Earth Observation and Data Analysis

Homework 2

Submitted by:

Azimedem Tsafack Vigèr Durand (Matricola ID: 1792126)

1. Data acquisition and preparation

Our goal was to perform Chlorophyll-A (Chl-a) and Total Suspended Sediments (TSS) estimation using Sentinel-2 Multispectral Imager (MSI) Level 1C data. We choose as target area the Tiber River estuary located in the central region of Italy. The data was downloaded from Copernicus website over the month of July 2019 having 10 days distance between each other (10/07, 20/07 and 30/07). Our focus was mainly on the 30/07 image as it appeared to be the cleanest. The following figure illustrates the downloaded data.

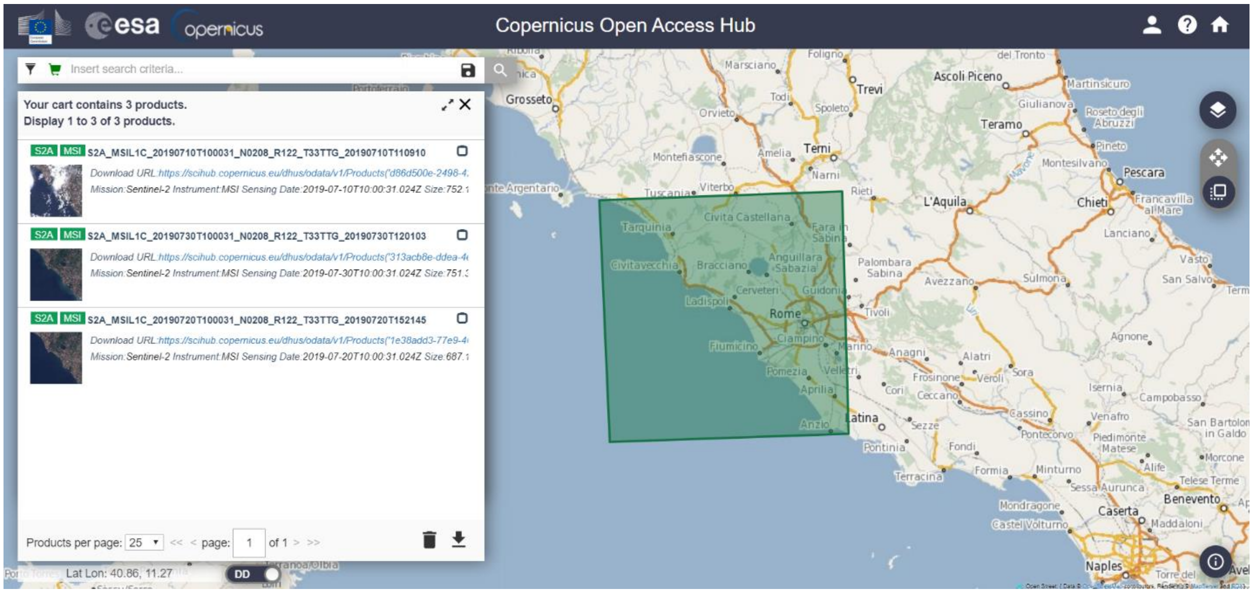


Fig 1.1. Sentinel-2 MSI Level 1C data - Copernicus schihub web application

Subsequently, we resampled all the bands of the data through the SNAP raster tool to a resolution of 10m and we finally used a rectangular vector to further subset the data over a region of interest. The following are two figures illustrating the resampling and the sub-setting operations.

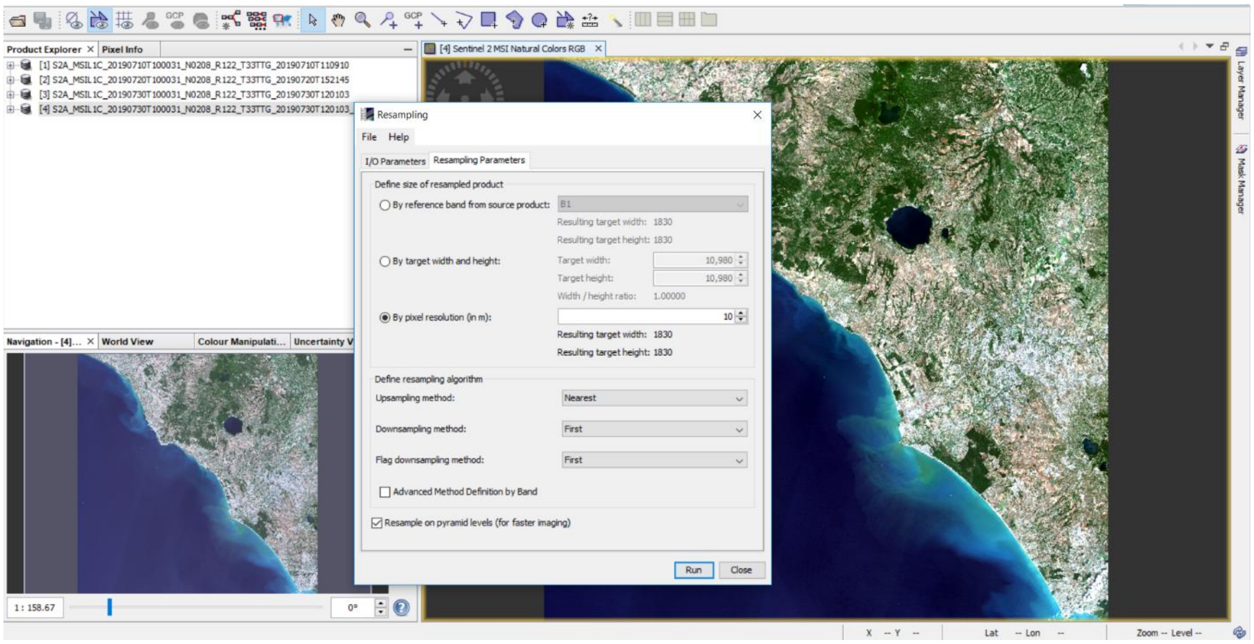


Fig 1.2. SNAP Raster Resampling tool

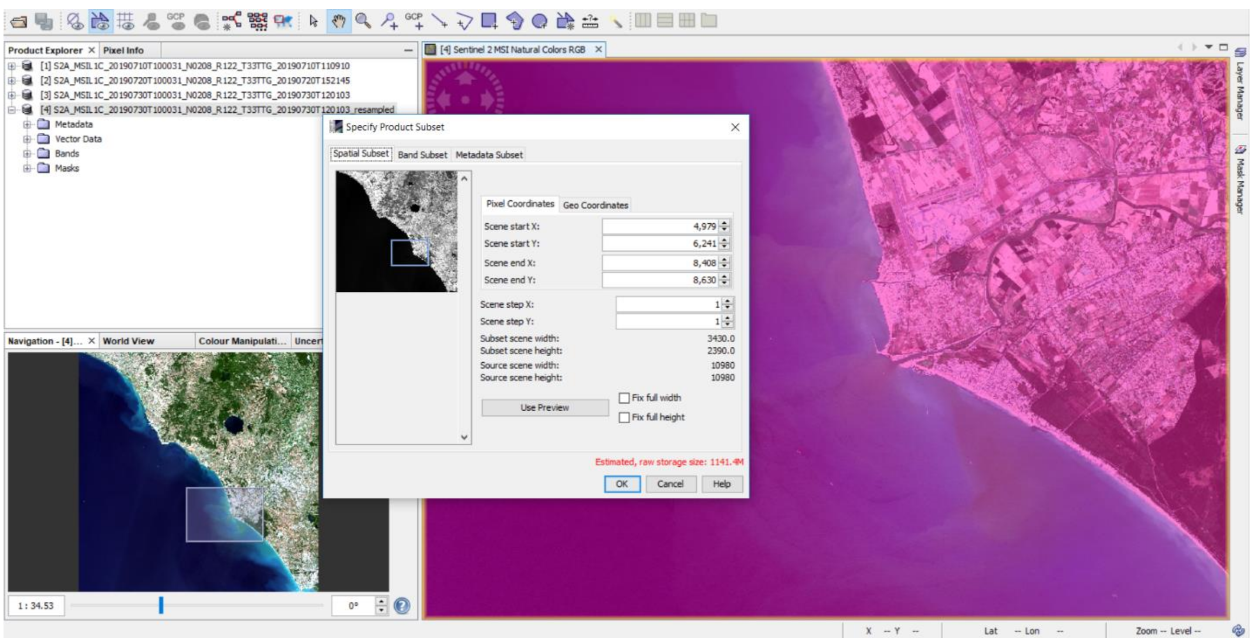


Fig 1.3. SNAP Raster Subset tool

The following is a figure showing a true color RGB visual composite of the resampled and subset data that we used in the present experiment.

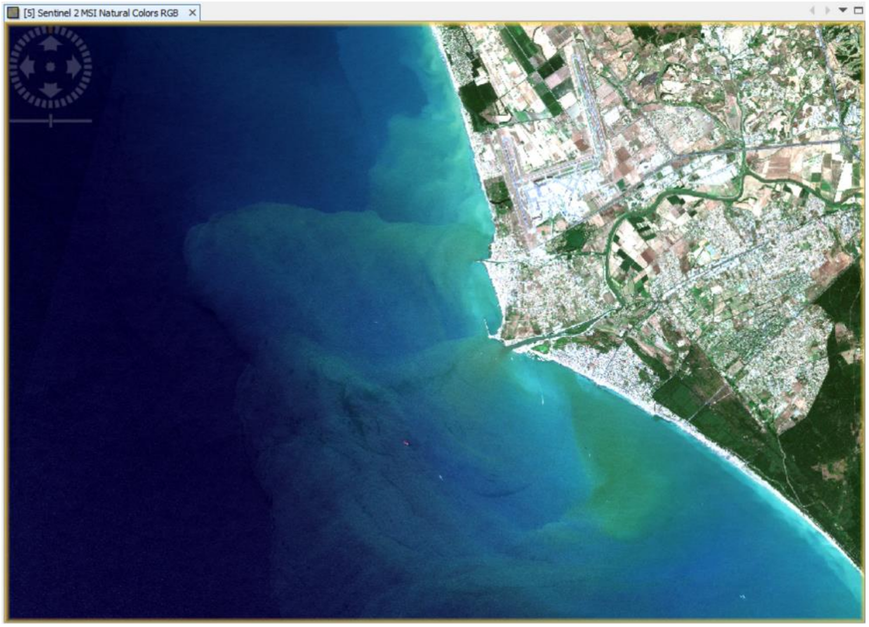


Fig 1.4. True color RGB visual composite of the data (30/07/2019)

2. Data quality check

All the 13 data bands were visually inspected and the only band that we found to have noise was band B10 (1375 nm). The following figure shows an overview of all the 13 bands of the product.

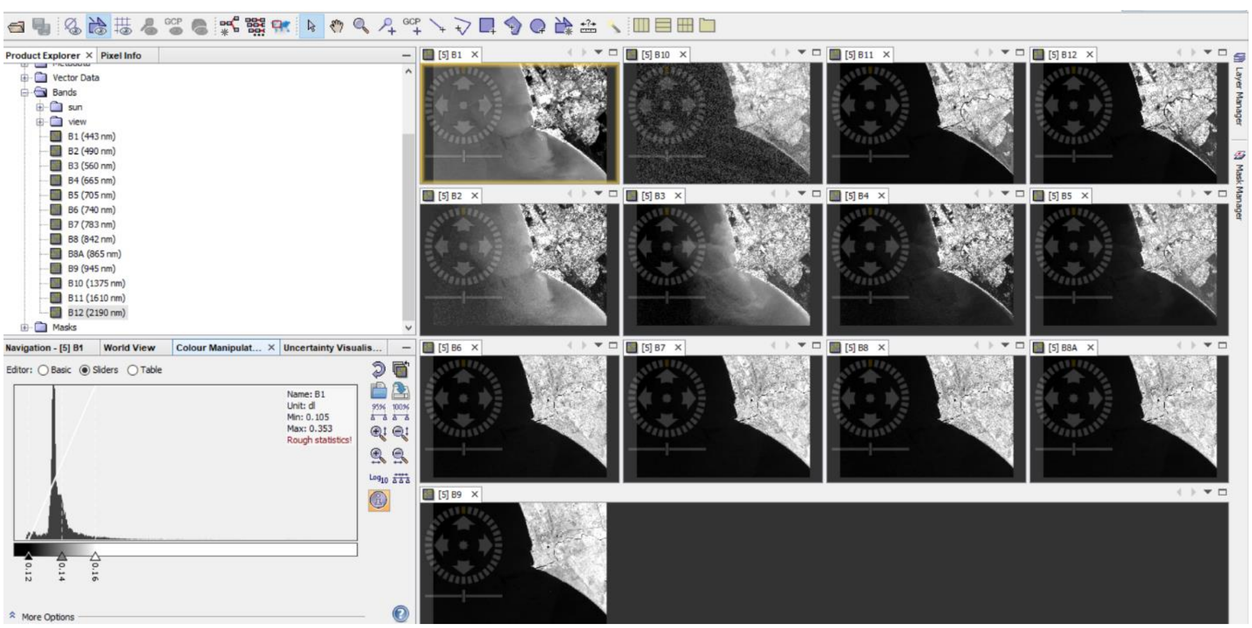


Fig 2.1. Visual overview of all the bands of the product

3. Atmospheric correction

The downloaded product was of type S2-MSI level 1C. Therefore, we used the C2RCC (Case 2 Regional CoastColour) tool to perform the desired atmospheric correction in order to obtain an estimation of the bottom-of-the-atmosphere reflectance. The following figure illustrates the tool configurations used.

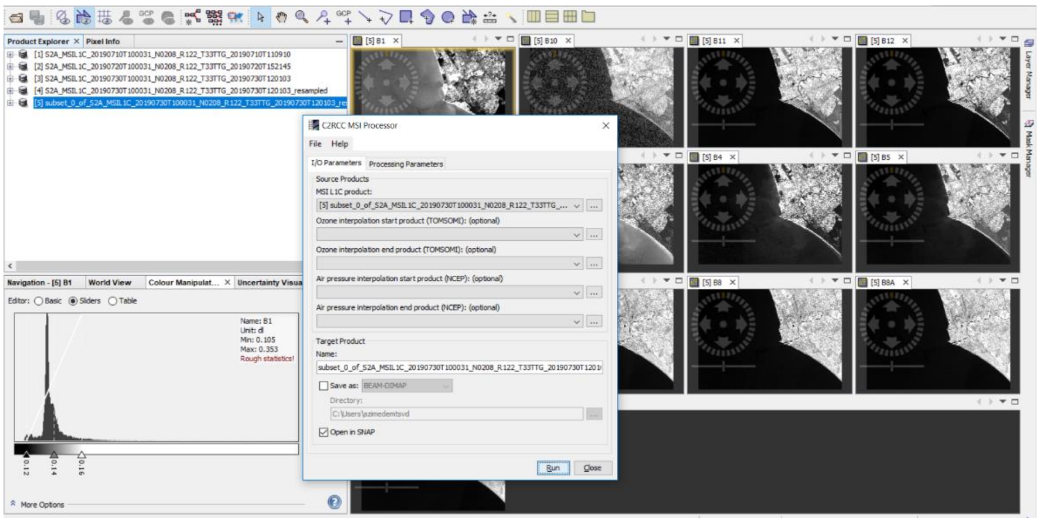


Fig 3.1. SNAP C2RCC configuration for atmospheric correction

The following figure shows the product before (left) and after (right) the application of the atmospheric correction.

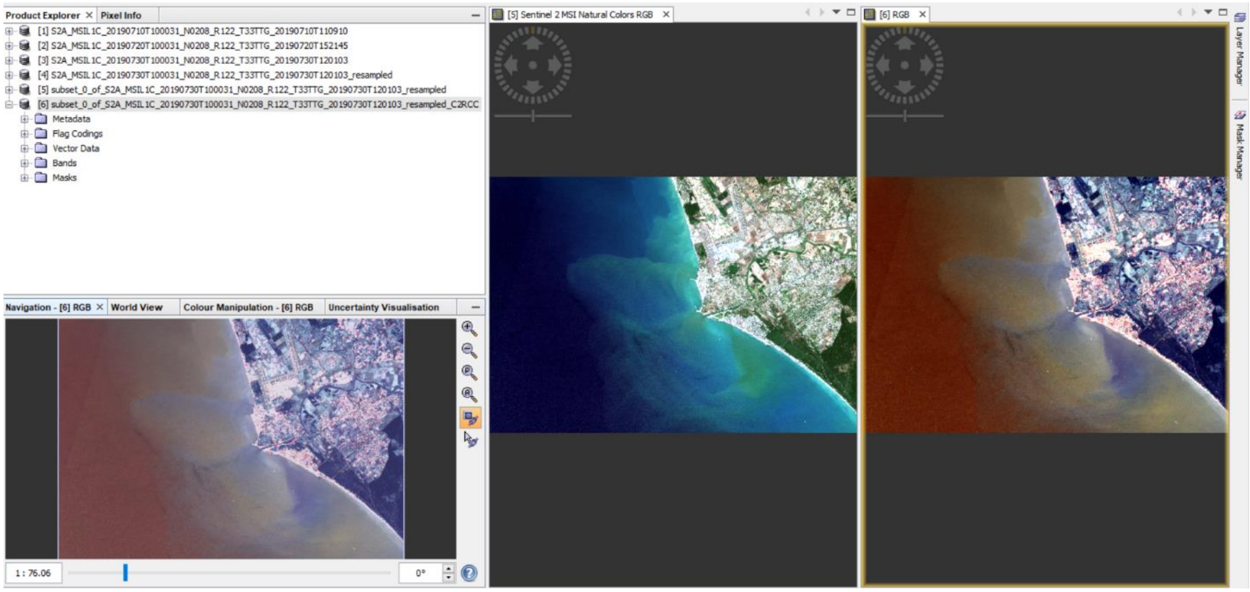


Fig 3.2. Qualitative comparison between original and atmospheric corrected data

As observable on the above figure, there is an obvious color difference between the two images. The second image seems to be an inversion of the first. The water tends to be more opaque than blue, which is a sign of a high concentration of dead organic and inorganic.

4. Channel Data Correlation of ROI

The following is the scatter plot of channel data correlation between two selected bands (B4 and B6) over the initially selected Region of Interest (ROI). The plot has been created using the SNAP scatter plot analysis tool.

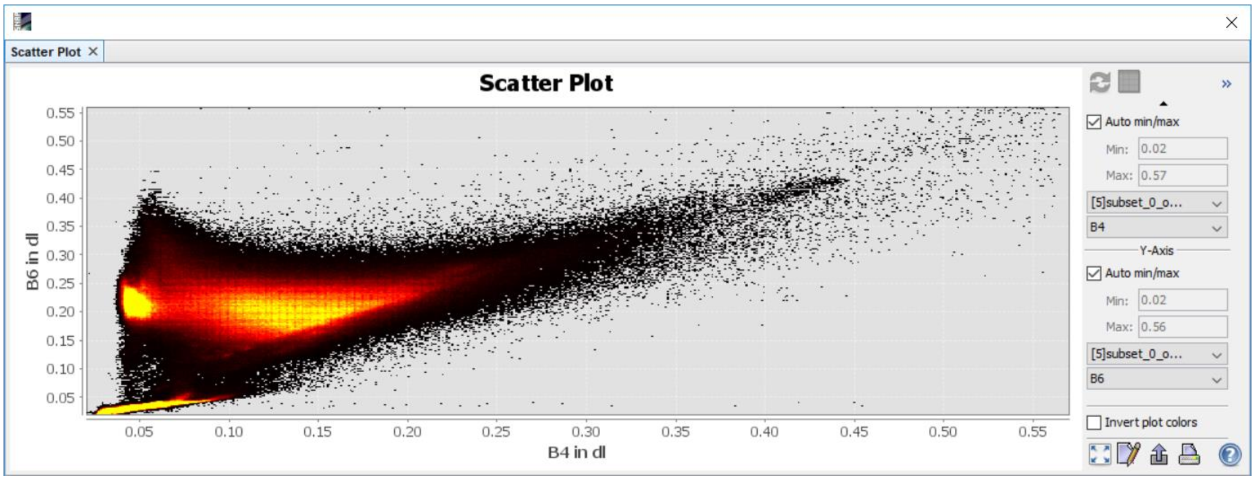


Fig 4.1. A sample scatter plot for correlation between bands B4 and B6

5. Chlorophyll-a (Chl-a) estimation through regressive algorithms

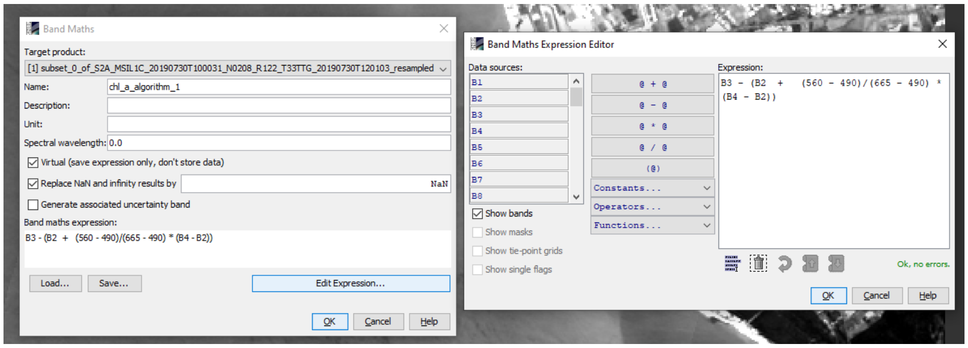
We used the following two algorithms to estimate the chlorophyll-a presence in the downloaded product.

$B_i \rightarrow Band\ i$

$\lambda_i \rightarrow Wavelength\ in\ nanometers(nm)$

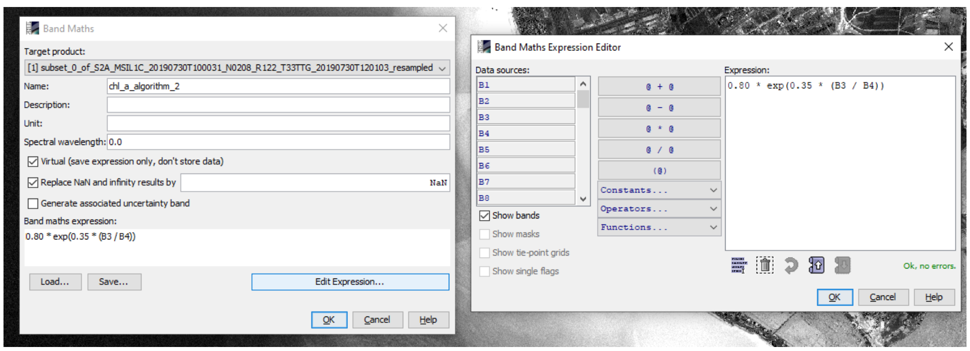
5.1. First Algorithm

$$Chl_a = B_3 - \left(B_2 + \frac{(\lambda_3 - \lambda_2)}{\lambda_4 - \lambda_2} (B_4 - B_2) \right)$$



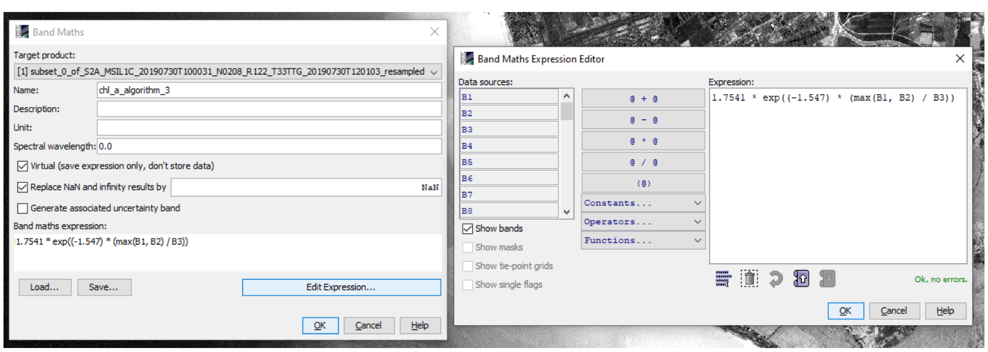
5.2. Second Algorithms

$$Chl_a = 0.80 \exp\left(0.35 \frac{B_3}{B_4}\right)$$



5.3. Third Algorithm

$$Chl_a = 1.7541 \exp\left(-1.547 \frac{\max(B_1,\ B_2)}{B_3}\right)$$



Results:

Fig 5.1 Qualitative comparison of Chlorophyll-A estimation algorithms

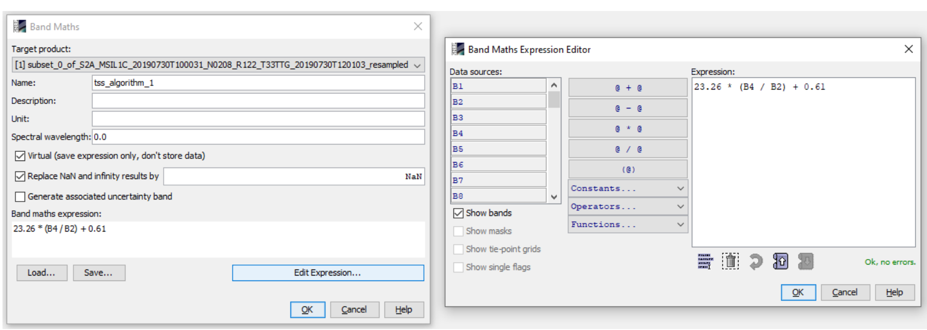
We clearly observe that the outcome of thrid algorithm has better contrast for representing the range of values and has less grain noise compared to first two algorithms.

6. Implementation of 2 regressive algorithms to estimate Total Suspended Sediments (TSS)

We used the following two algorithms to estimate the Total Suspended Sediments for the downloaded product.

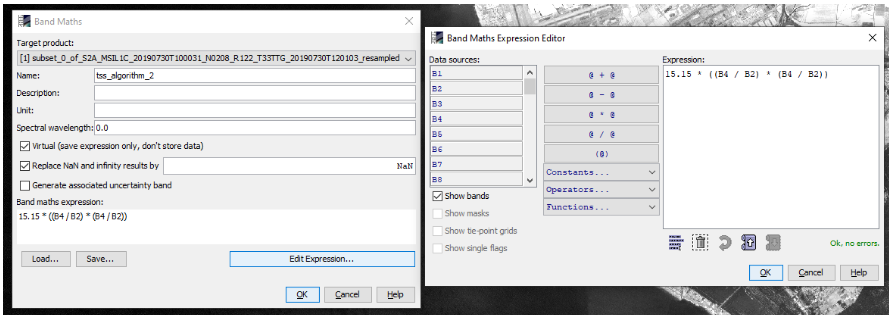
6.1 First Algorithm

$$TSS = 23.26\,\frac{B_4}{B_2} + 0.61$$



6.2 Second Algorithm

$$TSS = 15.15\,\frac{{B_4}^2}{B_2}$$



Results:

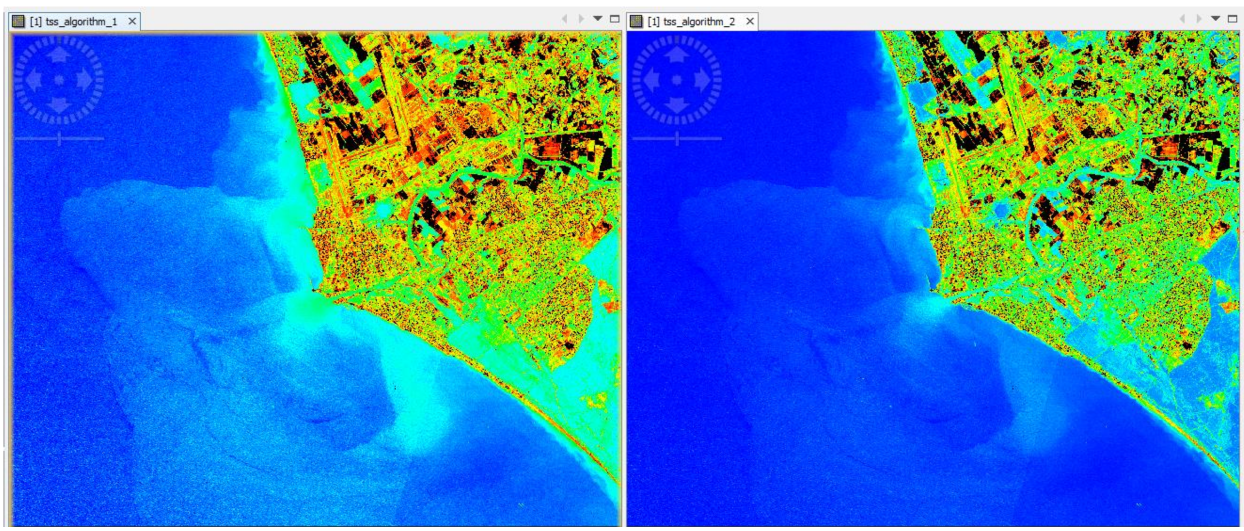


Fig 6.1 Qualitative comparison of TSS detection algorithms

We can observe on the above result that the first algorithm is more sensitive compared to the second one in such a way that TSS level is detectable far into the sea apart from shore lines.

7. Time series evaluation of Chl-a and TSS over a 3 weeks period

7.1 Time-series of Chlorophyll A: July 10, July 20 and July 30

Fig 7.1 Time-series qualitative comparison of Chlorophyll A

7.2 Time-series of TSS: July 2, March 12 and March 22

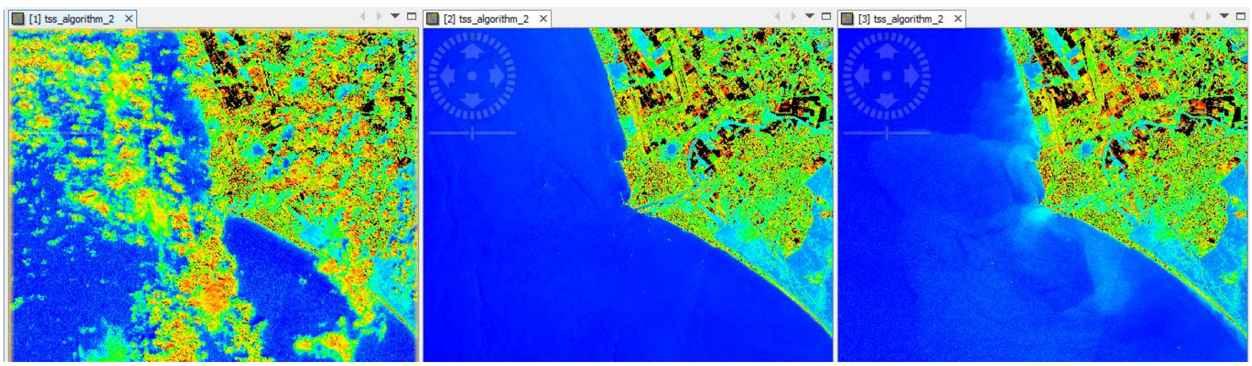


Fig 7.2 Time-series qualitative comparison of TS

Results:

In this section, we performed a time-series evaluation of Chl-a and TSS estimation on the Tiber estuary shore line over a three weeks range of time with data points at 10/07/2019, 20/07/2019, and 30/07/2019. Despite the amount of cloud present in the 10/07 product we were able to notice a substantial increase in both Chl-a and TSS quantity starting from the first week were the quantity was close to null, passing through the second week were we observed a slight increase in both Chl-a and TSS quantity, and finally reaching the third week with a much greater quantity of both substances.

8. Comparative evaluation with data generated from Copernicus Marine Service

In this section, we downloaded from Marine.Copernicus website the Chlorophyll A observation for the dates of interest: July 10 2019, July 20 2019 and finally July 30 2019.

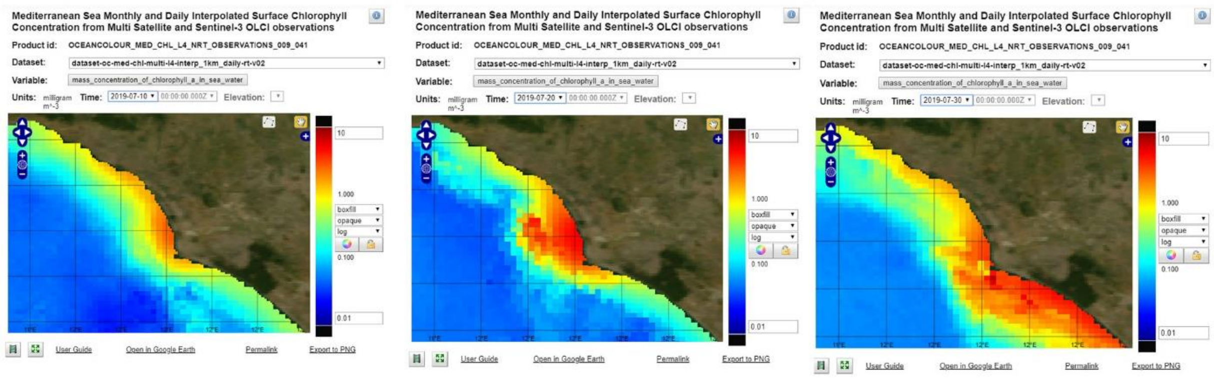


Fig 8.1 Time-series Chlorophyll A data from Copernicus Marine Service

Result:

We can observe a higher Chl-a concentration in the water by the third week (30/07/2019), visible through the reddish pixels around the estuary shore line. Furthermore, we can clearly read a progressive reduction of reddish pixels by the second and first week. This observation corroborate with our previous observation using S2 MSI data and SNAP tool.