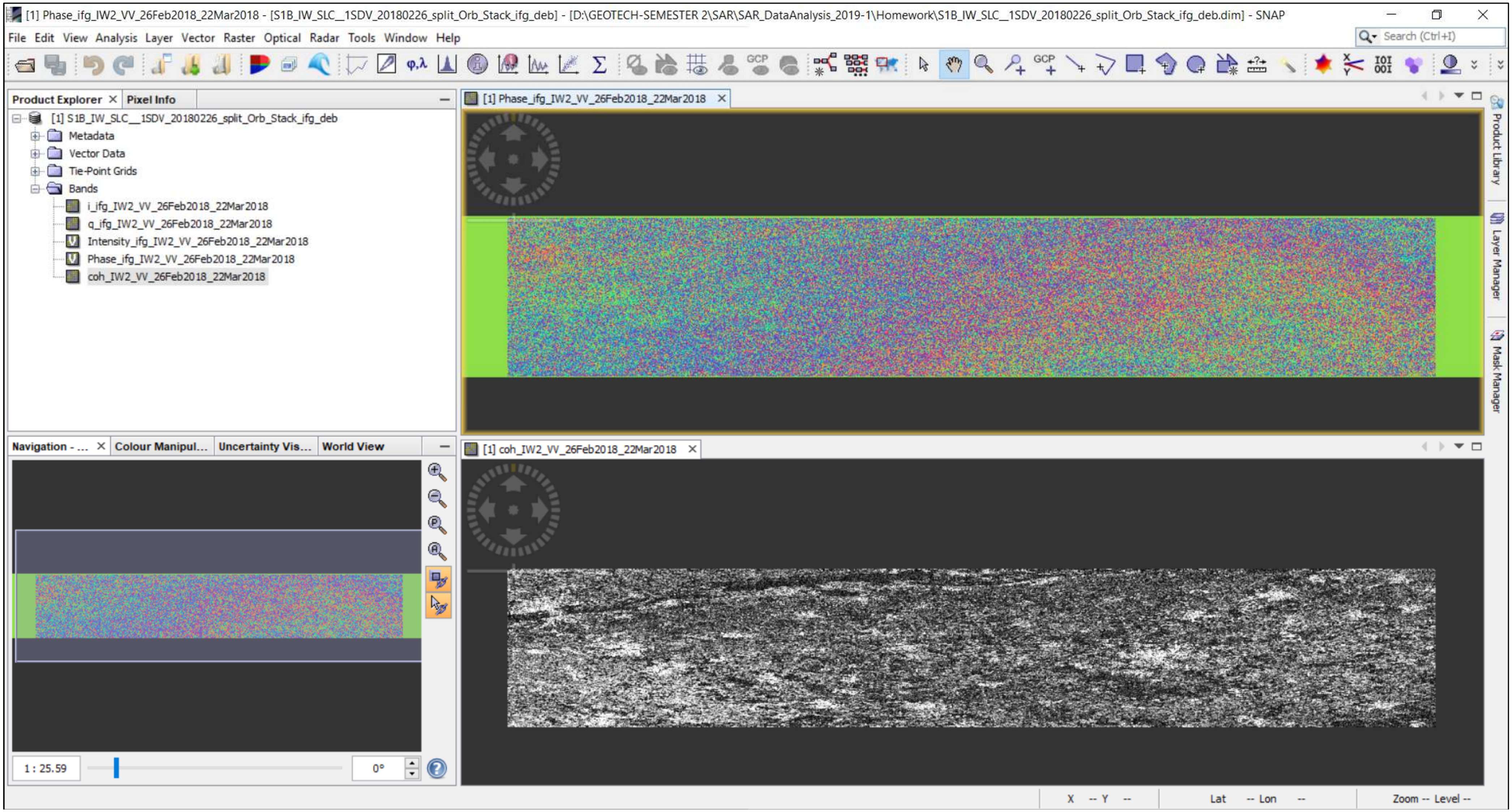
Topographic Phase Removal

- The Topographic Phase Removal step flattens the debursted Interferogram image by removing the topographic phase. The operator will simulate an Interferogram based on the reference DEM and subtract it from the processed Interferogram.
- “Output topographic phase band” box is checked and the DEM used was strm 3sec(Auto Download)



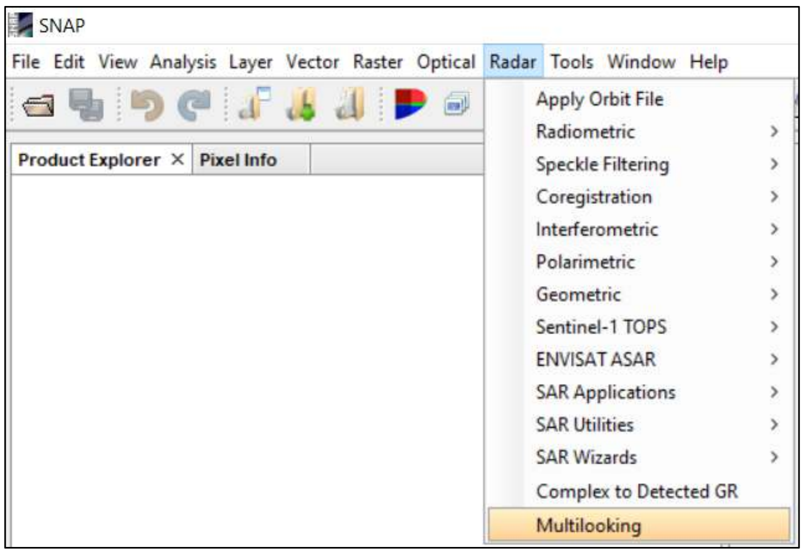


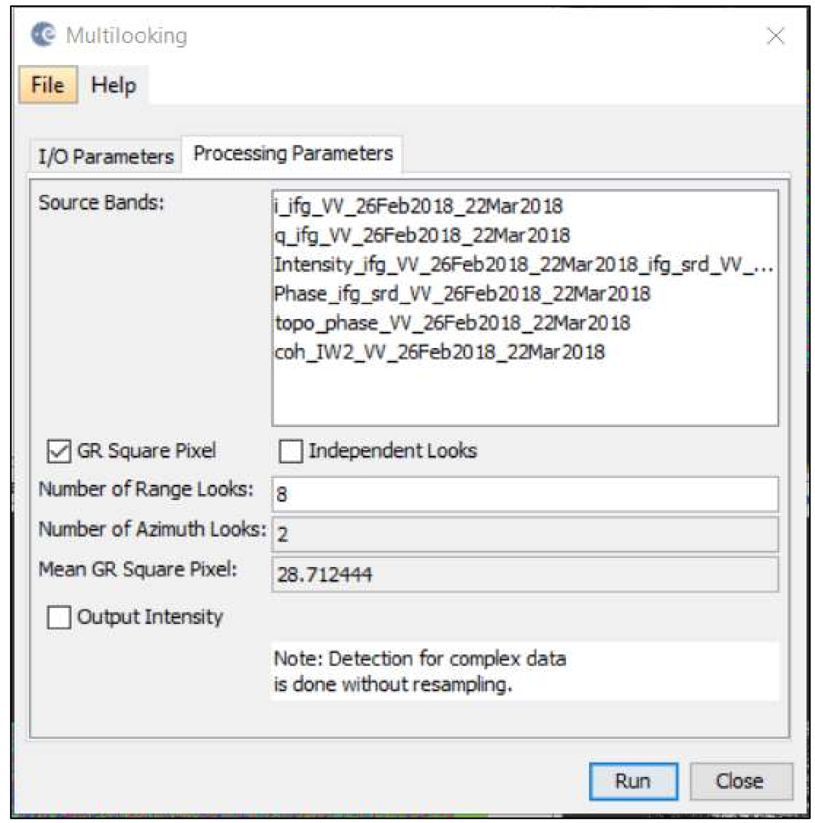
Topographic Phase Removal



Multilooking

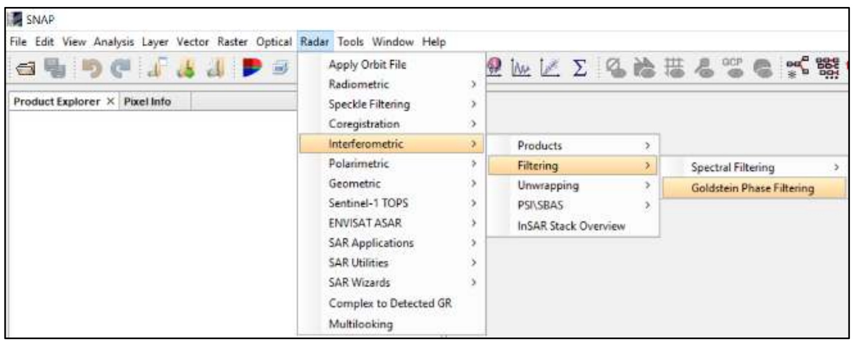
- Multilooking is applied to reduce speckle noise and to improve the images interpretability in order to have a resultant image with nominal image pixel size. This improves radiometric resolution though it degrades spatial resolution. The produced image will have less noise and approximate square pixel spacing after being converted from slant range to ground range.

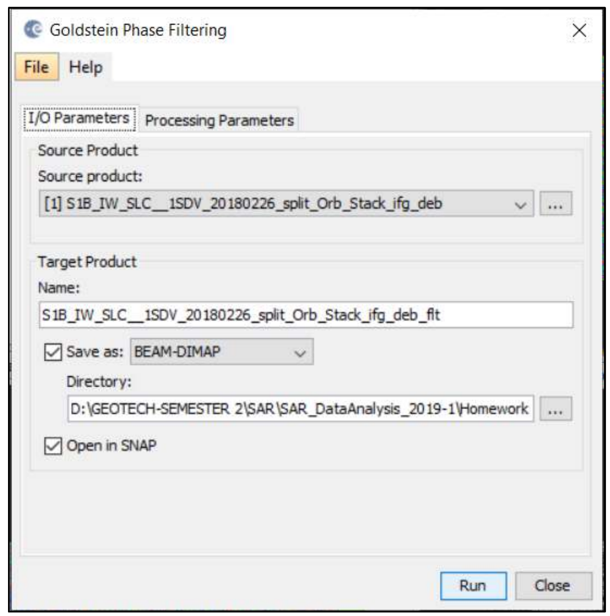


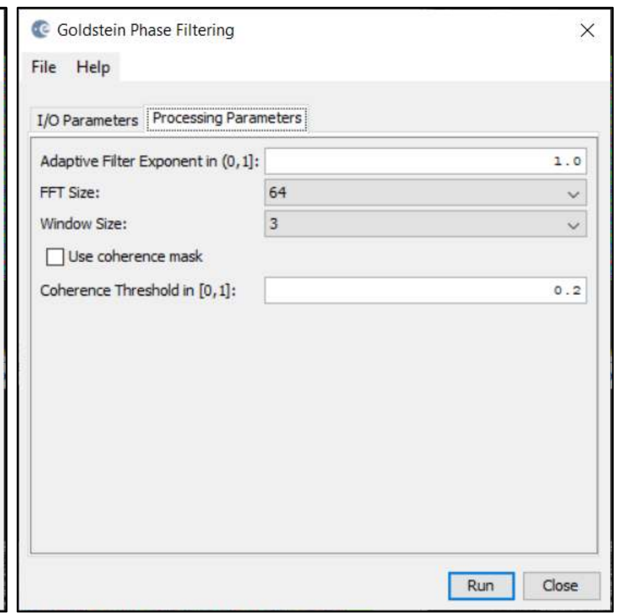


Phase Filtering

- Since the interferometric phase can be corrupted by noise from Temporal and Geometric decorrelation, Volume scattering and processing errors, there need to perform phase filtering to reduce the noise. This is sequentially necessary to enable proper phase unwrapping.

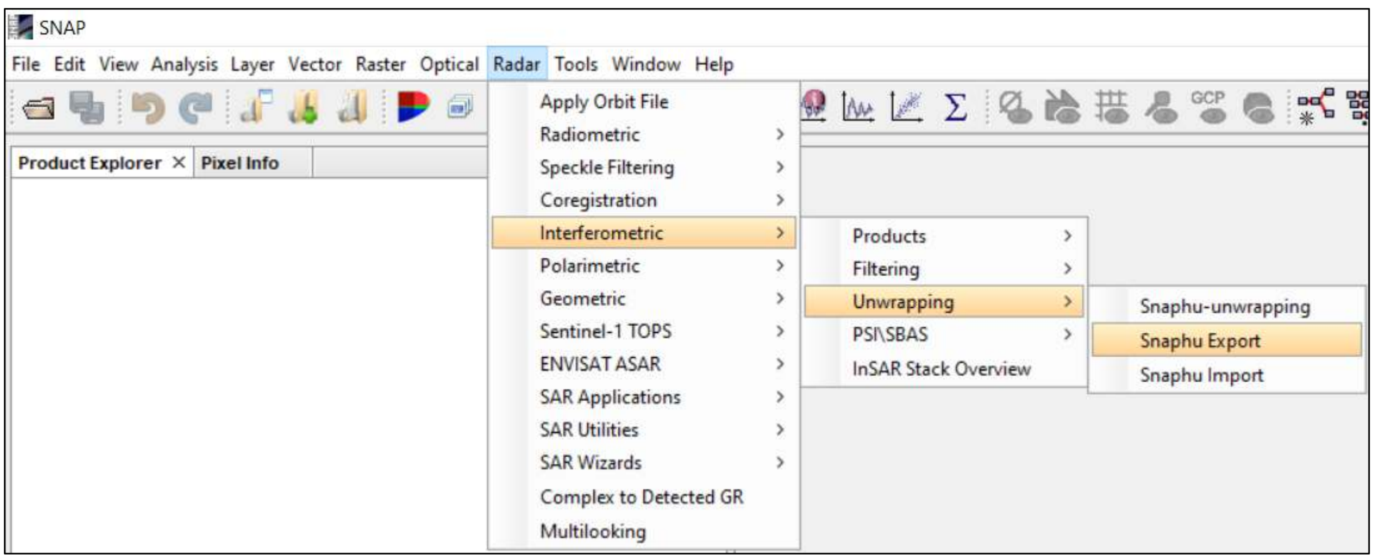




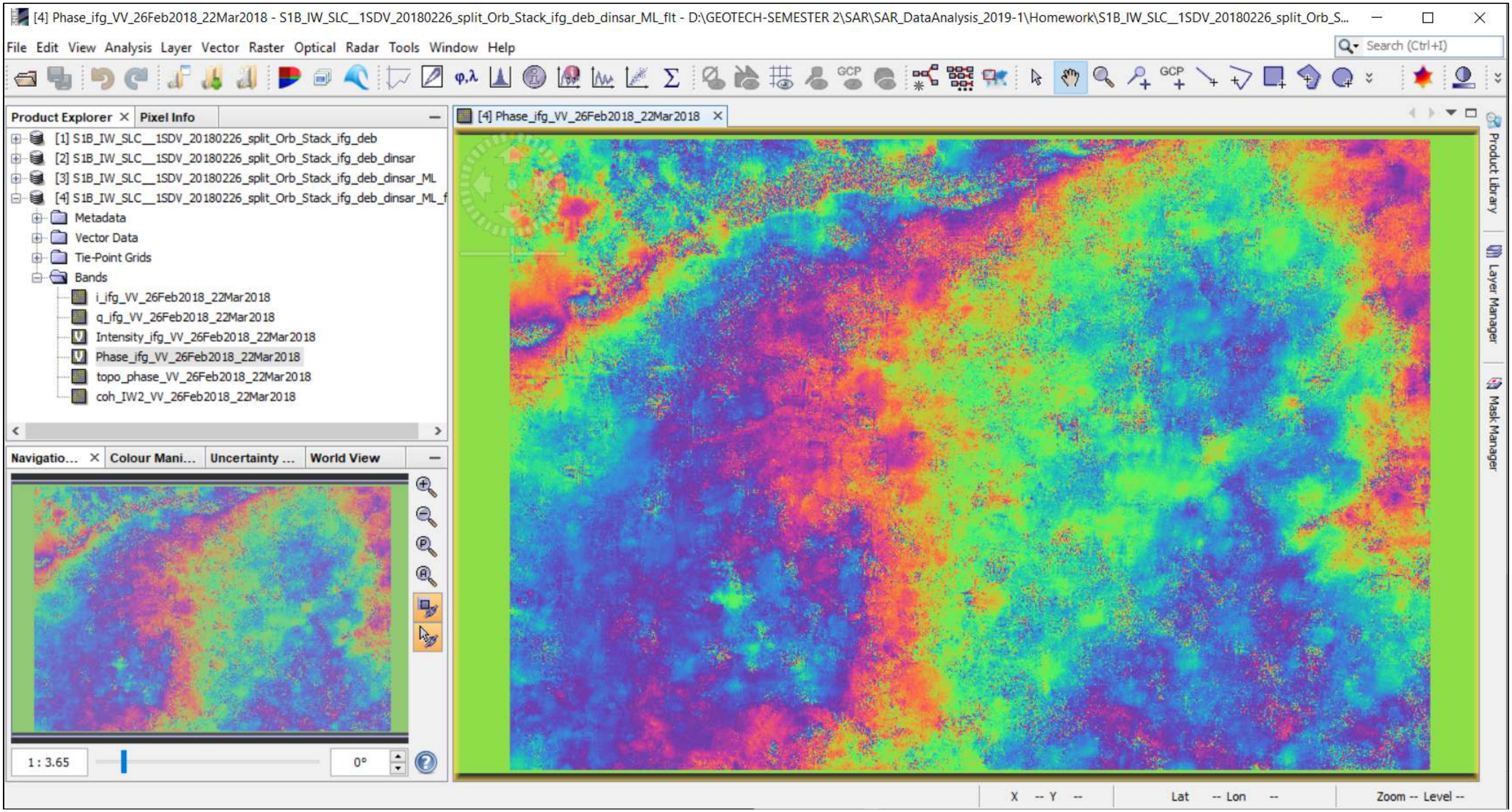


Phase Unwrapping

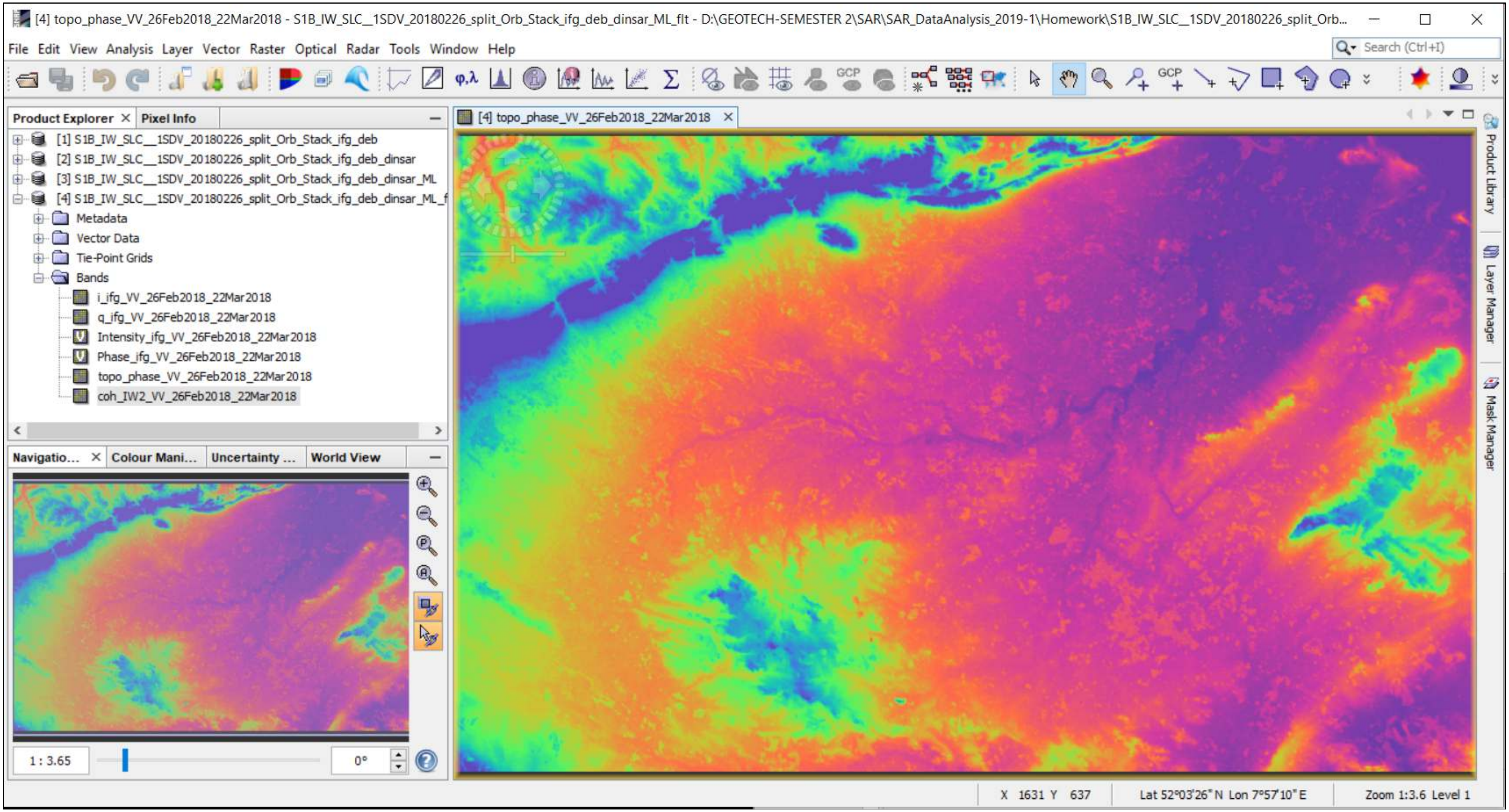
- Phase unwrapping is applied to recover the absolute interferometric phase difference to obtain sequential phase values across the image and to integrate phase difference between neighboring pixels. For this task, I am using SNAPHU which is a two-dimensional Statistical-cost phase unwrapping algorithm. SNAPHU is installed before-hand. The Interferogram is exported to SNAPHU and the Initial METHOD, Minimum Cost Flow Algorithm (MCF) and Statistical-cost mode: DEFO is used for mapping.



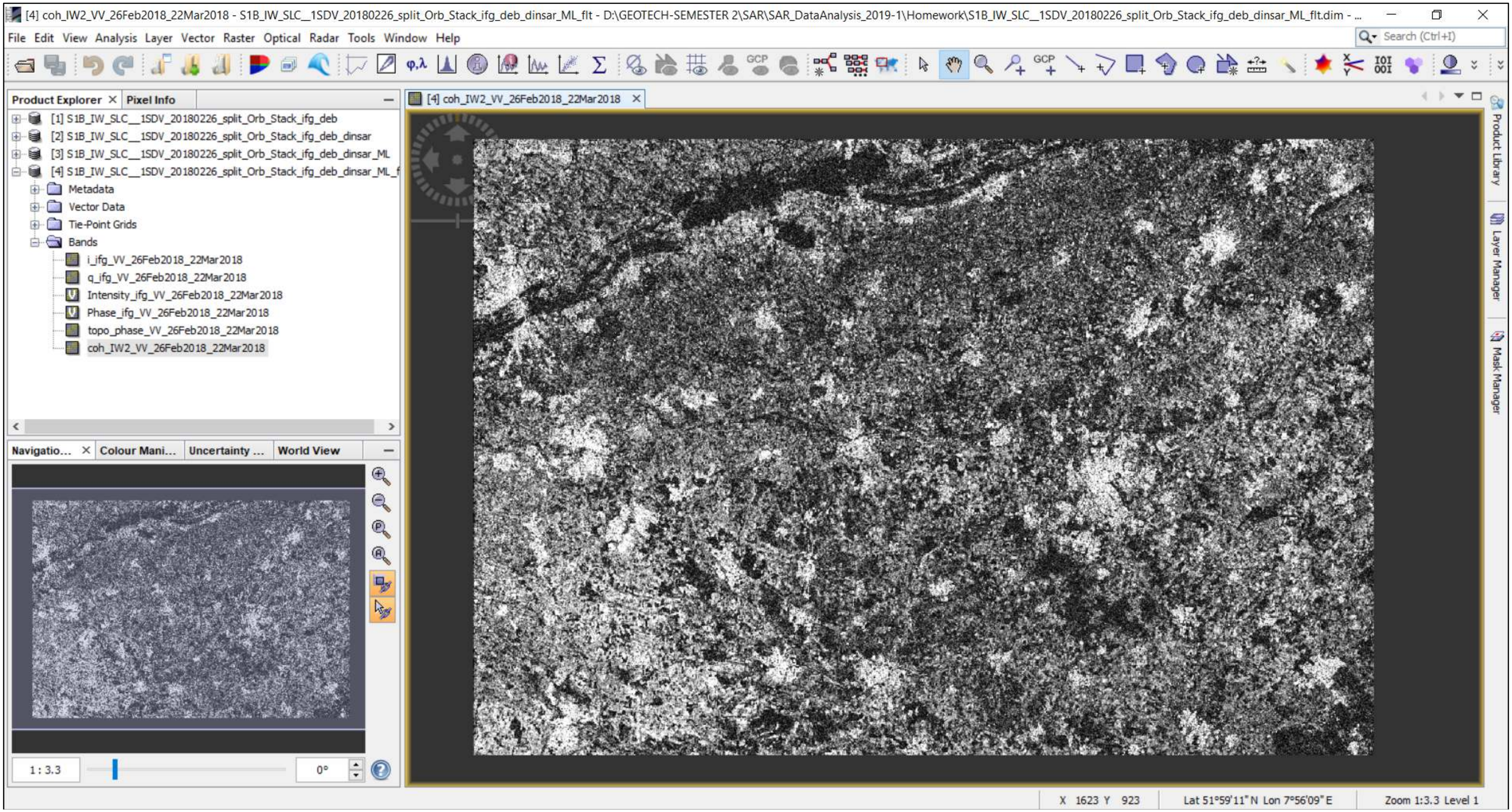
Phase Results



Topo_phase Result



Coherence Result

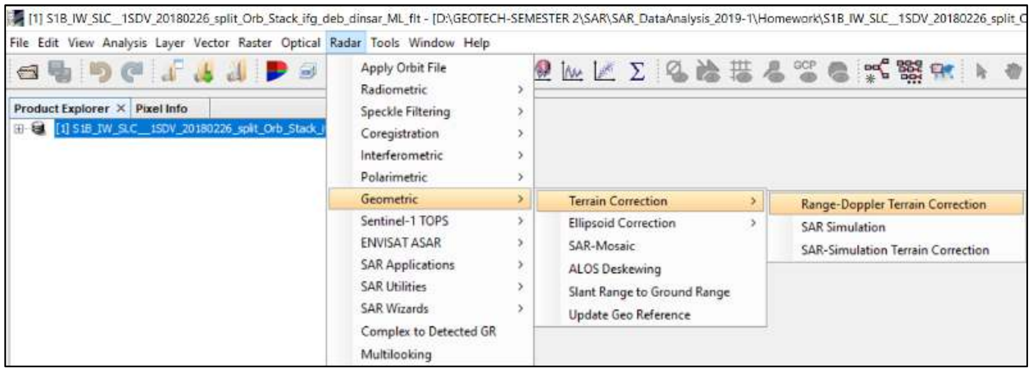


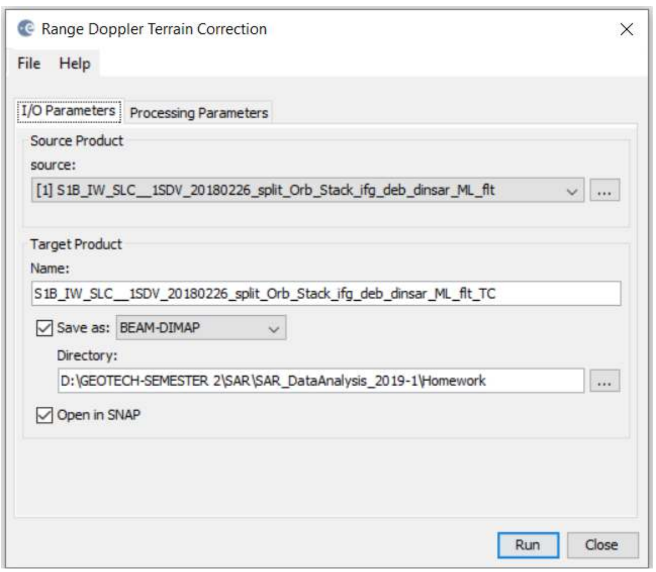
Discussion

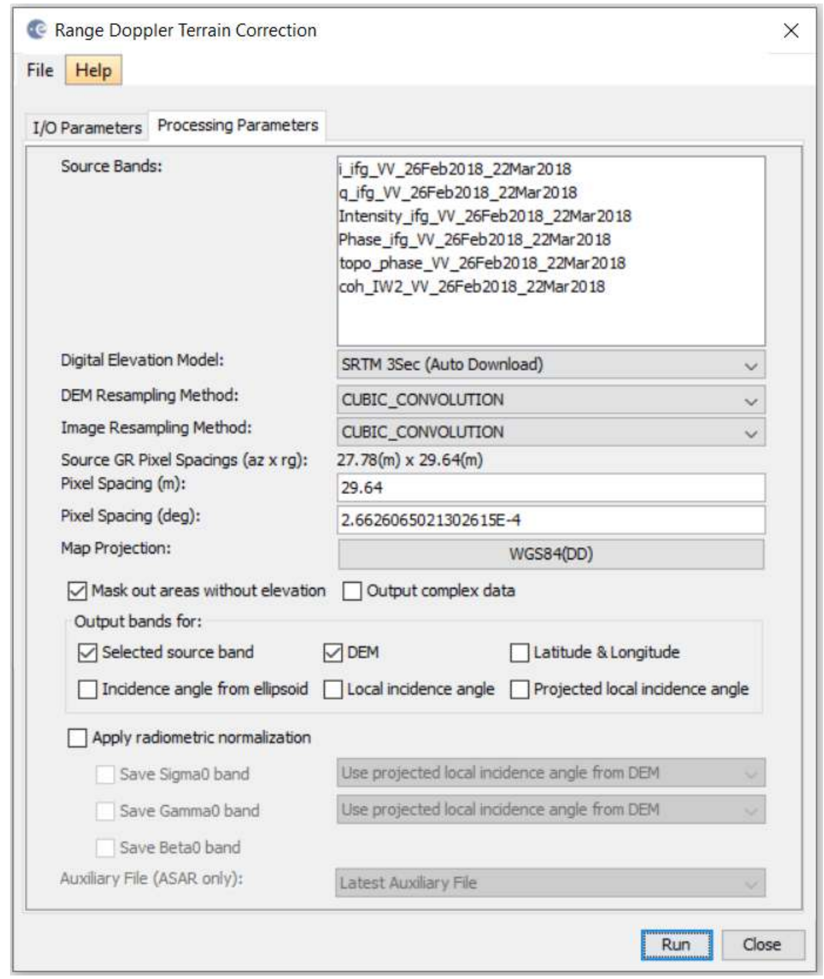
- The results above show the topo_phase which is the generated from the debursted Interferogram using the DEM.
- The phase is the differential Interferogram which is represented in the form of fringes. The values vary between pi and –pi. The extent of the image has square pixels which makes it easy to interpret. When the fringes are closer, the deformation is bigger and vis versa.
- The coherence image values range from 0 (the interferometric phase is just noise) which are dark areas to 1 (complete absence of phase noise) which are light areas.

Range Doppler terrain correction

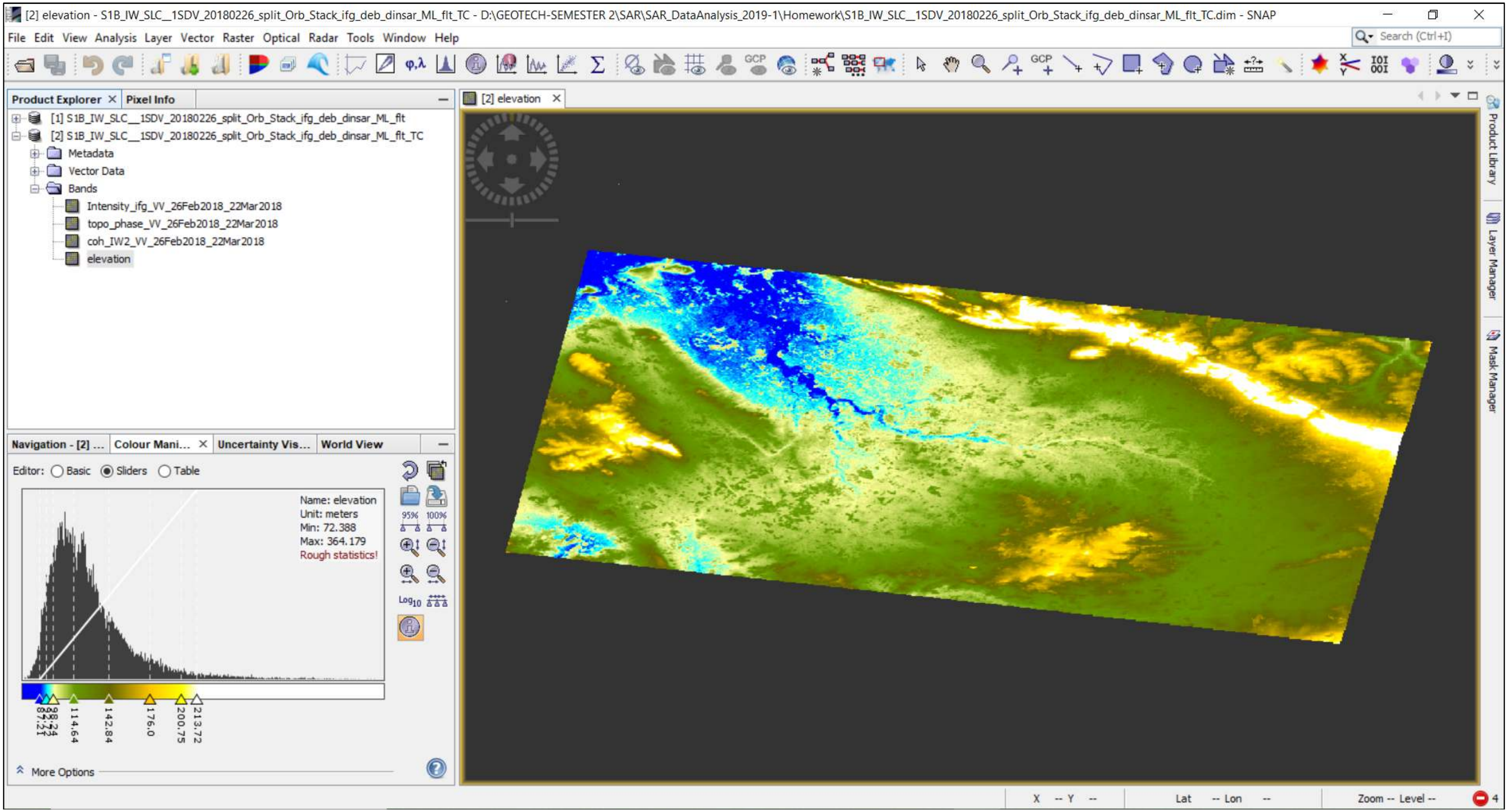
- Range Doppler terrain correction of the differential Interferogram was carried out and resultant DEM exported as .kmz for view in Google Earth.



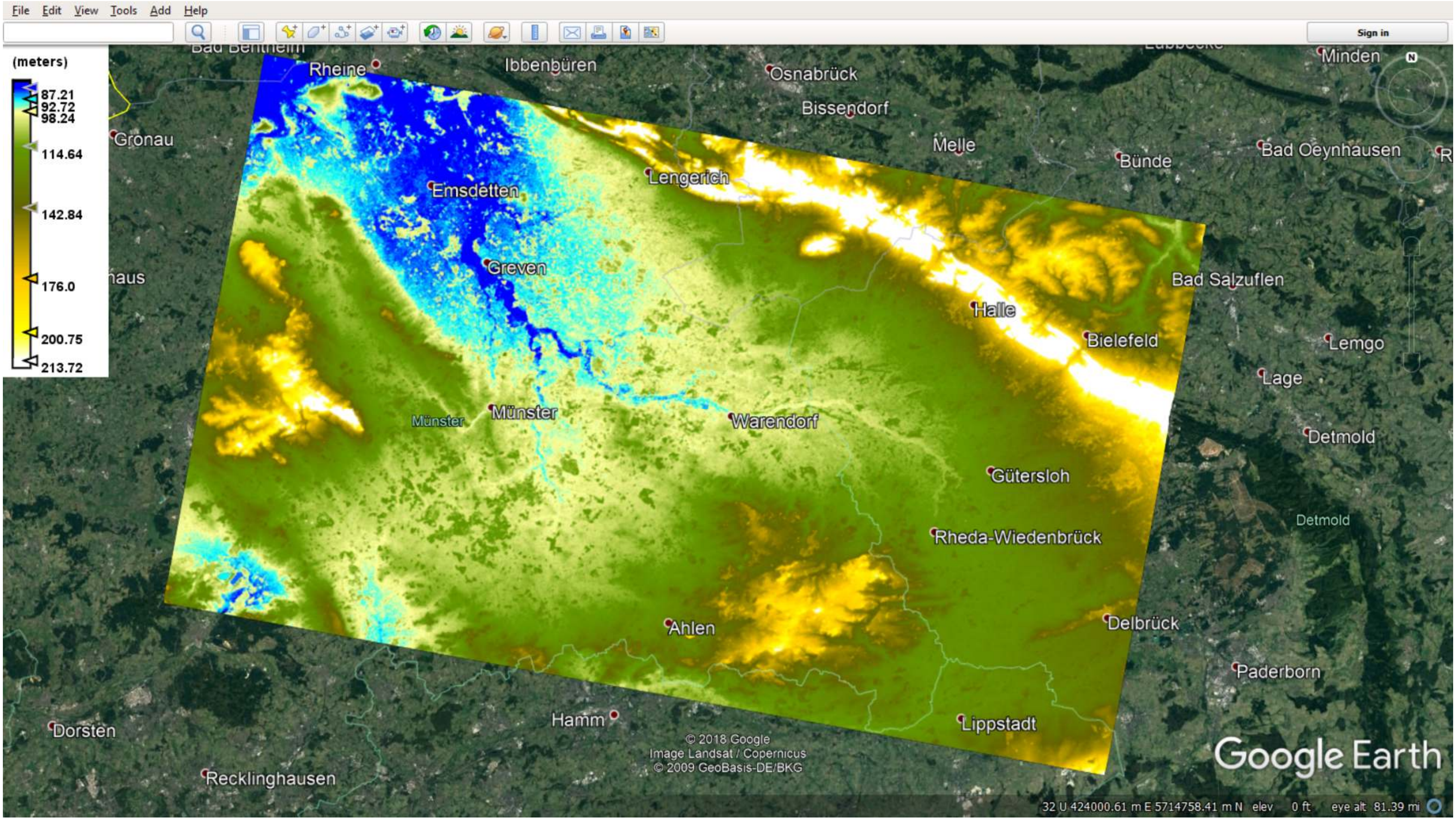




Terrain Correction DEM results

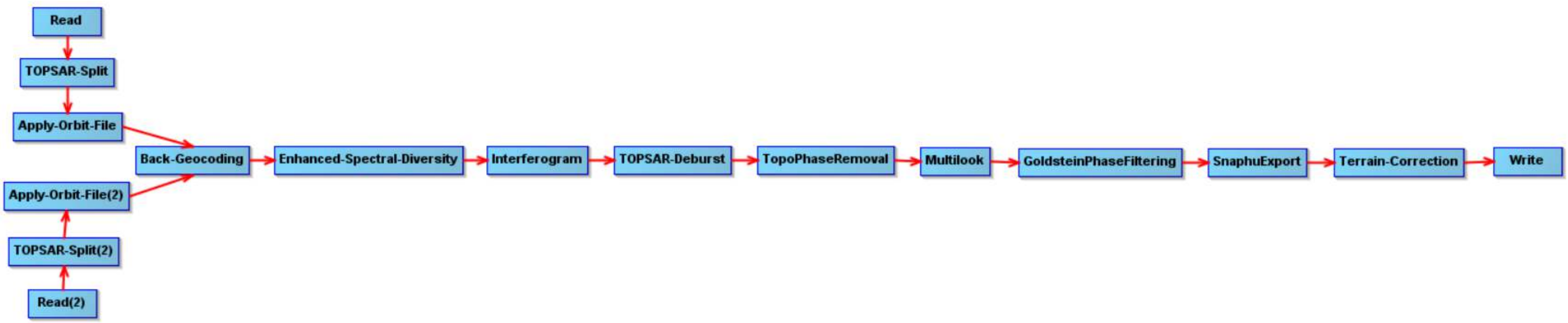


DEM visualization in Google Earth



Conclusion

- Overall Methodology Workflow Graph



- This entire homework experience has been insightful for me on how SAR data analysis can be used as a technique spatio-temporal analysis.

References

- http://step.esa.int/main/doc/tutorials