Earth Observation for data Science

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SURFACE DETECTION FROM SAR SENTINEL-1 DATA

Homework 3 (July 2020)

HOMEWORK 3

POINT 1 – AMATRICE EARTHQUAKE
Sentinel-1 SAR Interferometry

Situation Overview.

An earthquake, measuring 6.2 of magnitude, hit Central Italy on 24 August 2016 at 03:36:32 CEST.
Its epicenter was close to Accumoli, with its hypocentre at a depth of 4 km, approximately 75 km (47 mi) southeast of Perugia and 45 km (28 mi) north of L'Aquila, in an area near the borders of the Umbria, Lazio, Abruzzo and Marche regions.

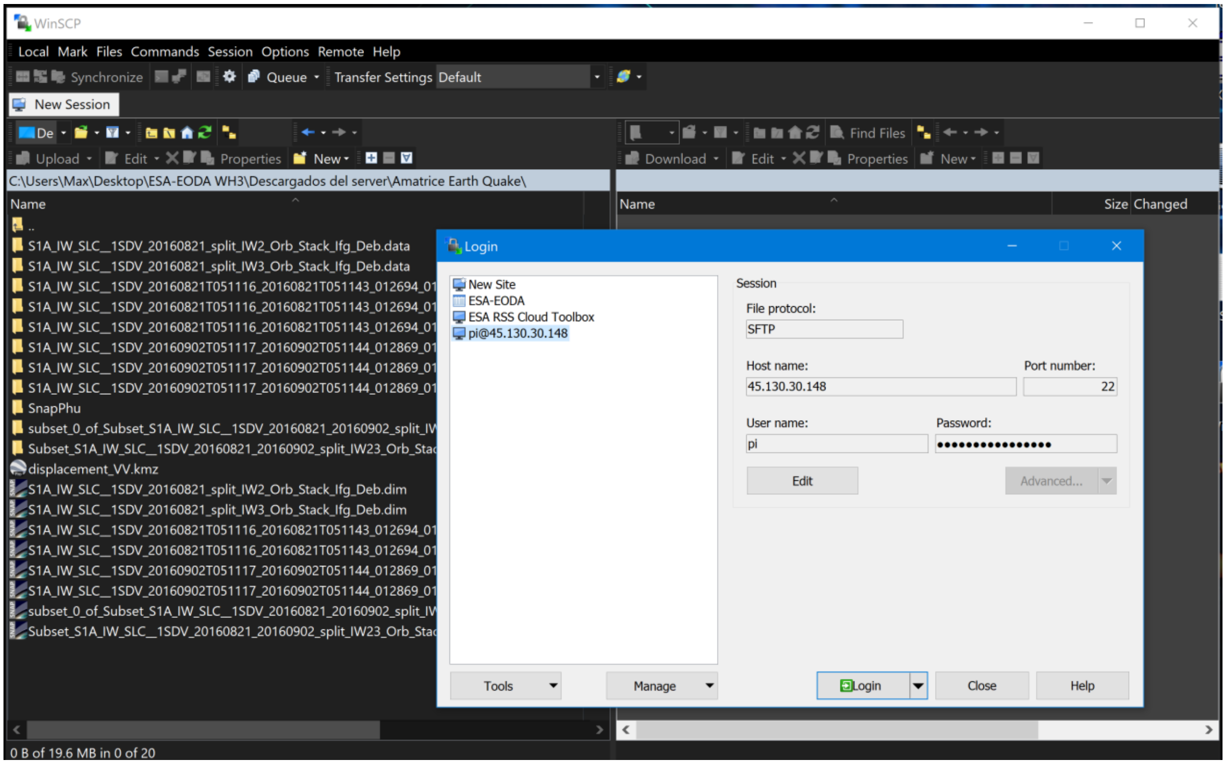
In this laboratory we will analyze the earthquake of 2016, with the usage of SAR interferometry.

Due to some problems with the virtual machine and taking advantage of the fact that the computer in which we will perform the analysis offers good performance, we will download the images and work locally.

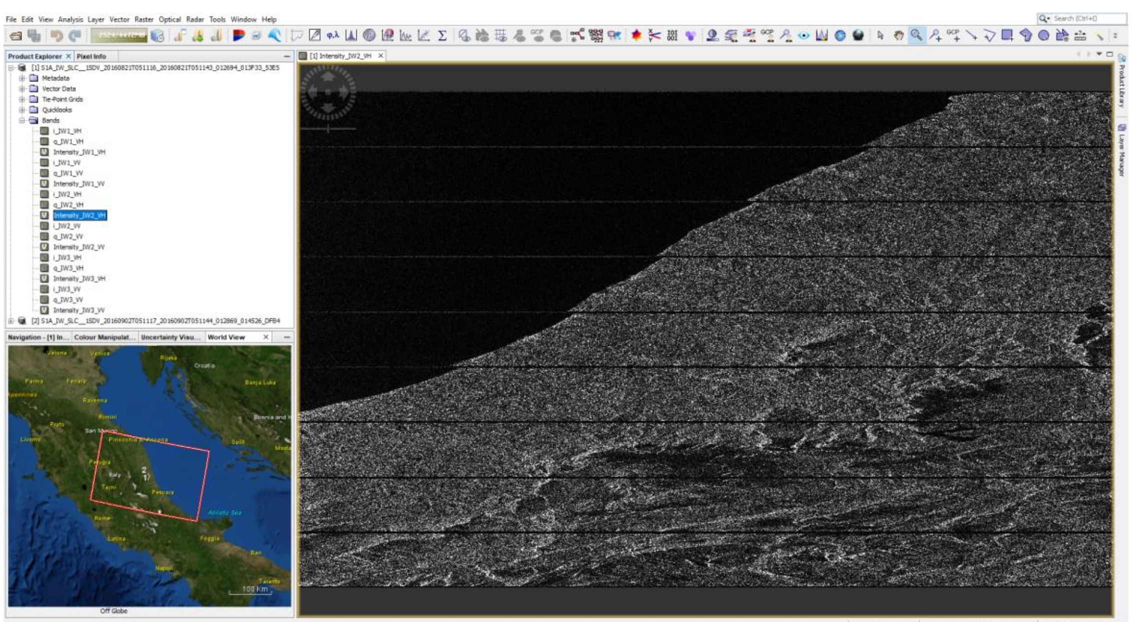
https://www.peertechz.com/articles/JCEES-3-116.php

Procedure

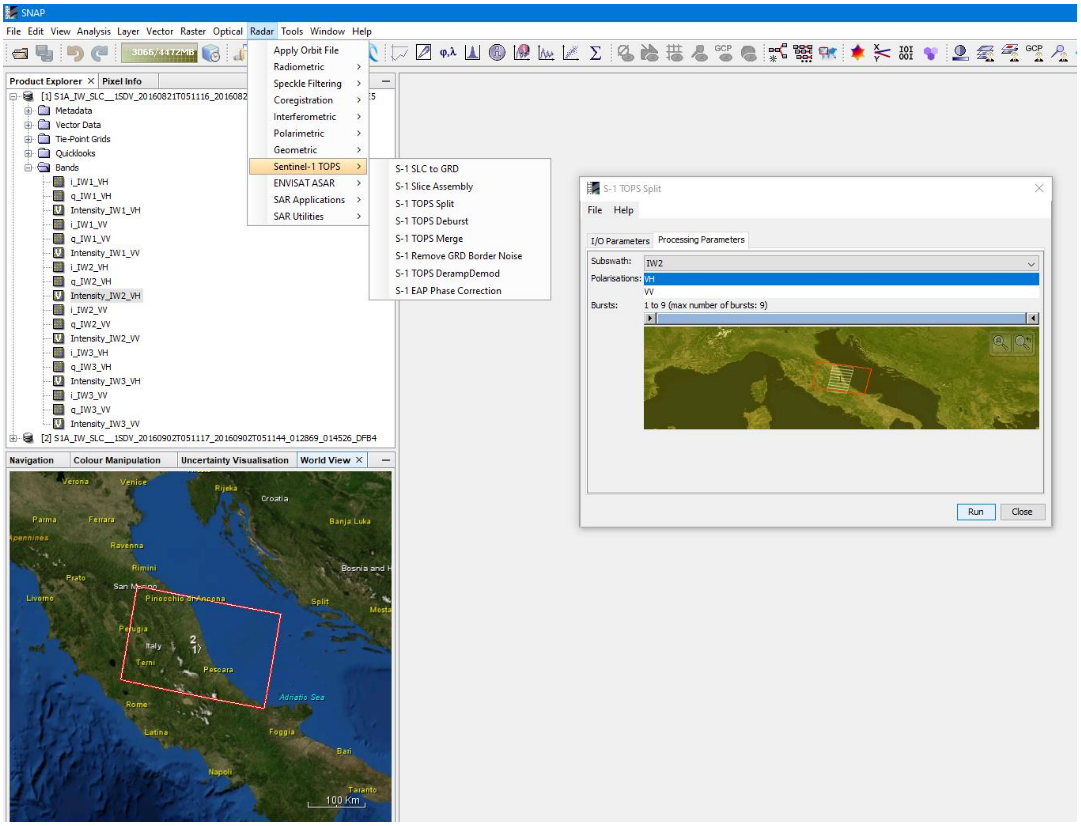
First step we download the images from the Virtual Machine using WinSCP software.
Pre-Event and Post-Even Acquisition:

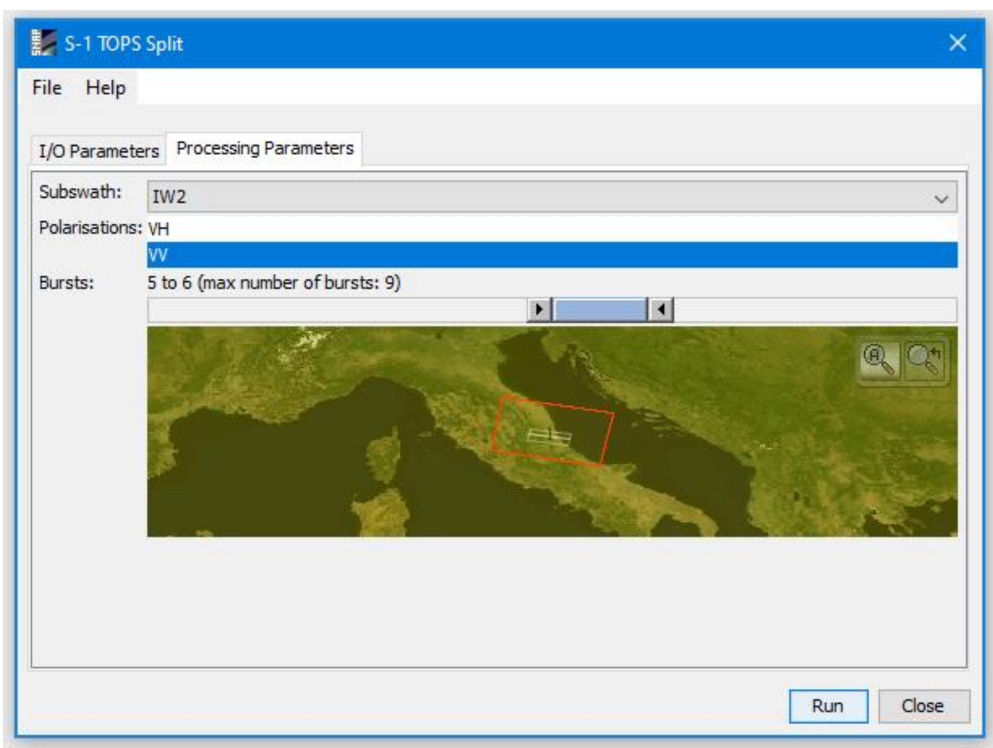


Once downloaded, we can open the images into SNAP to visualize them.

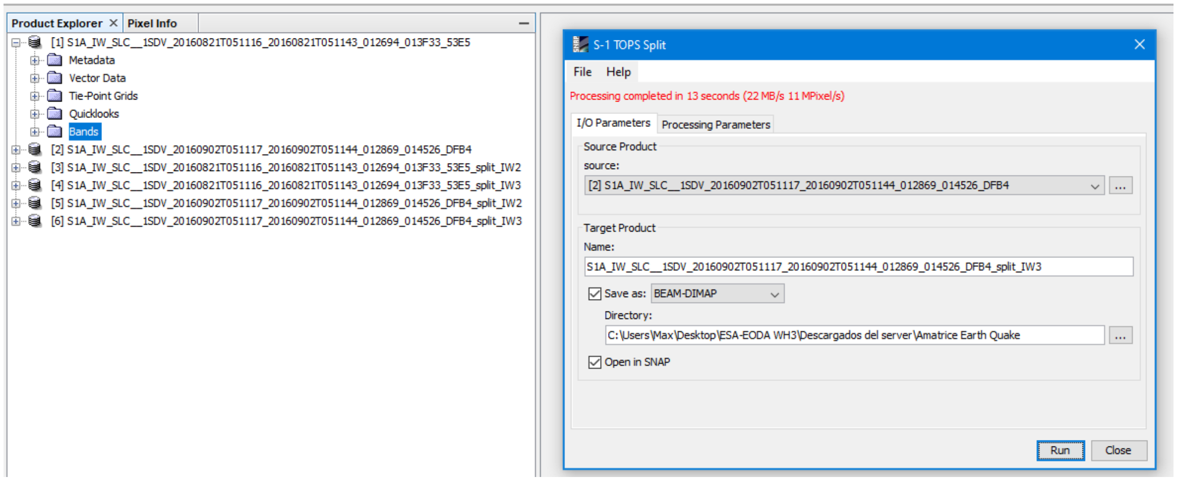


We select only the sub swath of the image related to the earthquake zone (burst 5 and 6).

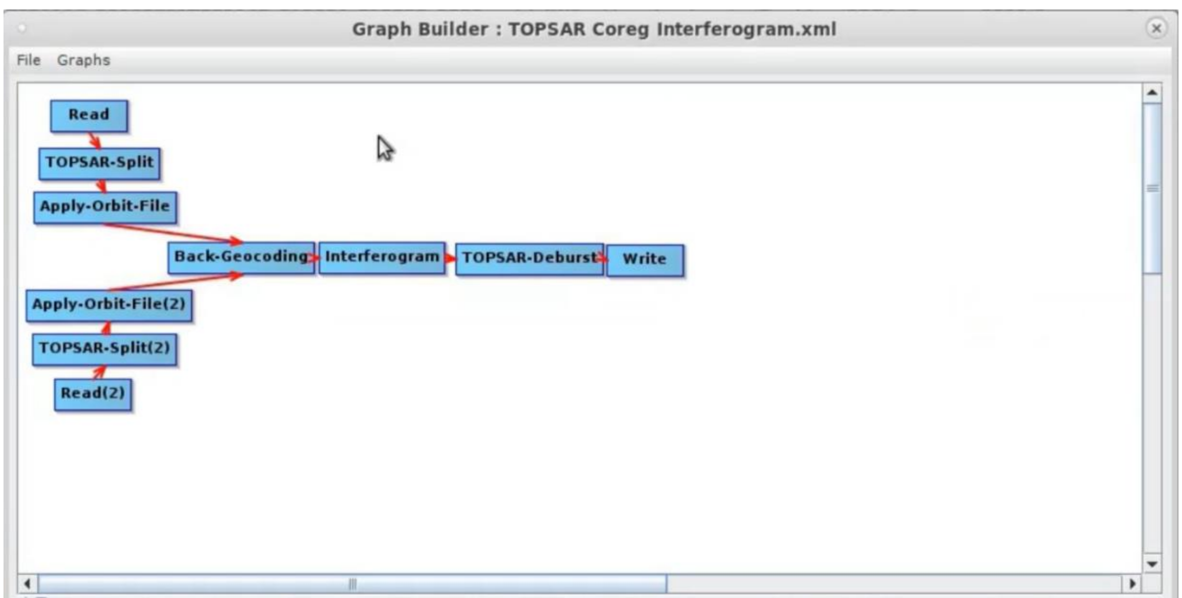




This is the result after the split operation selecting the sub swath IW2 and IW3 and VV Polarization respectively.



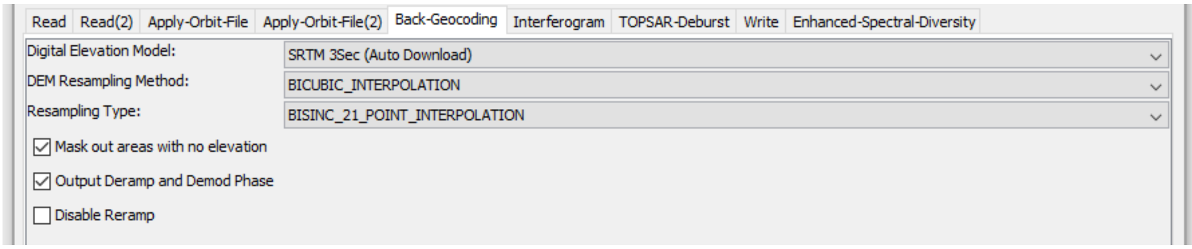
Using the Graph Builder, we open a predefined graph. We select TOPSAR Correg Interferogram



Because we already manually split our images, we can delete the **TOPSAR Split** operator from our workflow.

We must modify the predefined graph adding **Enhanced Spectral Diversity** operator. This operator is needed to compensate and avoid discontinuity between phases.
Back geocoding is the operation needed to co-register the master and the slave acquisition, in this operator we will modify the Resampling Type and Method as follows:

- DEM Resampling Method: BICUBIC_INTERPOLATION
- Resampling Type: BISINC_21_POINT_INTERPOLATION



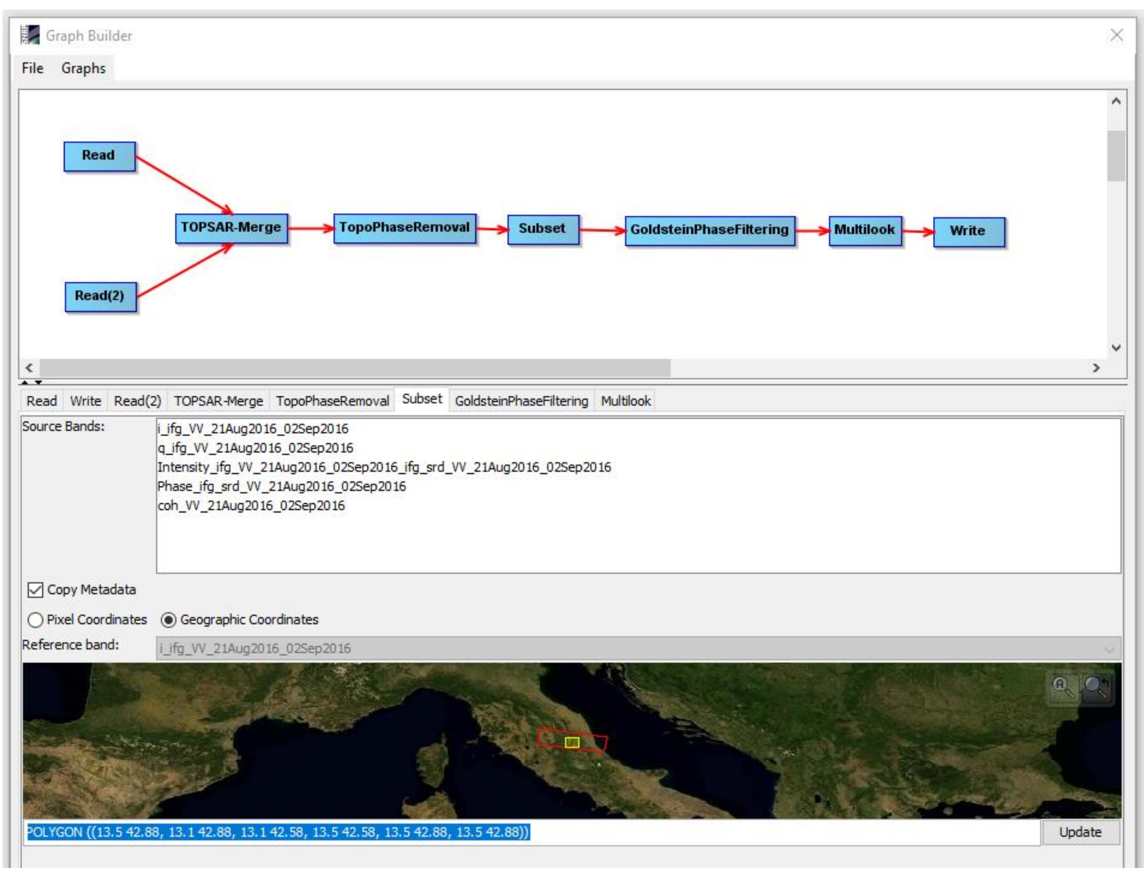
For the Enhanced Spectral Diversity, we will leave the default values.
Interferogram: we need to calculate the interferometric phase and subtract the contribute to the flat earth. We also use the default values.

Interferometric Phase contributions Summary

$$\Delta\varphi = \Delta\varphi_{flat} + \Delta\varphi_{elevation} + \Delta\varphi_{displacement} + \Delta\varphi_{atmosphere} + \Delta\varphi_{noise}$$

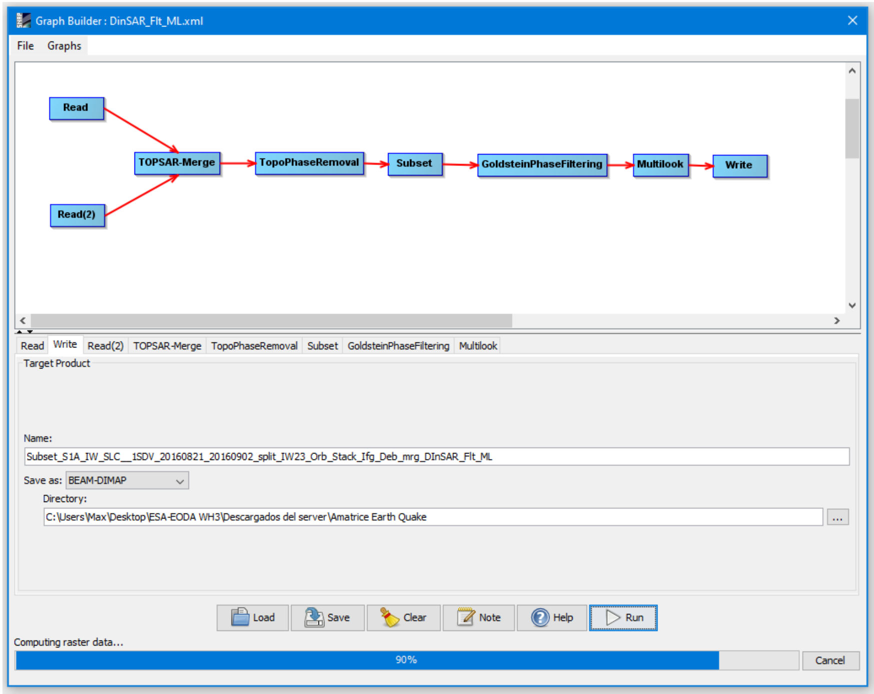
TOPSAR Deburst: will help us to merge the discontinuity between the adjacents bursts
Write: write our result into a disk

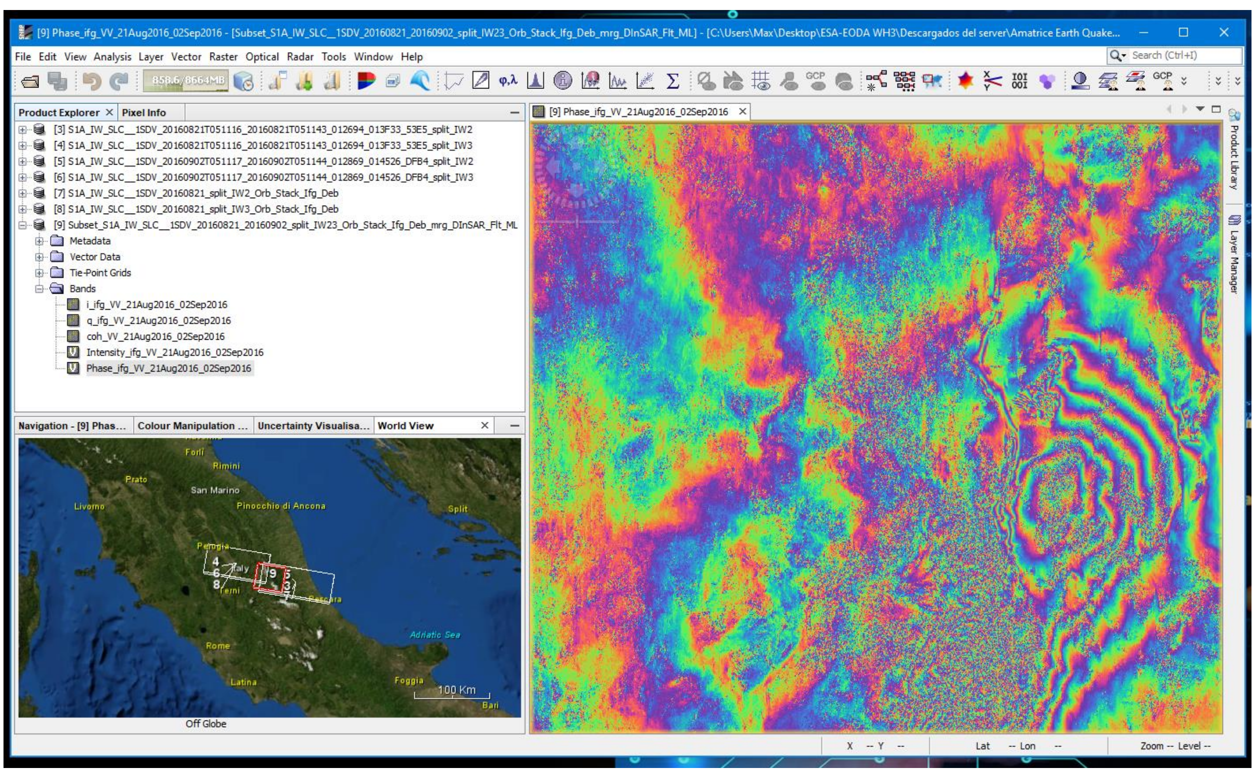
FOOD PRINT: POLYGON ((13.5 42.88, 13.1 42.88, 13.1 42.58, 13.5 42.58, 13.5 42.88, 13.5 42.88))



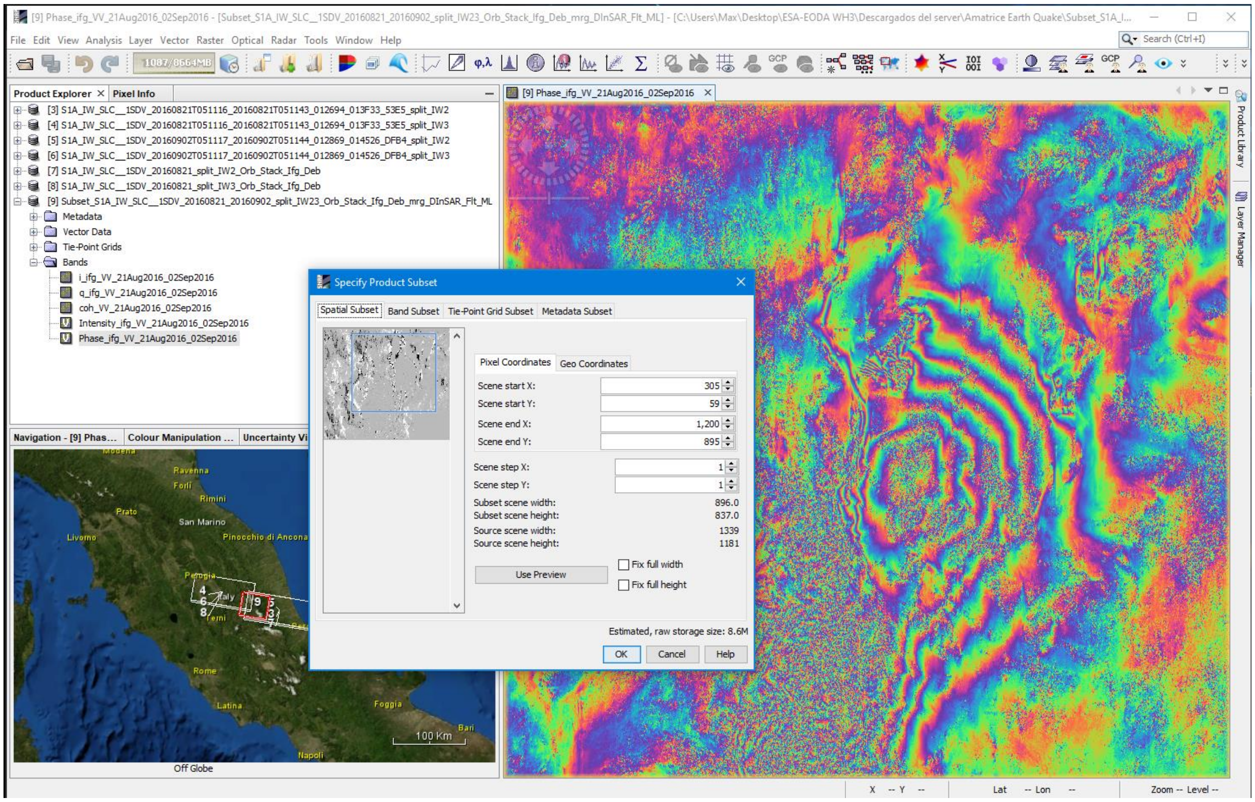
Performing the process

After creating the Interferogram for both IW2 and IW3 we merge them in one image.
In this step we will subtract the topographic phase contribute from the interferometric inputs.





Sub setting the image to avoid **no data** parts in the image due to the overlapping.

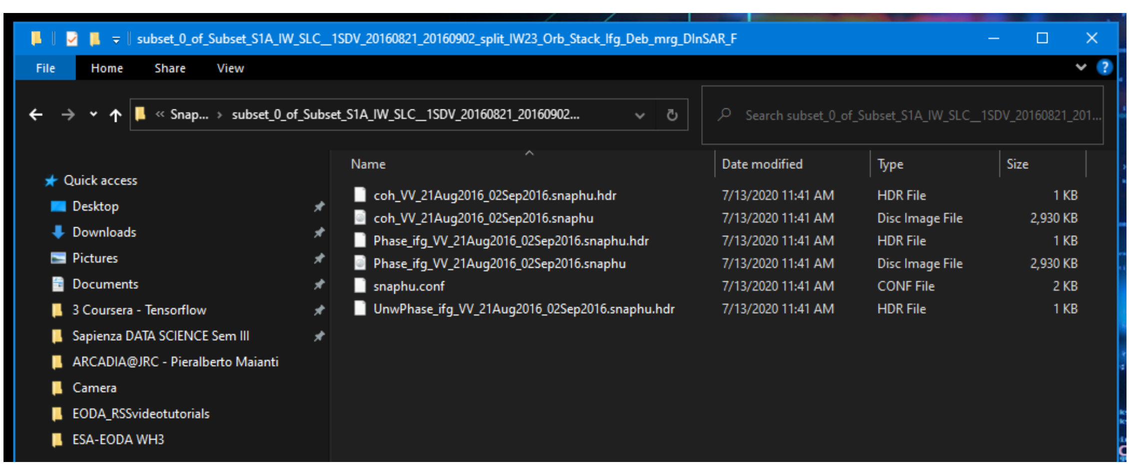


To automatically count all the phases cycles SNAP uses the following operation:

Phase Unwrapping Operation

$$\phi = \phi_m + 2\pi k$$

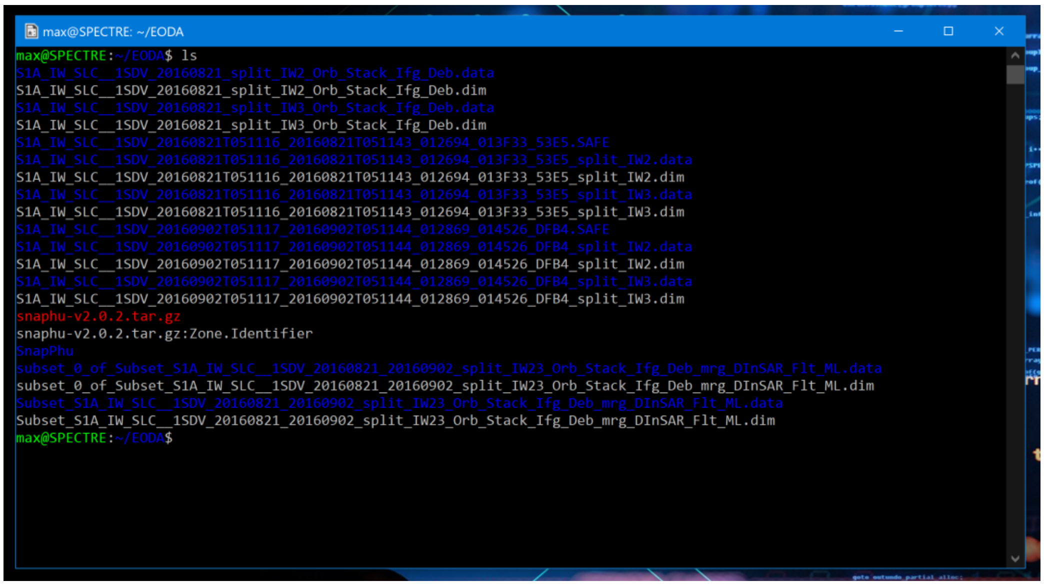
After the operation is performed, we can see the result folder



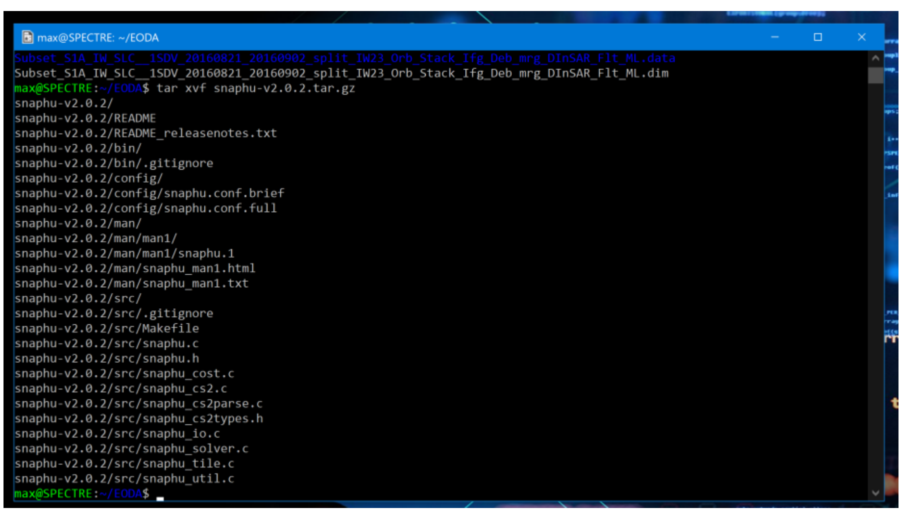
To work with the output files, we need SNAPHU software, SNAPHU is a Statistical-Cost, Network-Flow Algorithm for Phase Unwrapping from Curtis W. Chen. The last version is 2.0.3, released on November 2019. The software is written in C and should run on most Unix/Linux platforms only.

Given an input interferogram and other observable data, snaphu attempts to compute congruent phase-unwrapped solutions that are maximally probable in an approximate a posteriori sense. The algorithm's solver routine is based on network optimization. By default, snaphu assumes that its input is a synthetic aperture radar (SAR) interferogram measuring surface topography.

We download (https://web.stanford.edu/group/radar/softwareandlinks/sw/snaphu/) and install SNAPHU software on our local WSL (Windows Subsystem for Linux Environment) For that reason we will copy the files back to a folder in the LINUX environment to perform the snaphu unwrapping process.

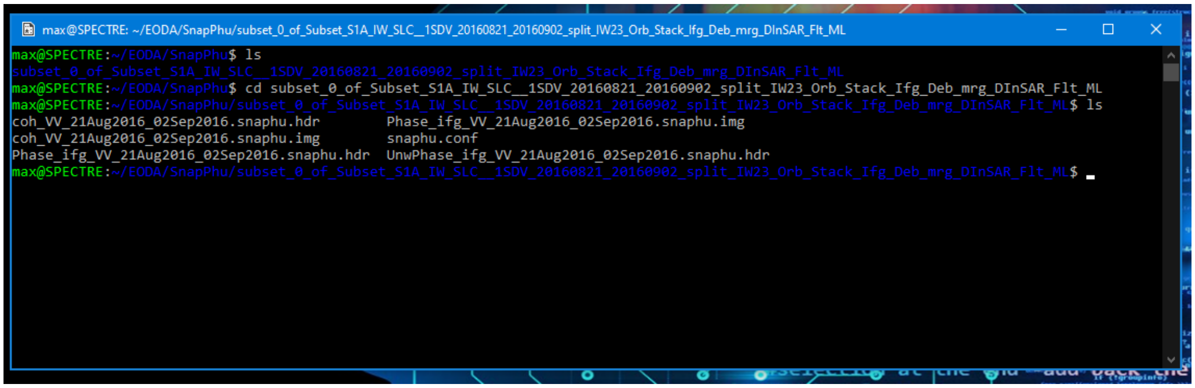


In RED the Snaphu installer.

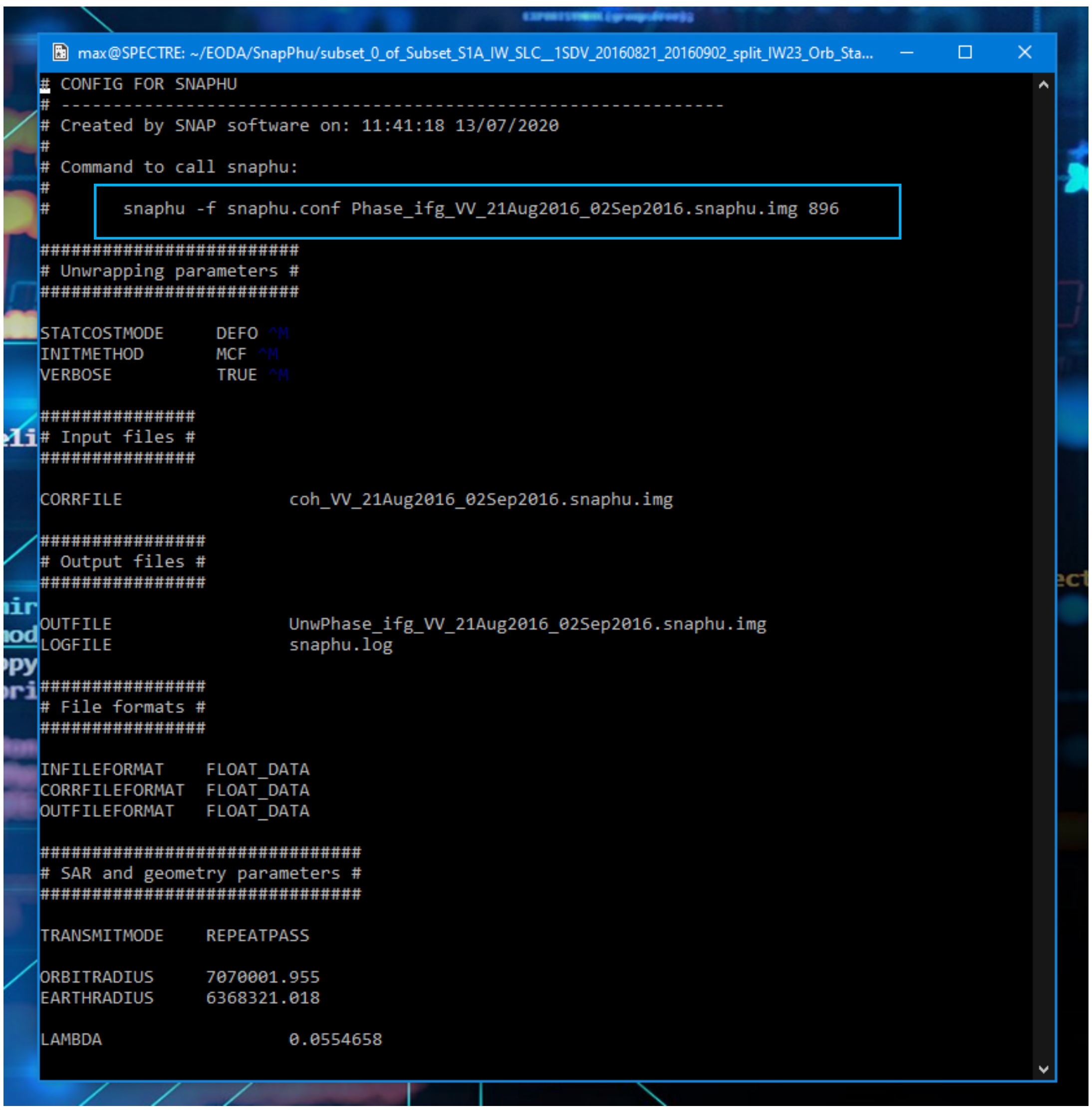


Now snaphu is installed locally in our Linux environment and ready to use

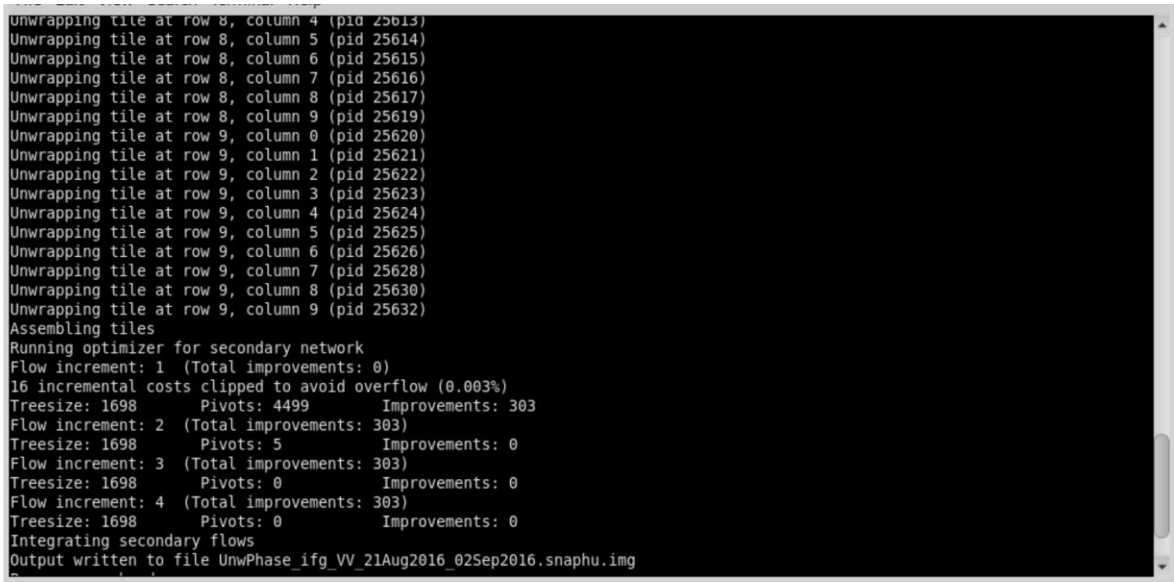
We go inside of our folder to check the files



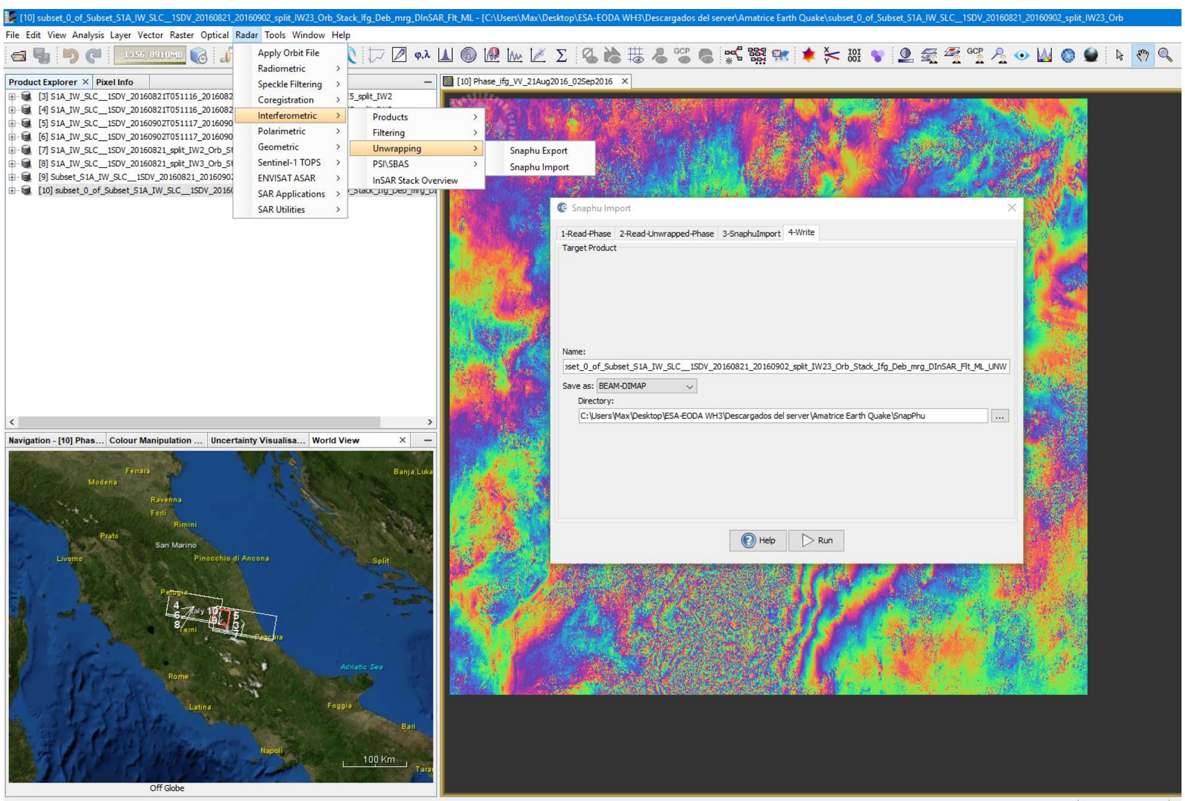
Let's open the config file.



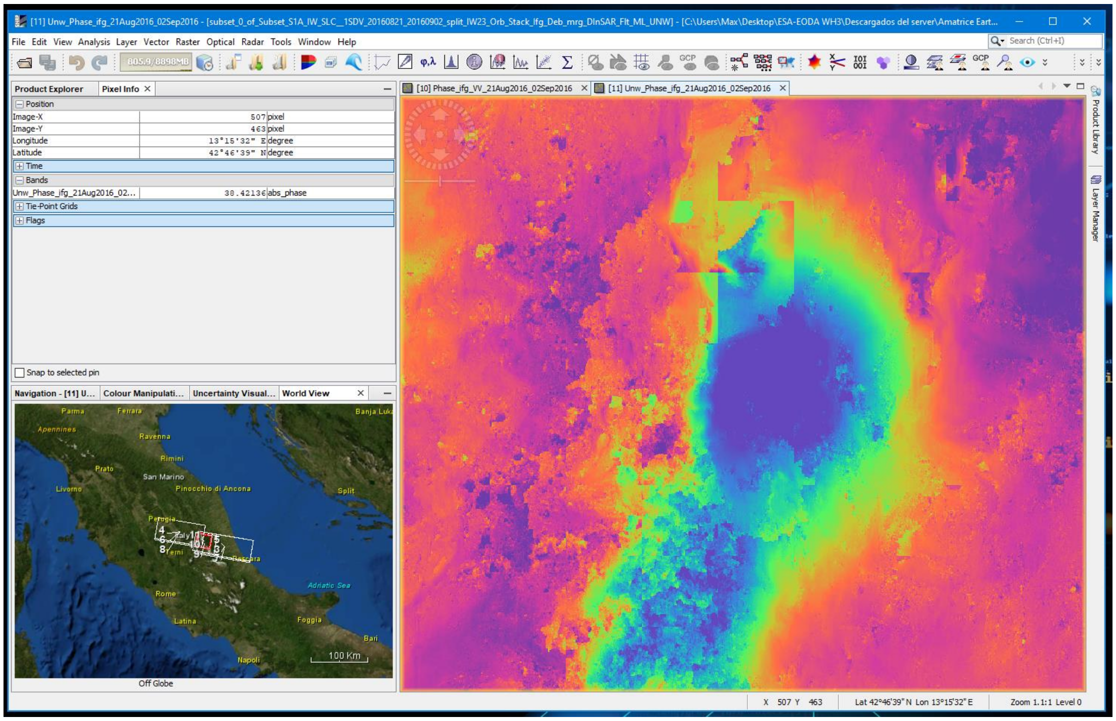
Lest now run the command



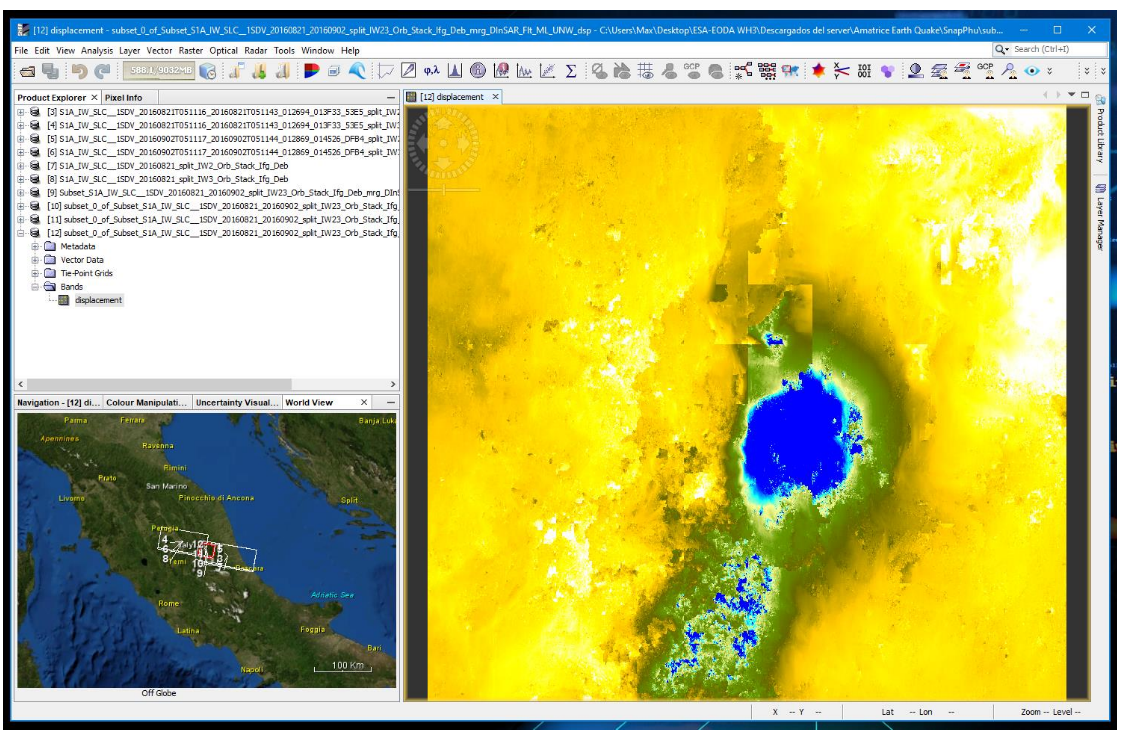
After created the image we can import it into SNAP.



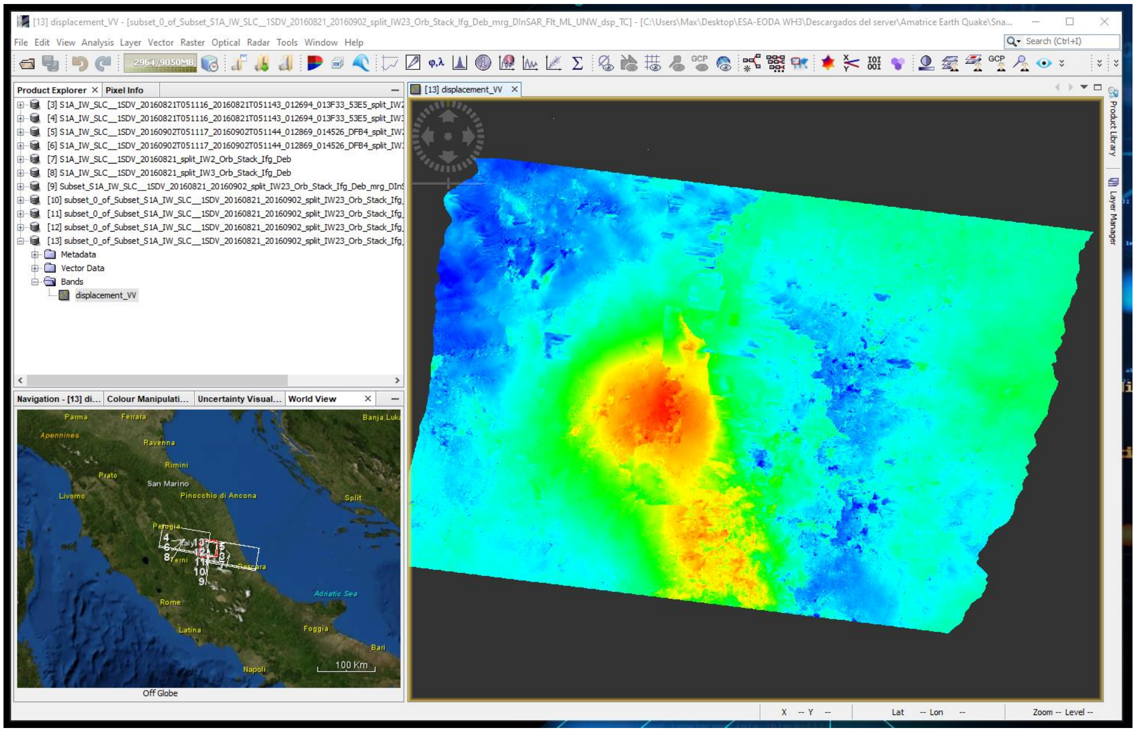
After imported we will visualize the unwrapped phase band.



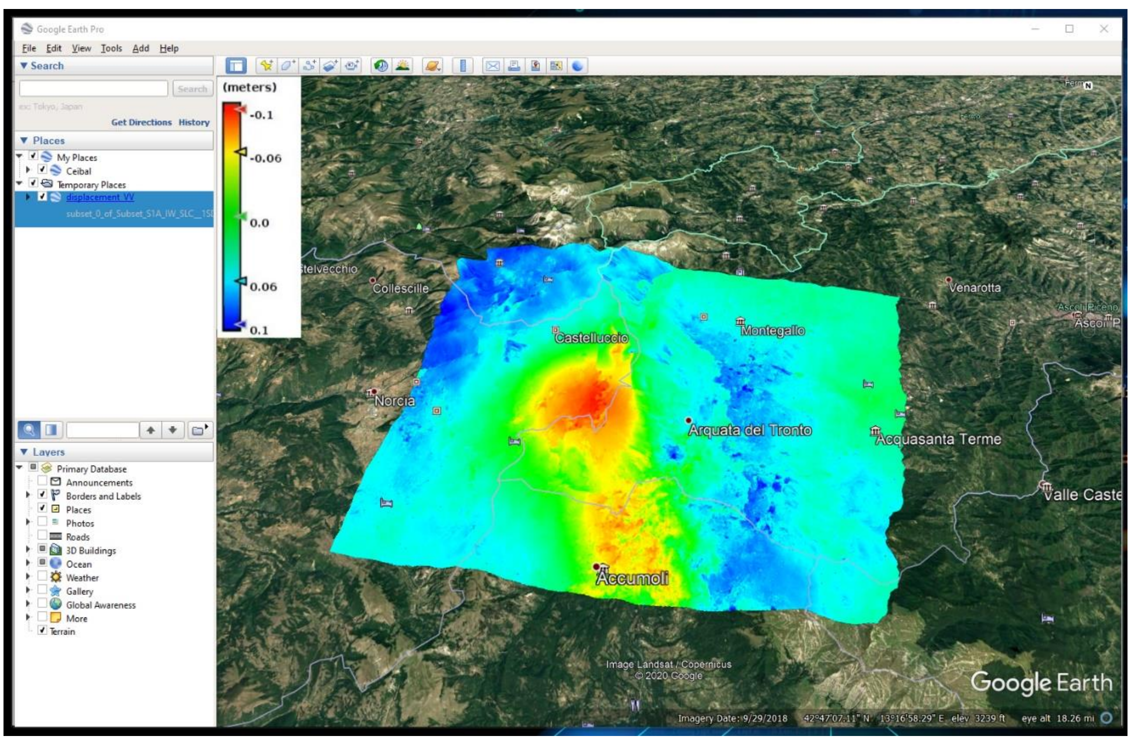
Converting the image into Displacement map



Let's do a Terrain Correction and apply the JET Palette visualization to enhance the deformation



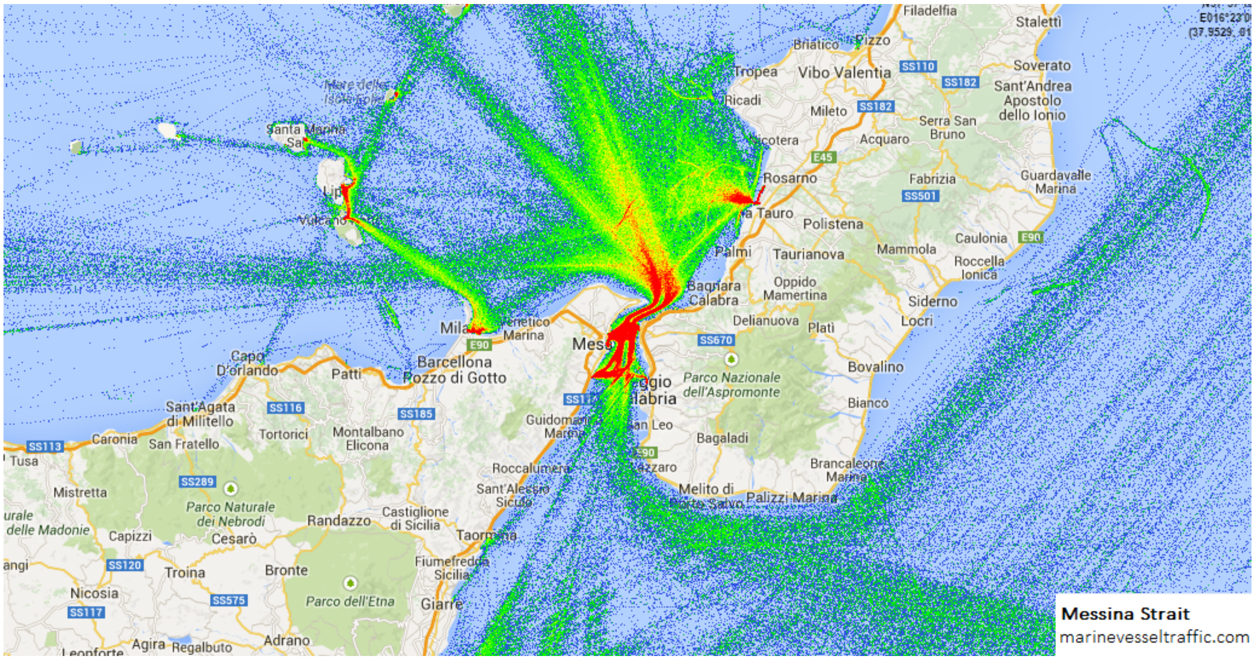
Finally we can export the map as KMZ format to open it on Google Earth or any GIS software.



POINT 2 – SHIP DETECTION BY SAR BACKSCATTERING

Messina Strait, Southern Italy.

Situation Overview.



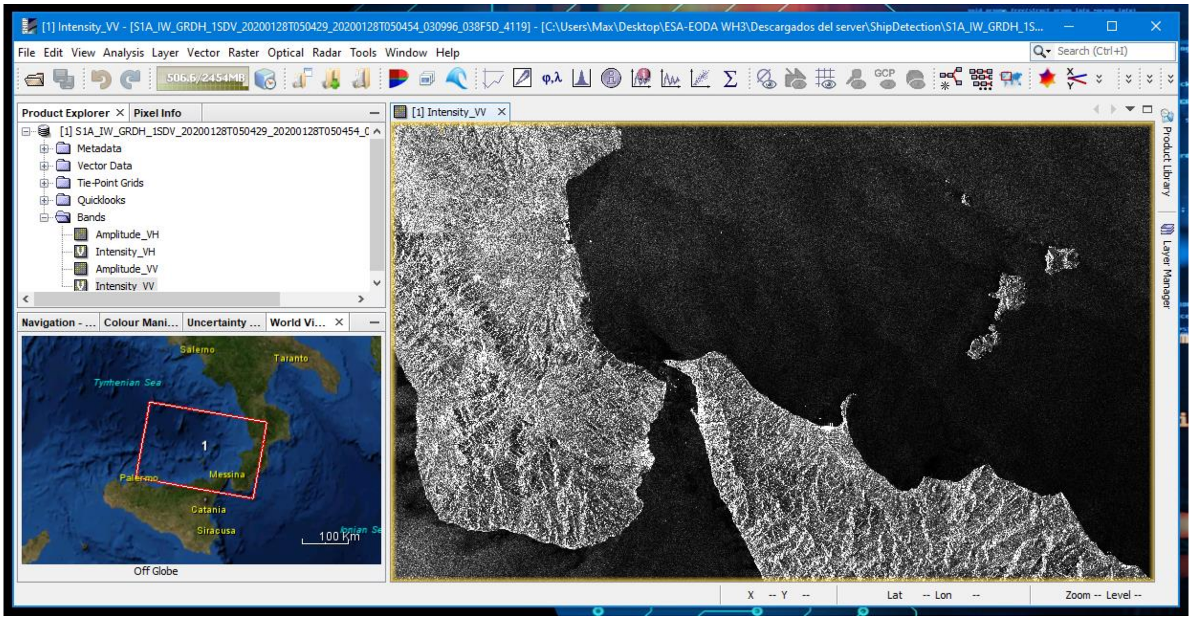
The Strait of Messina is a very busy sea area that separates Sicily and the Italian mainland. In respect of environment and for the prevention of human loss, it is fundamental to have an estimate of the possible ship accidents that could occur. In this work, the approach used is the International Association of Lighthouse Authorities Waterways Risk Assessment Program (IWRAP) model. The first part of the paper describes the local and global traffic and the separation scheme in the Strait of Messina. The model input data is obtained from the Vessel Traffic Service (VTS) system thanks to the Coast Guard of Messina. The second part concerns calculation of the geometrical collisions (number of collisions in different scenarios) and the causation probability. This analysis is the basis for the discussion of new regulatory constraints due to the future realization of new piers in the south and the planned unification of the two Port Authorities of the two shores into one single authority.

https://www.cambridge.org/core/journals/journal-of-navigation/article/frequency-of-ship-collisions-in-the-strait-of-messina-through-regulatory-and-environmental-constraints-assessment/B1522B8A1C0FB693E53F68CC27D14263

Procedure.

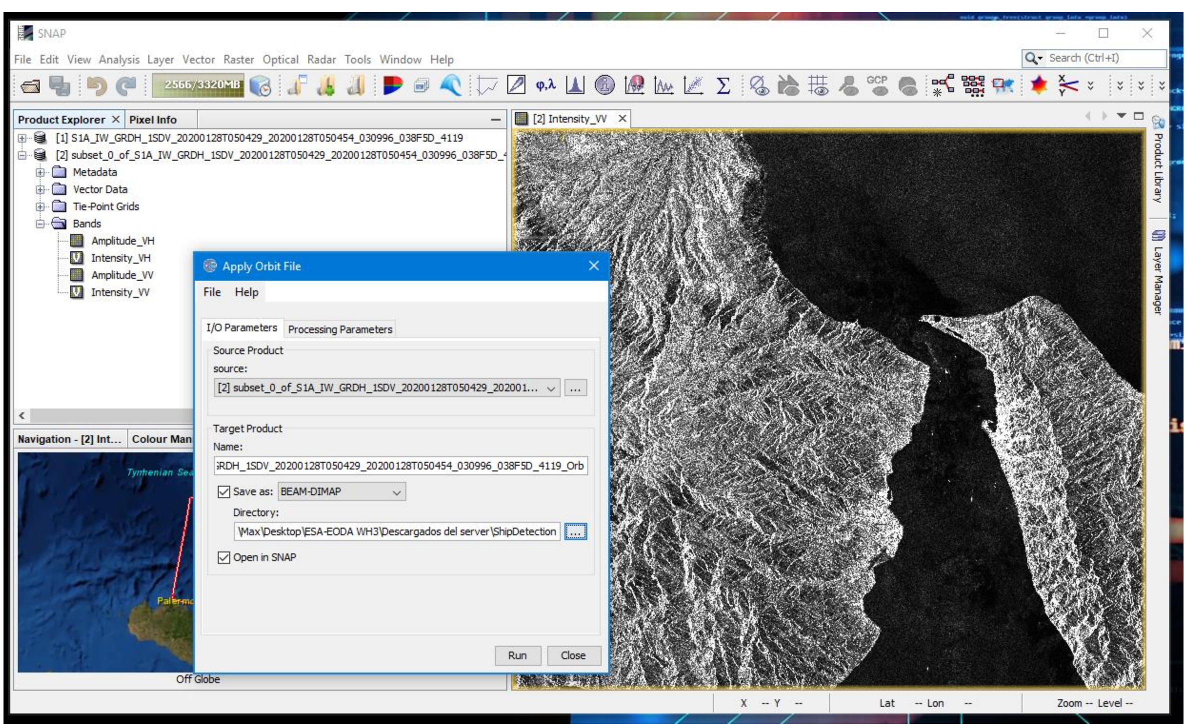
a.Data band exploration and subsetting for ROI

After downloaded, we open the image using SNAP



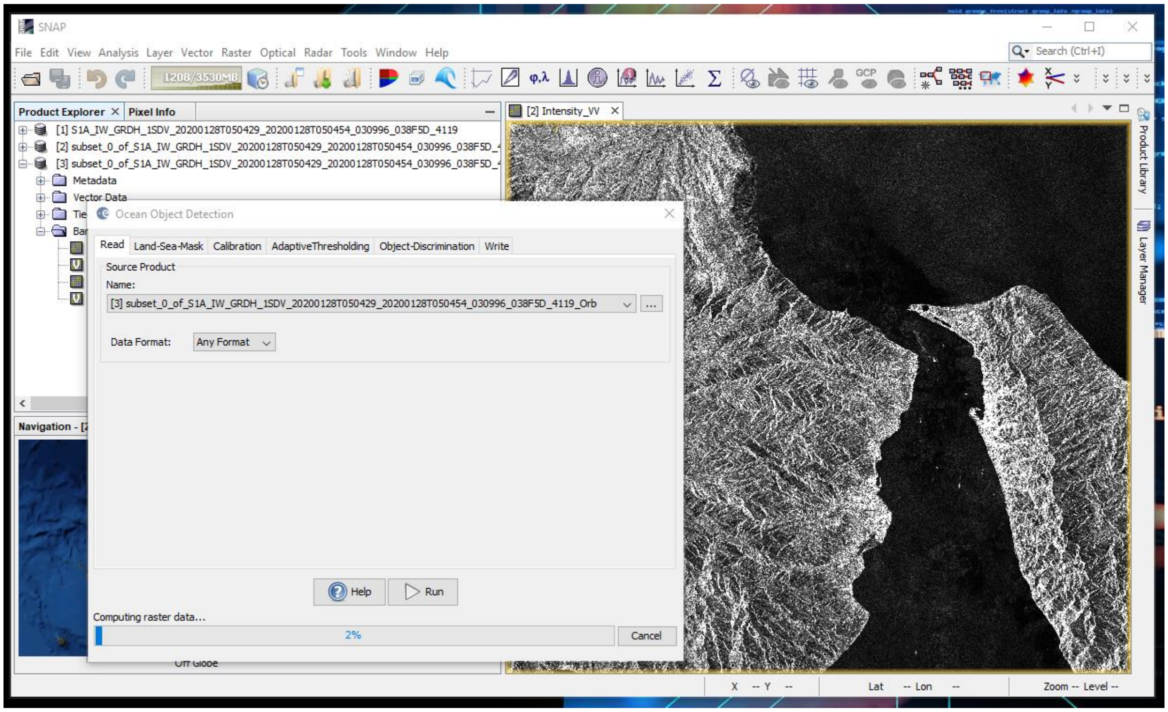
b.Orbit Precising.

We create a Raster Subset for the ROI, and then we apply Orbit File

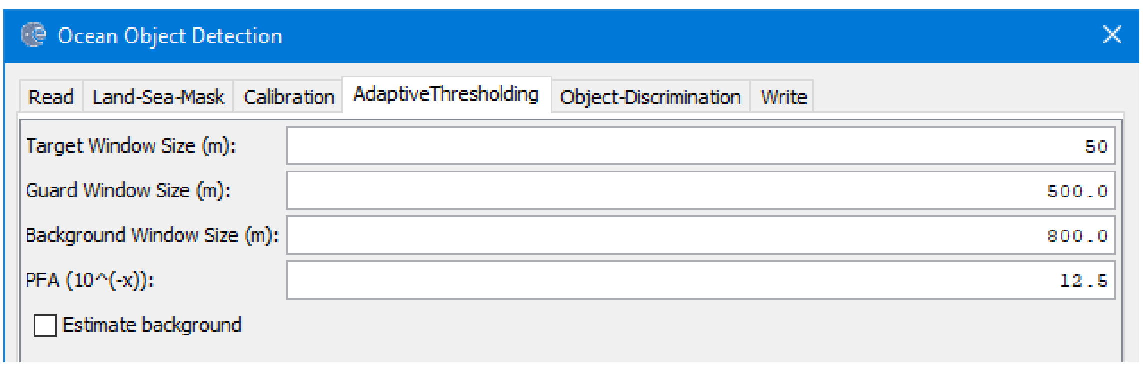


c.Land-Sea masking and calibration

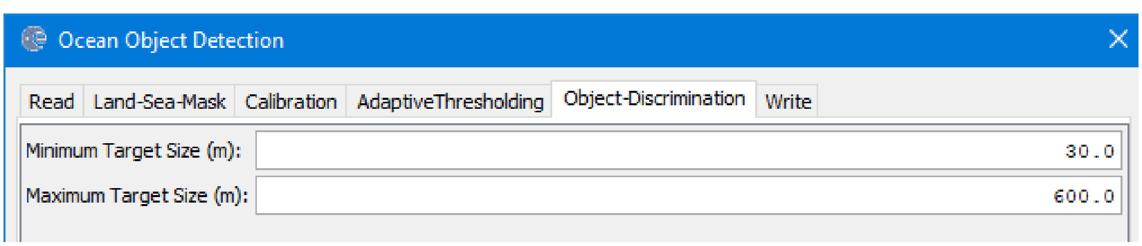
Now we perform an object Detection to our subset image.



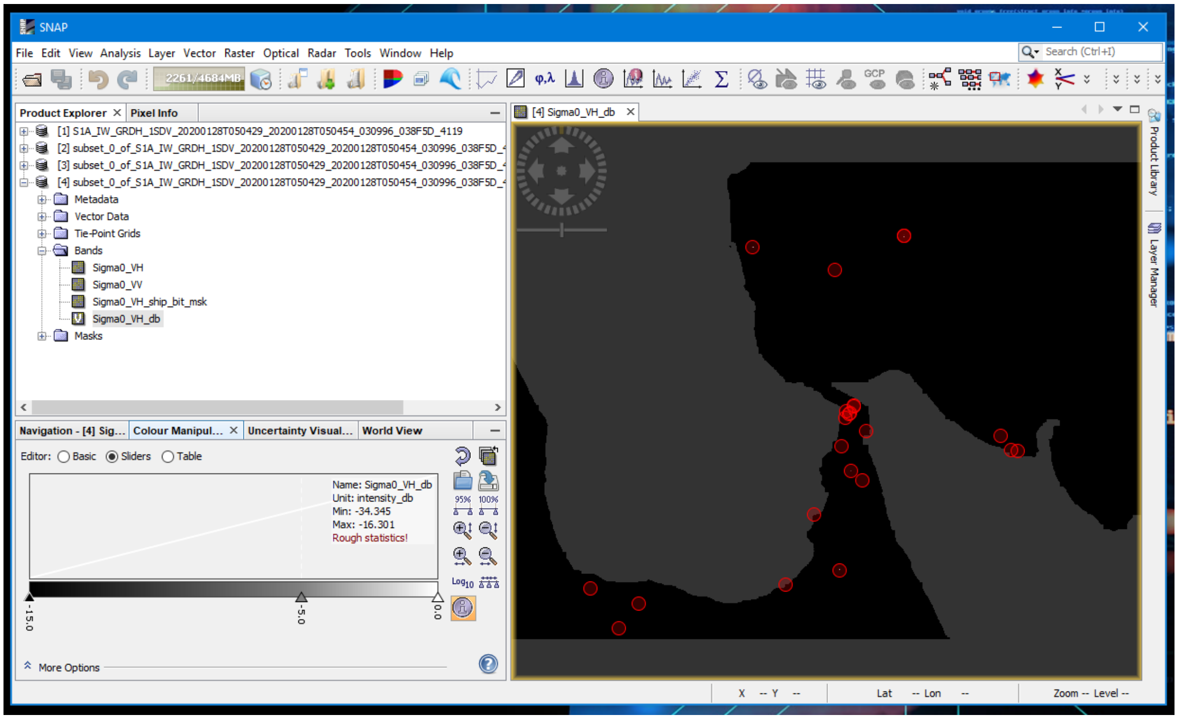
d. Adaptive thresholding by appropriate windowing and PFA



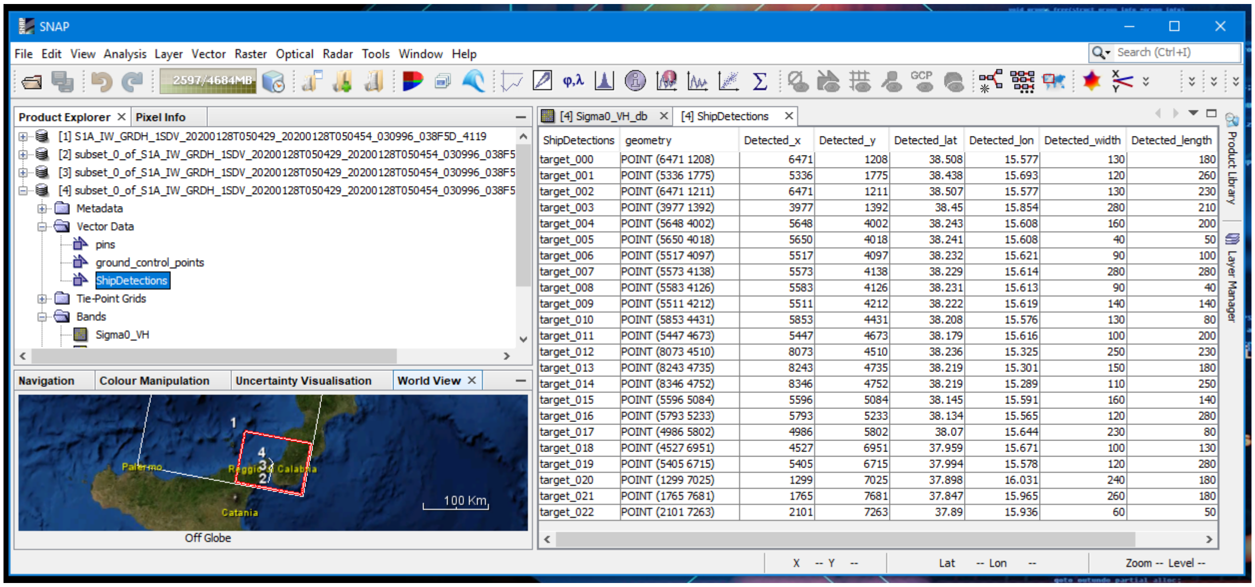
e. Object discrimination by min-max sizing and conversion to dB.



Finally we will modify some parameter to obtain a better visualization.



Metadata Ship Detection Table.



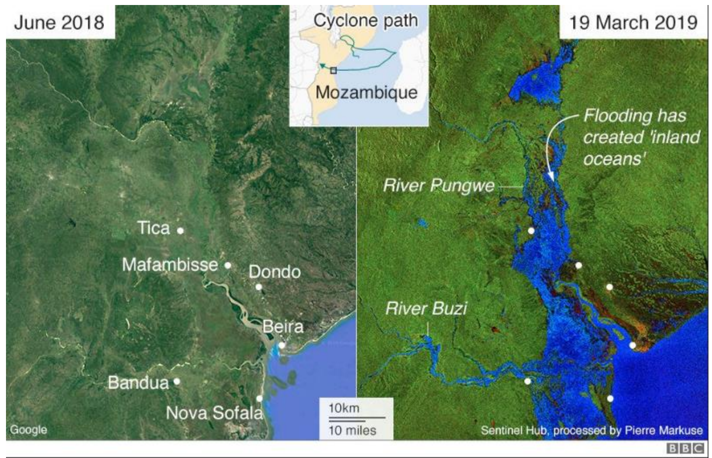
Conclusion:

It is possible to detect objects (ships) using SAR backscattering techniques and satellite images.

POINT 3 – FLOODING IN MOZAMBIQUE

Situation Overview.

At least 202 people have died following Cyclone Idai's landfall, according to the President of Mozambique, Filipe Nyusi, and the death toll is expected to rise in the days ahead. An estimated 260,000 children have reportedly been affected, according to UNICEF, and are in desperate conditions.



The situation is likely to deteriorate, and the number of people affected is likely to increase, as weather experts predict heavy rainfall in Sofala and Manica provinces from 19 to 21 March. Flood waters may rise up to around eight metres and at least 350,000 people are at risk, according to media reports quoting the President. There are also growing concerns regarding the potential effects of the overflow of the Marowanyati Dam in Zimbabwe on water levels in Mozambique.

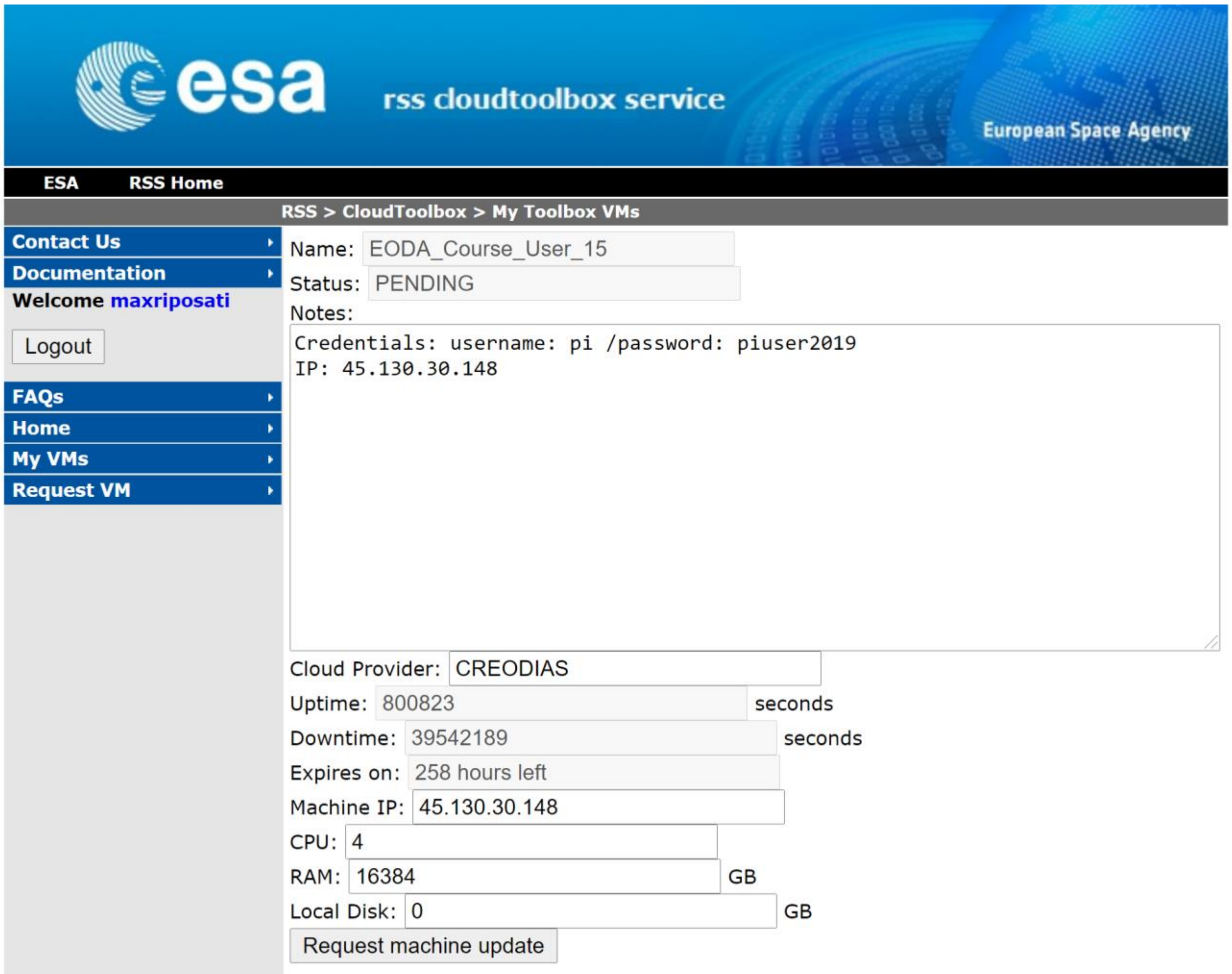
On 18 March, Government officials and representatives from the humanitarian community conducted an aerial survey of Buzi area – home to more than 200,000 people - after reports that the Buzi and Pungwe rivers had burst their banks. Thousands of people were reportedly marooned on rooftops and an aerial survey showed that more than 50 kilometers of land in Buzi town had been submerged. The immediate priority is search and rescue for people stranded and isolated by flood waters, with priority being given to trauma victims.

Main roads into and out of Beira remain cut due to flood waters and extensive damage to the road network. Meanwhile, the Beira Central Hospital remains only partially functional due to damage sustained during Cyclone Idai and other clinics in surrounding areas are also reportedly not functioning.

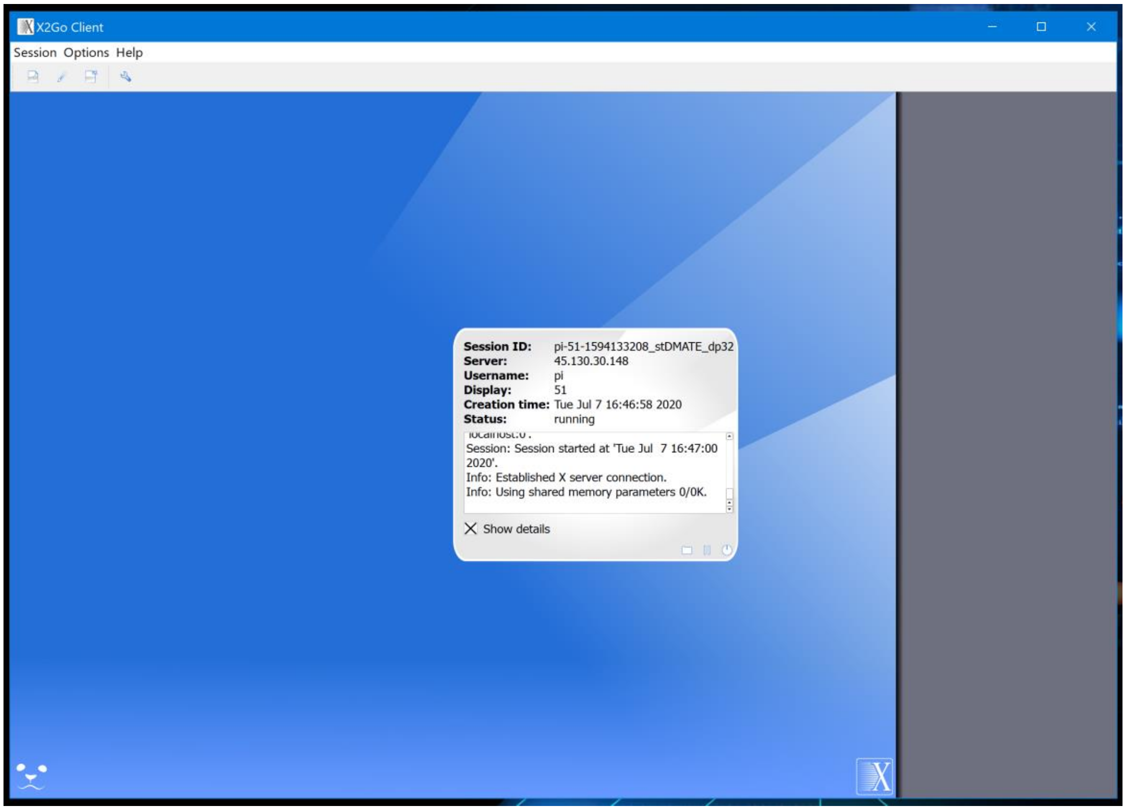
https://reliefweb.int/report/mozambique/mozambique-cyclone-idai-floods-flash-update-no-5-19-march-2019

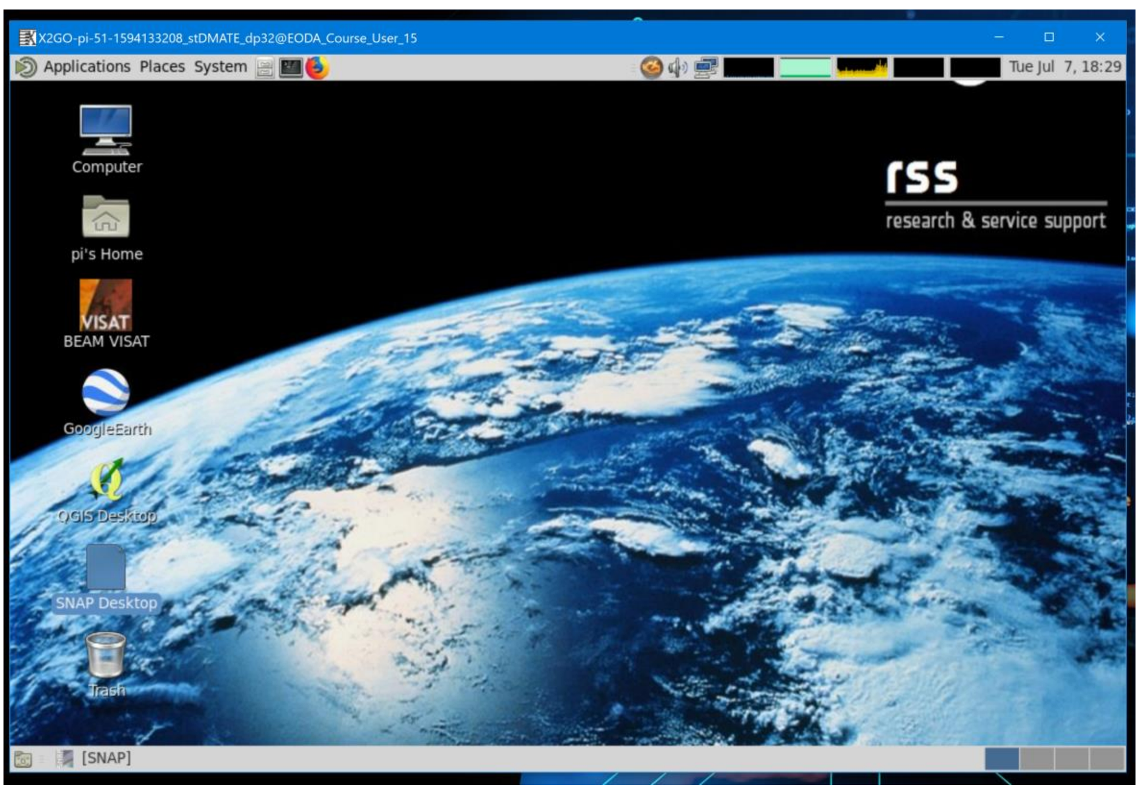
Procedure :

Start the virtual Machine from Toolbox page: http://eogrid.esrin.esa.int/cloudtoolbox/myvm.php

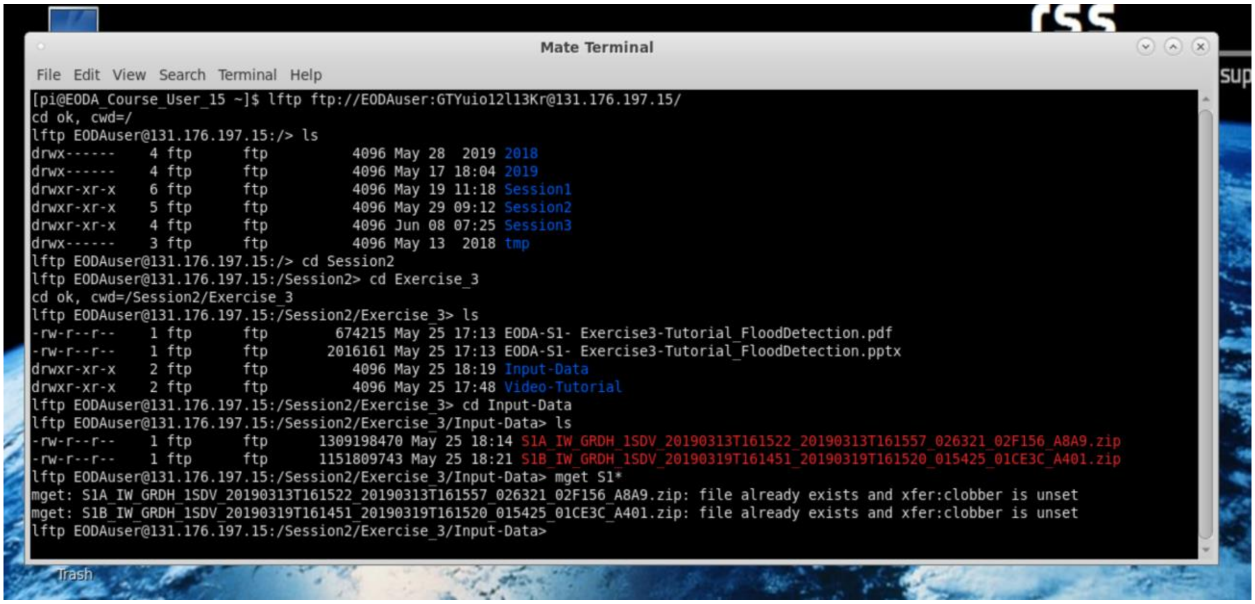


Log in into the virtual machine

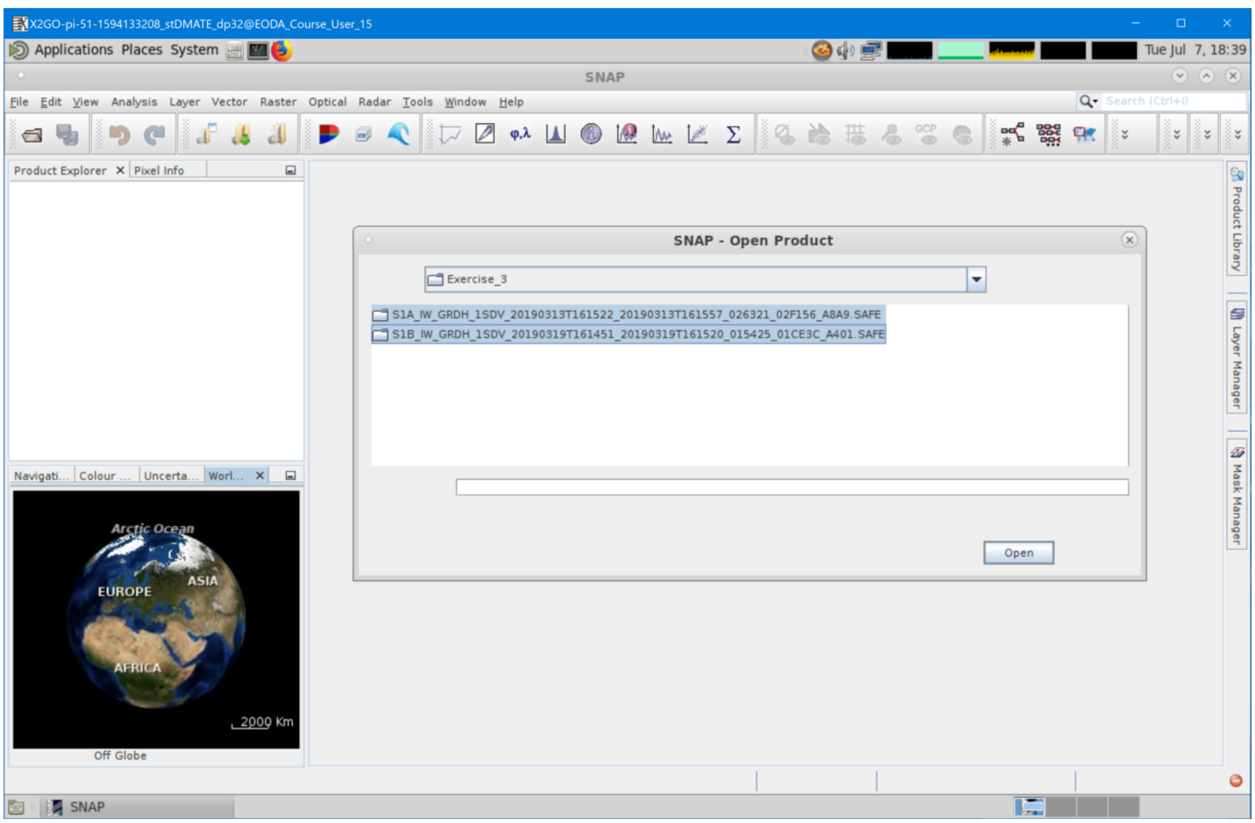


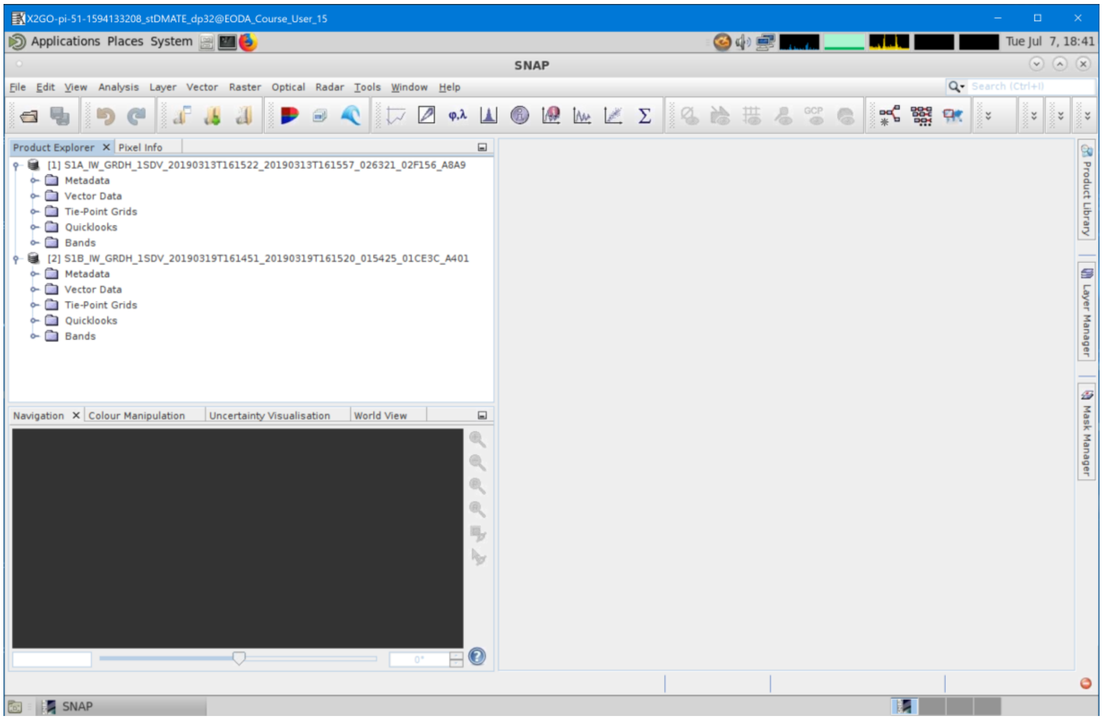


Use a Windows Terminal to Download the Images

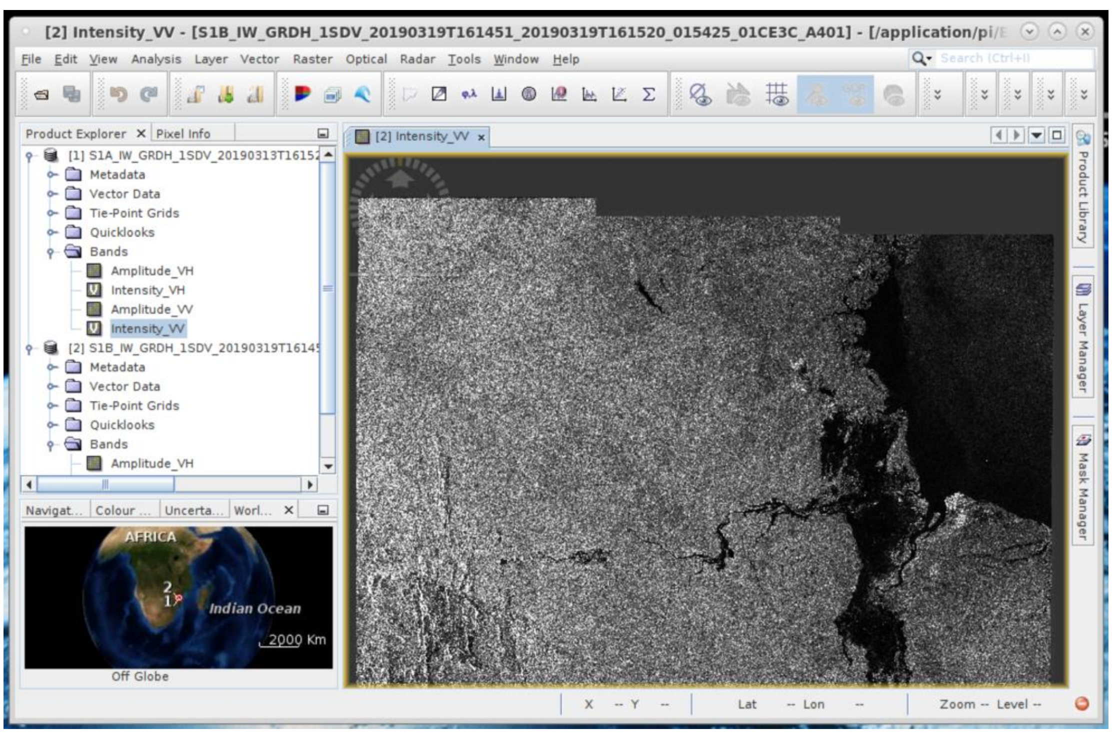


Now we use SNAP to open the downloaded files.

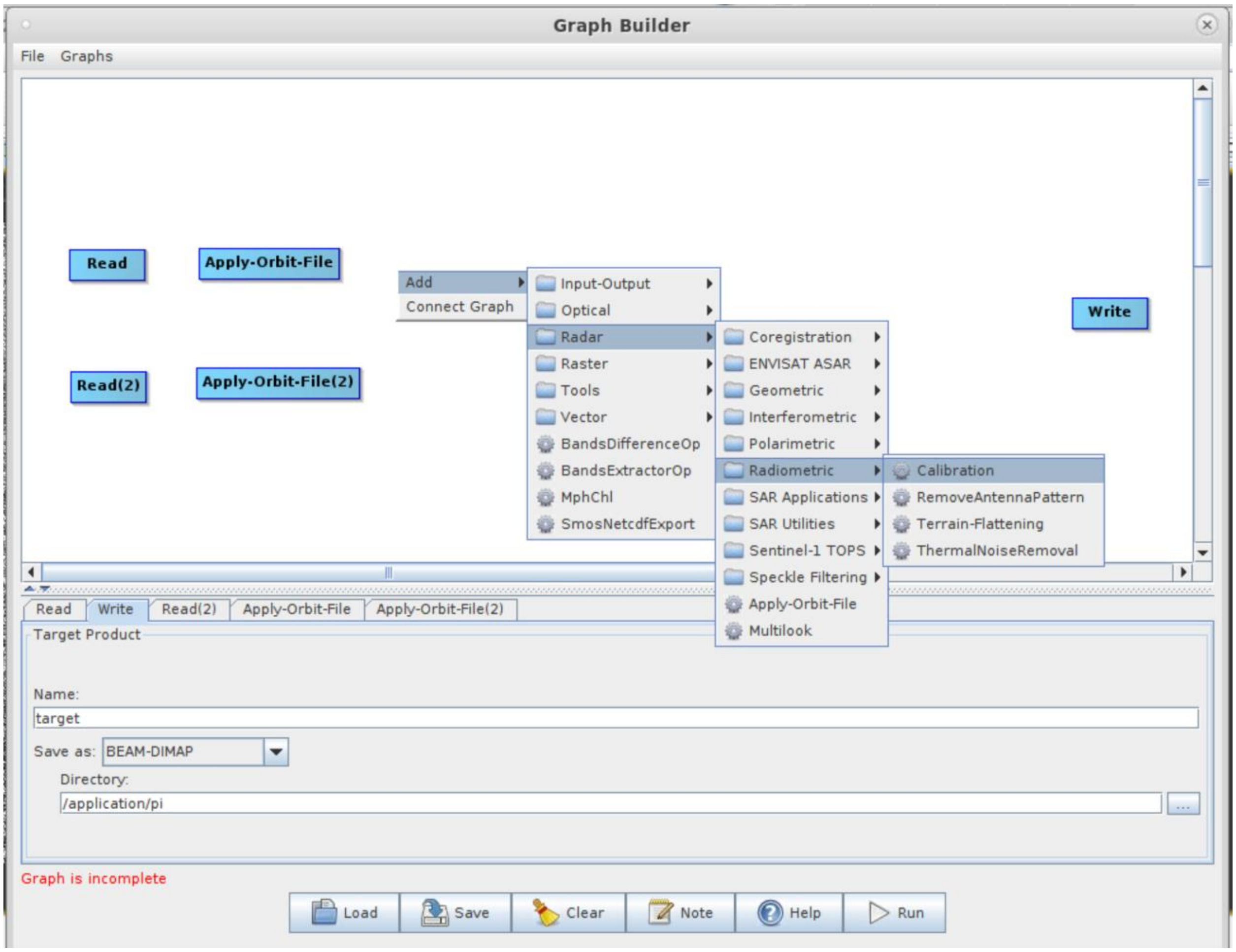




Visualize the Image



Let's now apply a processing chain creating a Batch Workflow with the Graph Builder GUI Tool. Adding and connecting one by one the parameters we will have the desired output.



Connecting and setting the parameters before Run the process.

Read: Read the input images (master and slave)

Apply Orbit File : This element provide accurate satellite position

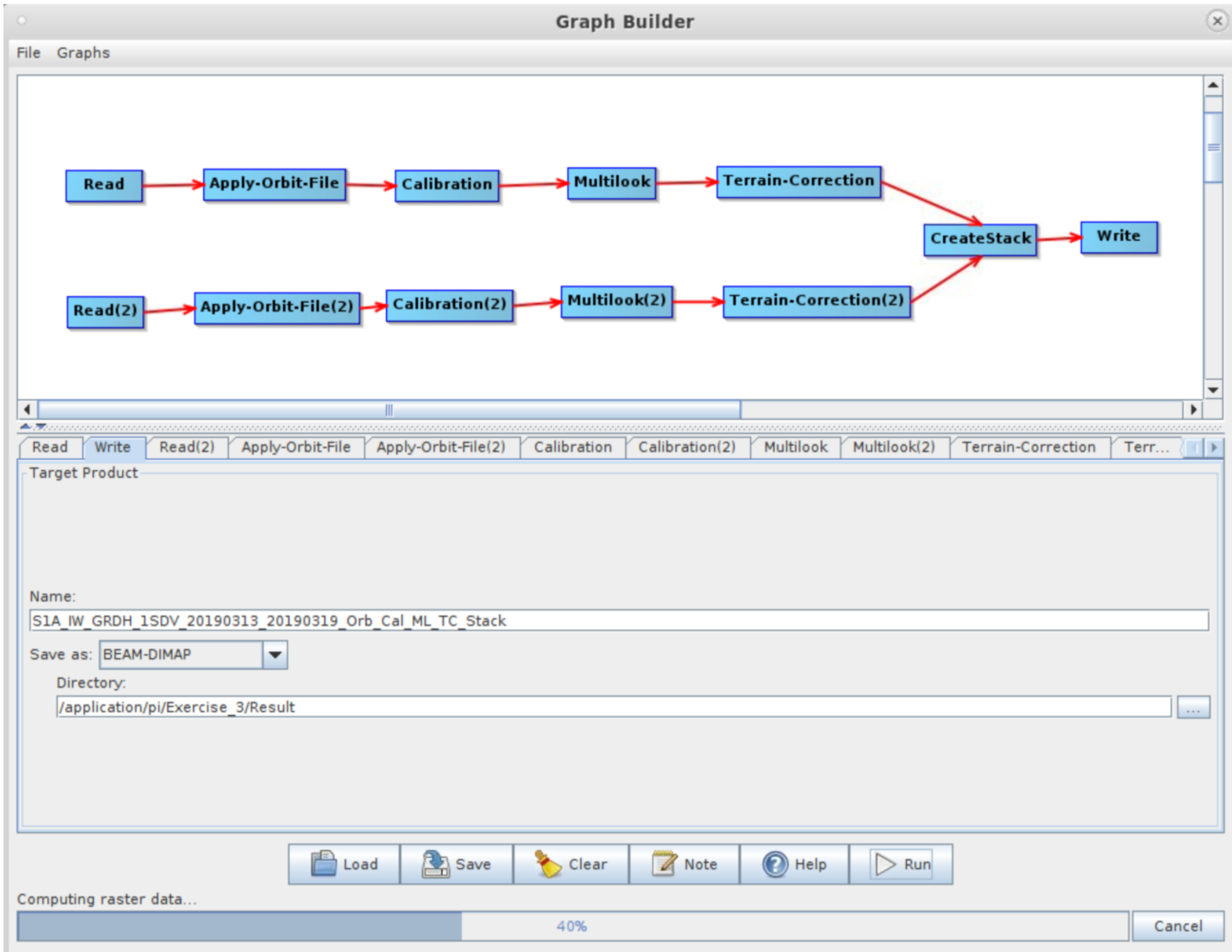
Calibration: This is essential to compare two images, we will go from digital numbers to a physical quantity which in this case is Sigma naught, which is the ratio instant to receive backscatter.

Multi Looking: in order to reduce the speckle, the dimension of the image and speed up the processing time.

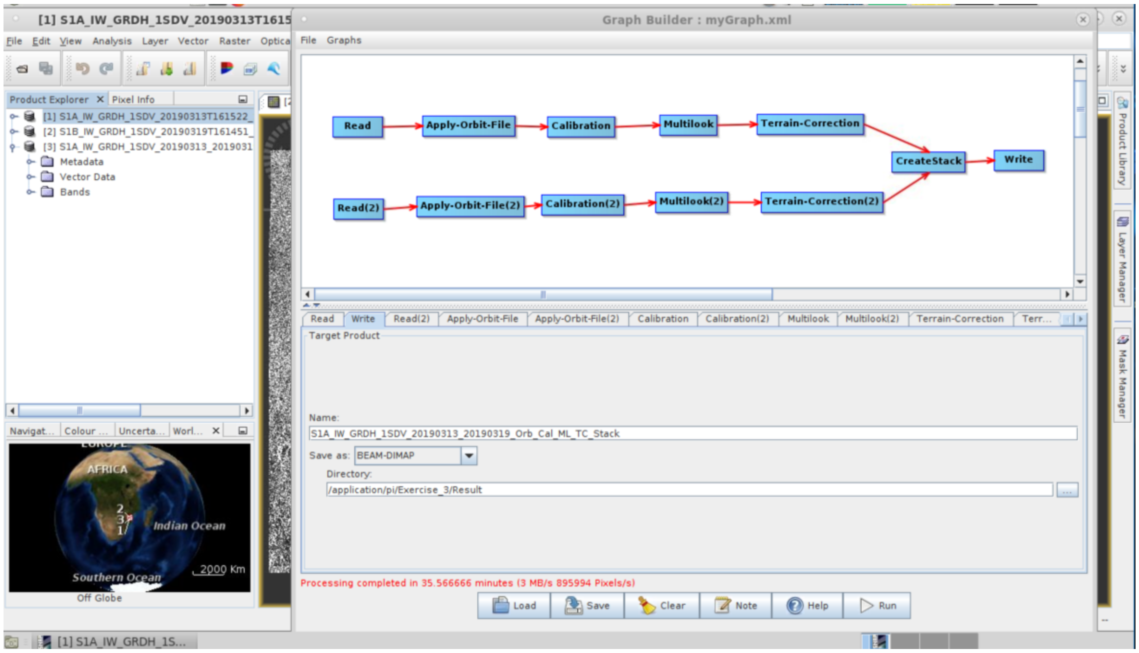
Correction: Then we will do a terrain correction to project the images onto a map system and also correct the distortion due to the terrain.

Create Stack: We will combine the images and create an RGB composite using its Product Geolocation information, in order to overlay one image onto the other, to distinguish between flooded areas and permanent water bodies

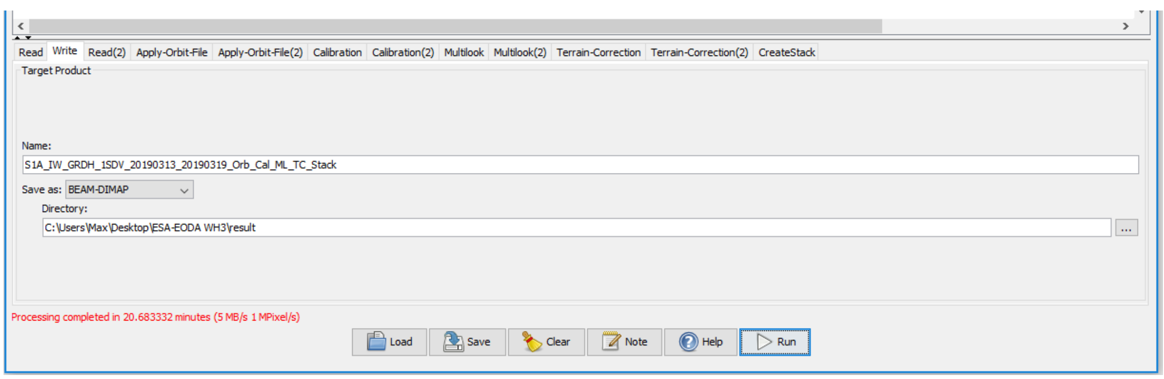
Write: Here we will save the image into our working directory.



Start Time: 19:00
Ending Time: 19:35
Elapsed Time: 35.56 min
Process Speed: 3 Mb/s
Pixels by Second: 895.994 Pixels/s



I repeat the same procedure on my laptop and the time was reduced significatively for that reason we will continue working locally instead on the Virtual Machine.
Elapsed Time: 20.05 min



XML FILE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  + <node id="Apply-Orbit-File(2)">
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  + <node id="Multilook(2)">
  + <node id="Terrain-Correction">
  + <node id="Terrain-Correction(2)">
  + <node id="CreateStack">
  + <node id="Write">
  + <applicationData id="Presentation">
  </graph>
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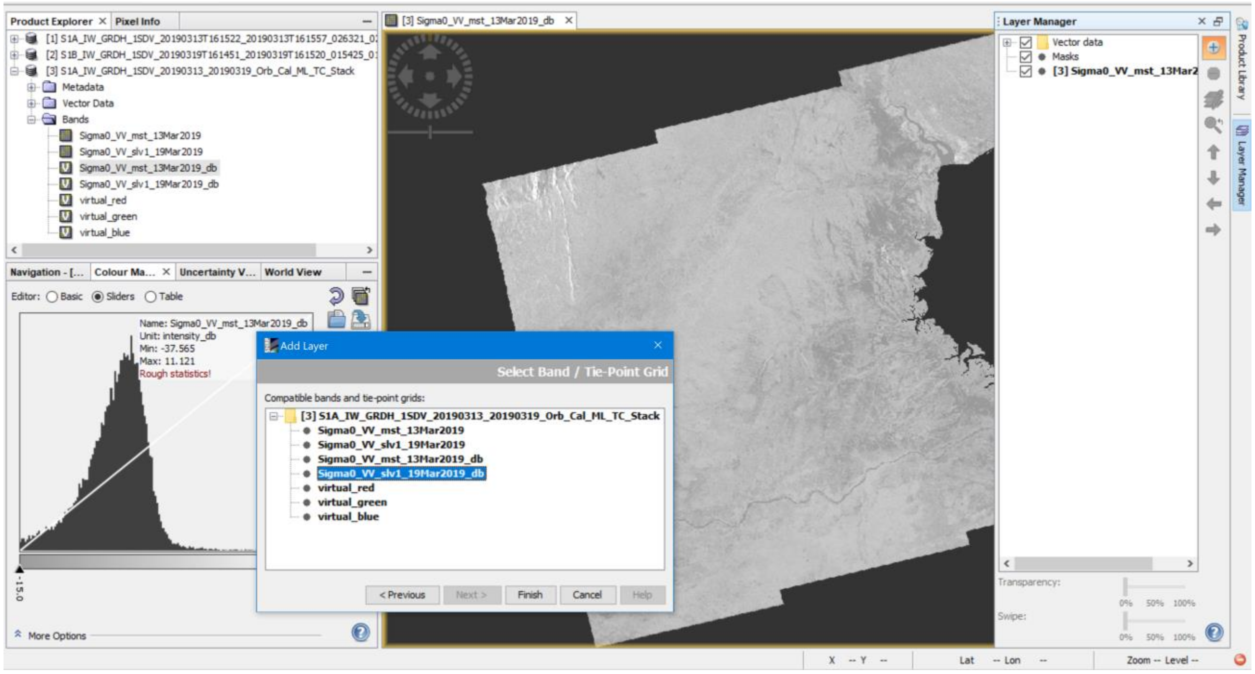
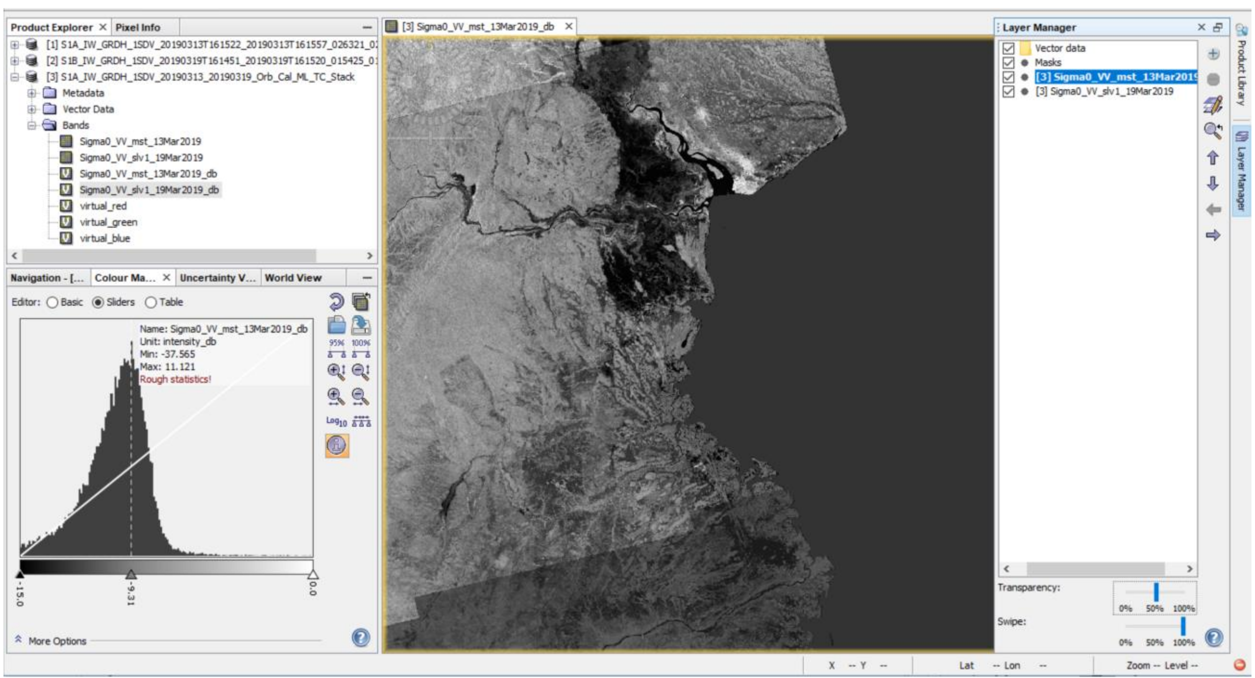
Let’s performs a change detection between the master and the slave image
First, we convert both images from linear to dB to have a much better visualization and also an histogram that is easier to manipulate.



Using the Layer Manager tool I will stack the Master and the Slave image in order to see the flooding process using the transparency tool



Next step it to apply a RGB combination formula to create a composite image.

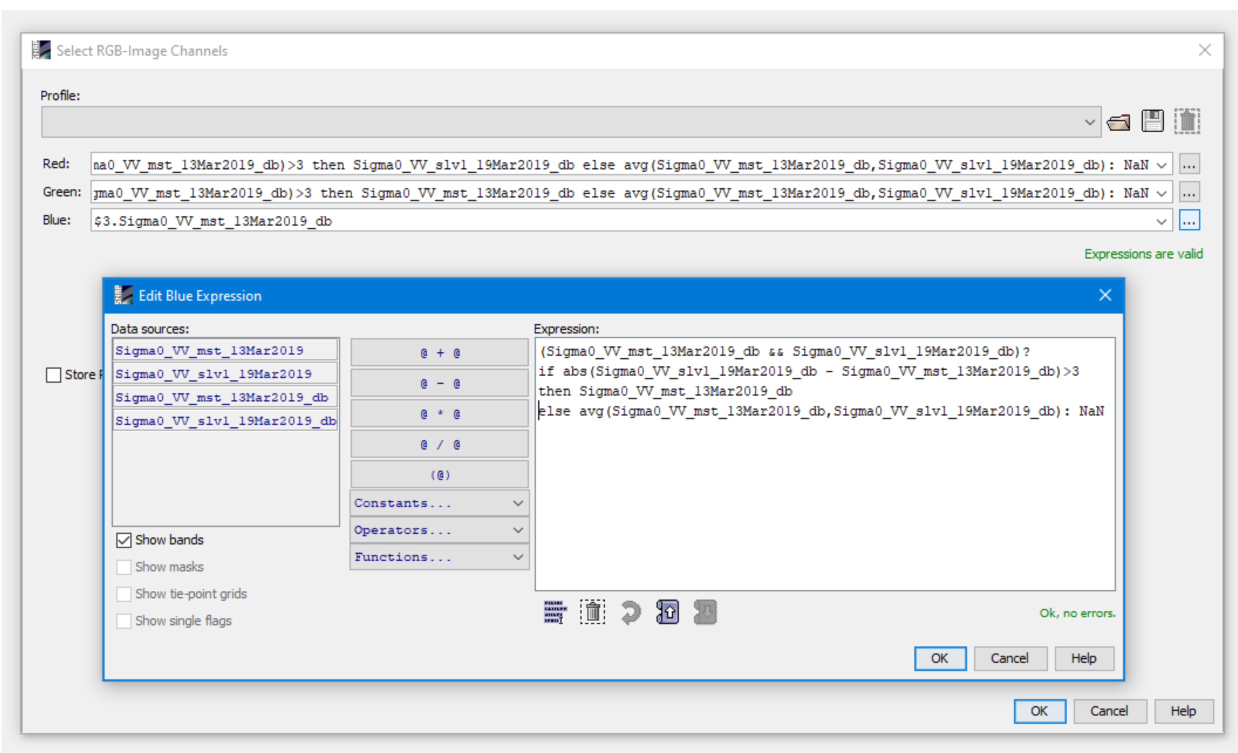
RGB combination formula to consider.

RED If (Sigma0 Slave – Sigma0 Master) > 3dB Then Sigma0 Slave Else average (Sigma0 Master, Sigma0 Slave)	The RED band contains the values of the Sigma0 Slave band only if the differences in absolute value with the master are higher than 3 dB, otherwise its value is an average between the two

GREEN If (Sigma0 Slave – Sigma0 Master) > 3dB Then Sigma0 Master Else average (Sigma0 Master, Sigma0 Slave)	The GREEN band contains the value of the Sigma0 Master band only if the differences in absolute value with the slave is higher than 3 dB, otherwise its value is an average between the two.

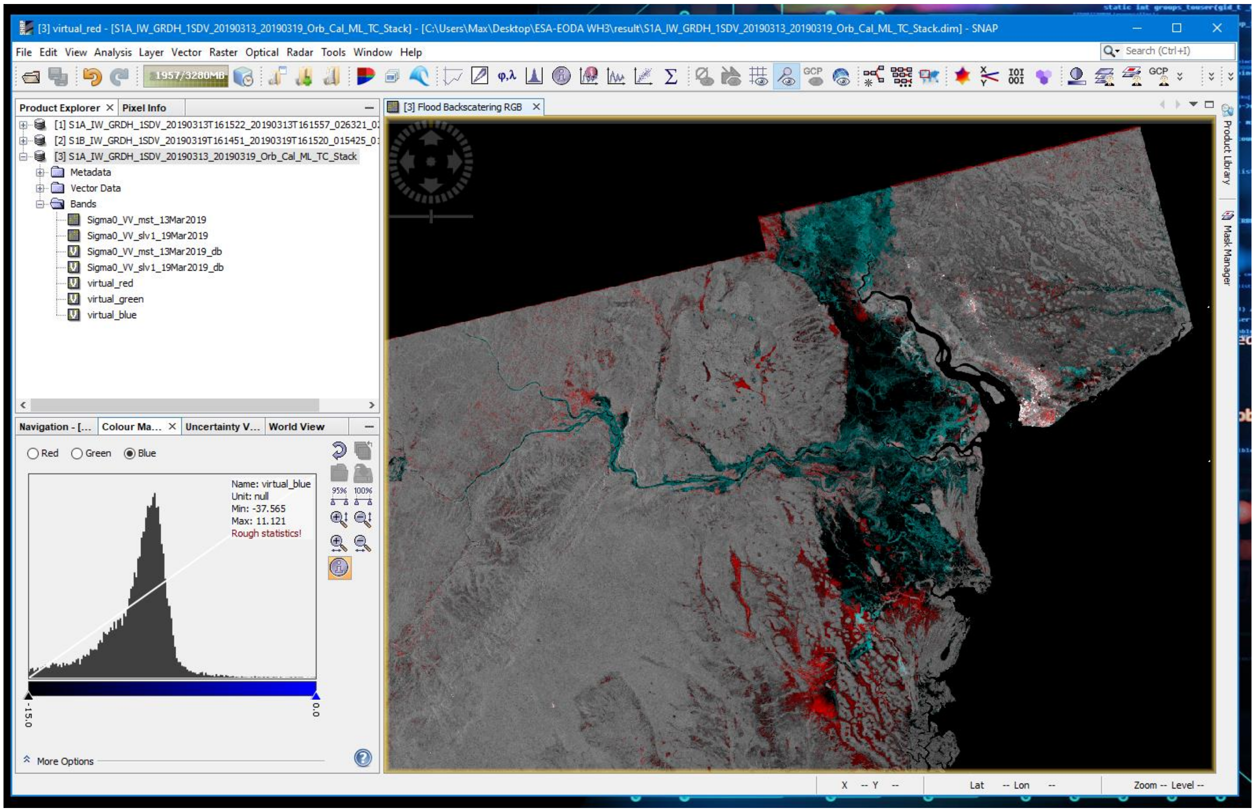
BLUE If (Sigma0 Slave – Sigma0 Master) > 3dB Then Sigma0 Master Else average (Sigma0 Master, Sigma0 Slave)	The BLUE band contains the value of the Sigma0 Master band only if the differences in absolute value with the slave is higher than 3 dB, otherwise its value is an average between the two.

The choice to set a threshold of 3 dB is justified by the need to avoid minor differences of the backscatter values.



In the red channel we will have over the flooded areas a high radar response, because this areas will be land in the archive image we do not expect to see flooded areas and therefore we will have a high backscatter return.
In the flooded areas we will have a low backscatter return in the slave image

Final Result:



Interpretation

We can see in the image basically 4 different colors:
the flooded areas, representing in cyan color, where the differences between the two images is higher.
the white areas where the backscattering is very Hight representing urban areas
Zones in Black Grey and red zones are the part that remain without any backscattering variation.