Earth Observation Data Analysis: Homework #1

Due on Monday, April 10, 2016

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Contents

1. 2. Install SNAP and download a MODIS image over Italy

- Download the MODIS file

First of all we download the MODIS file from the NASA site: https://ladsweb.nascom.nasa.gov/search/
The product name is "MYD021KM", the platform "Aqua", Processing Level "Level-1B", Temporal Resolution "5 minute", Spatial Resolution "1km".

The file contains calibrated and geolocated at-aperture radiances for 36 discrete bands located in the 0.4 m to 14.4 m region of the electromagentic spectrum. The resolution of channels 1 and 2 is 250 m, channels 3 through 7 are 500m resolution, and the rest are 1 km resolution. However, for the MODIS L1B 1 km product, the 250 m and 500 m band radiance data and their associated uncertainties have been aggregated to 1 km resolution.

We download an image of Italy of date 2016-08-15 (ferragosto) at time 12:20:00.

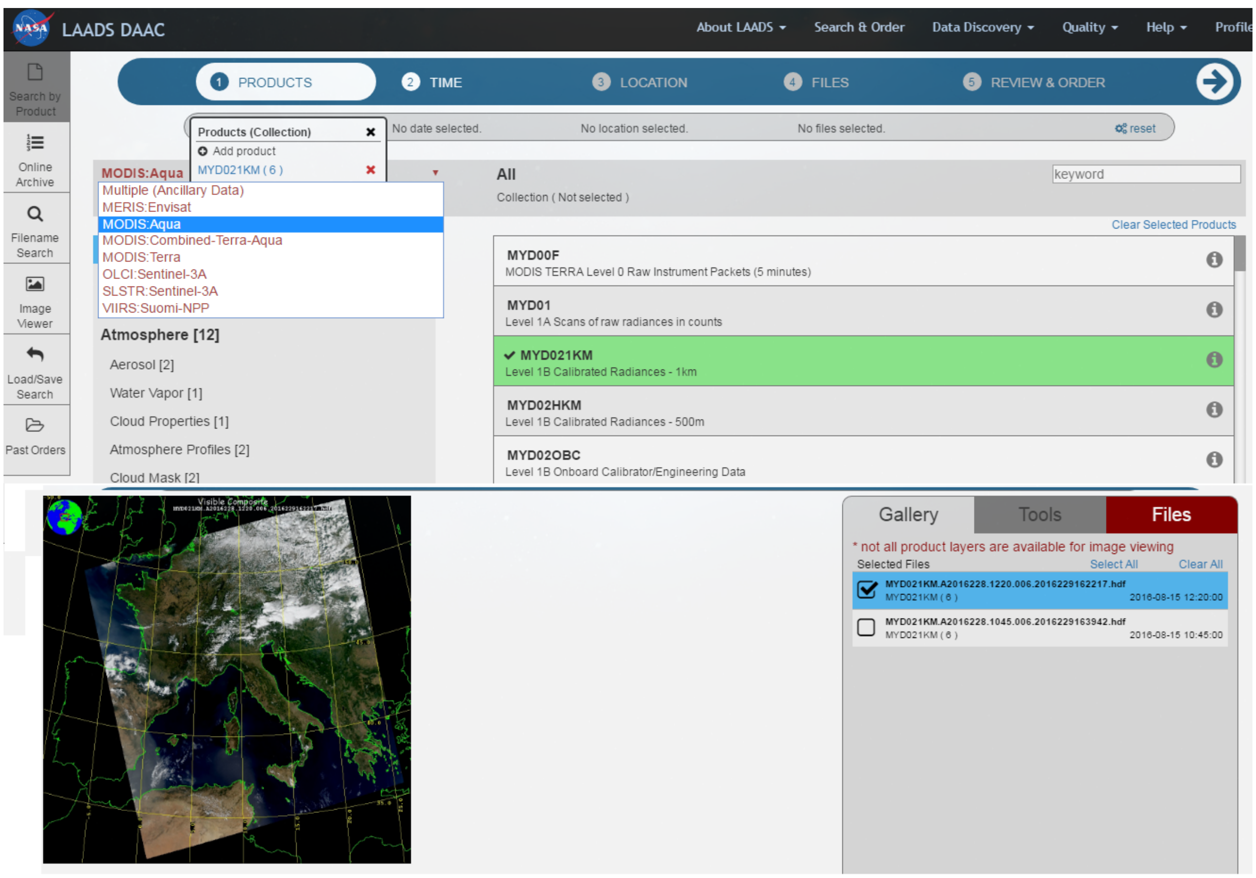

Figure 1: RGB image on the NASA Database

3. Perform data quality check

- File informations

Opening the file in SNAP, we can check in "Abstracted_Metadata" subsection the first line time of the image and the last line time whereas, in "World View", the track moving.
Being an Aqua platform, the orbit is Ascending.

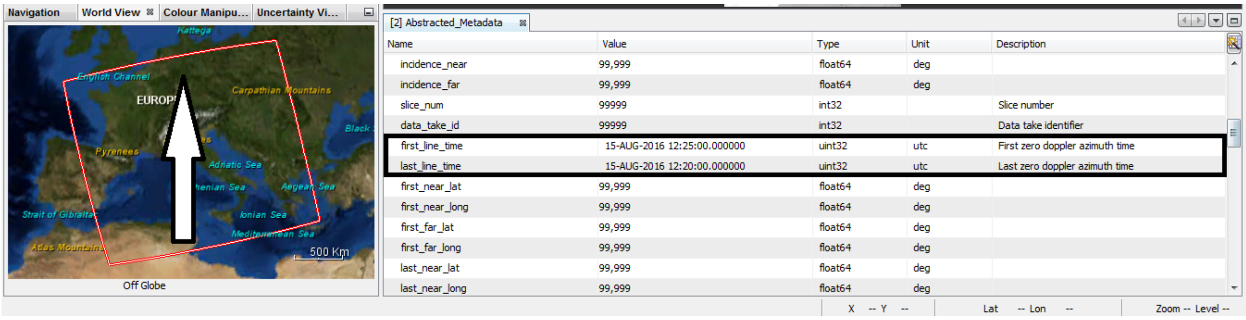

Figure 2: Brief file informations

- Checking image quality

Emissive Channels that are OK: 20-23, 25-35
Emissive Channels with slight strips: 24, 36
Reflective Channels Aggr. 1km that are OK: 1-5, 7
Reflective Channel Aggr. 1km with heavy strips: 6

We're not going to use the channels with slight or heavy strips for the algorithm processing since they can compromise the results.

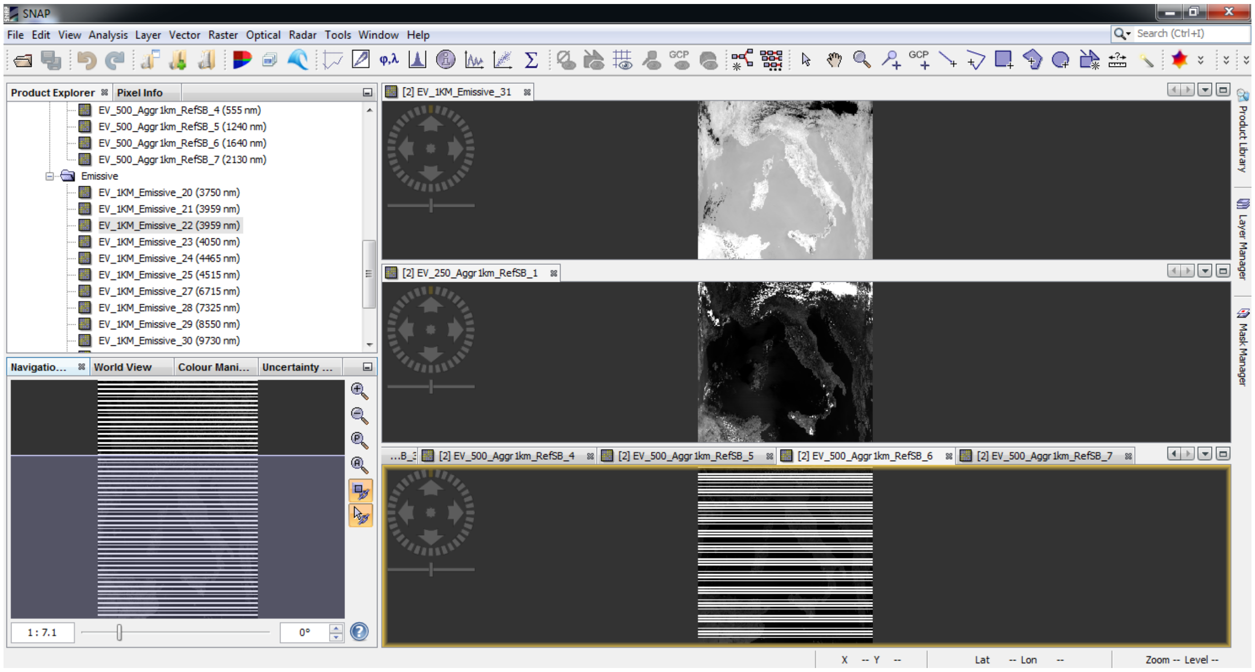

Figure 3: Channels image quality

- Tiling Horizontally and checking pixel info

We can tile, for example, horizontally the images of different bands and check pixel band informations in "Pixel Info".

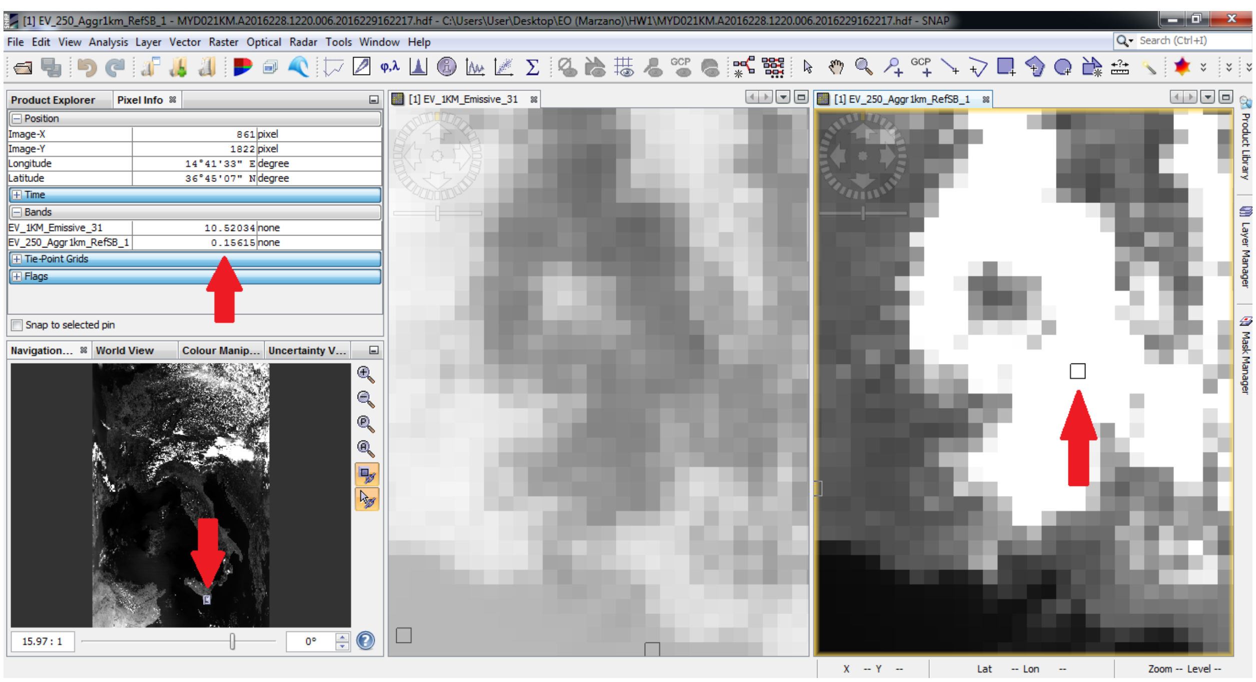

Figure 4: Pixel info of the tiled images

4. Perform and display data analysis by spectrum, histogram and profile tools

- Creating ROI and placing pins

The area we're interested in is Sicily. We place pins on salient points (Land, Sea, Clouds and two cities) and make the ROI (Region of Interest) around the italian region.

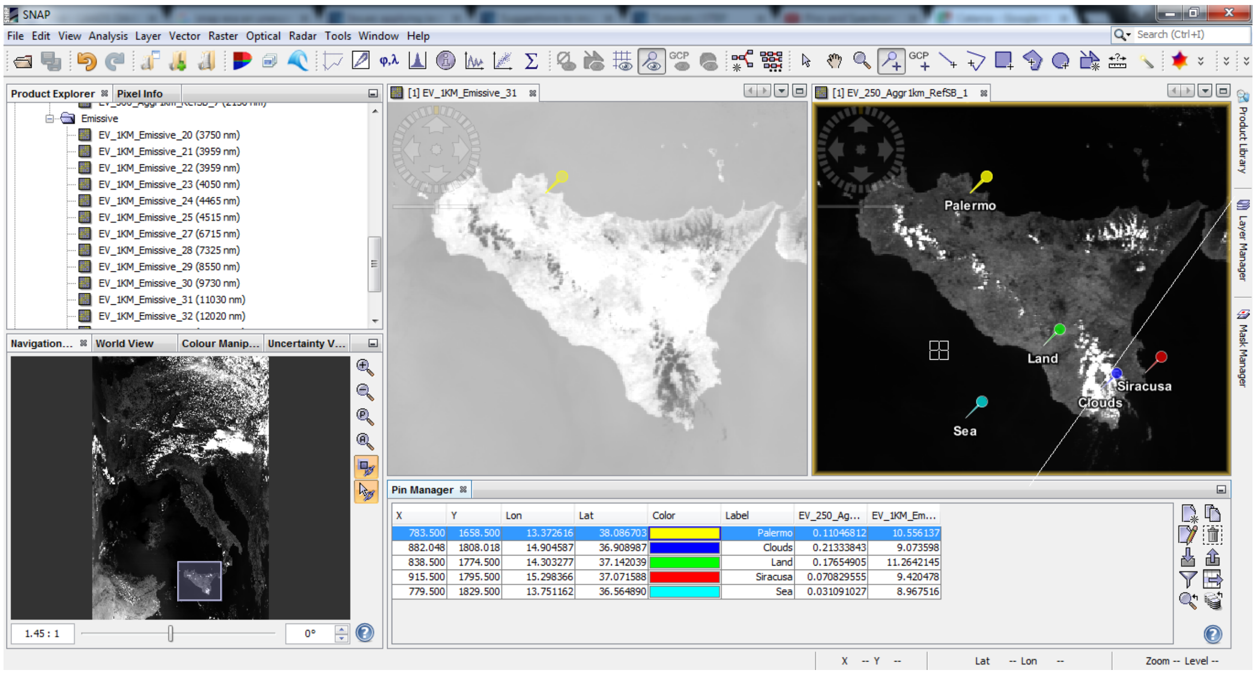

Figure 5: Pins on the ROI Sicily in Emissive 31 and Refl.Aggr.1 bands

- Spectrum view

In "Spectrum View", selecting "Show spectra for all pins", we can see the intensities in all the wavelengths of the chosen pins. In the left part there are the reflective bands, in the right part the emissive ones; the marks represent the different available bands.

The higher intensities seem to be showed by picks in the NIR and IR bands.

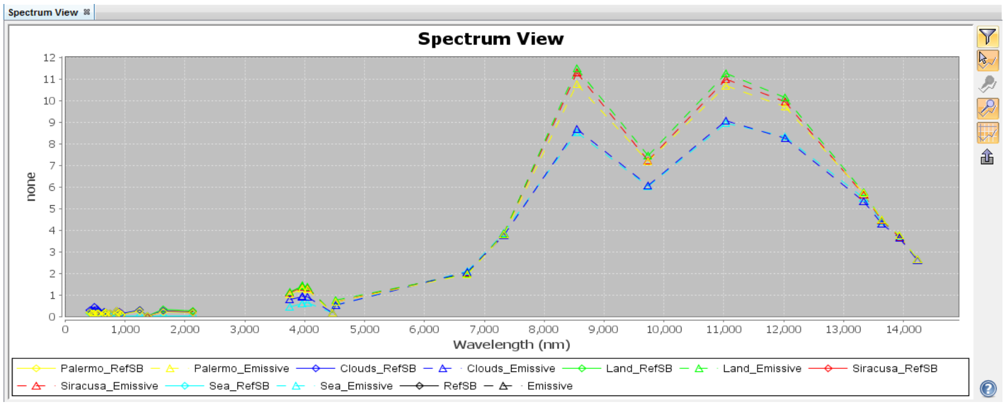

Figure 6: Spectrum view

- ROI histograms

The histograms of the ROI show the frequency in pixels of the refl.aggr._1 and emissive_31 bands

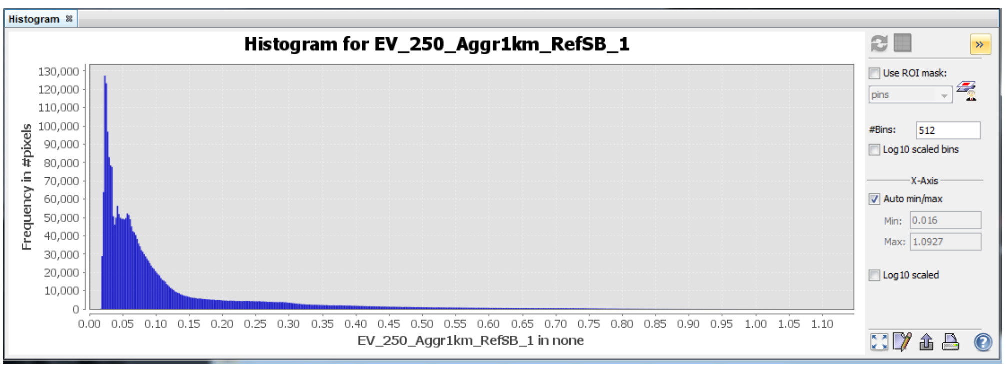

Figure 7: ROI histogram in Refl. Aggr._1

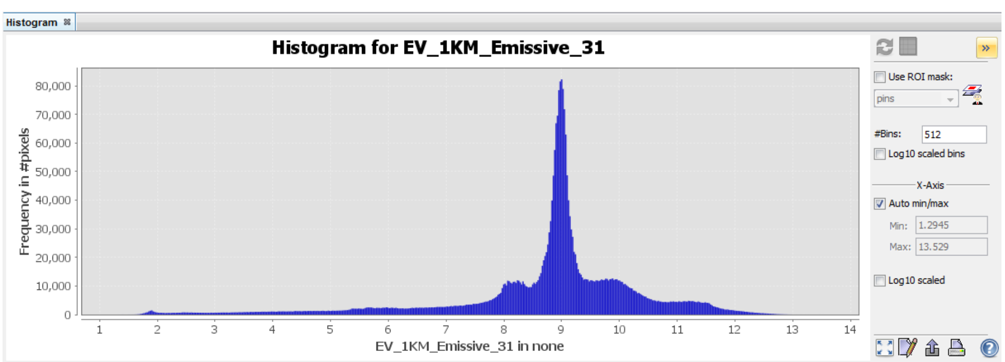

Figure 8: ROI histogram in Emissive_31

- Profile plots

The profile plots show intensities along its path of the geometric line cutting Sicily (see Figure 5). We can see the highest anomalies around the 135-200 pixels because the line is passing from sea (more or less constant) to cut different objects like land and clouds (high variations).

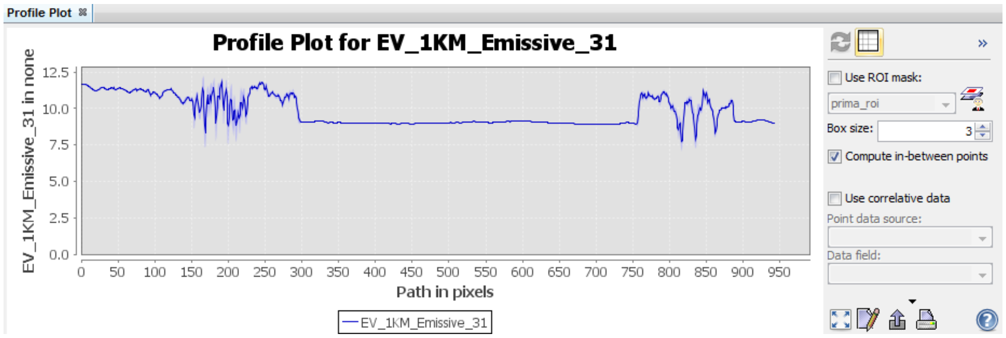

Figure 9: Profile plot in Refl. Aggr._1

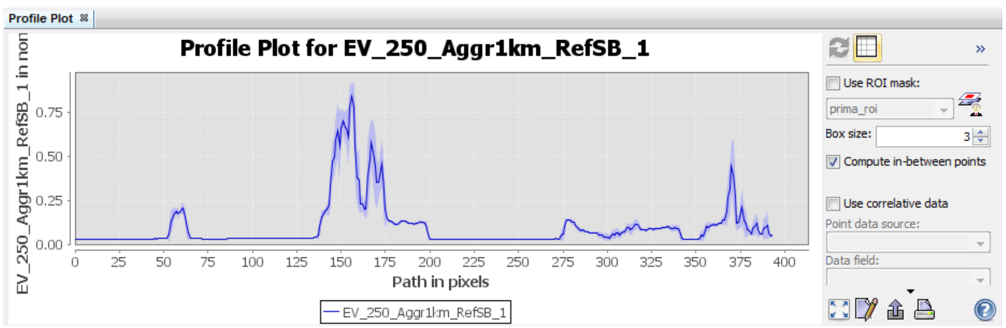

Figure 10: Profile plot in Emissive_31

5. Perform and display channel data correlation of the whole image

The scatter plot shows a sort of correlation between two images. The yellow stands for large amounts of pixels, black for small ones.

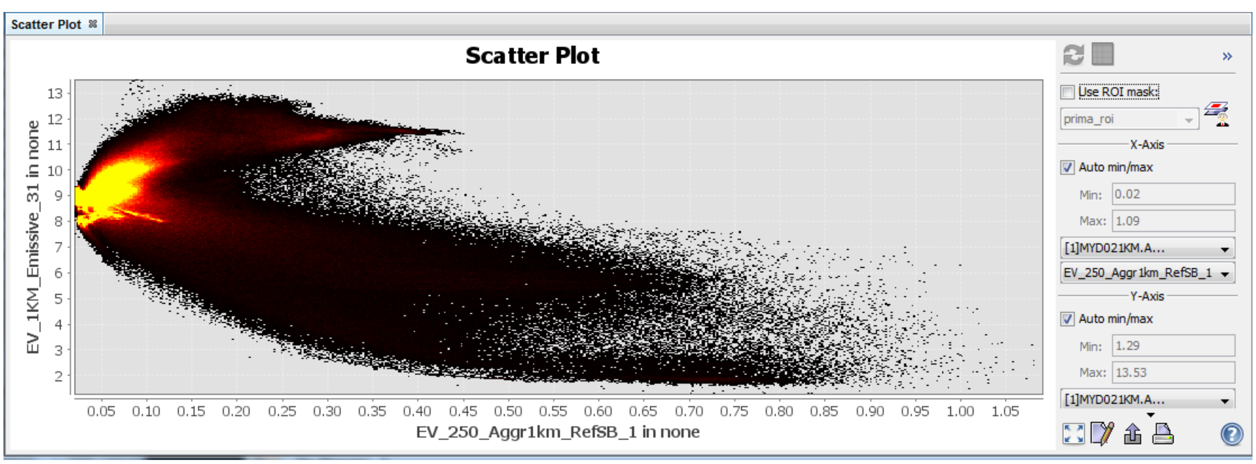

Figure 11: Scatter plot of the whole image

We can say that there are at least two classes around 8,9 and 10 values in the Emissive band that correspond to the sea and the land.

6. Perform and display channel data correlation of selected ROI (Region of Interest)

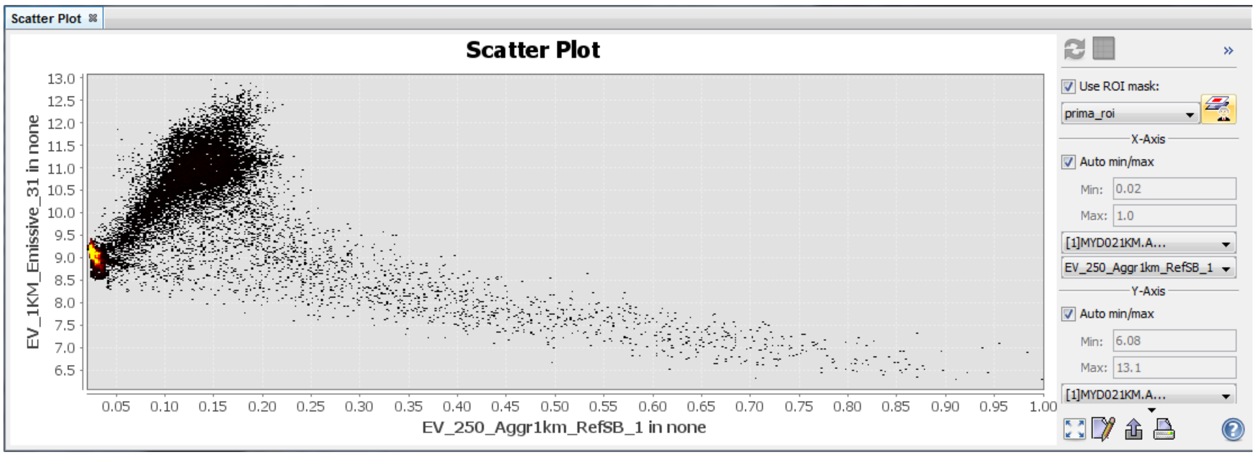

Figure 12: Scatter plot of the ROI

In this case the result is concentrated around a value of 9 for the Emissive corresponding to the sea whereas there is a slight correspondence (considering also the low number of the pixels of the ROI) around 11 corresponding to the land.

7. Perform and display principal component analysis

- Principal Component Analysis

"The Principal Component Analysis (PCA) consists of a remapping of the information of the input co-registered images into a new set of images" (more information in the documentation).

The new set images carry the best informations in the first and second components whereas the last two ones approximate mostly noise.

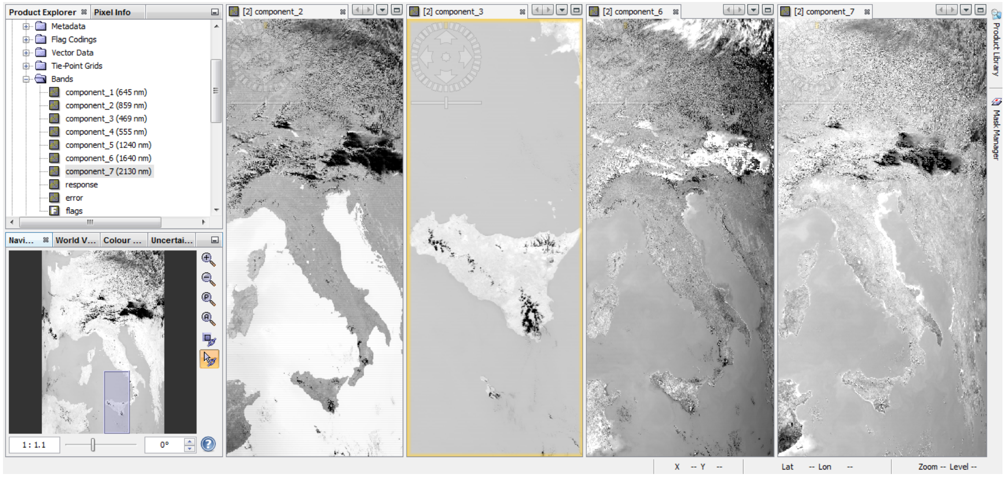

Figure 13: 2-3 and 6-7 components

- Coverage Masks

SNAP software requires to create coverage masks of all the image with a great amount of RAM (more than 8gb). Because of machine performance limitation (4gb), we'll process the function "Land/Sea mask" chosing in "Processing Parameters" the option "Use Vector as Mask" and selecting just an area, the ROI of Sicily.

For this option the result seems to cover both sea and land, leaving similar images that isolate the clouds.

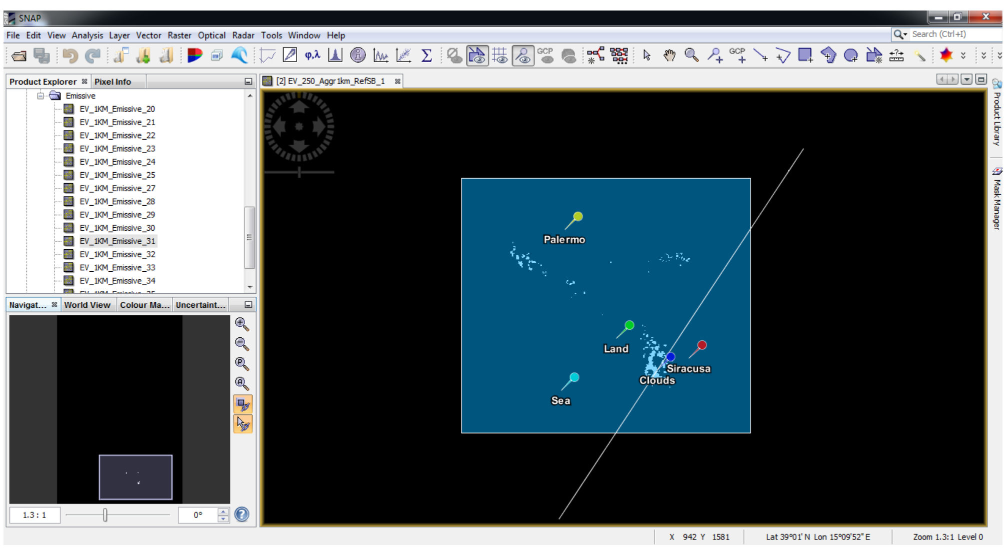

Figure 14: Isolating clouds of Sicily

8. Perform, display and interpret unsupervised classification with at least 3 classes (sea, land, cloud)

- K-Means cluster analysis

We make now let run an unsupervised algorithm, the K-means cluster analysis, to discriminate the images in different classes.
In Figure 15, for the top three resulting images we chose, in "Processing Parameters" and "Source Band names", the reflective bands 3,4,5,7 whereas for last bottom three images we chose the emissive bands 20,22,23,29,31,32. The top and bottom results are made chosing 3, then 4 and finally 5 classes.

The results for the reflective ones seem to approximate better the classes. The first one perfectly differentiates the clouds, the land and the sea whereas the other two ones add more informations. The results for the emissive ones are less clear.

Interesting to see that in the reflective ones there is an insolated area in the north-east of Sicily. The algorithm was able to recognize a different ground that we know it corresponds to the Etna volcano.

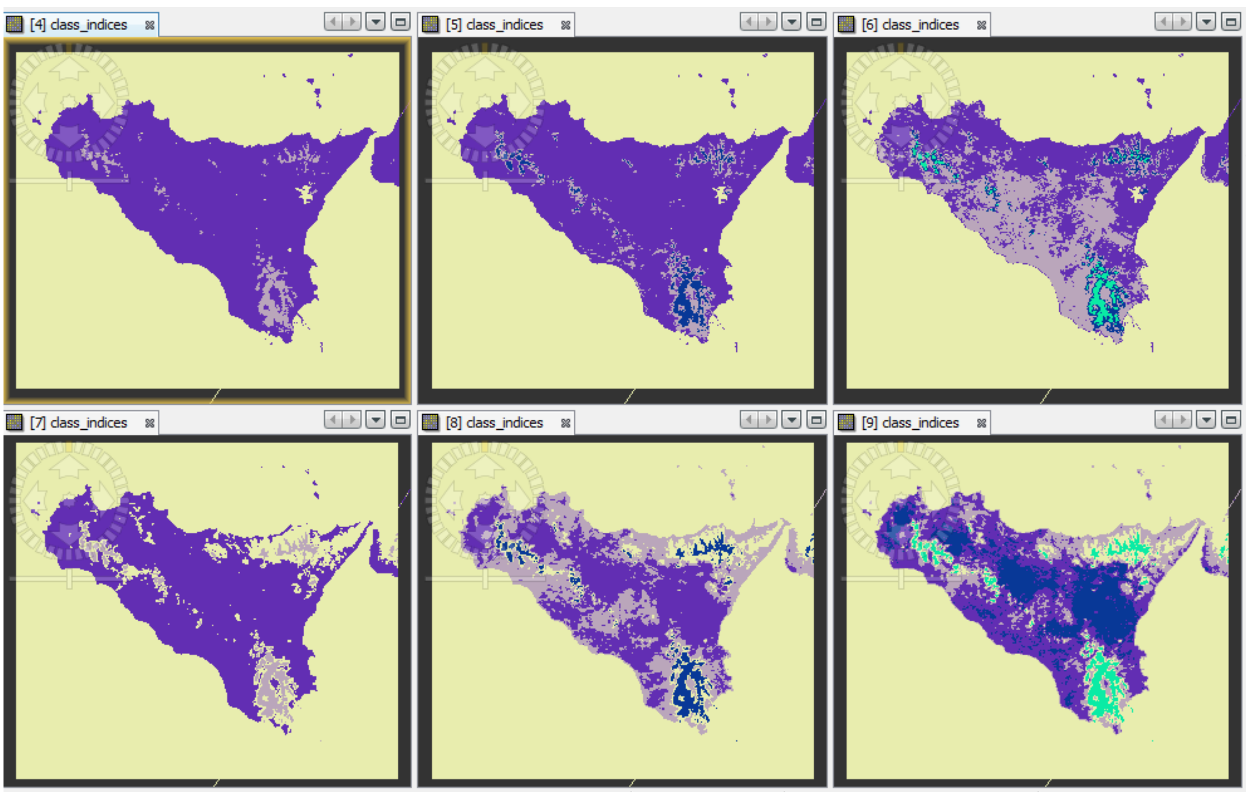

Figure 15: K-means results for different bands and classes (Sicily)

9. Perform, display and interpret supervised classification with at least 4 classes (sea, land, cloud)

Before applying a supervised classification, we need to make the RGB image choosing the bands RED, GREEN and BLUE corresponding respectively to EV_200_Aggr1km_RefSB_1, EV_200_Aggr1km_RefSB_4 and EV_200_Aggr1km_RefSB_3. It will be useful to better choose the classes.
We make different polygons that cover land, sea and clouds. Their pixel data are so contained in three "Vector Data Container" that will represent the 3 classes. We choose now so a supervised algorithm (ex. Maximum Likelihood Classifier), import the file .dim we made and then select the vectors and bands.

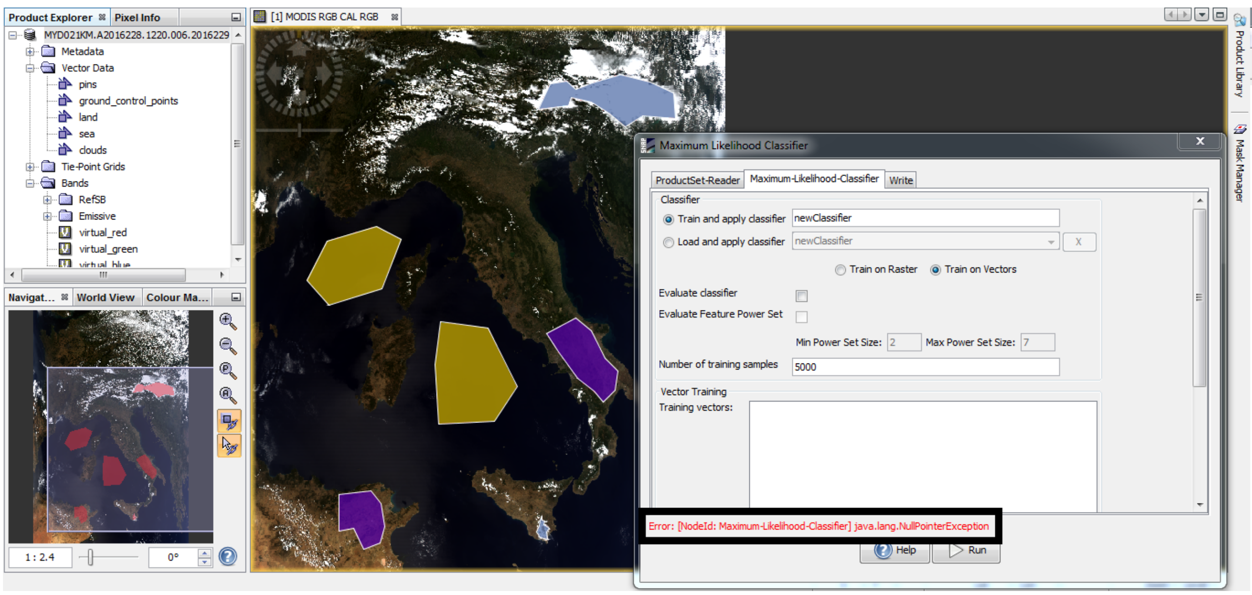

Figure 16: Application of a supervised algorithm

Unfortunately there is again a problem of RAM but the operations until now should be right and the results of a supervised algorithm were successfully seen on the laptop of Lorenzo Lancia.

10. Implement at least 3 formulas of 2-band and 3-band vegetation index (VI) using SNAP processing tools

The vegetation indexes are a quantitative estimate of biomass and vegetation vigor/turgor from space. Natural surfaces reflect solar radiation similarly in the red and NIR bands, except for vegetation whereas vegetation absorbs red wavelengths but it strongly reflects the NIR wavelengths.

For the NIR wavelength we use EV_250_Aggr1km_RefSB_1 (645nm) whereas for the RED one EV_250_Aggr1km_RefSB_1 (859nm)
We apply two 2-band VI, NDVI and SAVI, and one 3-band VI, EVI.

Formulas and correspond expression inserted in "Band Maths" - "Edit Expression" - "Expression":

$$NDVI = \frac{NIR - RED}{NIR + RED} \tag{1}$$

($1.EV_250_Aggr1km_RefSB_2 - $1.EV_250_Aggr1km_RefSB_1)/($1.EV_250_Aggr1km_RefSB_2 + $1.EV_250_Aggr1km_RefSB_1)

$$SAVI = \frac{NIR - RED}{NIR + RED + L} * (1 + L) \tag{2}$$

($1.EV_250_Aggr1km_RefSB_2 - $1.EV_250_Aggr1km_RefSB_1)/($1.EV_250_Aggr1km_RefSB_2 + $1.EV_250_Aggr1km_RefSB_1 + 0.5) * (1 + 0.5)

$$EVI = 2.5 * \frac{NIR - RED}{NIR + C1 * RED - C2 * BLUE + L} \tag{3}$$

($1.EV_250_Aggr1km_RefSB_2 - $1.EV_250_Aggr1km_RefSB_1)/($1.EV_250_Aggr1km_RefSB_2 + 6 * $1.EV_250_Aggr1km_RefSB_1 - 7.5 * virtual_blue + 1)

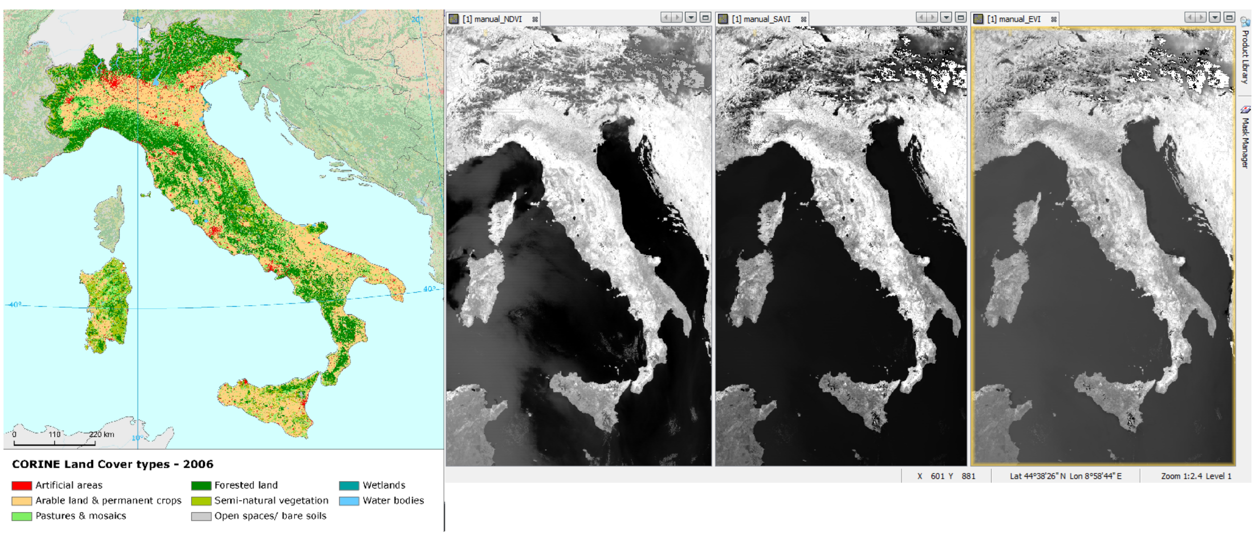

Figure 17: Real vegetation map, NDVI,SAVI and EVI VIs