EARTH OBSERVATION DATA ANALYSIS

Surface Detection from SAR Sentinel-1 data

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Contents

1 Introduction

Objective: Explore Sentinel-1 SAR data for estimating vegetation cover, inland water, chlorophyll-a sea concentration and supervised classification within a region of interested (ROI) [2] [1] . Details of the image are reported in the

1.1 Data Exploration and Subswath

Before starting to analyze the images we have to perform a visual quality check to assure there aren't errors in the bands that we will use.
Band IW2 VV 2:

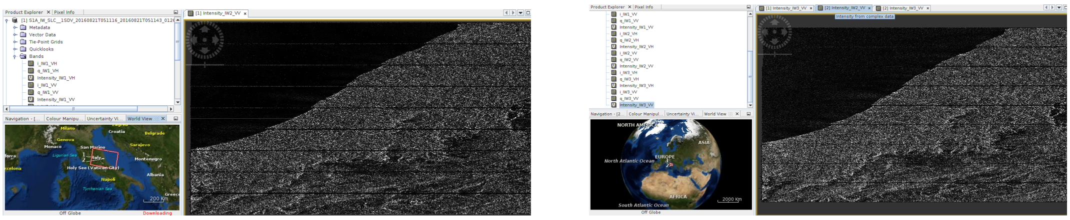


Figure 1: Left: before earthquake (master), Right: after earthquake (slave)

and the same for the band IW3 VV:

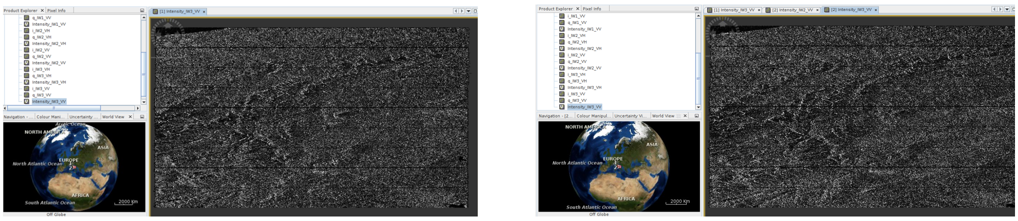
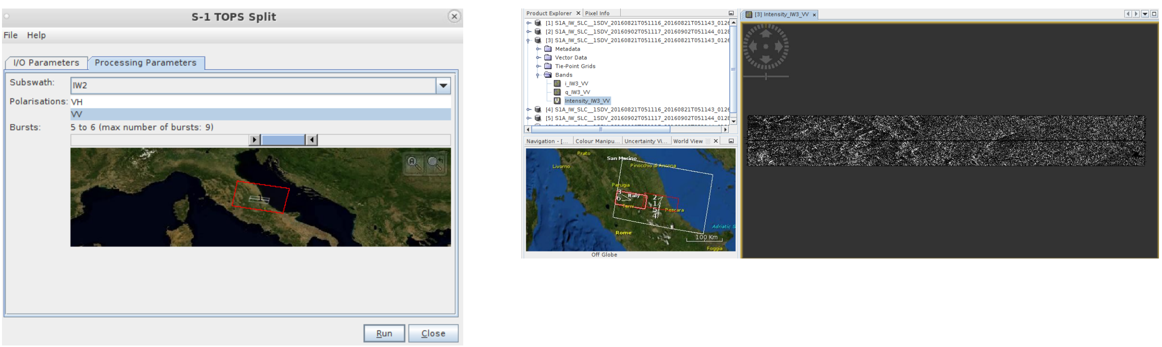


Figure 2: Left: before earthquake (master), Right: after earthquake (slave)

To speed up the computation we focus on the area in which the earthquake struck and, with a subswath, we can isolate and analyze it. We will use the *S1 top Split* tool with VV polarization to obtain a better accuracy for the IW2 and IW3 bands. The splitting process is reported here in figures 3

Figure 3: Splitting operation



1.2 Data Analysis

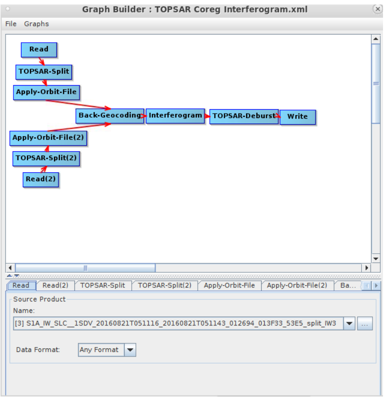


Figure 4: TOPSAR Coreg Interferogram.

With the splitted image we can start the data analysis using the *Graph Builder* tool, that allow us to build a workflow for a faster and replicable analysis. We can use a preset graph as base, for example the TOPSAR Coreg Interferogram, reported in fig. 4.

This operation performs a coregistration between master and slave, but we have to remove the part we have already done (TopSar split) and add the *Enhanced Spectral diversity* step. This lead us to the final workflow defined in fig. 5

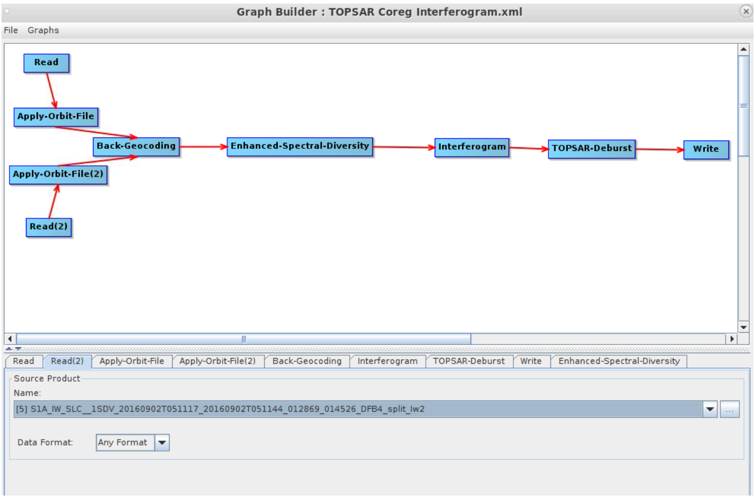
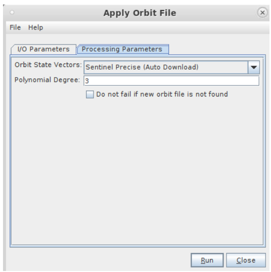
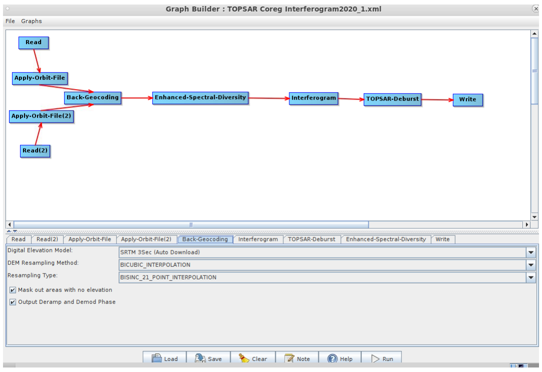
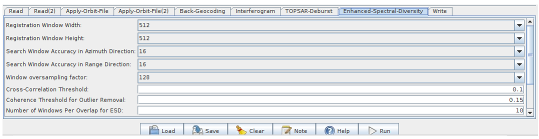


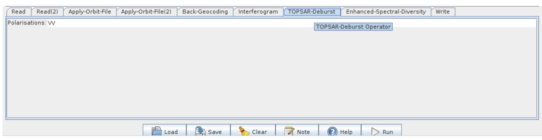
Figure 5: Workflow

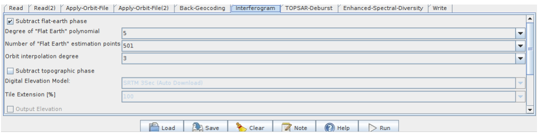
We are now able to configure the workflow, sending the master and slave file as input, changing the resampling method from *Bicubic Interpolation* and *bisinc 21 point* in order to preserve the phase, subtract the flat earth phase. The *Enhanced Spectral diversity* is needed to remove phase jumps between adjacent burst in the overlapping regions. Again we report step by step the workflow.











After we ran it we can finally check the product output (see fig. 6). In the coherence output, we can see certain area with lower values (the black part). The coherence is a cross-correlation coefficient computed between master and slave acquisition, it provides information about quality e similarity.

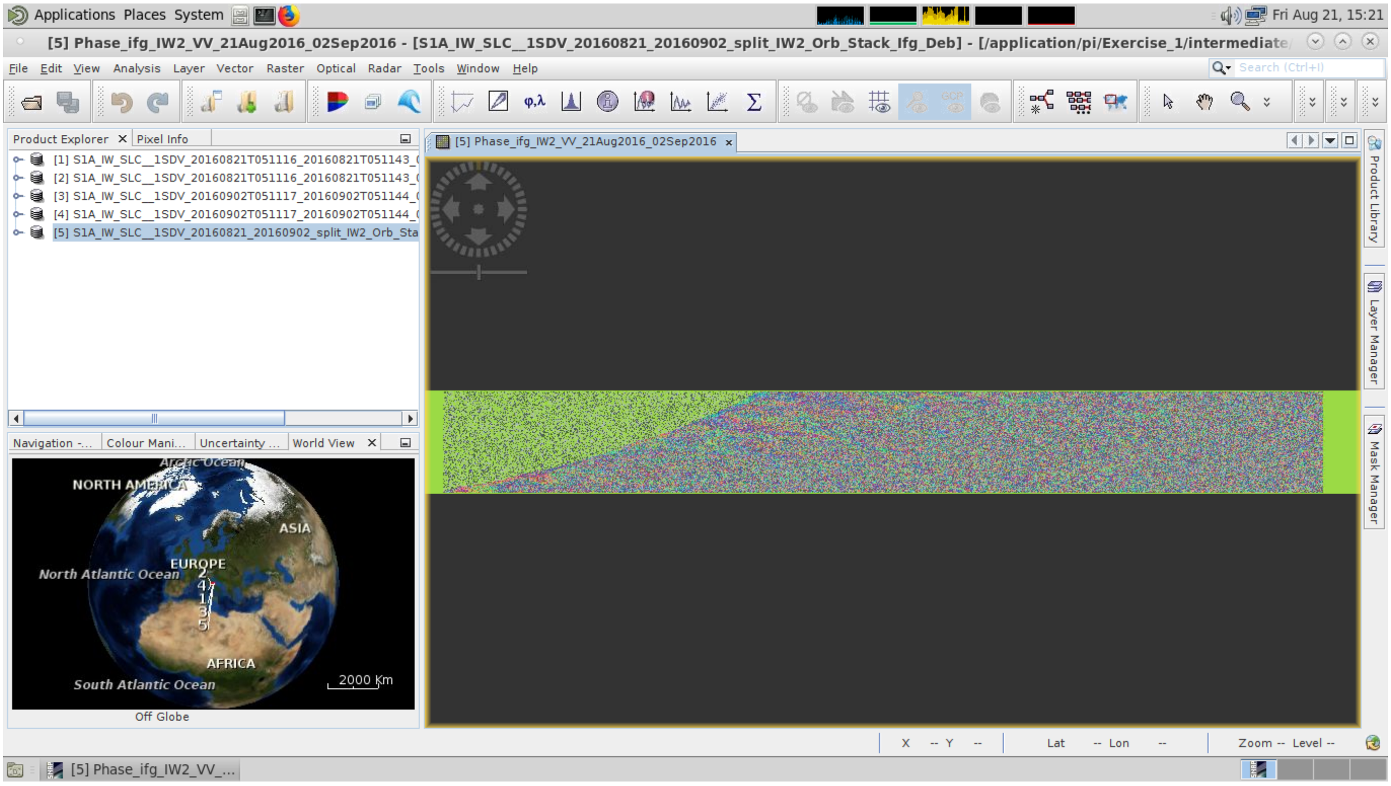


Figure 6: Analyzed Picture

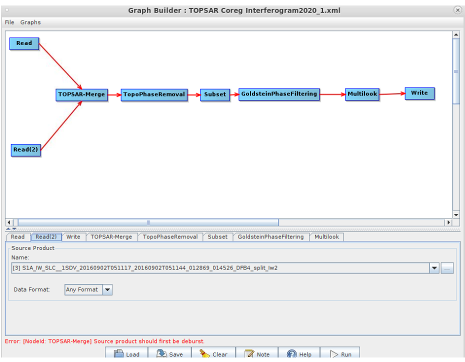


Figure 7: ????

Now we can merge the two products : master and slave analyzed. By doing this, the noise will be eliminated.The operation needed are: TOPSAR-Merge, TopoPhaseRemoval, Subset, GoldsteinPhaseFiltering and Multilook.

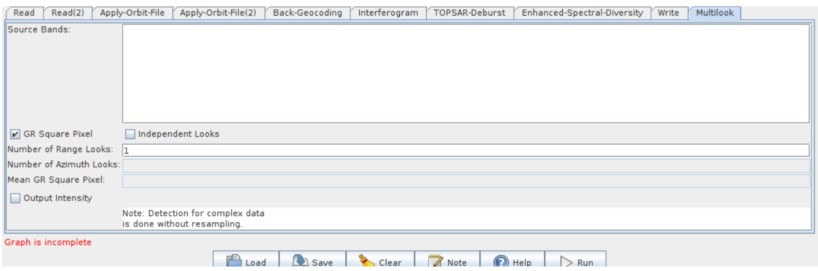


Figure 8: multilook

Opening the generated product (fig. 9) we can see the fringes, a phase cycle, each of it corresponds to a relative displacement of around an half of the wavelength, in our case is 2.8 cm almost.

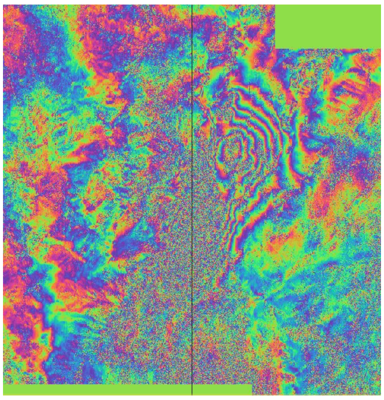


Figure 9: Fringes

The green part of no data is due to the fact that the two bursts we merged were superimposed. We than can subset our product to eliminate those part.

1.3 Snaphu

Now that we have a clean product, we can apply the phase unwrapping, converting phase unit in *cm* unit. The operator we will use is Snaphu. Snaphu is a program outside snap that we can call from the terminal. It gives us back an image. We then have to import back the product in snap (fig. 10).

1.4 Final product elaboration

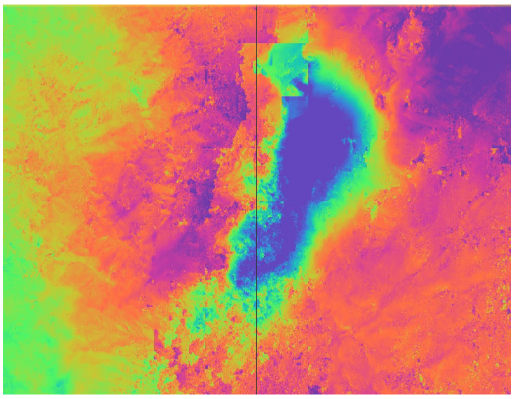


Figure 10: Snaphu Elaboration

We are still in the phase domain. To pass in a displacement map we have to use the tool *Phase to displacement*. Resulting in fig. 11

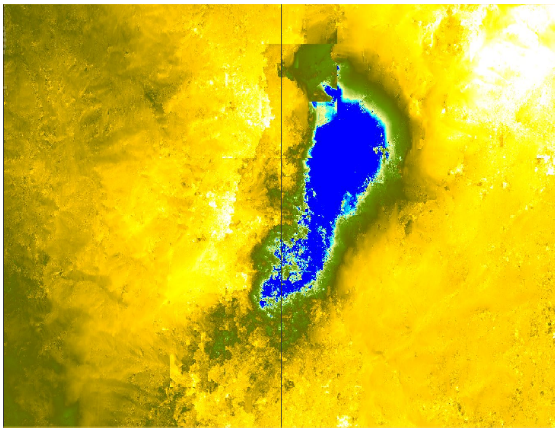


Figure 11: Map

We are still in the radar geometry, but we want to have our displacement map terrain corrected, we want square pixel on the ground that correspond to the ground. There is a terrain correction tool, that we will run. The final product is showed in figure 12

We can then manipulate the colour of our product, to better appreciate our result.We can see in the red area a negative displacement of the terrain, meaning a lowering of the terrain. While the blue area means an uplift of it. The little blue area in the bottom probably is due to a loss of coherence. This

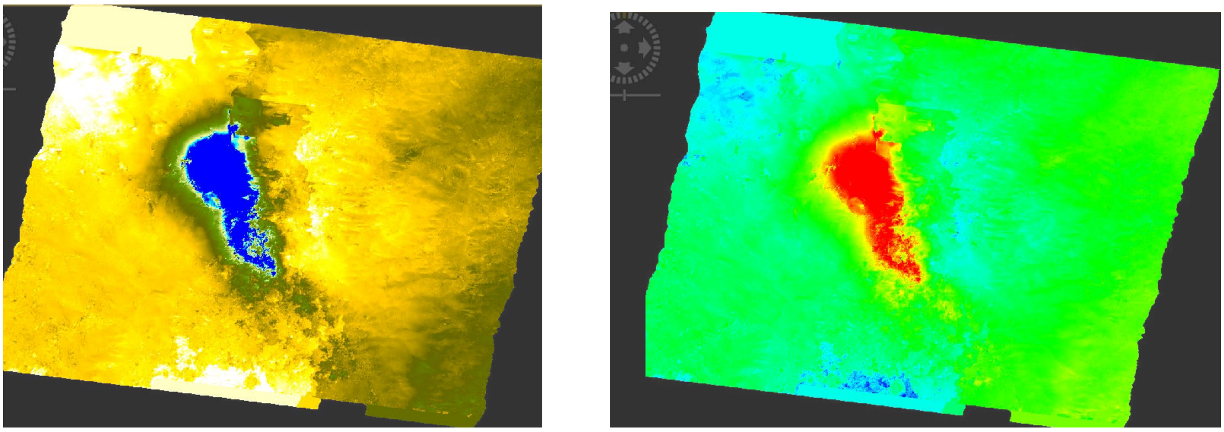


Figure 12: Terrain Corrected (left), terrain colored (right)

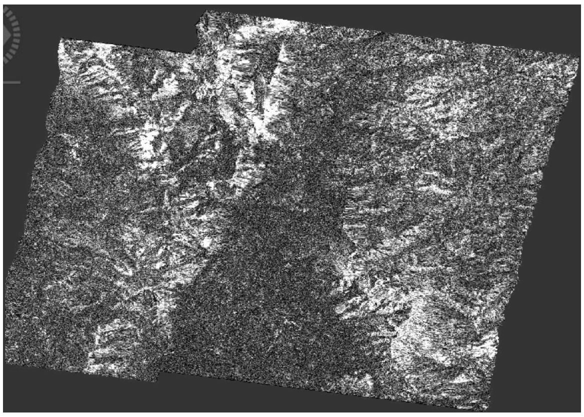


Figure 13: Coherence

can be seen in the coherence image (once we use the terrain correction tool), the darkest part of the black area is in correspondence of the blue area in the other image.

We can show this map on google earth.

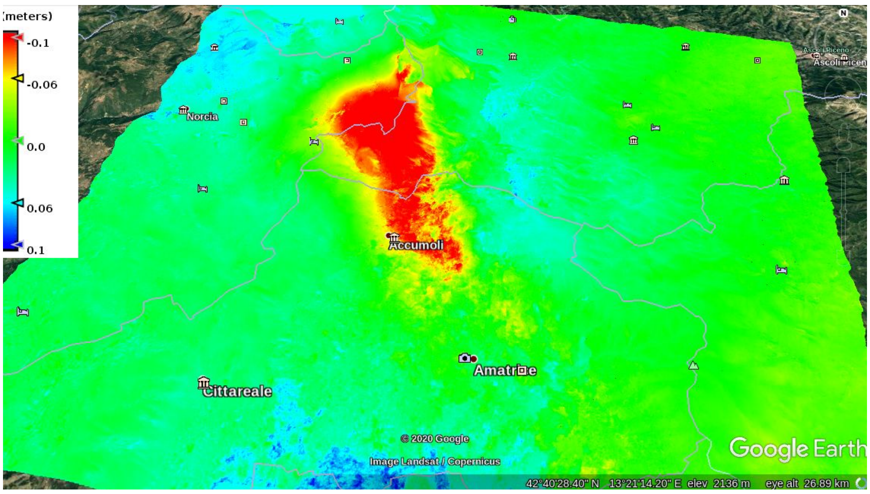


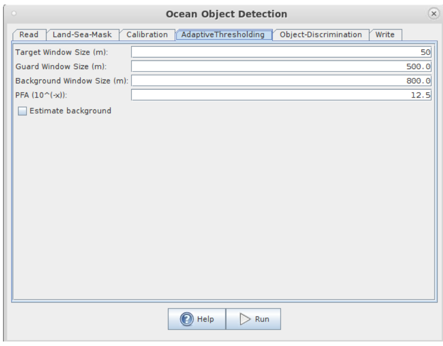
Figure 14: Google Earth superimposition

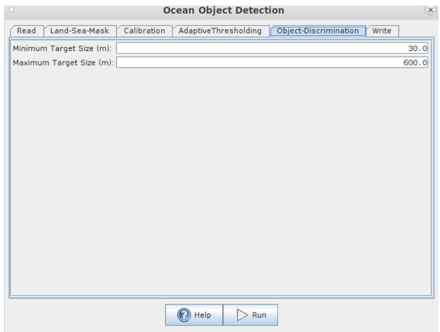
2 Ship Detection by Sar Backscattering

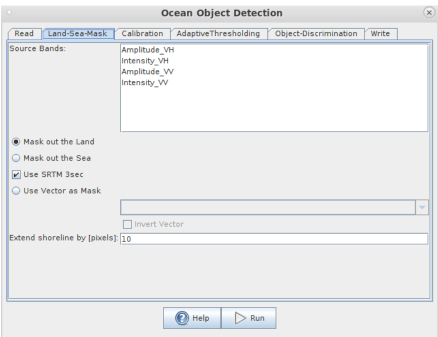
The first operation is to visually check the product and subset the image on the area of interest.

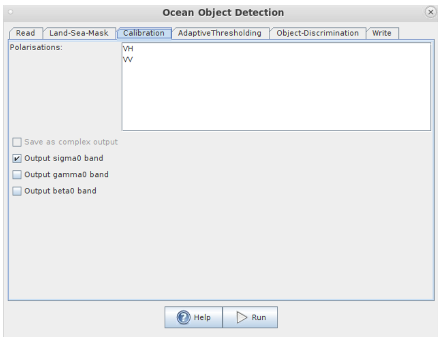
2.1 Detection

Now we run the *apply* orbit file tool, and then the ocean object detection. The adaptive thresholding is the very core of the ocean object detection algorithm. This filter define a guard window that is the maximum dimension of the target, plus a certain tolerance. There's also a background window. The algorithm calculate the difference deviation between this two windows. If this is high enough, what's inside the target windows is a candidate to be our target object. The object-discrimination will scan all the pixel selected by the adaptive thresholding and detect all the object that satisfy its parameter.









2.2 Analysis

We can highlight the object changing the colour in the final product to better see them. (fig 15).

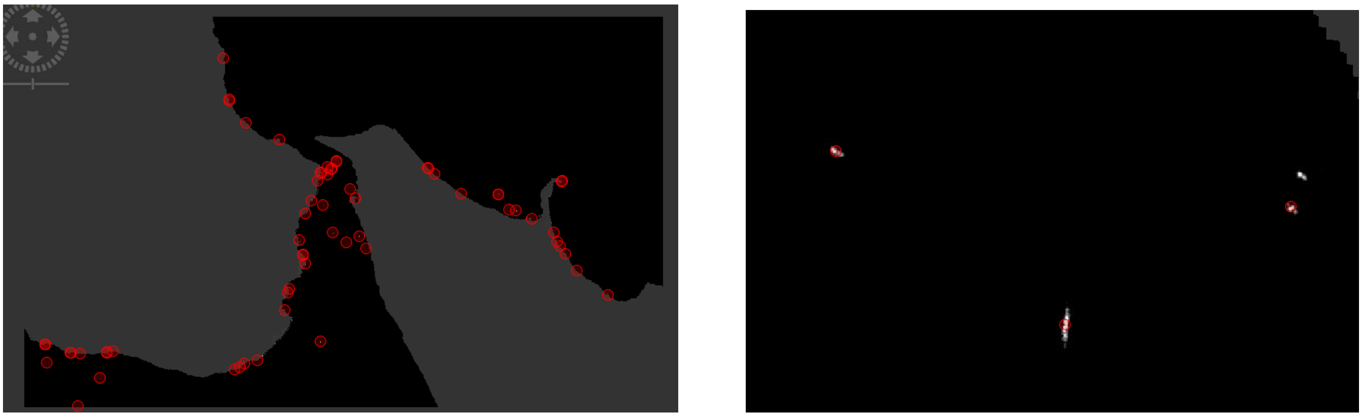


Figure 15: Ship highlighted

Finally we can see the object we found by opening in the directory VectorData the file ShipDetections

ShipDetections	geometry	Detected_x	Detected_y	Detected_lat	Detected_lon	Detected_width	Detected_length	style_css
target_000	POINT (29...	2988	626	38.353	15.833	30	40	fill: #ff000...
target_001	POINT (30...	3070	1246	38.299	15.81	80	70	fill: #ff000...
target_002	POINT (30...	3072	1268	38.297	15.809	70	40	fill: #ff000...
target_003	POINT (33...	3324	1590	38.272	15.774	70	40	fill: #ff000...
target_004	POINT (38...	3828	1850	38.257	15.711	190	230	fill: #ff000...
target_005	POINT (48...	4888	2590	38.208	15.576	130	80	fill: #ff000...
target_006	POINT (46...	4683	2161	38.243	15.608	160	200	fill: #ff000...
target_007	POINT (46...	4685	2177	38.241	15.608	40	50	fill: #ff000...
target_008	POINT (45...	4552	2256	38.232	15.621	90	100	fill: #ff000...
target_009	POINT (46...	4608	2297	38.229	15.614	280	280	fill: #ff000...
target_010	POINT (46...	4618	2285	38.231	15.613	90	40	fill: #ff000...
target_011	POINT (44...	4448	2338	38.223	15.631	80	80	fill: #ff000...
target_012	POINT (44...	4455	2349	38.222	15.63	80	80	fill: #ff000...
target_013	POINT (45...	4546	2371	38.222	15.619	140	140	fill: #ff000...
target_014	POINT (44...	4402	2464	38.211	15.633	40	30	fill: #ff000...
target_015	POINT (60...	6054	2267	38.256	15.452	80	70	fill: #ff000...
target_016	POINT (60...	6059	2276	38.255	15.451	70	70	fill: #ff000...
target_017	POINT (61...	6156	2364	38.249	15.438	20	40	fill: #ff000...
target_018	POINT (80...	8069	2461	38.271	15.221	50	30	fill: #ff000...
target_019	POINT (80...	8060	2471	38.27	15.222	120	200	fill: #ff000...
target_020	POINT (65...	6555	2655	38.229	15.387	60	30	fill: #ff000...
target_021	POINT (71...	7110	2663	38.237	15.324	200	120	fill: #ff000...
target_022	POINT (42...	4211	2955	38.164	15.644	110	90	fill: #ff000...
target_023	POINT (43...	4307	2757	38.183	15.637	60	60	fill: #ff000...
target_024	POINT (44...	4482	2832	38.179	15.616	100	200	fill: #ff000...
target_025	POINT (49...	4973	2727	38.197	15.563	80	50	fill: #ff000...
target_026	POINT (71...	7108	2669	38.236	15.325	250	230	fill: #ff000...
target_027	POINT (72...	7278	2894	38.219	15.301	150	180	fill: #ff000...
target_028	POINT (73...	7381	2911	38.219	15.289	110	250	fill: #ff000...
target_029	POINT (76...	7614	3038	38.211	15.26	90	260	fill: #ff000...
target_030	POINT (41...	4130	3356	38.126	15.645	90	130	fill: #ff000...
target_031	POINT (41...	4178	3574	38.107	15.634	80	70	fill: #ff000...
target_032	POINT (41...	4181	3581	38.107	15.634	40	30	fill: #ff000...
target_033	POINT (42...	4211	3710	38.096	15.628	80	90	fill: #ff000...

Figure 16: all the ship we found

3 Flood Detection by Sar Backscattering

3.1 Image check

As usually, first we check the image visually. We can see a clear difference between the two images 17. In the post event image, the dark part is likely to be the flood and the darker one correspond to a very low base cutter. This happens because in presence of water the specular reflection of the signal is facilitated, so a very small part is scattered back to the sensor. Instead, in the pre event image the area isn't much dark.

3.2 Graph builder and colouring

To analyze this area we will use the graph in figure 18

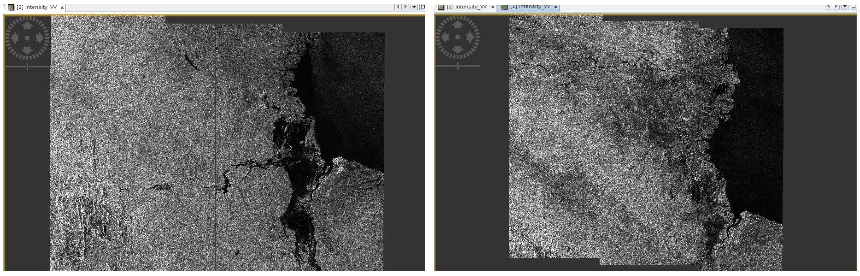


Figure 17: Post (left) and Pre (right) event

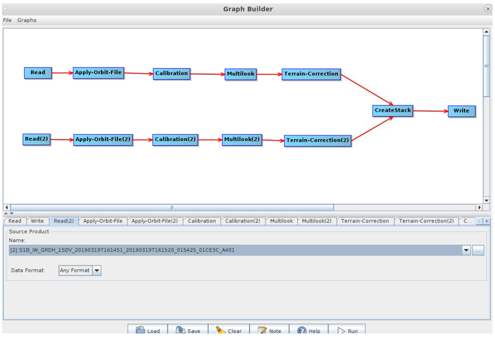


Figure 18: Graph Builder workflow

Changing the multilook parameter (Number of Range Looks), we can change the ground range square pixel around 90 m. It is useful because that correspond to the digital elevation model resolution. Even if we lose resolution in average of pixel spacing, the increase of multilooking can be used as a sort of filtering of the image, and that is helpful for performing the change detection.

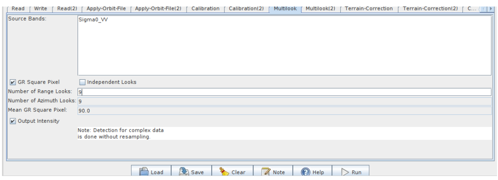


Figure 19: Multilook Configuration

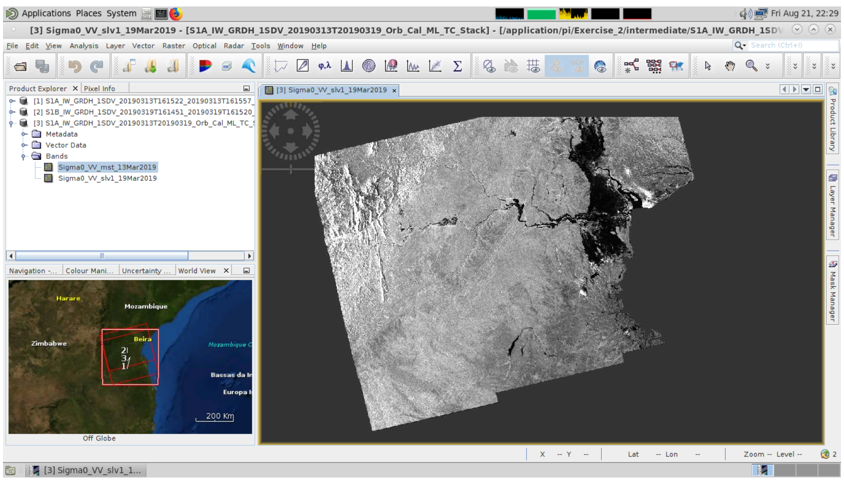


Figure 20: Monzambique Product

Now we will change the bands from linear to DBs. ???Then want to perform a change detection between master and slave acquisition. In the pre-event we're suppose to not see the flood, which is clearly visible in the post event. So we know that the back-scatter of the signal is significantly reduced because of the presence of the water (due to water specular reflection). So the signal is very feeble. We can use this knowledge and perform a change detection by combining the two bands and checking the difference, creating an RGB composite by combining the value of the two bands.
RED : contains the values of the signma0 slave band only if the differences in absolute value with the master are is higher than 3 dB, otherwise its value is an average between the two see fig. 21 GREEN,

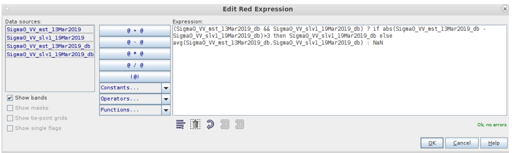


Figure 21: Red

BLUE : they contain the values of the sigma0 master band only if the differences in absolute value with the slave are higher than 3 dB, otherwise its value it's an average between the two of them. (see fig.22

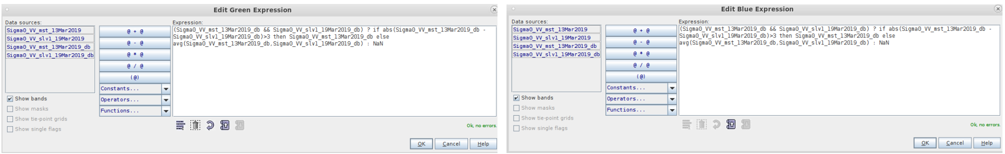


Figure 22: Green-Blue

By doing so we will discard all the possible minor differences between the acquisition, while considering only the ones with higher density. Applying this RGB channeling, the red pixel will be the one for which the back-scatter of the post-event is higher than 3dB than the back-scatter of the master. This shouldn't happen, because the excess of water (the remaining of the flood) should decrease the average signal dB of the slave. Instead the cyan pixel (green mixed blue) should apply to our case, due to the total absence of the red color.

3.3 Image Analysis

Now we have to set a common scale for all RGB bands. because we are comparing the back-scattering values of different products, that should respond to different bands in our RGB output. We can do that in the colour manipulation tool and manually set the values that we want.

In case we don't have an uniform scale for the channels, we could encounter the problem that maybe we're highlighting some difference that are not actually present.

As we can see in fig.23, there are some red areas. This means that the post-event acquisition back-scattering is higher than the previous, and that should not be related to the flood. While for the cyan zones we have the condition that the post-event acquisition is quite less than the pre-event acquisition, because to the flood.

So this is a way to visualize and qualitatively estimate the flooded part over an image. The other part, black, grey and white, are the part where the back-scattering of master and slave are kind of equal. We are forcing so by the threshold of 3 dB and doing the average between master and slave. The black area represents the zone where the master and slave back-scattering acquisitions are already very low,

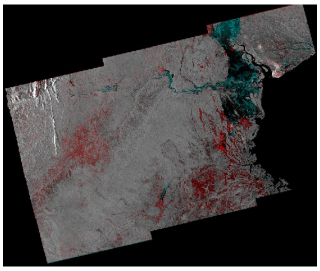


Figure 23: Coloured image

this should mean that these areas were already water. While the white area should stands to urban areas, where the back-scattering of acquisition of master and slave are high.

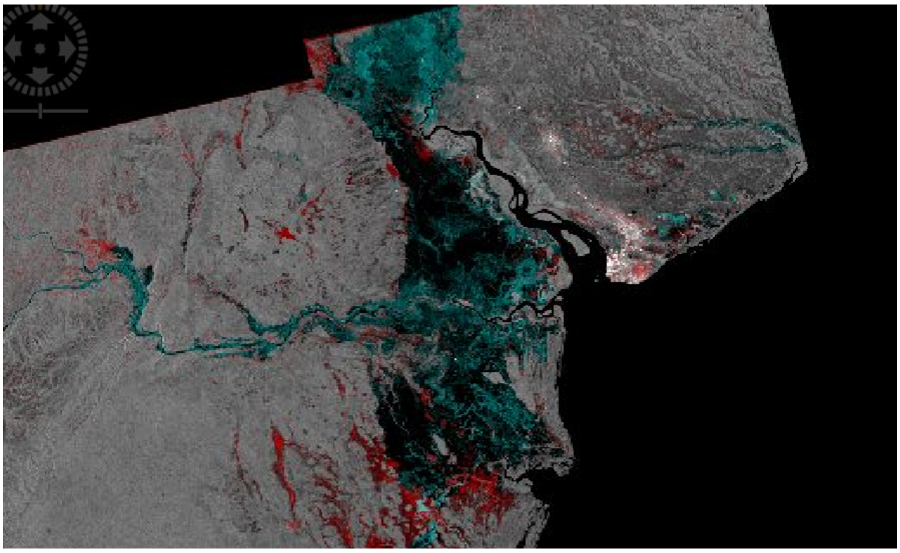


Figure 24: final product

References

[1] P. Bazzoffi, R. Francaviglia, U. Neri, R. Napoli, A. Marchetti, M. Falcucci, B. Pennelli, G. Simonetti, A. Barchetti, M. Migliore, et al. Environmental effectiveness of gaec cross-compliance standard 1.1 a (temporary ditches) and 1.2 g (permanent grass cover of set-aside) in reducing soil erosion and economic evaluation of the competitiveness gap for farmers. *Italian Journal of Agronomy*.

[2] A. Ferretti, A. Monti-Guarnieri, C. Prati, F. Rocca, and D. Massonet. Insar principles-guidelines for sar interferometry processing and interpretation, tm-19. *The Netherlands: ESA Publications*, 2007.