SNAP Exercise

Optical data processing

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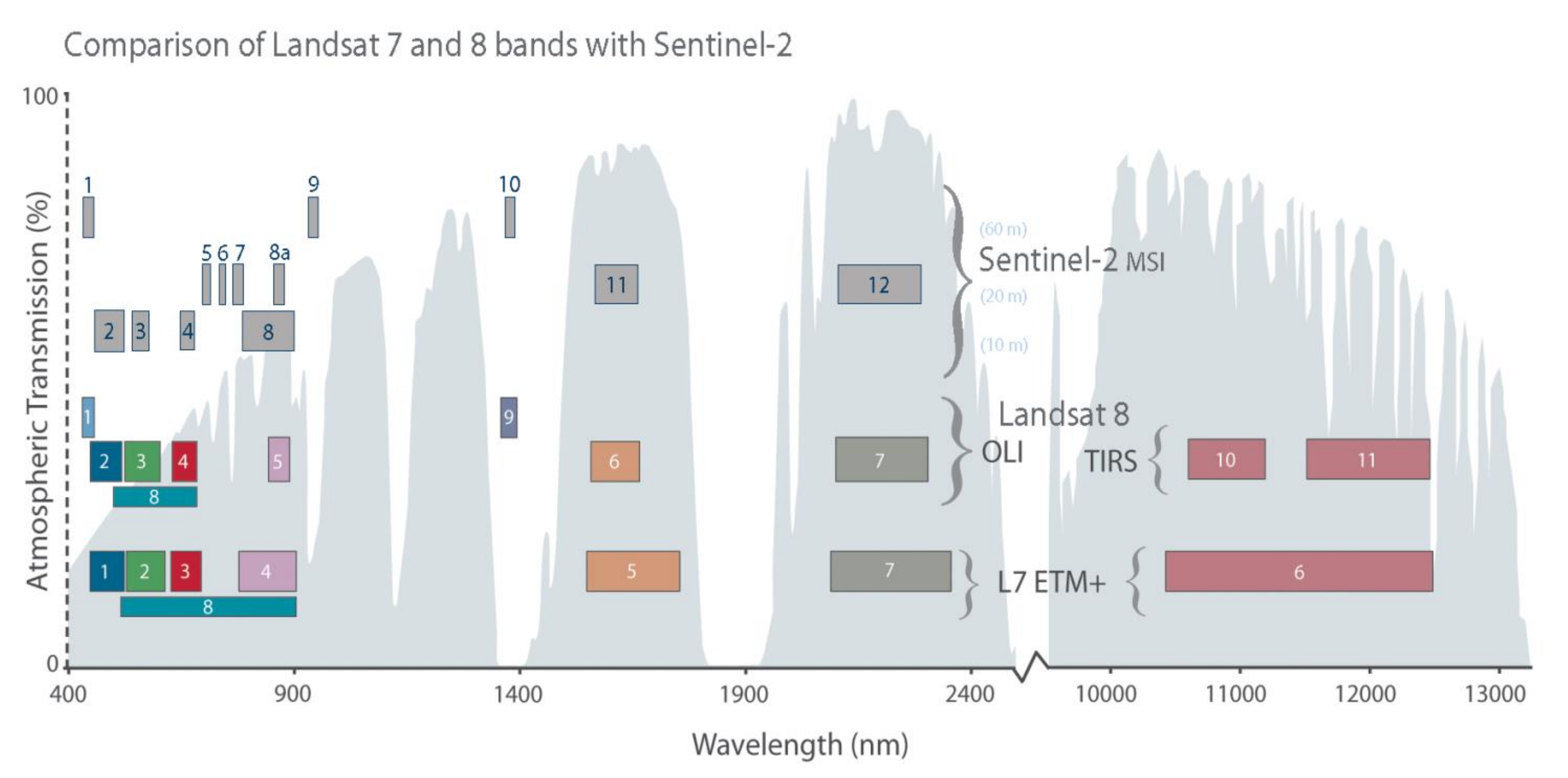
SNAP Exercise Optical data processing

- ✓ Overview of Sentinel-2
  - ✓ *Spectral bands*
  - ✓ *Level 2A products*
- ✓ Pre-processing chain starting from S2 L2A data
  - ✓ *Resampling*
  - ✓ *Subset*
  - ✓ *Band Maths*
  - ✓ *Radiometric Indices*
  - ✓ *S2 Biophysical processor*
- ✓ Graph Builder
- ✓ Batch Processing
- ✓ Time series analysis

Sentinel-2 spectral bands



Sentinel-2 L2A data overview

Sen2Cor is the Atmospheric Correction processor used in the ESA Payload Data Ground Segment to generate S2 L2A data and it is distributed via STEP to be used as SNAP plug-in or via command line.

✓ Bottom-of-atmosphere (BOA) reflectances in cartographic geometry (UTM/WGS84)

✓ Products additionally include:
- *Scene Classification Map*
- *Water Vapor Map*
- *Aerosols Optical Thickness Map*

✓ Algorithm includes:
- *Cloud and cloud shadow detection*
- *Cirrus detection and correction*
- *Slope effect correction*
- *BRDF effect correction*

Beyond Sen2Cor, Sentinel-2 data can be atmospherically corrected using others processors:

MAJA (developed by CESBIO/CNES)

i-COR (developed by VITO)

CorA (developed by Brockmann Consult)

LaSRC (developed by NASA GSFC/USA)

……

Sentinel-2 L2A data overview

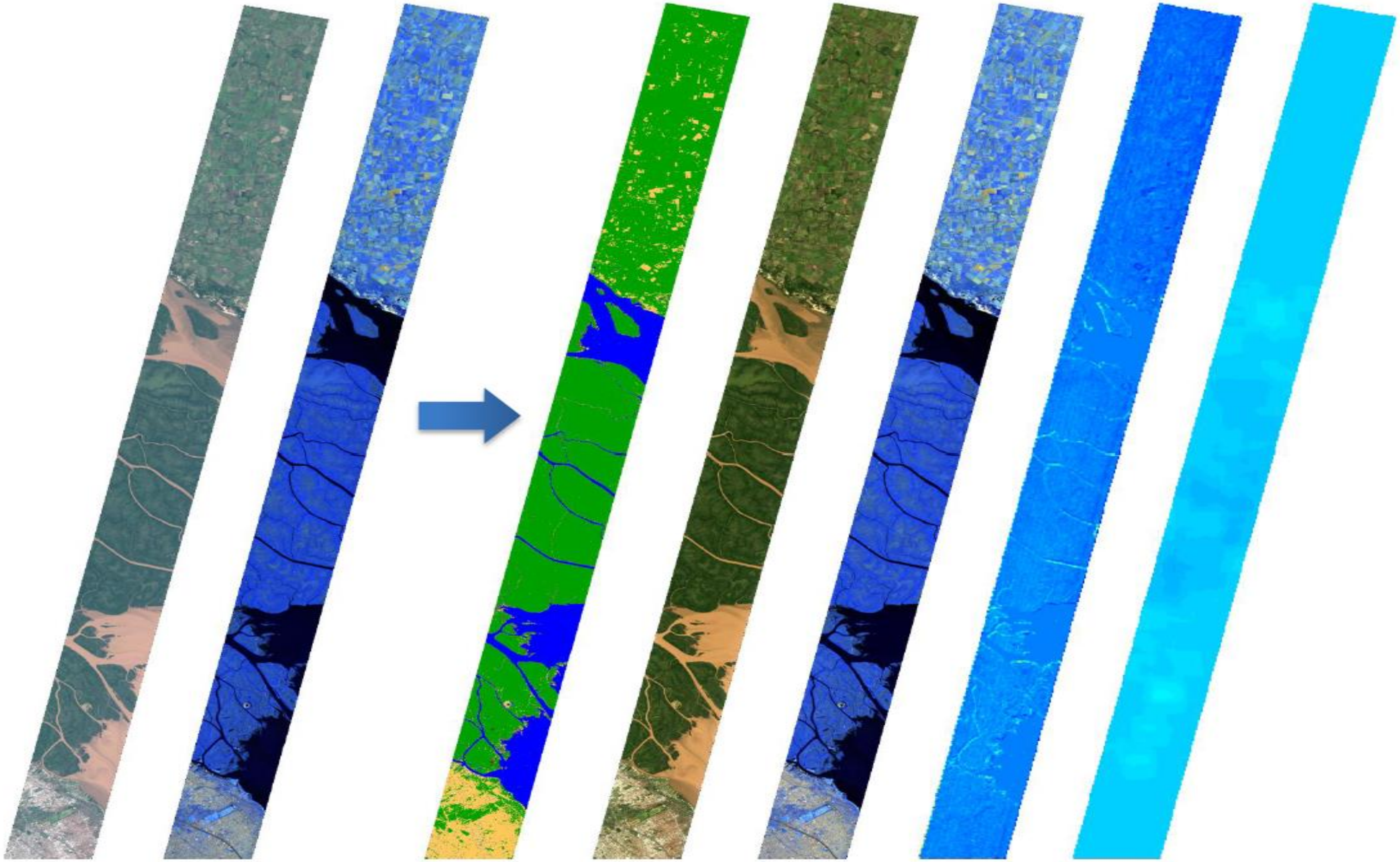
From left to right:

Level-1C [TOA]

- *[RGB] B4-B3-B2*
- *[RGB] B12-B11-B8a*

Level-2A [BOA]

- *Scene Classification*
- *[RGB] B4-B3-B2*
- *[RGB] B12-B11-B8a*
- *Water Vapour*
- *Aerosols Optical Thickness*



Sentinel-2 pre-processing

Essential pre-processing steps:

Resampling

The S2 products are multi-size

- *B2, B3, B4 and B8 @ 10m*
- *B5, B6, B7, B8A, B11 and B12 @ 20m*
- *B1, B9 and B10 @ 60m*

Needed if the user wants to combine bands with different spatial resolution

Subset (spatially/spectrally)

The S2 data are distributed in tiles 100x100 km^2 ortho-images in UTM/WGS84 projection.

Needed if the AOI covers a portion of the S2 scene or if only a subset of bands are useful in the next step (this will reduce the computation time)

Re-projection

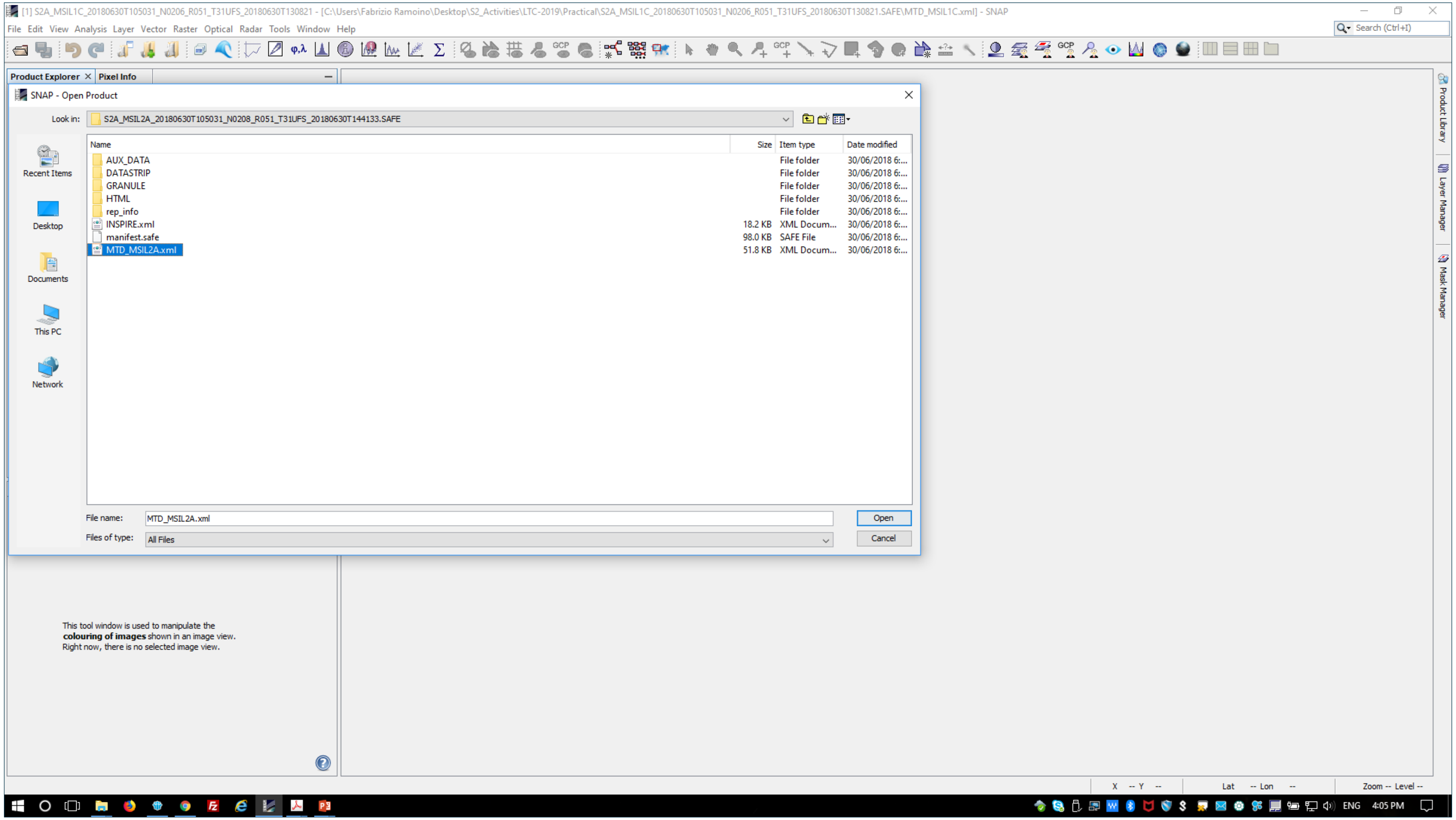
If the AOI covers more than one S2 tile in different UTM zones the user needs to re-project in a common CRS before to mosaic them.

If the user wants to merge different data sources projected in different CRS.

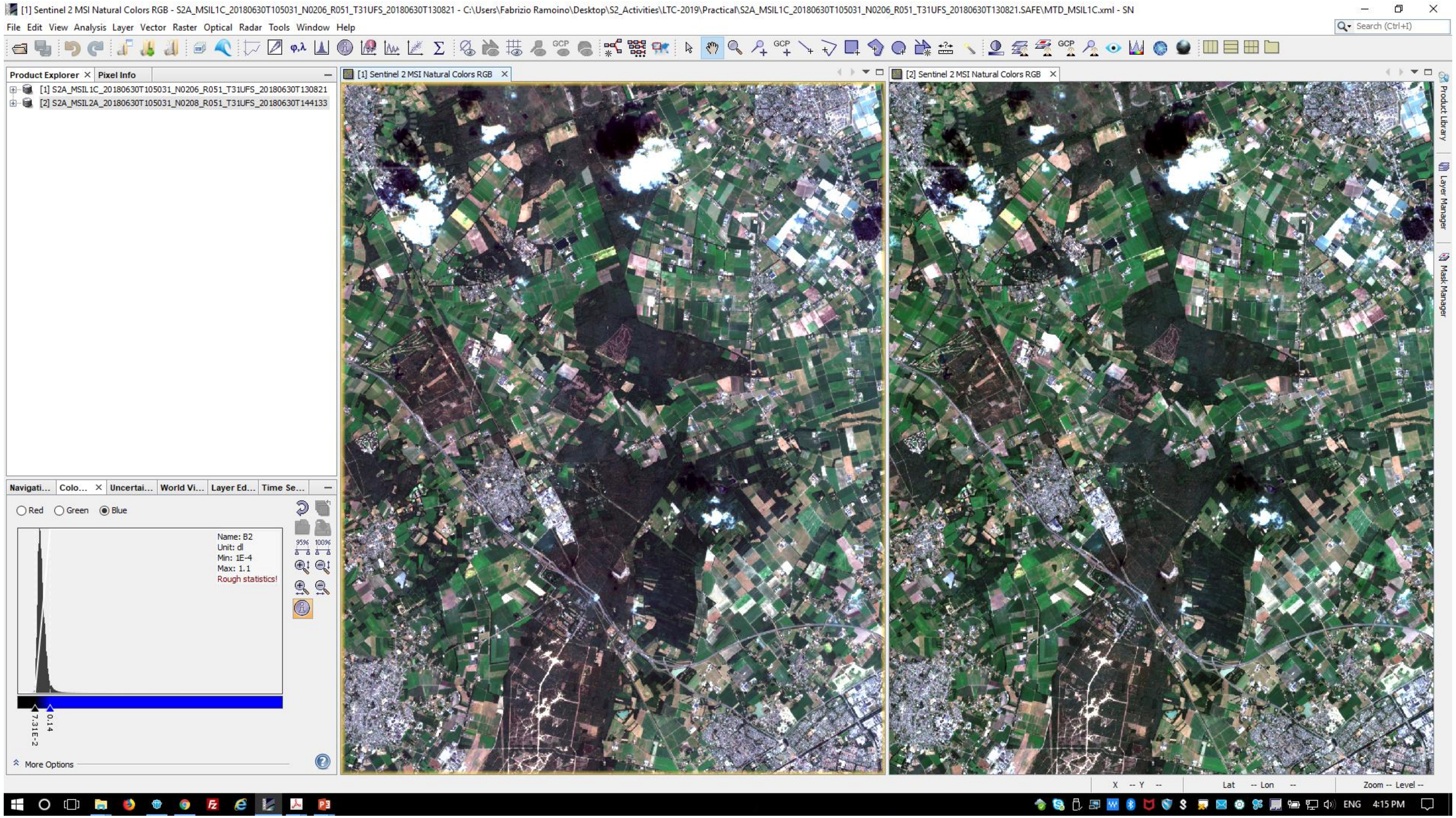
To export the view in KMZ and visualise your output in Google Earth.

Open Sentinel-2 data

Click on ‘File’ → ‘Open Product…’ → select the ‘*MTD_MSIL2A.xml*’ file



Visualize Sentinel-2 data

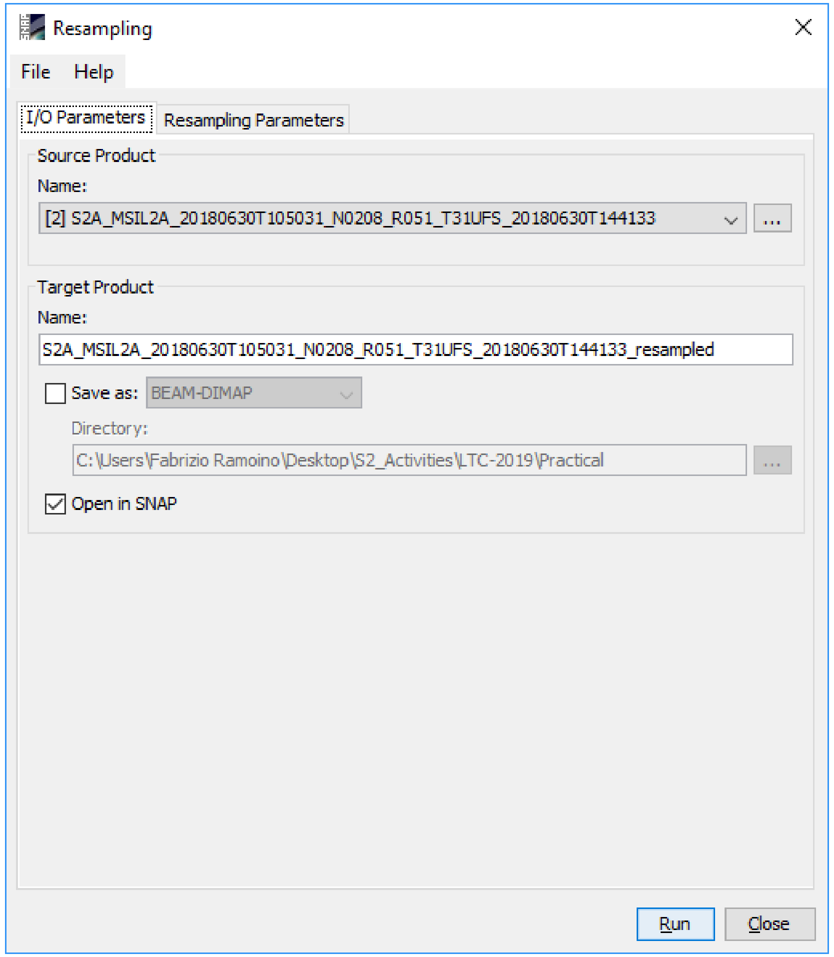


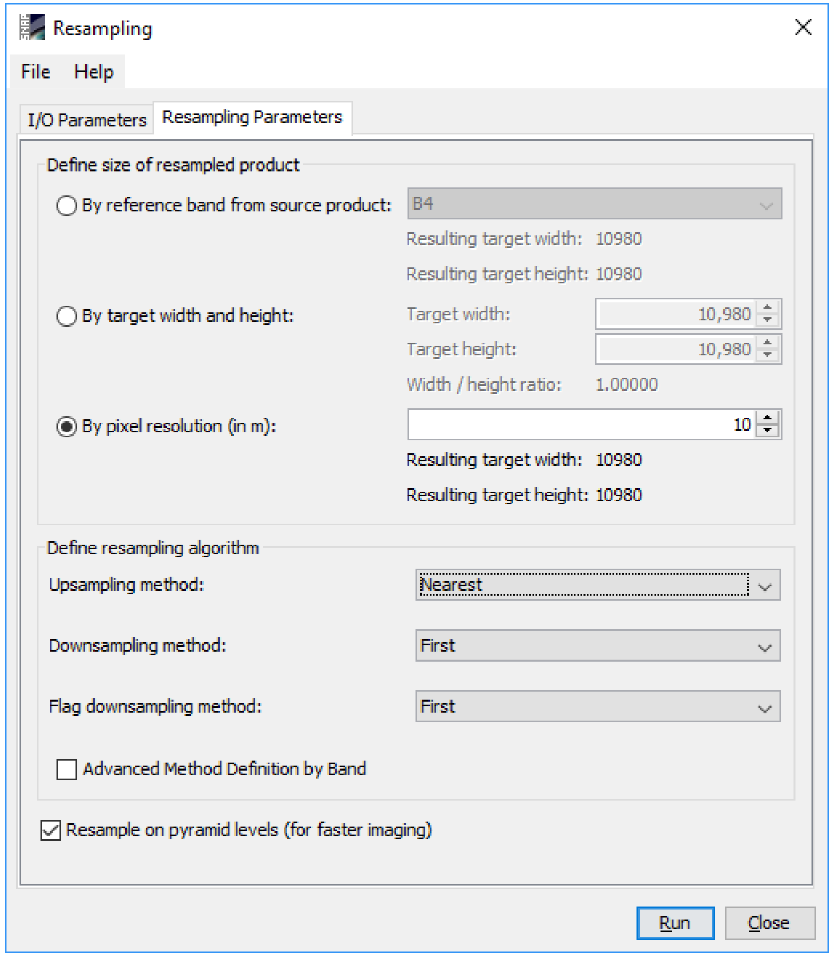
Resampling

1) Select the product in the Product Explorer window.
2) Click on ‘Raster’ → ‘Geometric Operations’ → ‘Resampling’

In the pop-up window set up the parameters as shown in the Figures:

- ✓ Unselect ‘Save as:’
- ✓ ‘10m’ as pixel resolution
- ✓ ‘Nearest’ as Upsampling method
- ✓ Click on ‘Run’



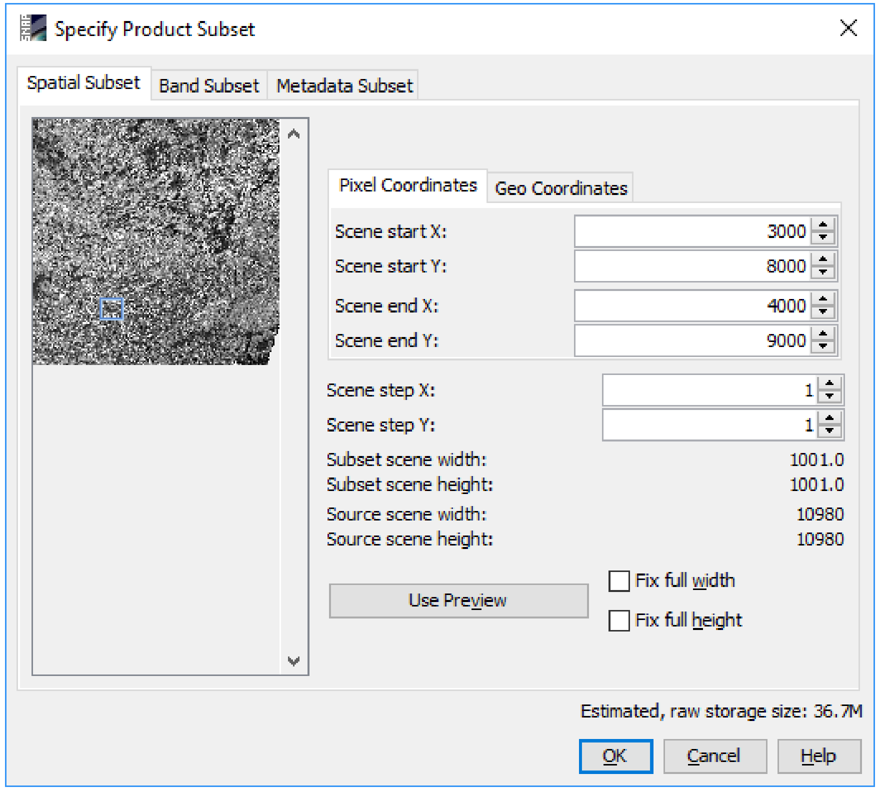


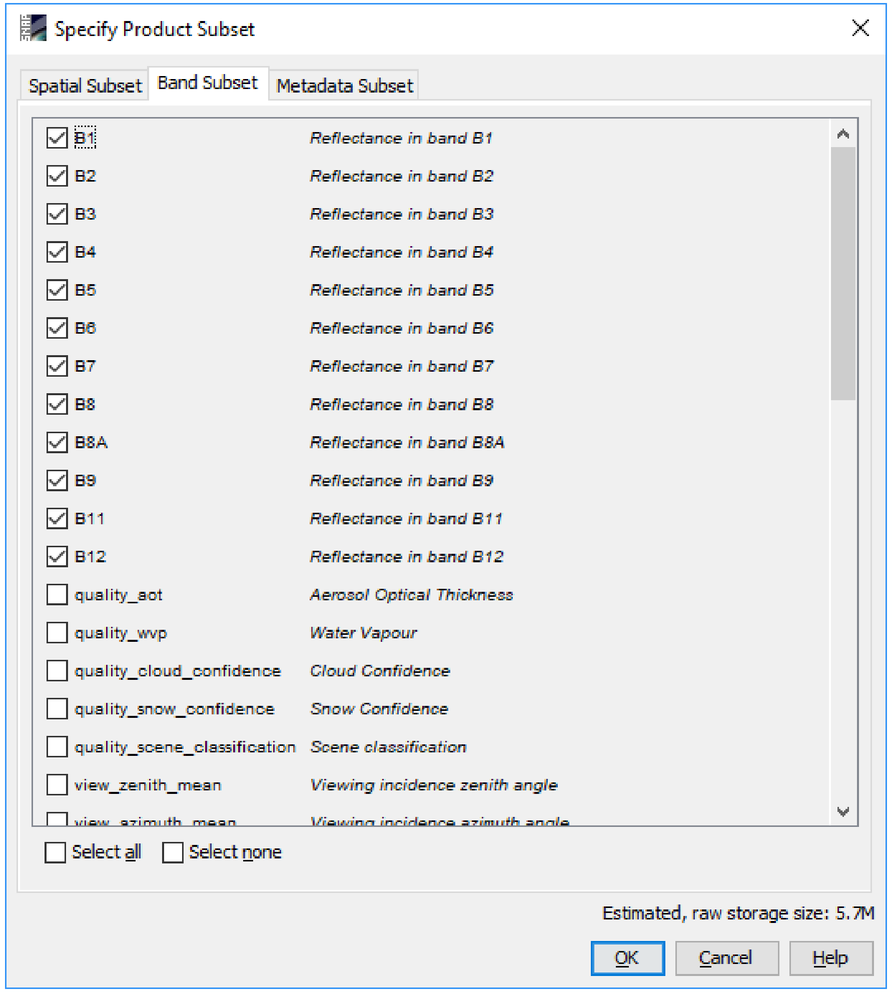
Subset (spatially/spectrally)

1) Select the new product in the Product Explorer window.
2) Click on ‘Raster’ → ‘Subset…’

In the pop-up window set up the parameters as shown in the Figures:

- ✓ Define the X and Y pixels range or the X and Y geo-coordinates to crop the input product
- ✓ Define which bands you want to export
- ✓ Click on ‘Run’



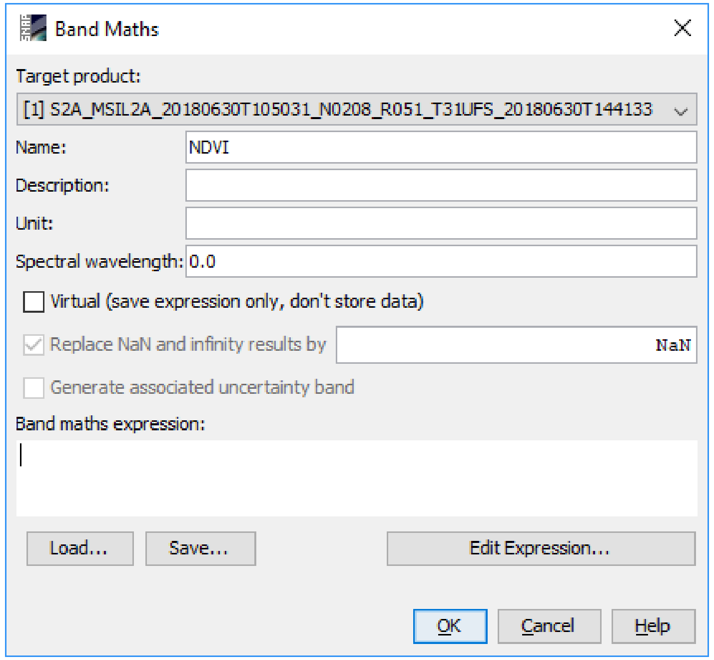


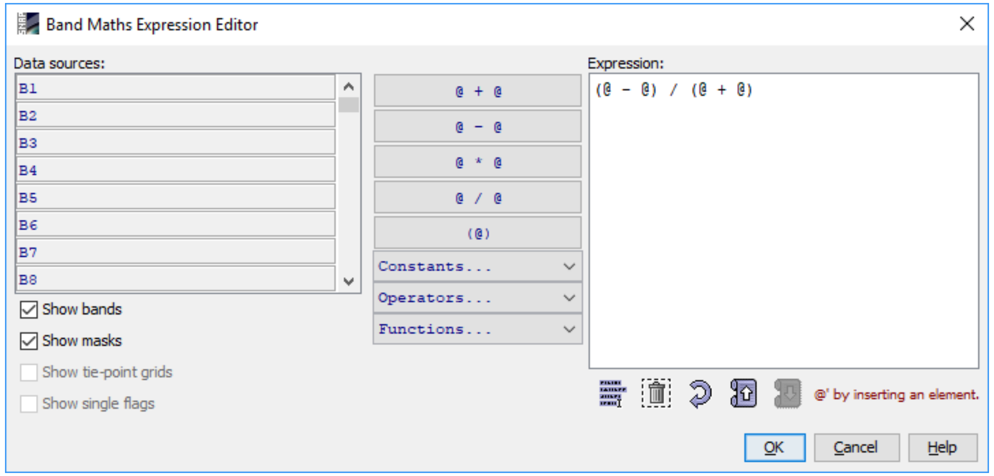
Band Maths (e.g. NDVI)

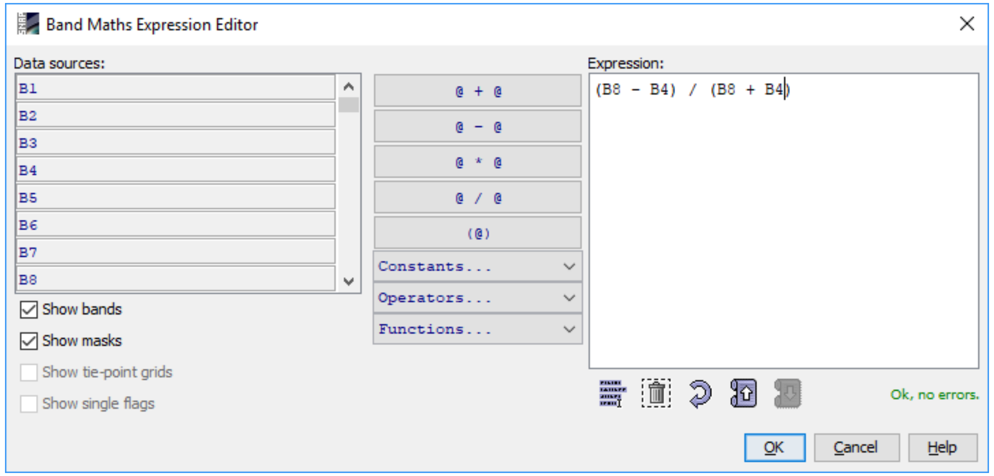
1) Select the product in the Product Explorer window.
2) Click on 'Raster' → 'Band Maths…'

In the pop-up window set up the parameters as shown in the Figures:

- ✓ Change the Name: 'NDVI'
- ✓ Unselect 'Virtual' box
- ✓ Click on 'Edit Expression…'
- ✓ Create your expression using '@' and after replace them with the bands
  - ✓ *(@ - @) / (@ + @)*
  - ✓ *(B8 – B4) / (B8 + B4)*
- ✓ Click on 'Run'







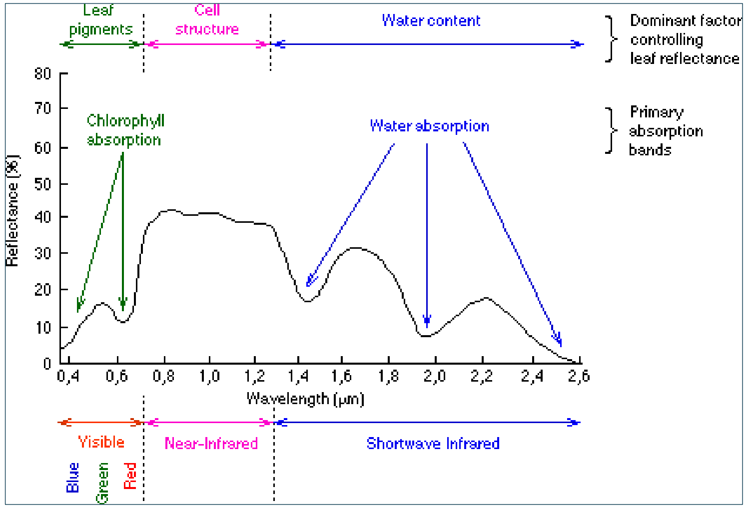
Normalized Difference Vegetation Index (NDVI)

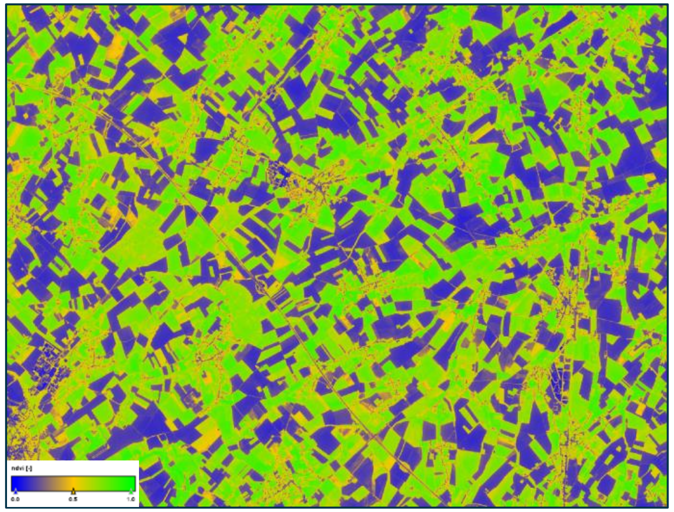
The Normalized Difference Vegetation Index (NDVI) algorithm exploits the strength and the vitality of the vegetation on the earth's surface.

Even if it is an old and classic method it is still much used to estimate the health of green vegetation and post processed high definition images for precision agriculture.

- *Vegetation has high NIR and low Red reflectance*
- *Other land cover have NIR and Red which are much close together*
- *-1.0 to +1.0*
- *vegetation from 0.3 to 0.8, depending on health/intensity*
- *water (sea, lakes, rivers) low positive or even negative*
- *bare soil low positive values from 0,1 to 0,2*

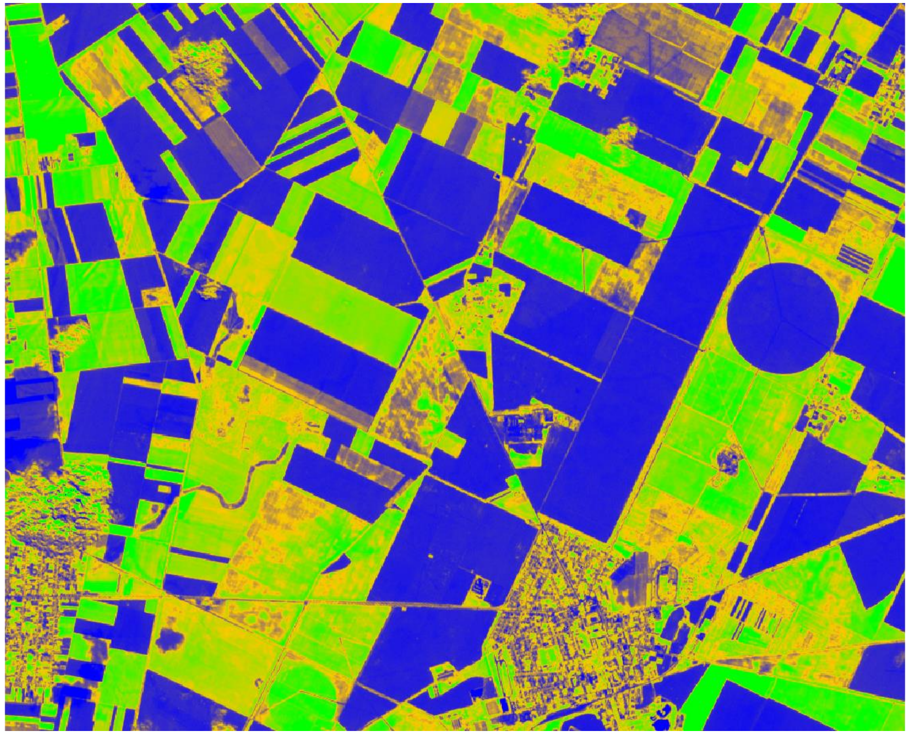
$$NDVI = \frac{(NIR - Red)}{(NIR + Red)} = \frac{(B_8 - B_4)}{(B_8 + B_4)}$$





Enhanced Vegetation Index (EVI)

The enhanced vegetation index (EVI) is an 'optimized' vegetation index designed to enhance the vegetation signal with improved sensitivity in high biomass regions and improved vegetation monitoring through a de-coupling of the canopy background signal and a reduction in atmosphere influences. EVI is computed following this equation:



$$EVI = G \times \frac{(NIR - Red)}{(NIR + C_1 \times Red - C_2 \times Blue + L)} = \frac{(\boldsymbol{B_8} - \boldsymbol{B_4})}{(\boldsymbol{B_8} + 6 \times \boldsymbol{B_4} - 7.5 \times \boldsymbol{B_2} + 1)}$$

where:

- NIR/red/blue are atmospherically-corrected and partially atmosphere corrected (Rayleigh and ozone absorption) surface reflectances
- L is the canopy background adjustment that addresses non-linear, differential NIR and red radiant transfer through a canopy
- C1, C2 are the coefficients of the aerosol resistance term, which uses the blue band to correct for aerosol influences in the red band.

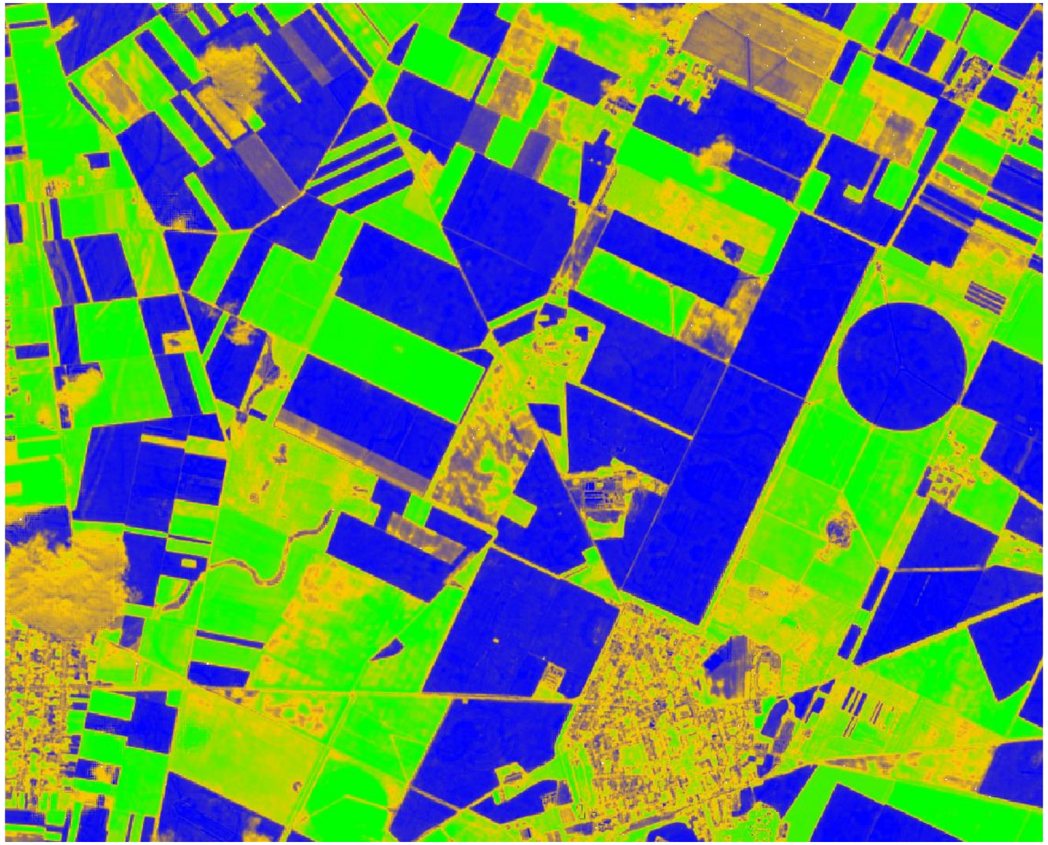
The coefficients adopted Sentinel-2 are: L=1, C_1 = 6, C_2 = 7.5, and G (gain factor) = 2.5.

Normalized Difference Moisture Index (NDMI)

The Normalized Difference Moisture Index (NDMI) detects moisture levels in vegetation using a combination of near-infrared (NIR) and short-wave infrared (SWIR) spectral bands. It is a reliable indicator of water stress in crops.

NDMI can detect water stress at an early stage, before the problem has gone out of hand. Further, using NDMI to monitor irrigation, especially in areas where crops require more water than nature can supply, helps to significantly improve crop growth.

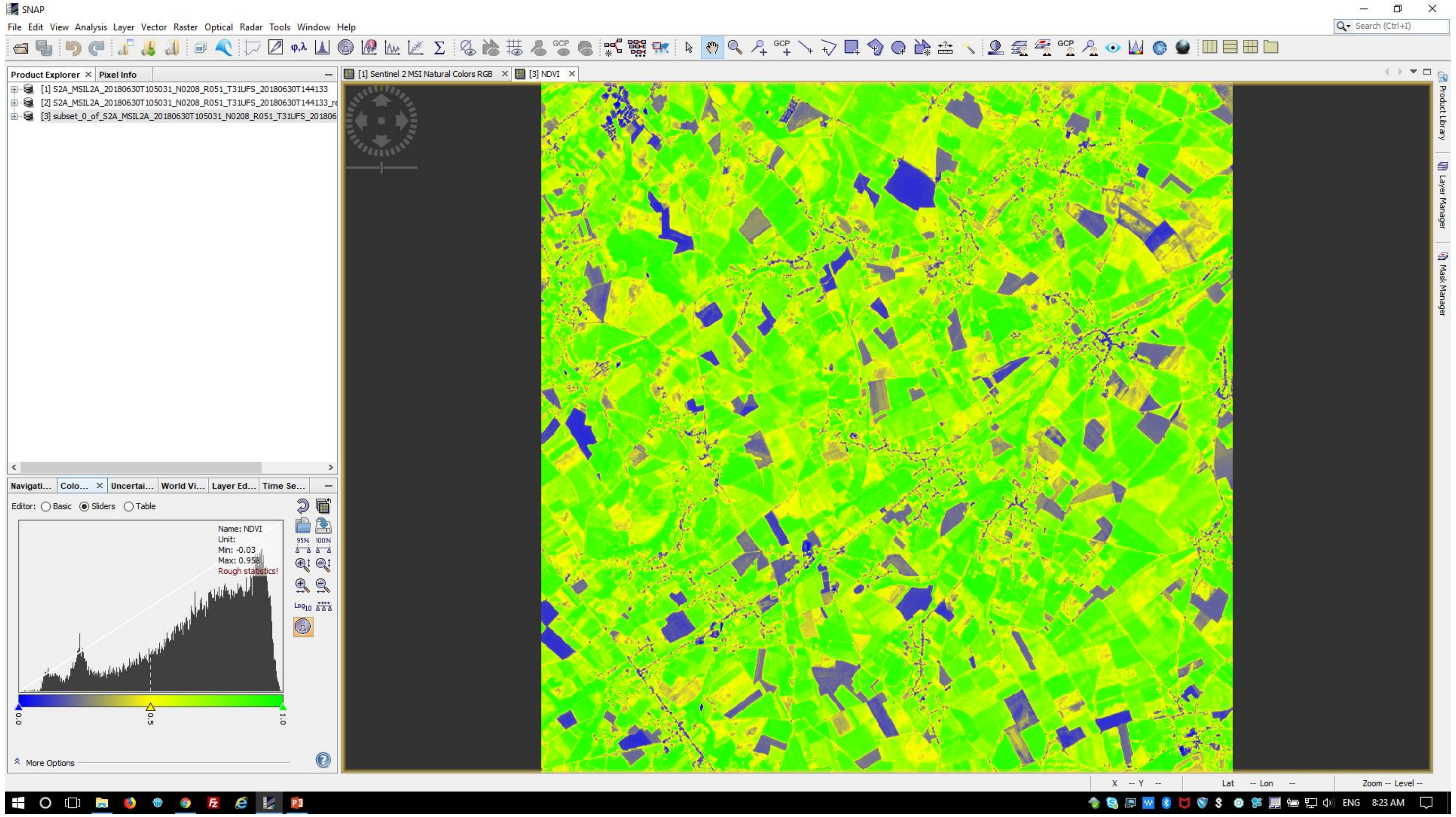
$$NDMI = \frac{NIR - SWIR_1}{NIR + SWIR_1} = \frac{(\boldsymbol{B_8} - \boldsymbol{B_{11}})}{(\boldsymbol{B_8} + \boldsymbol{B_{11}})}$$



Output Visualization

When the processing is finished the output will be automatically opened in the ‘Product Explorer’ of SNAP Select the product in the Product Explorer window.

Using the Colour Manipulation (bottom left) you can modify the colour palette.



SNAP Radiometric Indices

Radiometric indices are quantitative measures of features that are obtained by combining several spectral bands

Vegetation indices

- *DVI, RVI, PVI*
- *NDVI, WDVI, TNDVI, GNDVI*
- *SAVI, TSAVI, MSAVI, MSAVI2*
- *GEMI*
- *ARVI*
- *NDI45*
- *MTCI, MCARI, PSSRa*
- *S2REP, REIP, IRECI*

Soil indices

- *BI*
- *BI2*
- *RI*
- *GEMI*

Water indices

- *NDWI*
- *NDWI2*
- *MNDWI*
- *NDPI*
- *NDTI*

Biophysical processor (L2B)

1) Select the new product in the Product Explorer window.
2) Click on ‘Optical’ → ‘Thematic Land Processing’ → ‘Biophysical processor (LAI, fAPAR, …)’

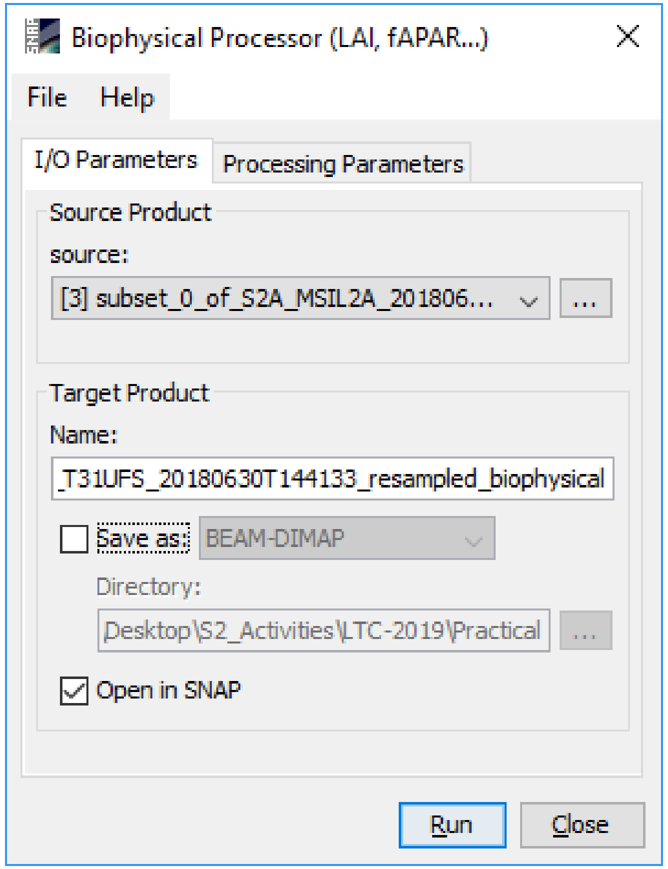
In the pop-up window set up the parameters as shown in the Figures:

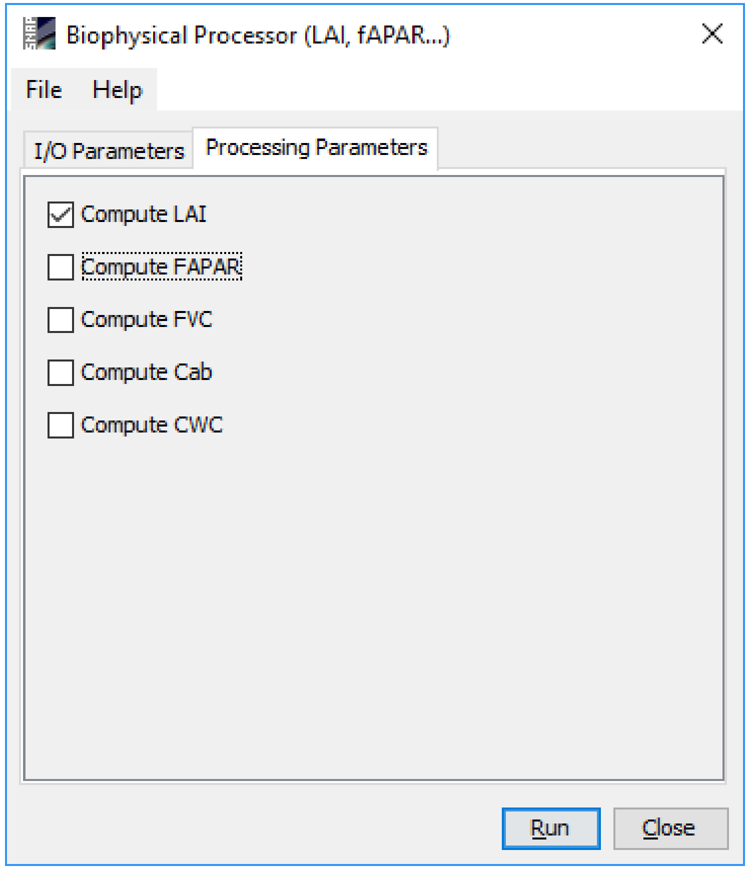
✓ Unselect ‘Save as:’

✓ Select only ‘LAI’

✓ Click on ‘Run’

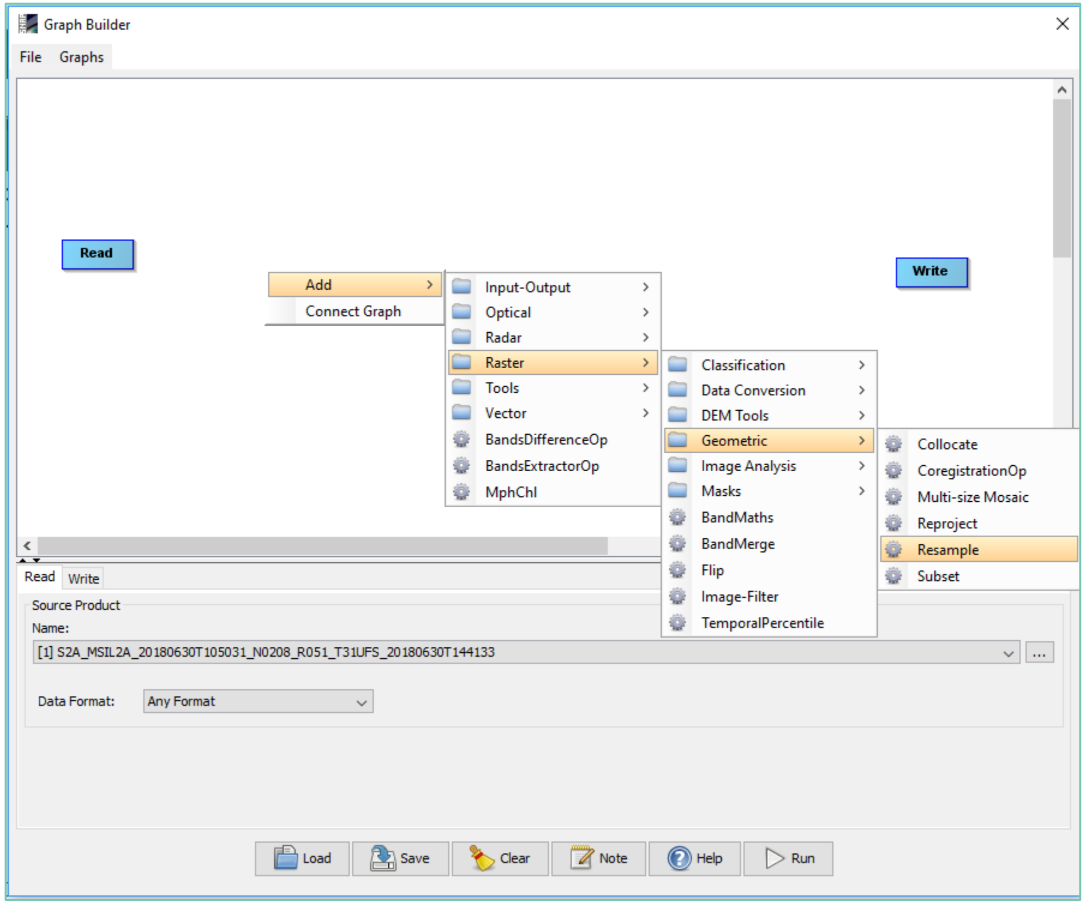
- LAI: Leaf Area Index
- fAPAR: Fraction of Absorbed Photosynthetically Active Radiation
- FVC: Fraction of vegetation cover
- Cab: Chlorophyll content in the leaf
- CWC: Canopy Water Content





SNAP GraphBuilder

The Graph Builder allows the user to assemble graphs from a list of available operators and connect operator nodes to their sources.
Right click on the top panel to add an Operator.



SNAP GraphBuilder

We can create our processing chain adding to the default blocks ‘Read’ and ‘Write’:

‘Rempling’
‘Raster’ → ‘Geometric’ → ‘Resample’

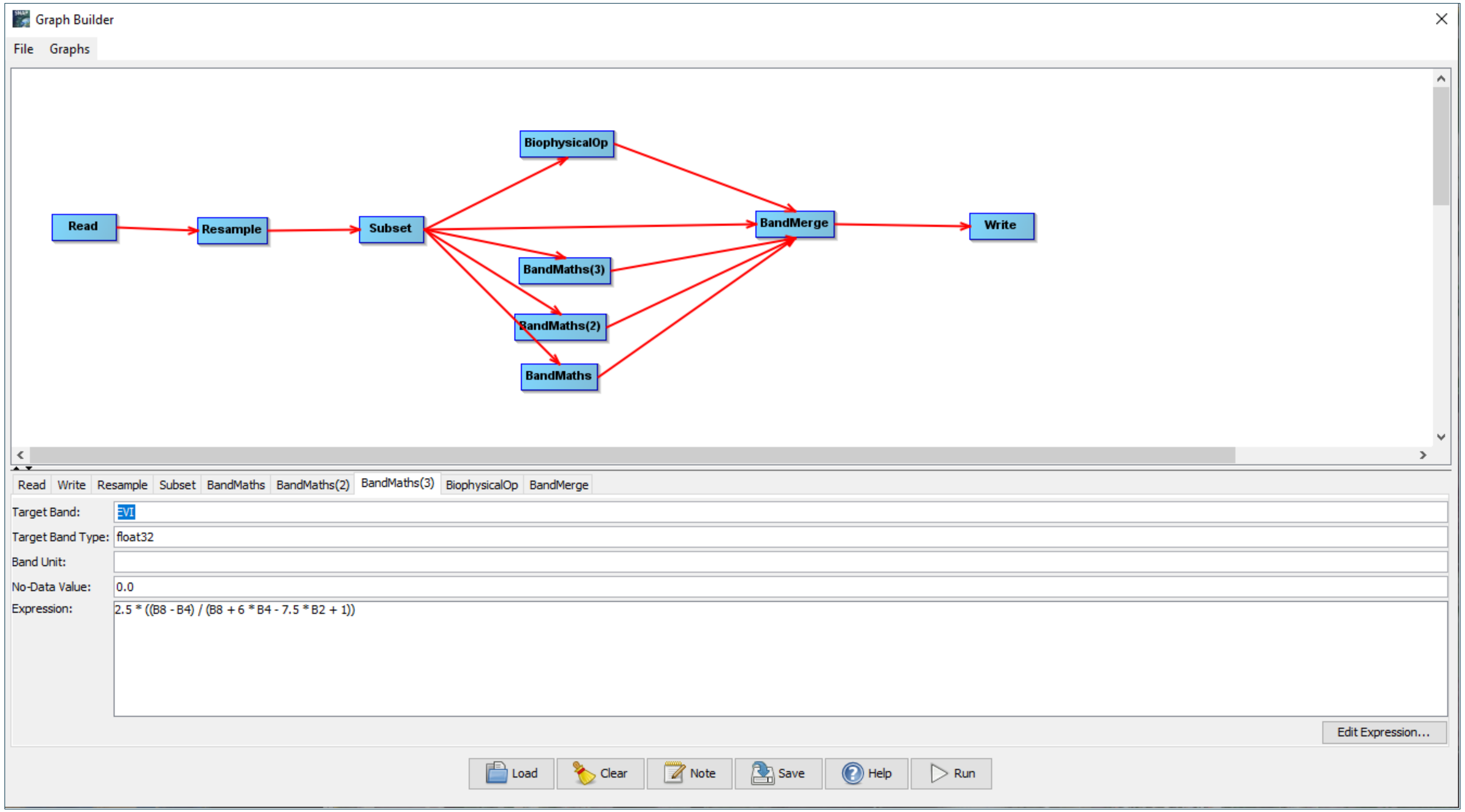
‘Subset’
‘Raster’ → ‘Geometric’ → ‘Subset’

‘Band Maths’
‘Raster’ → ‘BandMaths’

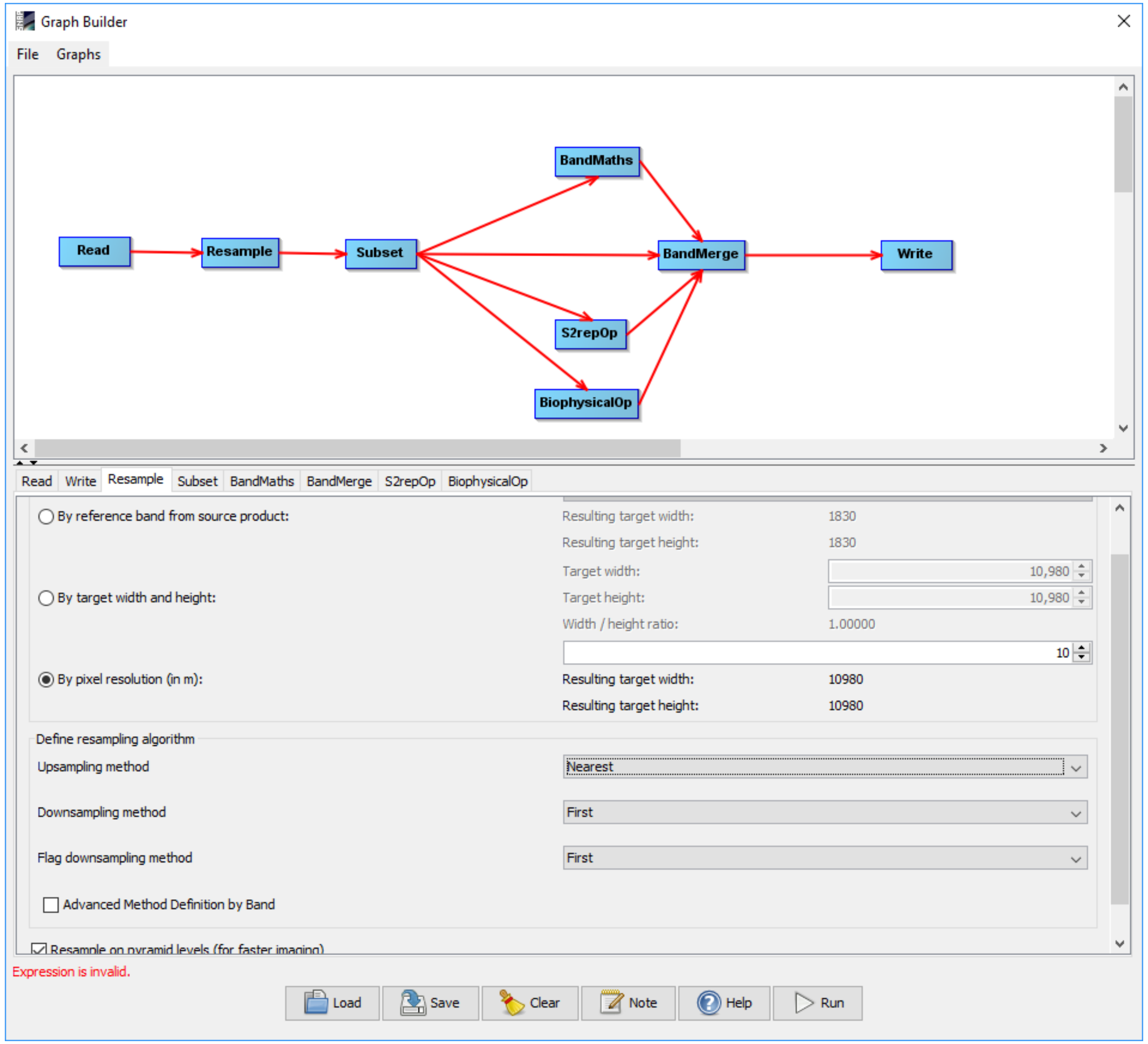
‘S2rep’ (S2 Red-Edge Position Index)
‘Optical’ → ‘Them. Land Proc.’ → ‘Veg. Rad. Ind.’ → ‘S2repOp’

‘Biophysical Processor’
‘Optical’ → ‘Thematic Land Processing’ → ‘BiophysicalOp’

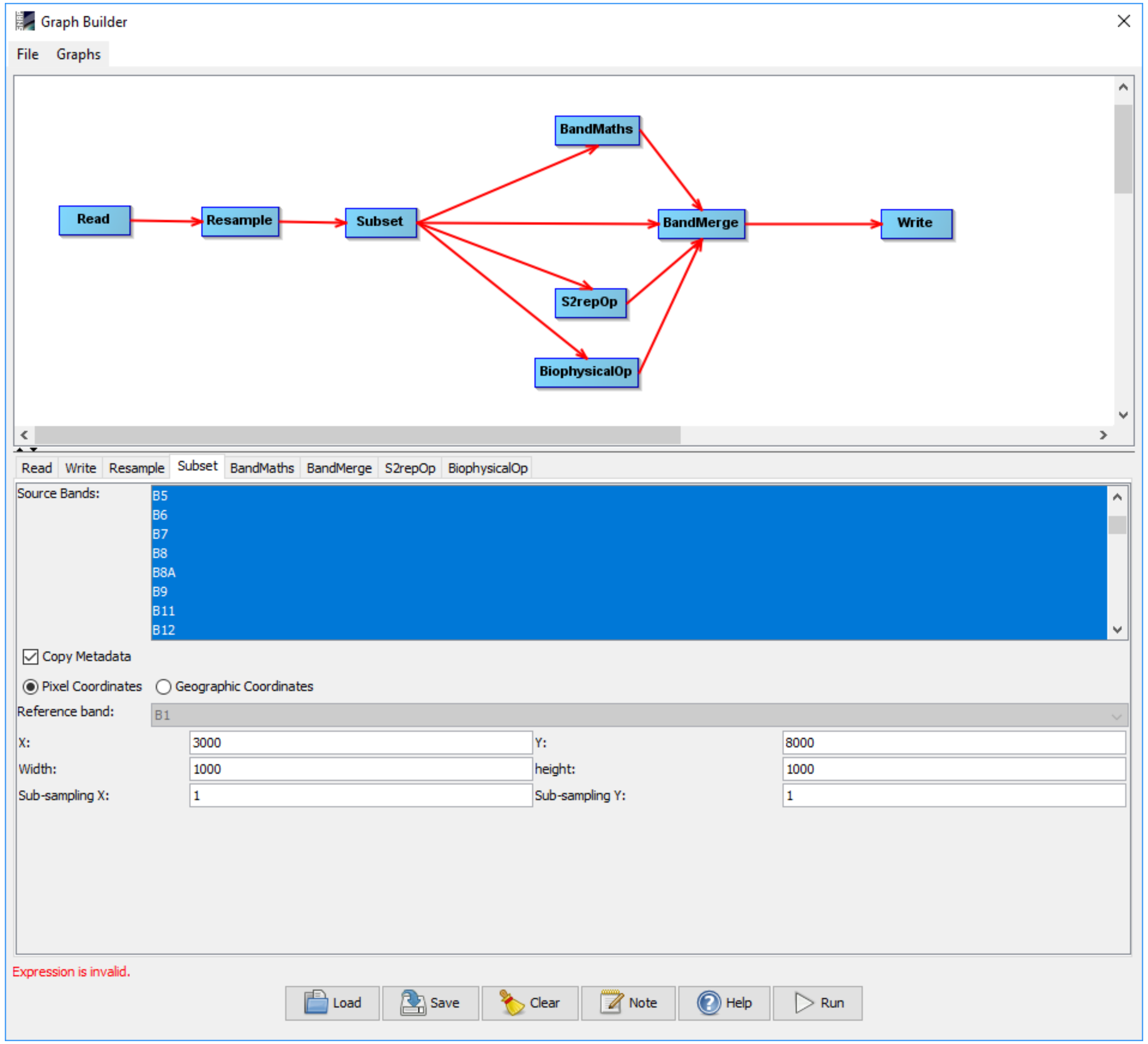
‘Band Merge’
‘Raster’ → ‘BandMerge’



GraphBuilder (Resample module)



GraphBuilder (Subset module)

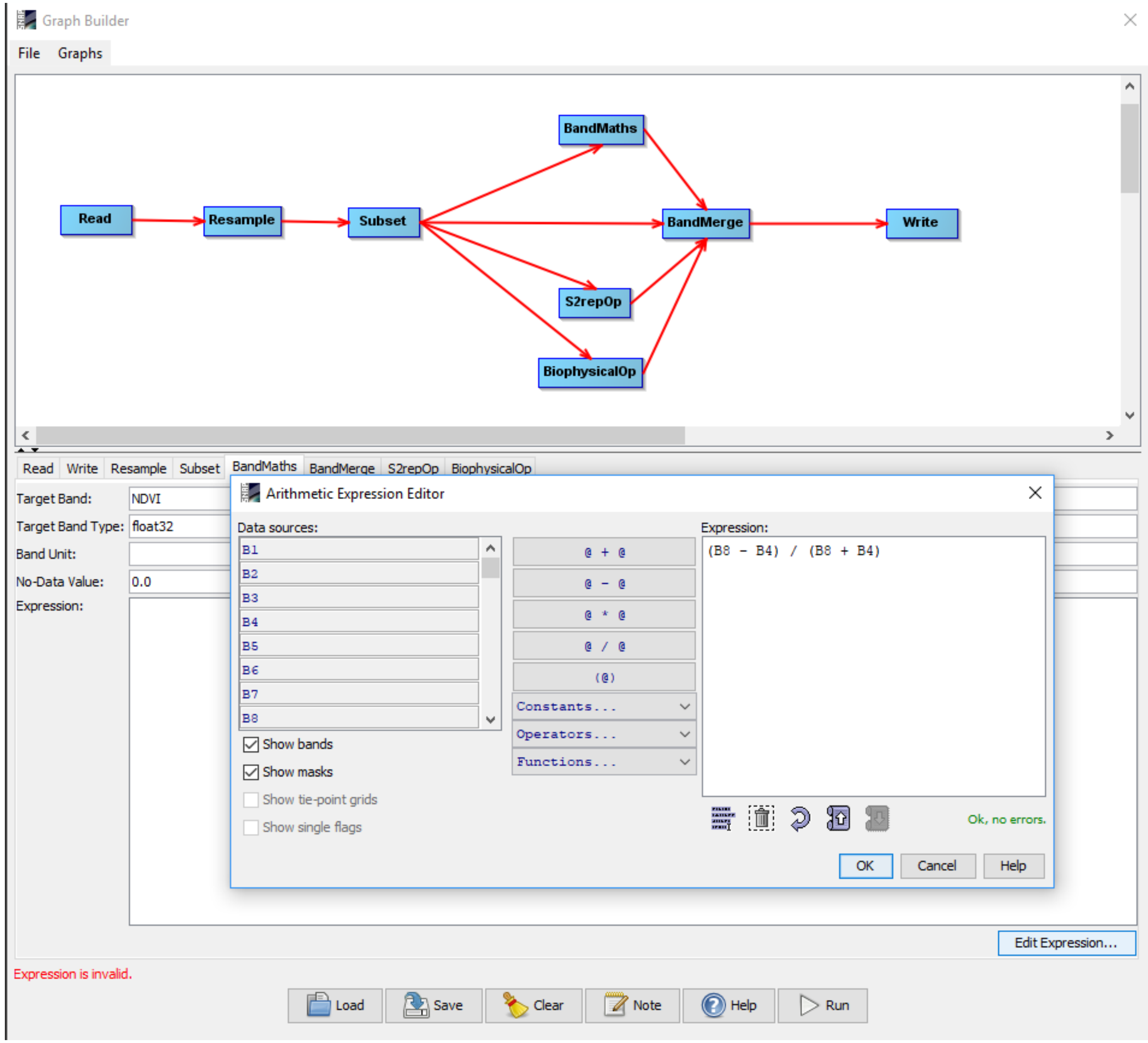


GraphBuilder (BandMaths module)

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)} = \frac{(B_8 - B_4)}{(B_8 + B_4)}$$

$$EVI = G \times \frac{(NIR - Red)}{(NIR + C_1 \times Red - C_2 \times Blue + L)} = \frac{(B_8 - B_4)}{(B_8 + 6 \times B_4 - 7.5 \times B_2 + 1)}$$

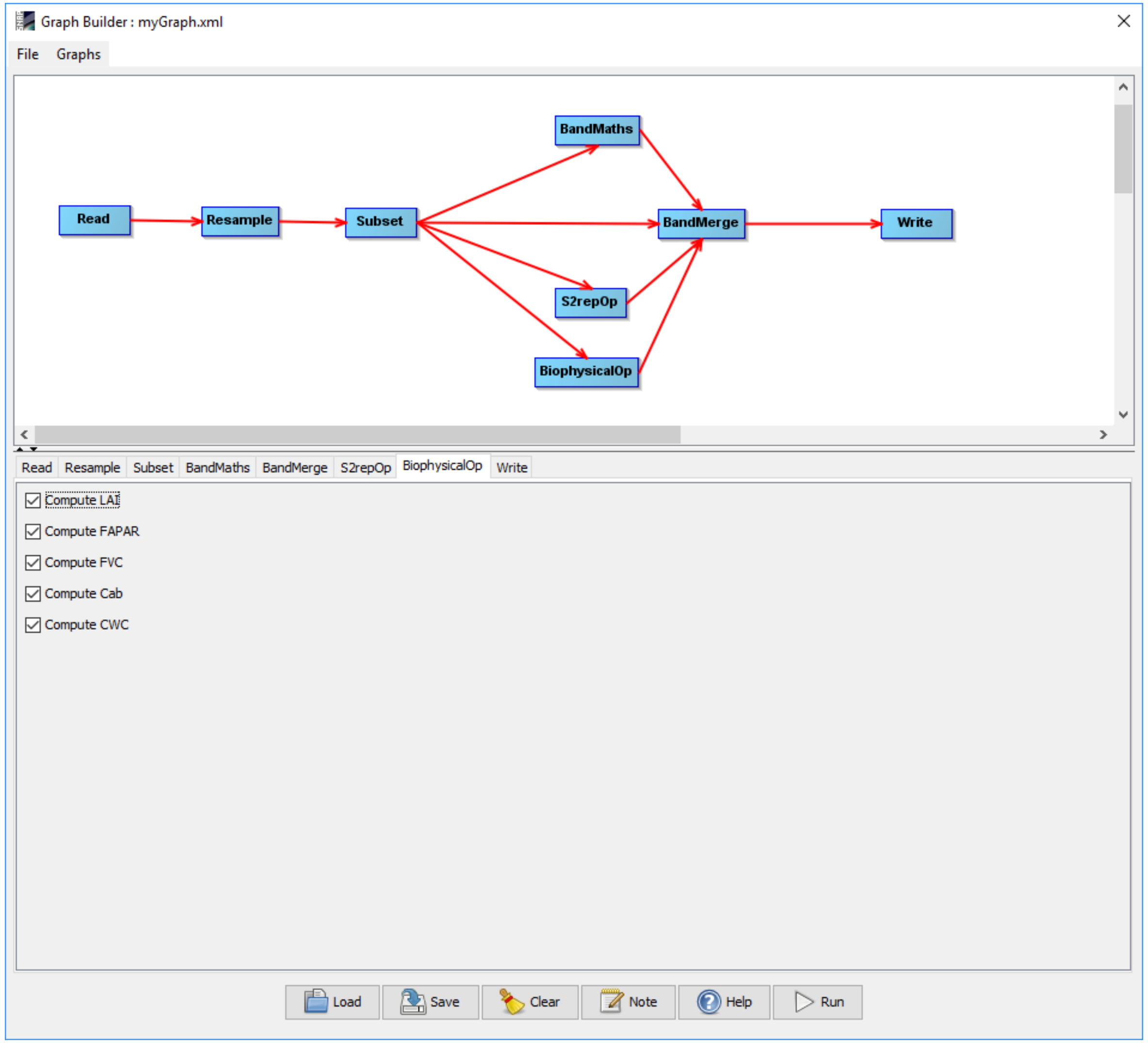
$$NDMI = \frac{NIR - SWIR_1}{NIR + SWIR_1} = \frac{(B_8 - B_{11})}{(B_8 + B_{11})}$$



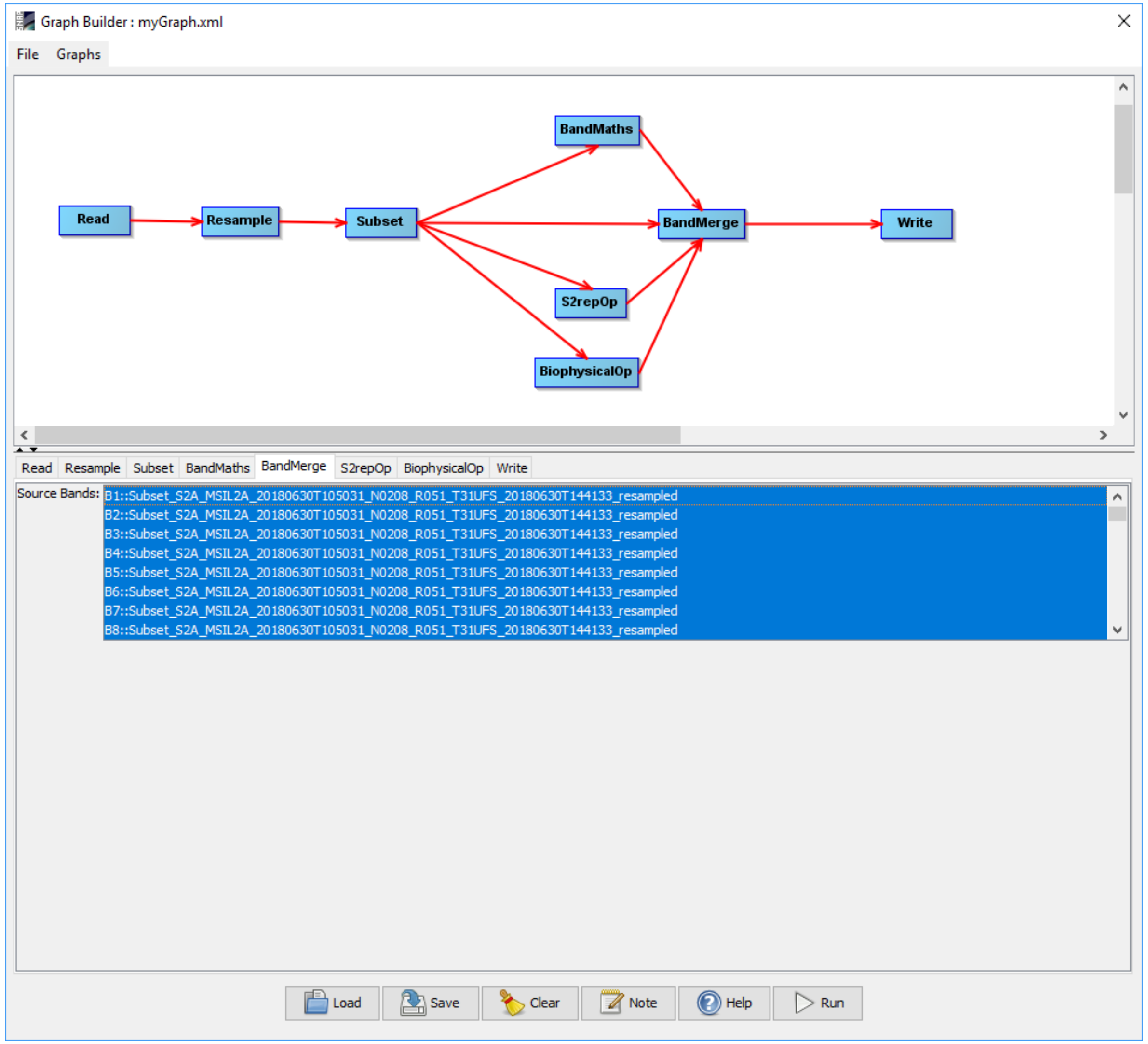
GraphBuilder (BiophysicalOp module)

The Biophysical Processor computes Level-2B Biophysical products from Sentinel-2 reflectances.
From Bottom Of Atmosphere normalized reflectance data, it derives a set of biophysical variables, namely:

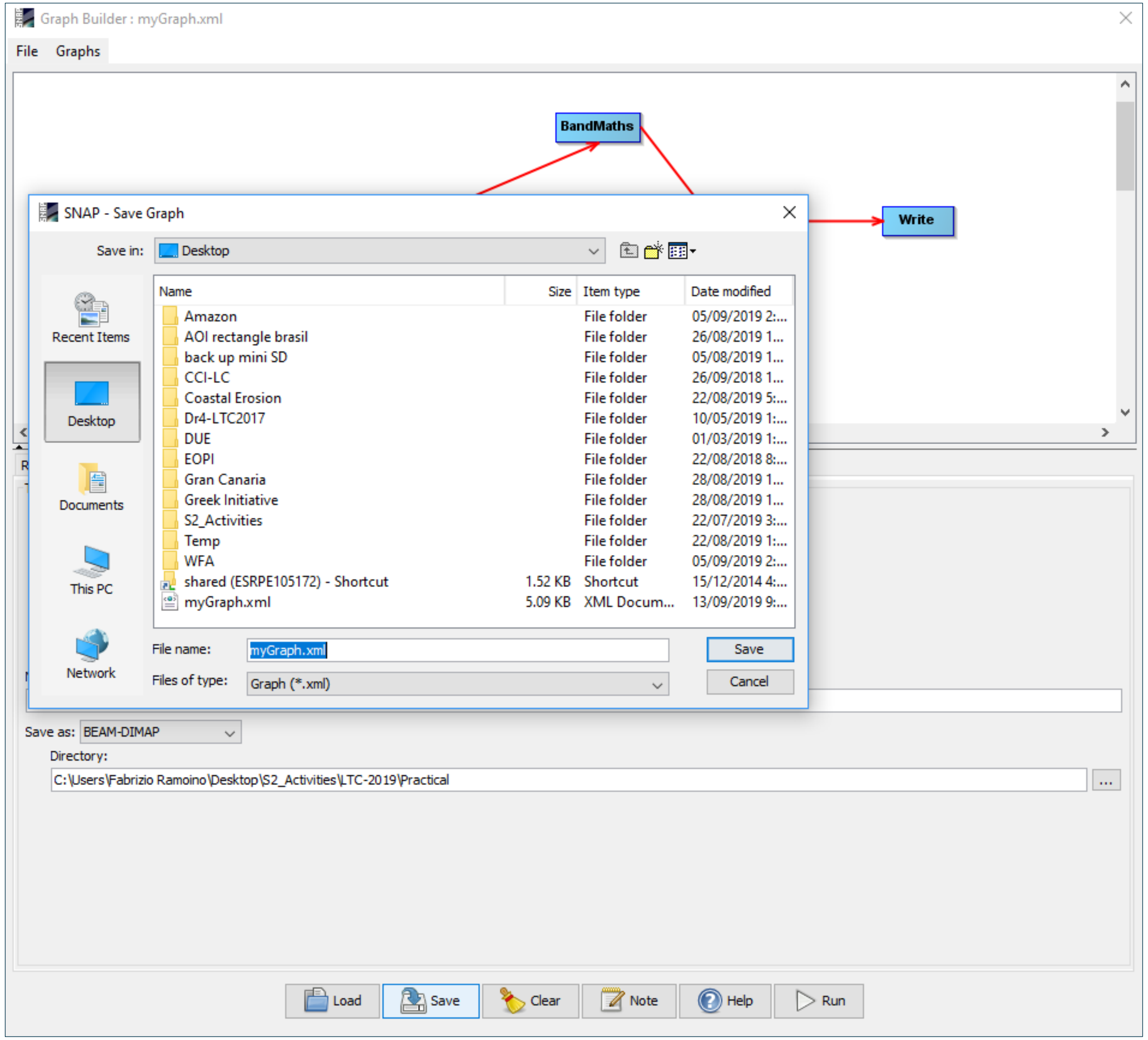
- ✓ LAI: Leaf Area Index
- ✓ fAPAR: Fraction of Absorbed Photosynthetically Active Radiation
- ✓ FVC: Fraction of vegetation cover
- ✓ Cab: Chlorophyll content in the leaf
- ✓ CWC: Canopy Water Content



GraphBuilder (Band Merge module)

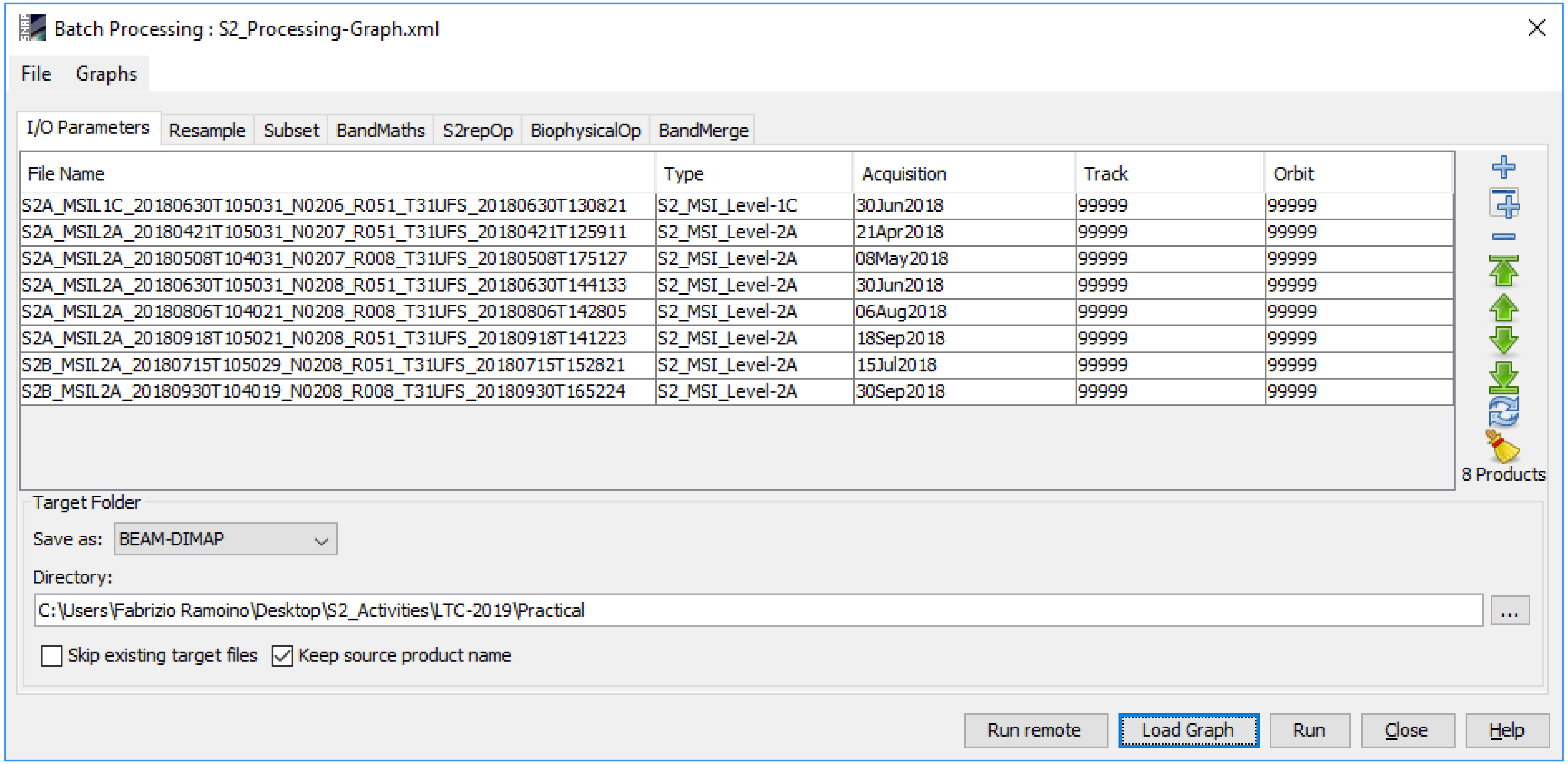


GraphBuilder (Save the graph)



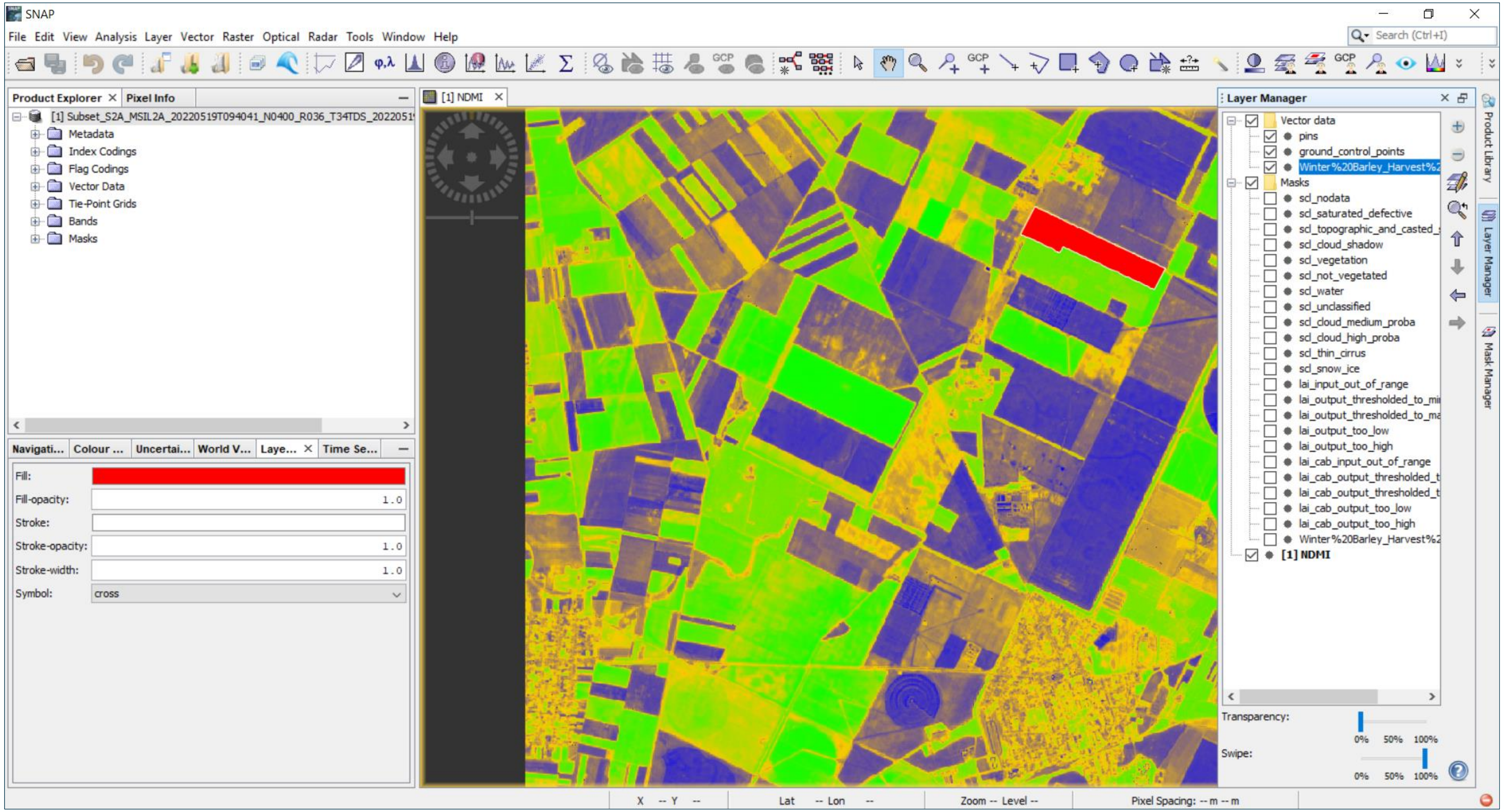
Batch Processing

The Batch Processing tool allows you to execute a single reader/writer graph for a set of products. Select the Batch Processing tool from the Graphs menu and then press the "Load" button to browse for a previously saved graph. Next, add products in the I/O tab by pressing the "Add" button. Set the target folder where the output will be written to and then press "Run“.



Import vector files (.SHP)

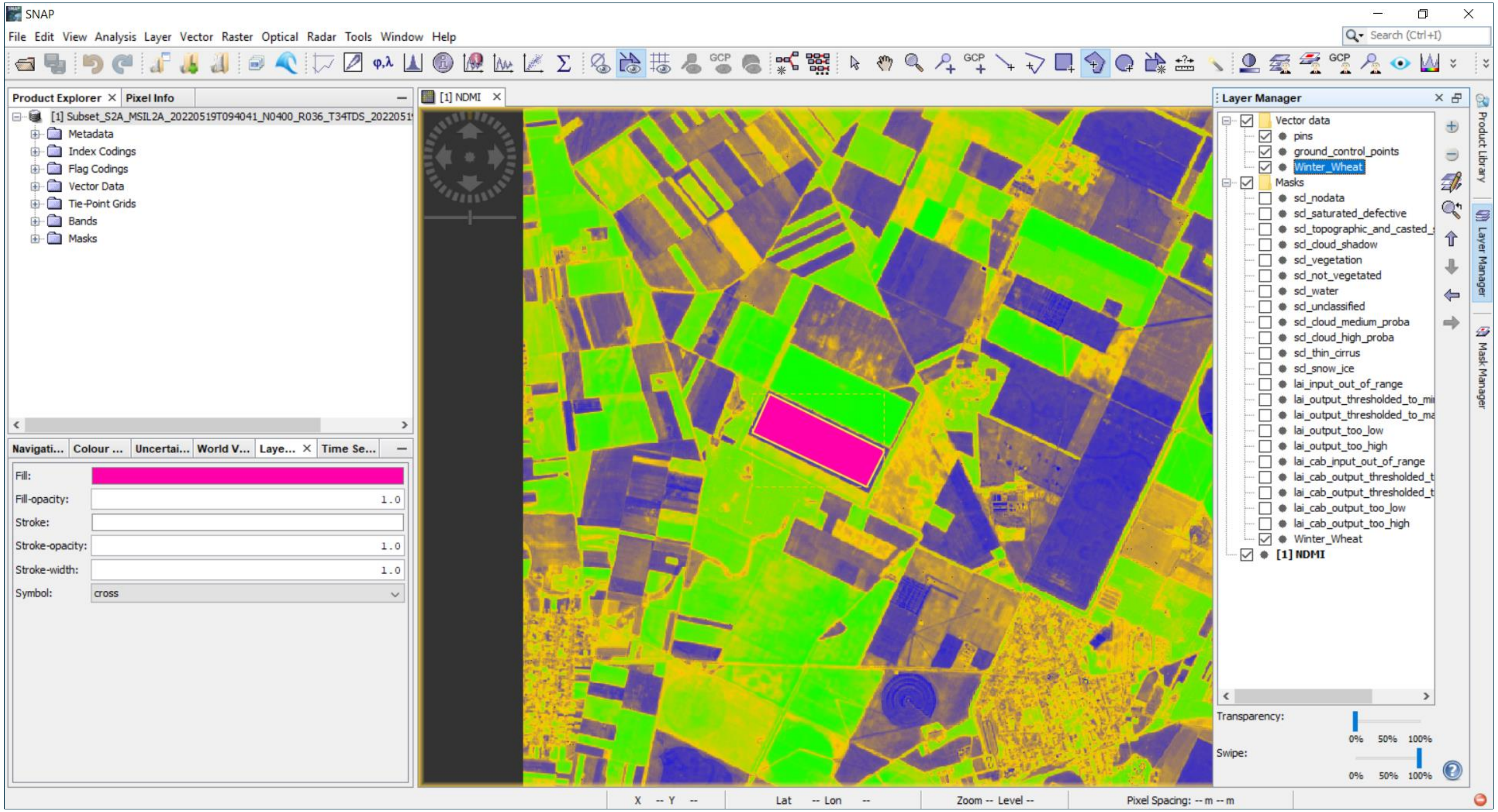
1) Select the product in the Product Explorer window.
2) Click on ‘Vector’ → ‘Import’ → ‘ESRI Shapefile’ → Select the SHP file (only one) in the ‘*\auxiliary data\extracted fields’



Vector file - Geometry

1) Select the product in the Product Explorer window.
2) Click on ‘Vector’ → ‘New Vector Data Container’

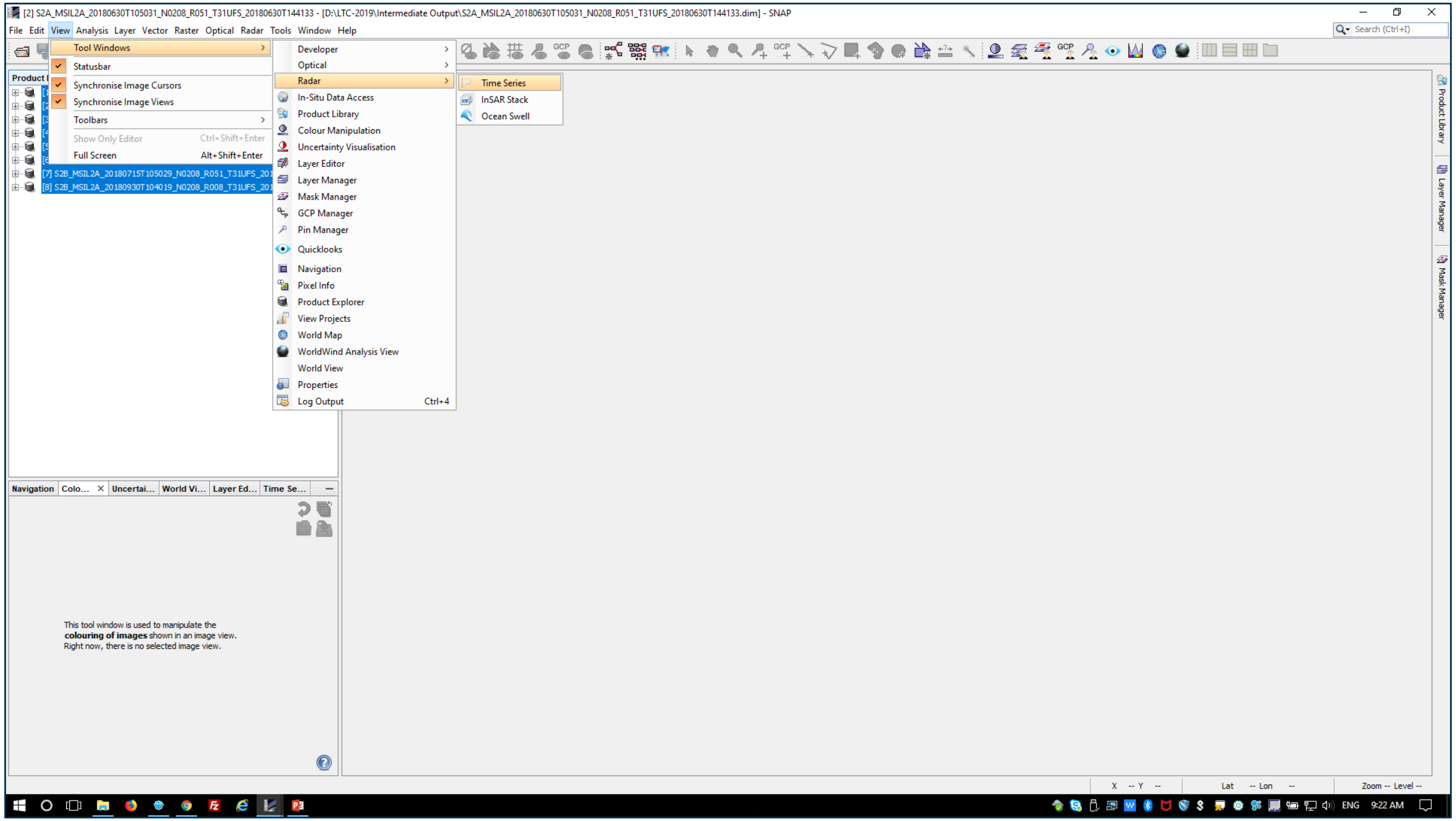
Edit the Geometry’s name
Click on the Polygon drawing tool
Draw your polygon
The polygon geometry can be used as ROI for time series analysis



Time Series

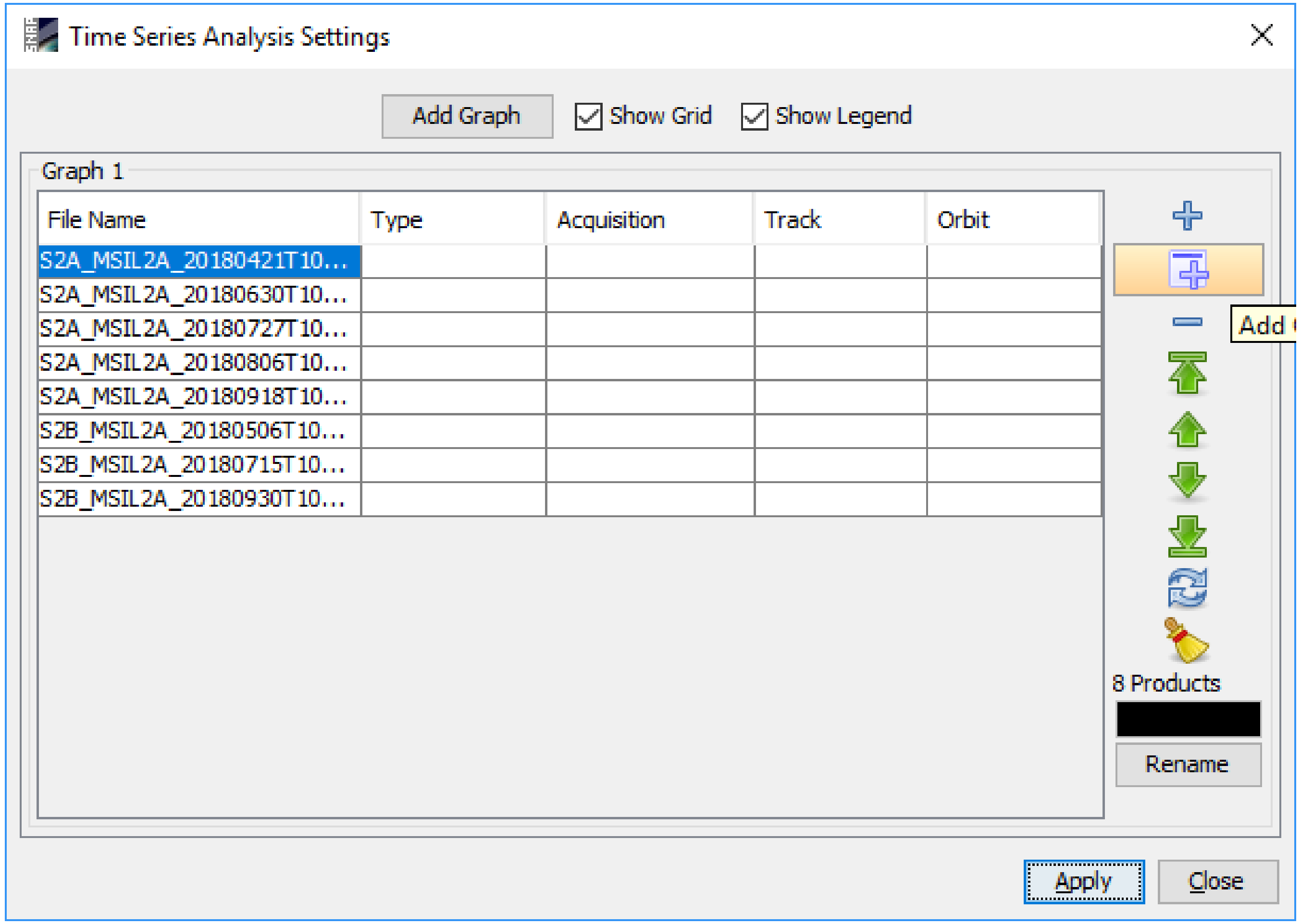
Due to the short time you can find the batch processing output in the ‘S2-Output’ folder in DIMAP format.

Open them in SNAP and then open the Time Series Window. ‘View’ → ‘Tool Windows’ → ‘Radar’ → ‘Time Series’



Time Series

To populate the time series you can add all the products opened in SNAP or browsing from your disk.



Time Series Analysis