→ 9th ADVANCED TRAINING COURSE ON LAND REMOTE SENSING: AGRICULTURE

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Université catholique de Louvain | Belgium

Practical on pre-processing of optical time series including S2

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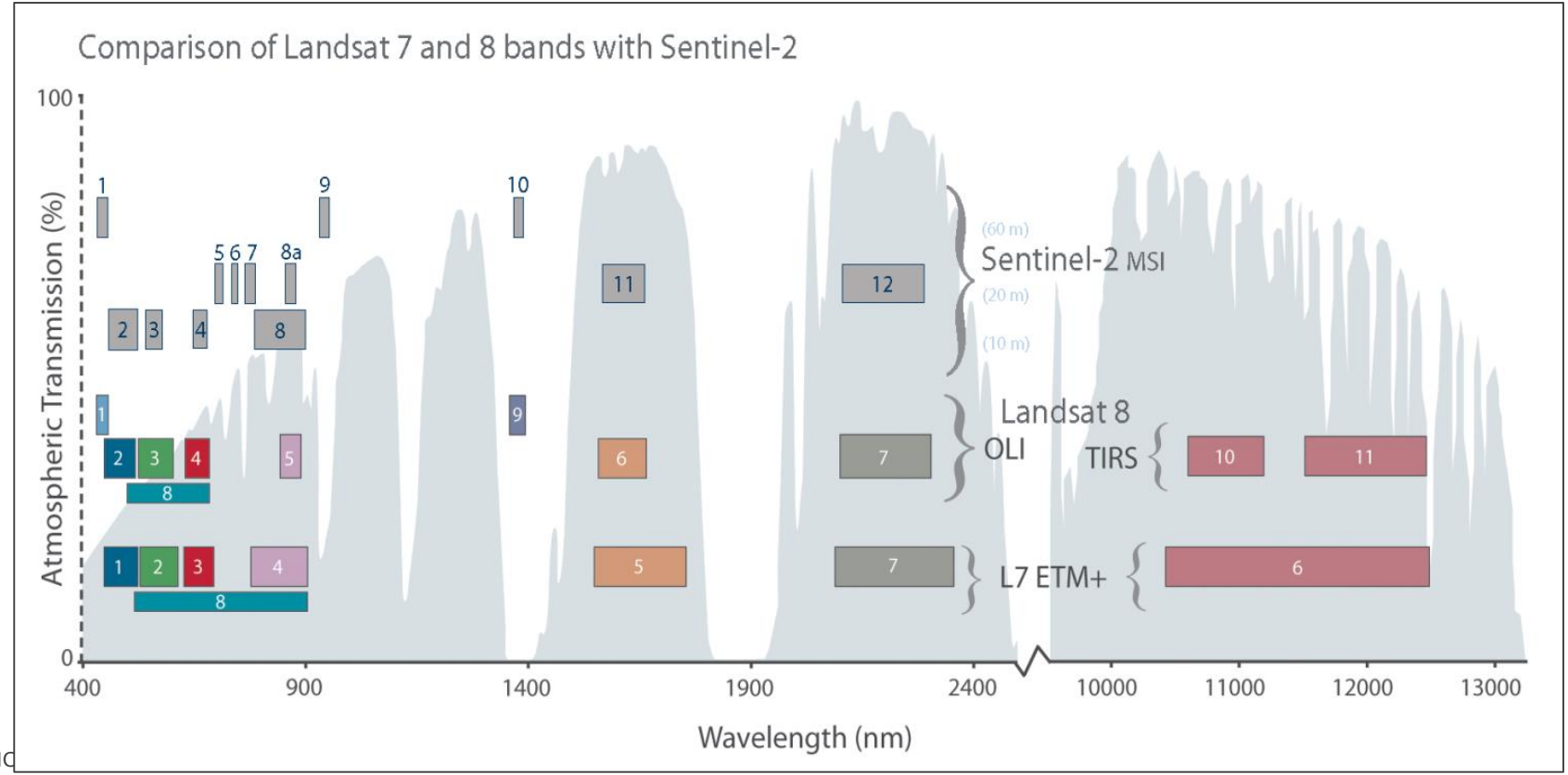
UCLouvain

Practical on pre-processing of optical time series including S2

- ✓ 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

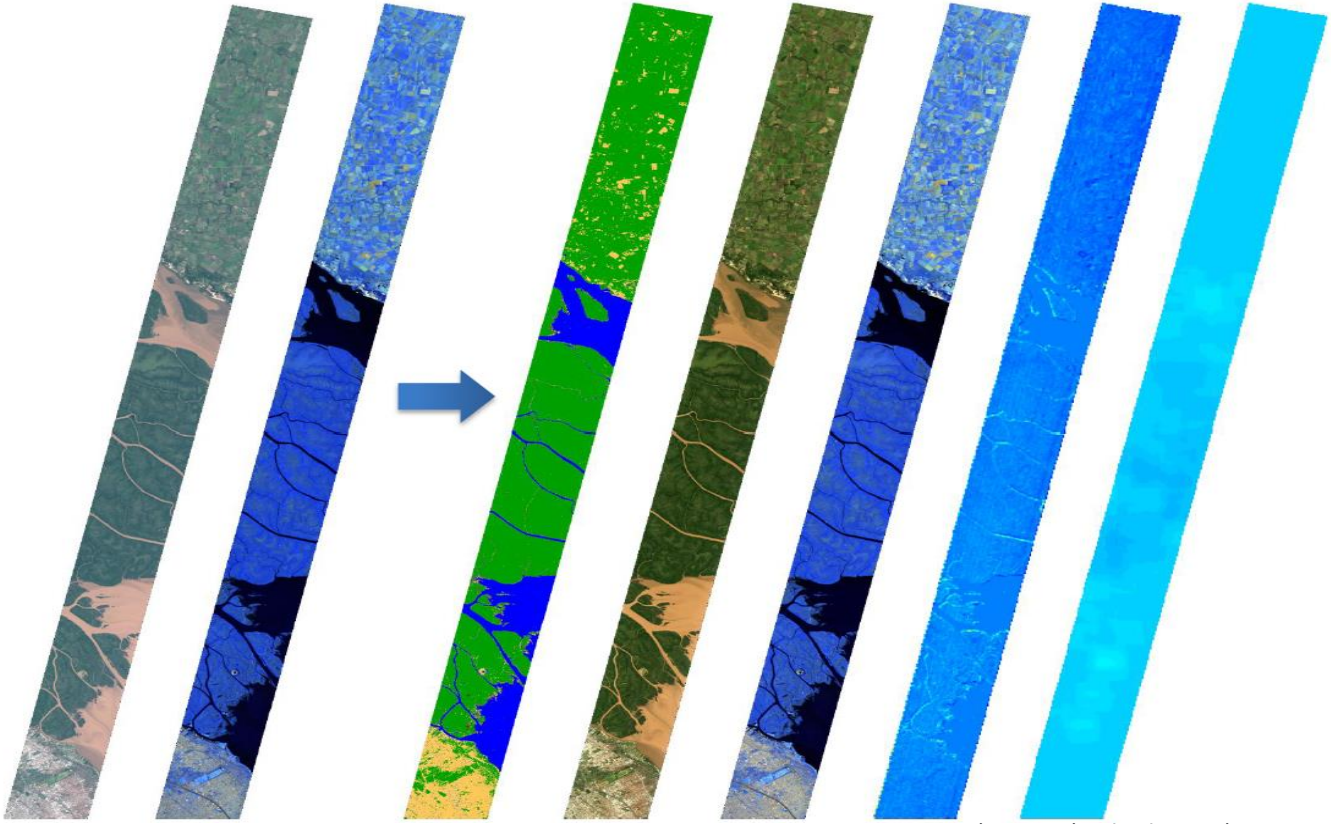
From left to right:

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

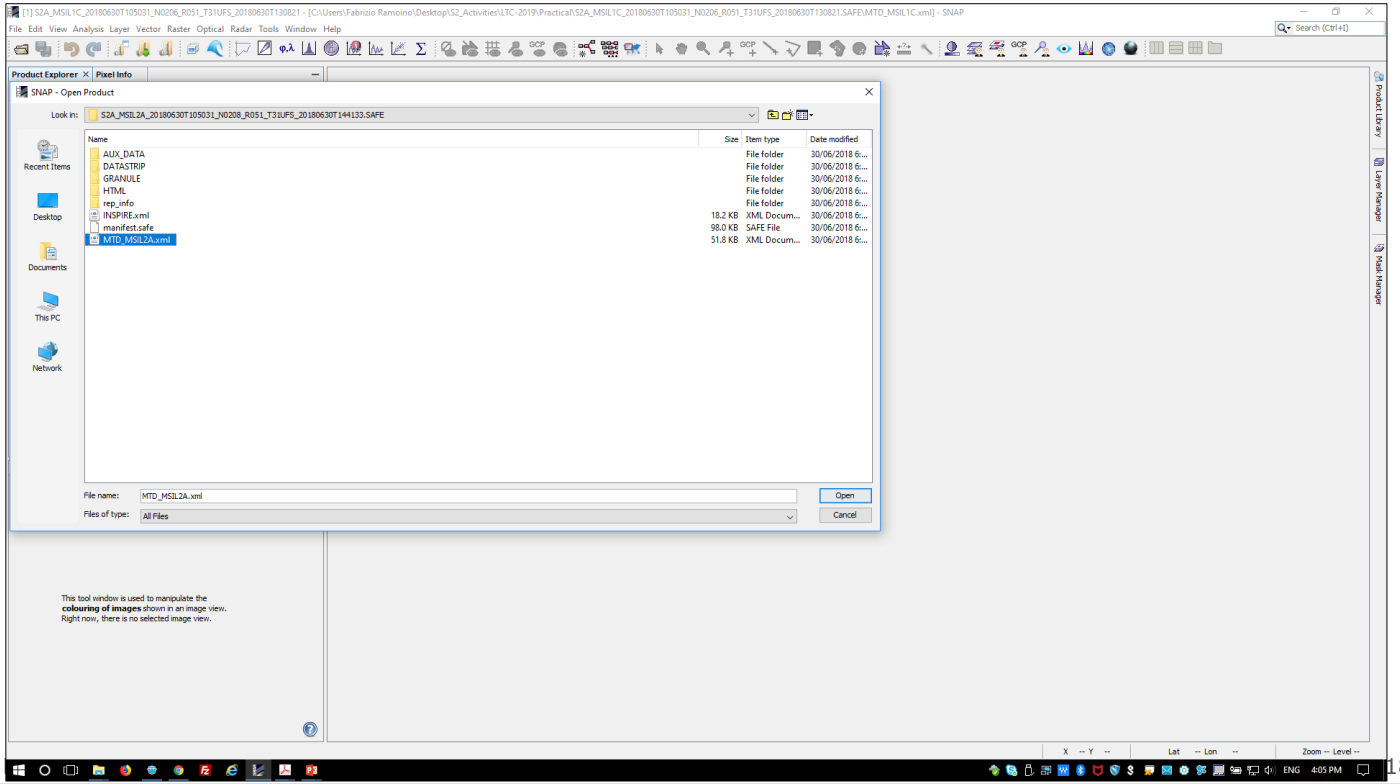
If the AOI covers more than one S2 tile in different UTM zones the user needs to re-project in a common CRS before to mosaic them.

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

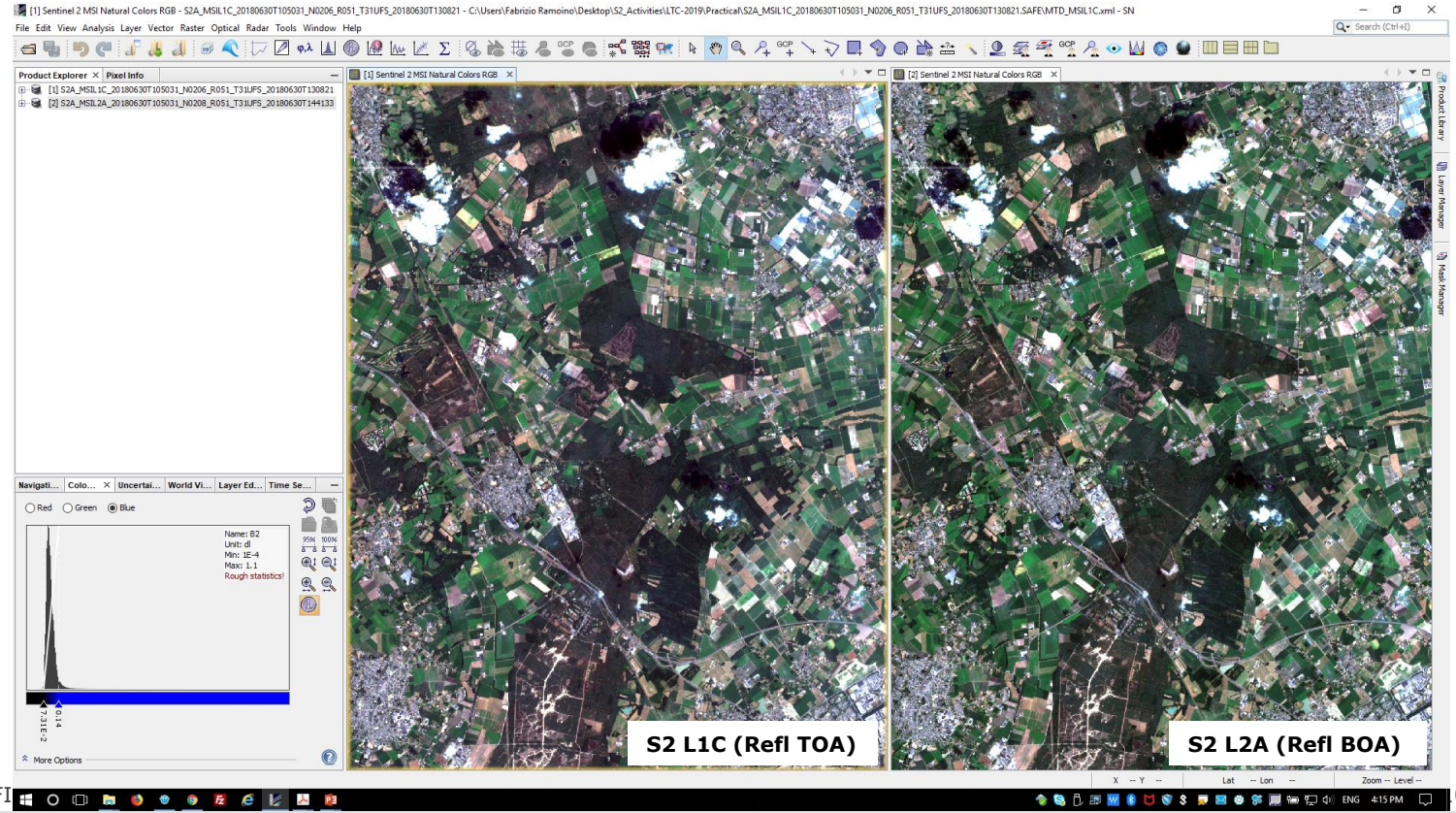
To export the view in KMZ and visualise your output in Google Earth.

Open a Sentinel-2 data

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



Visualize Sentinel-2 data

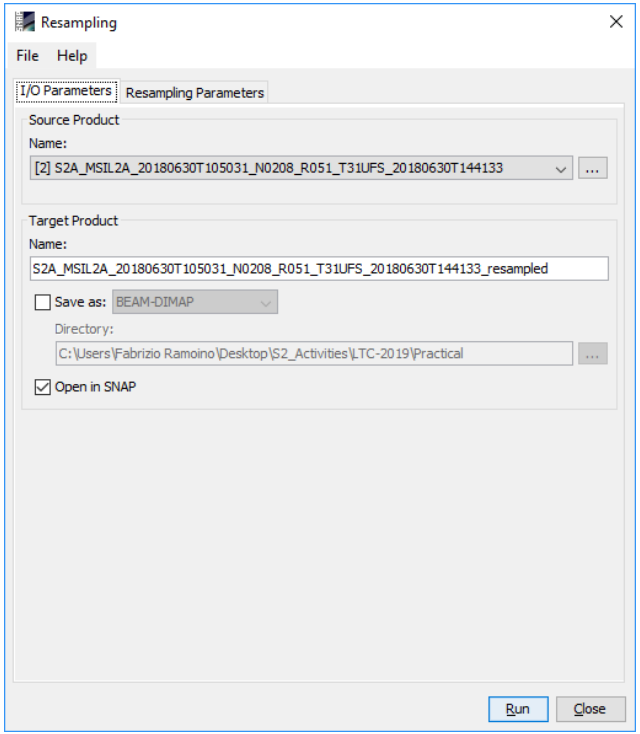


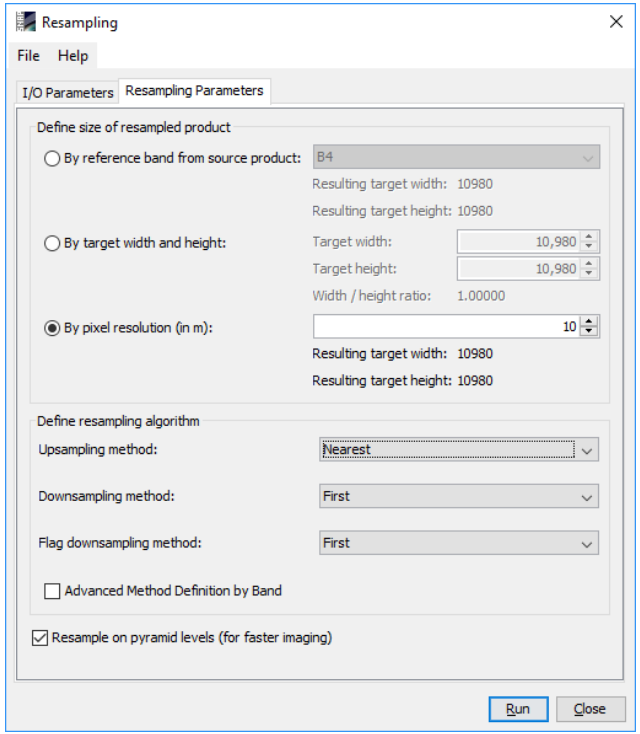
Resampling

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’



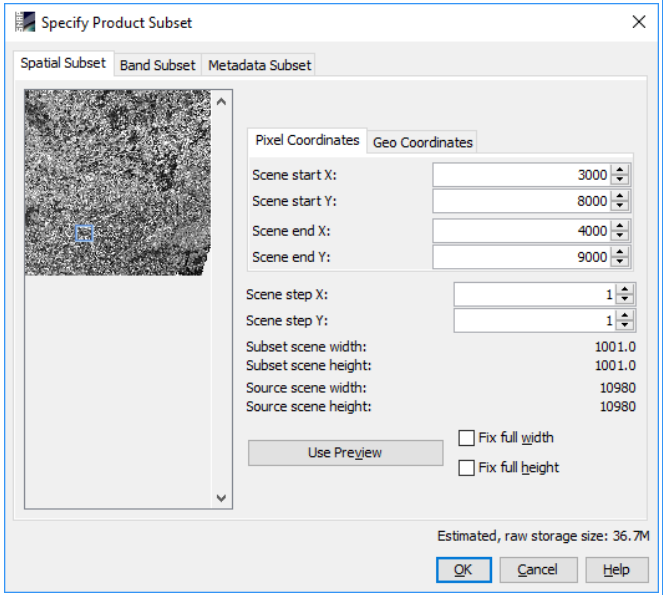


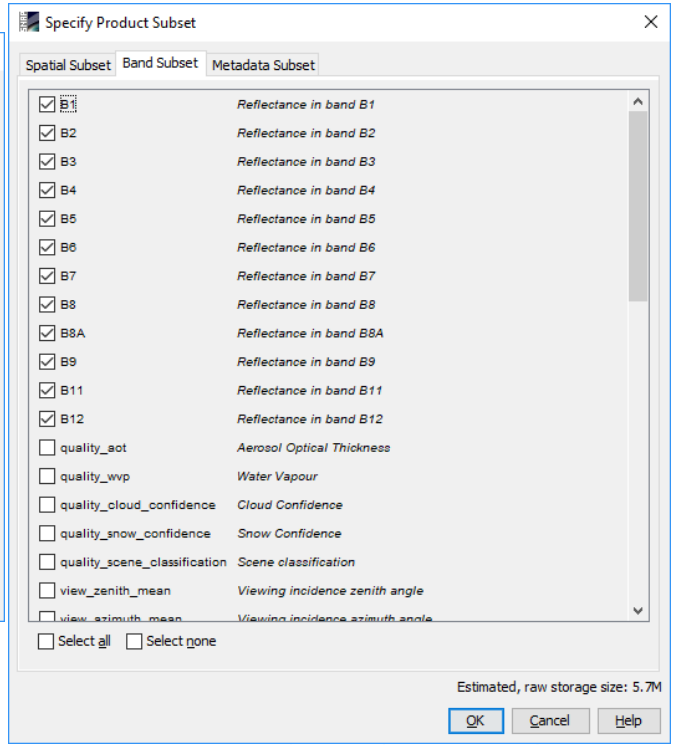
Subset (spatially/spectrally)

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’



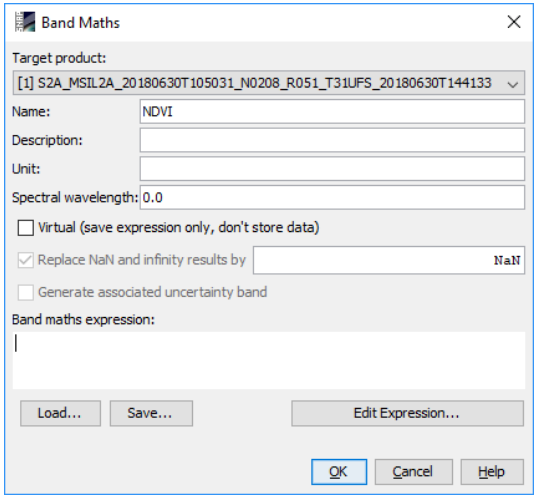


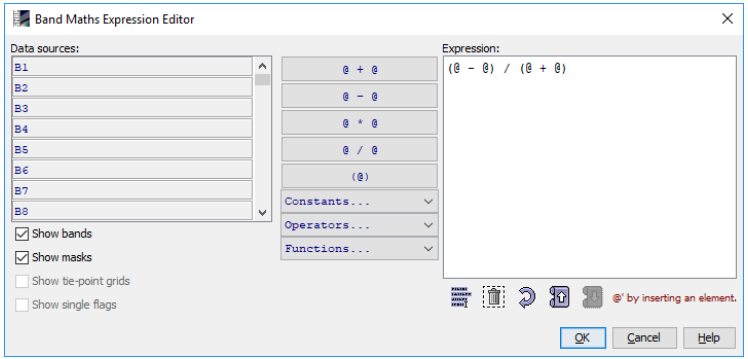
Band Maths (e.g. NDVI)

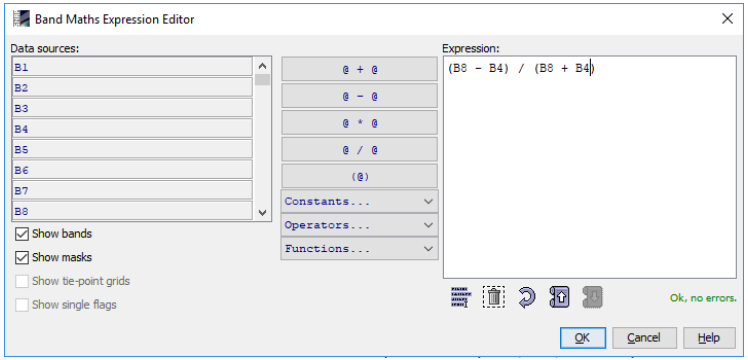
1) Select the product in the Product Explorer window.
2) Click on ‘Raster’ → ‘Band Maths…’

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’



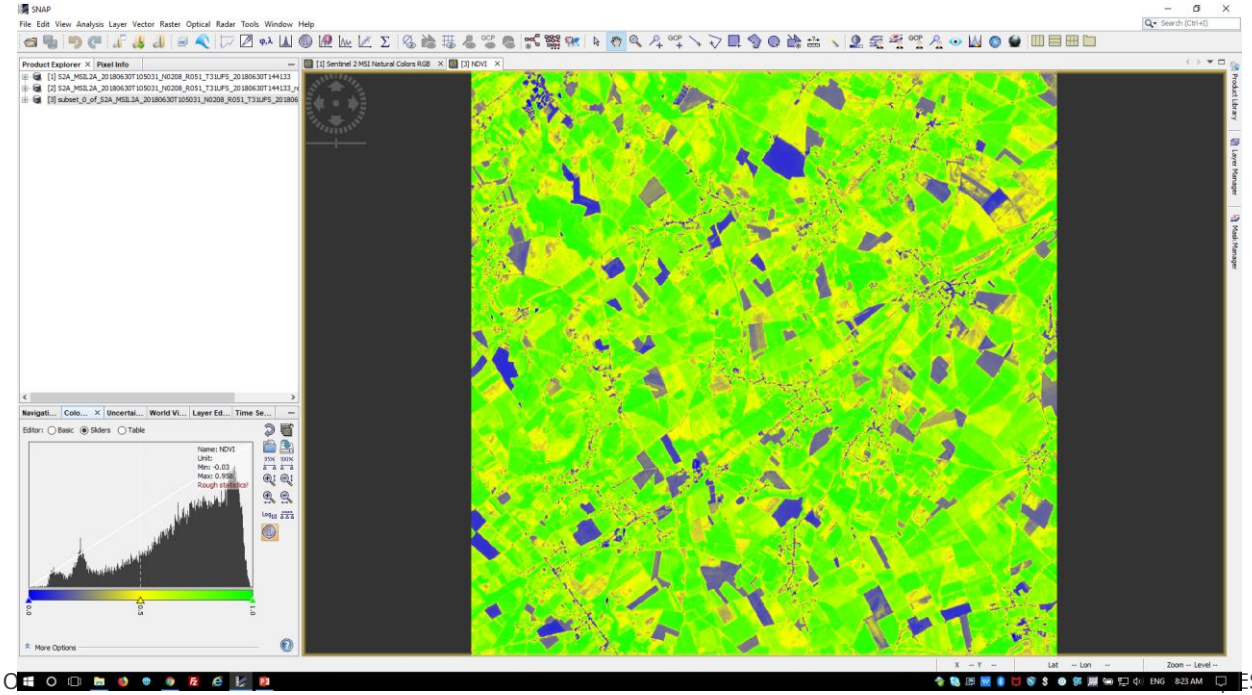




Output Visualization

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.



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

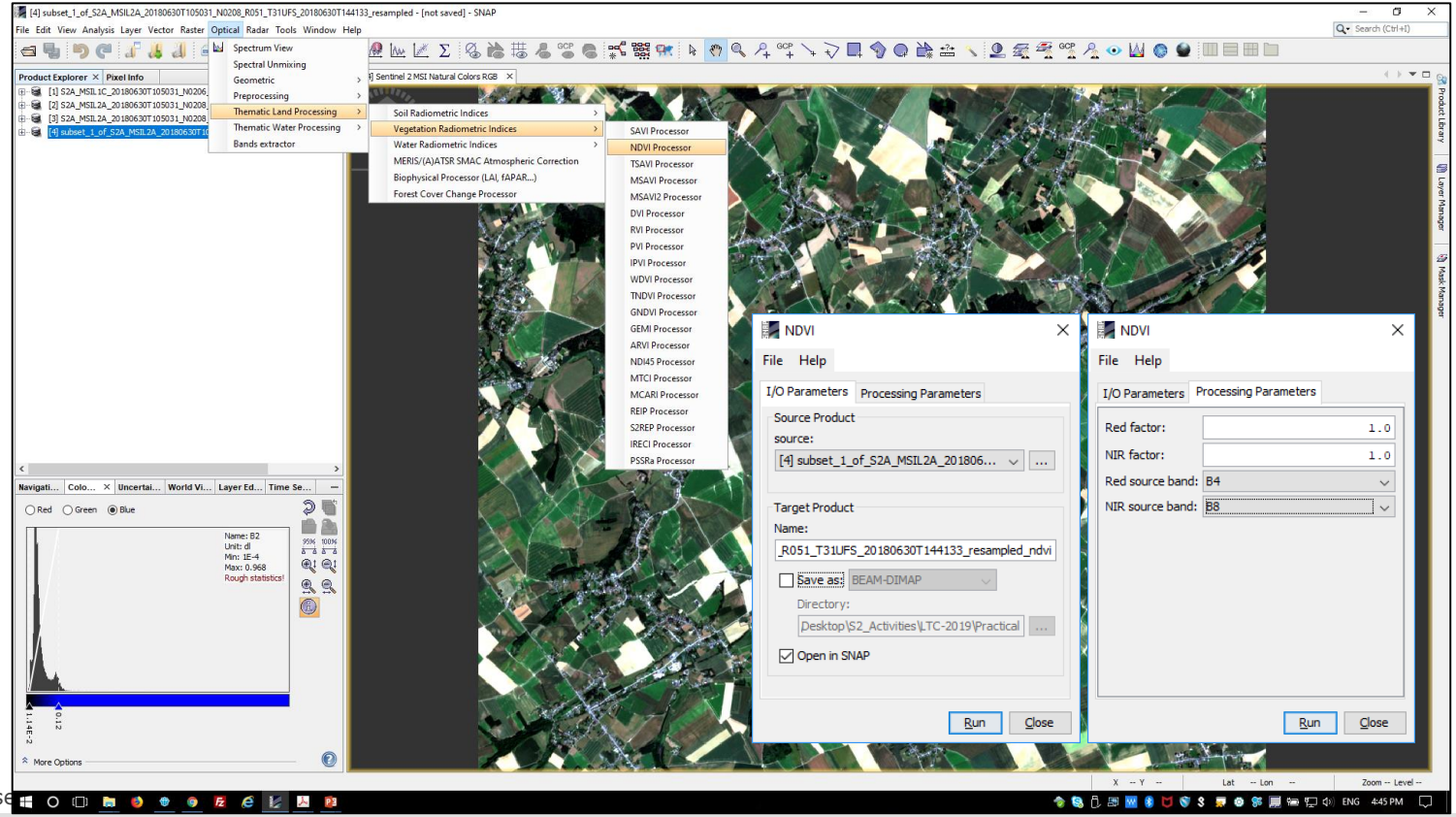
- NDWI
- NDWI2
- MNDWI
- NDPI
- NDTI

Radiometric Indices (e.g. NDVI)

$$\frac{(NIR - Red)}{(NIR + Red)}$$

$$\downarrow$$

$$\frac{(B8 - B4)}{(B8 + B4)}$$



Biophysical processor (L2B)

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

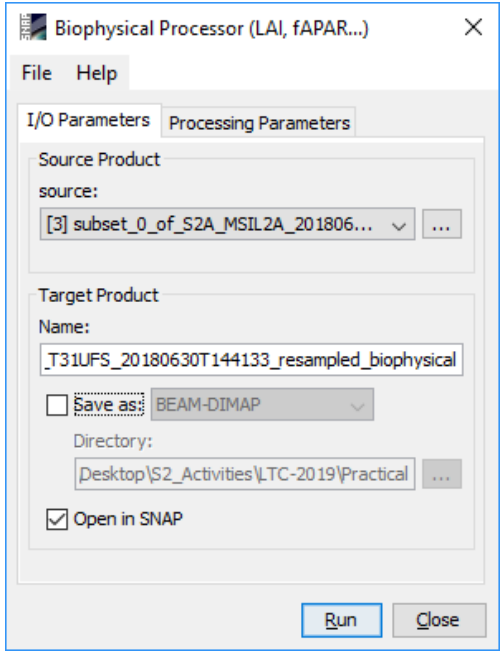
In the pop-up window set up the parameters as shown in the Figures:

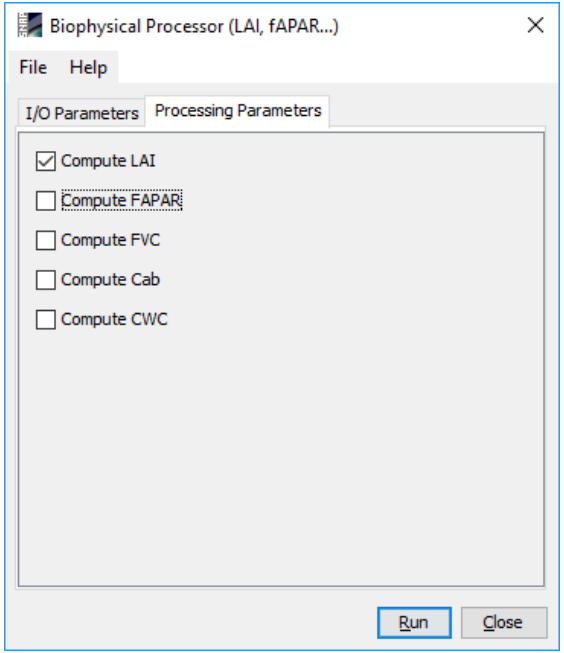
✓ Unselect ‘Save as:’

✓ Select only ‘LAI’

✓ Click on ‘Run’

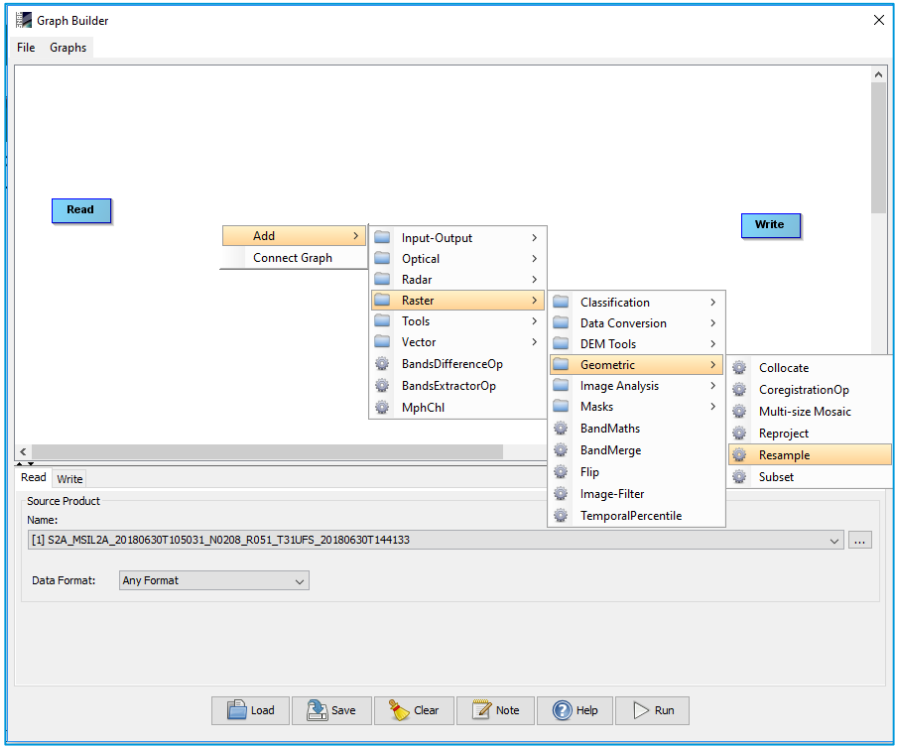
- LAI: Leaf Area Index
- fAPAR: Fraction of Absorbed Photosynthetically Active Radiation
- FVC: Fraction of vegetation cover
- Cab: Chlorophyll content in the leaf
- CWC: Canopy Water Content





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.



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)

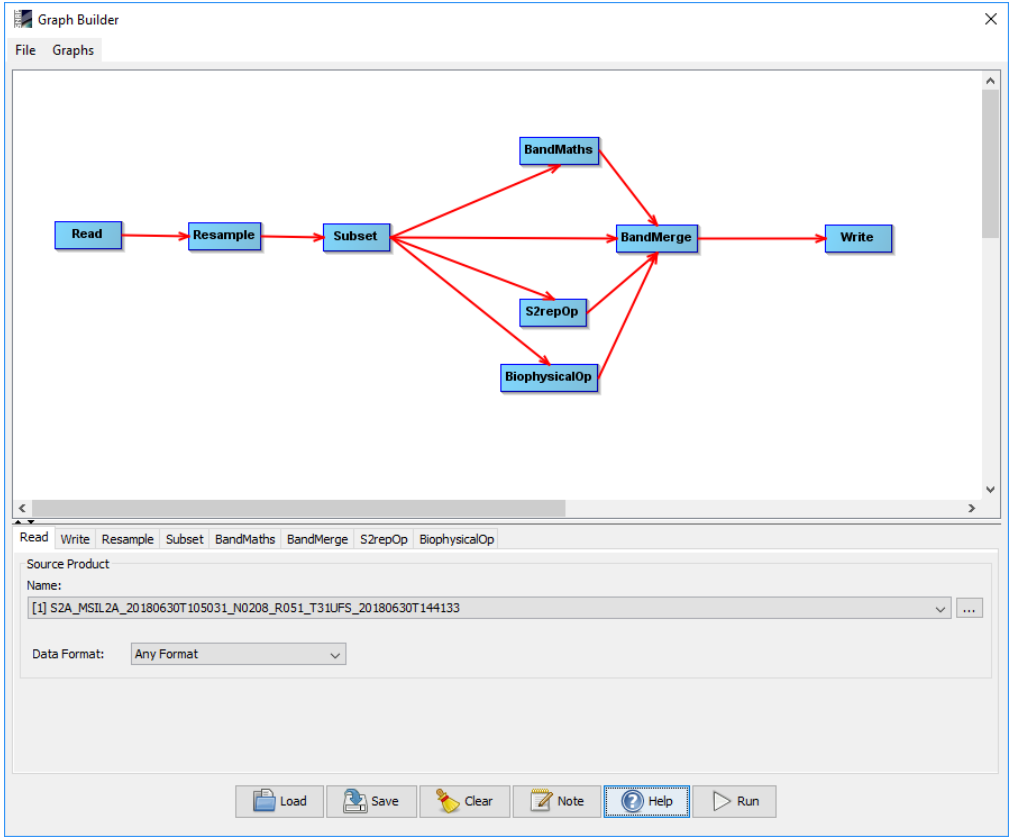
‘Optical’ → ‘Them. Land Proc.’ → ‘Veg. Rad. Ind.’ → ‘S2repOp’

‘Biophysical Processor’

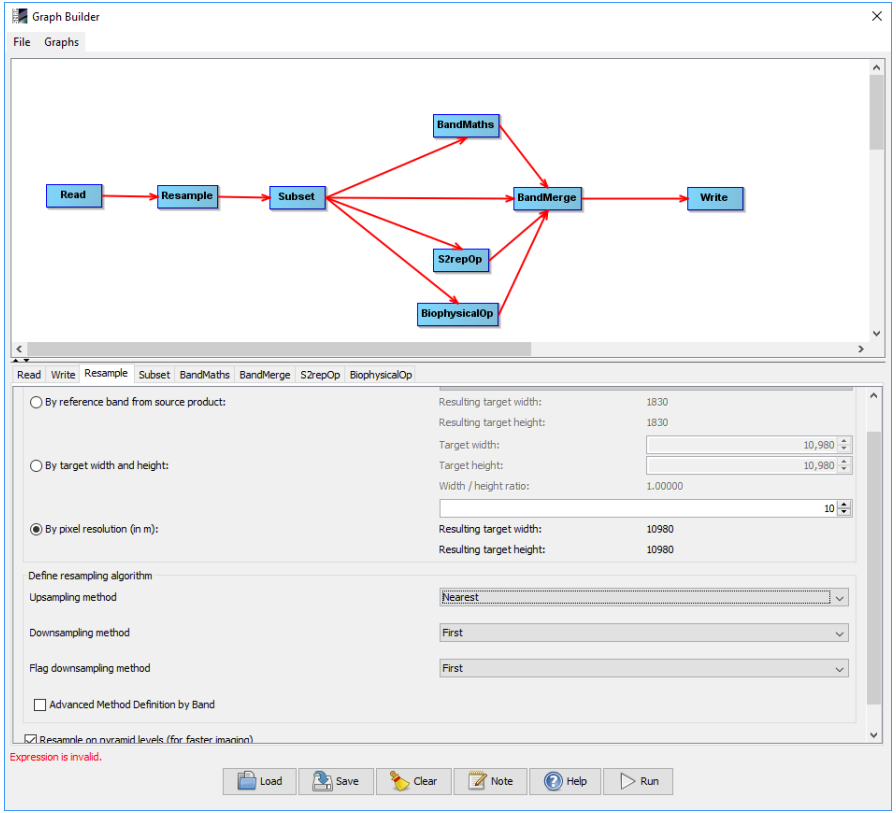
‘Optical’ → ‘Thematic Land Processing’ → ‘BiophysicalOp’

‘Band Merge’

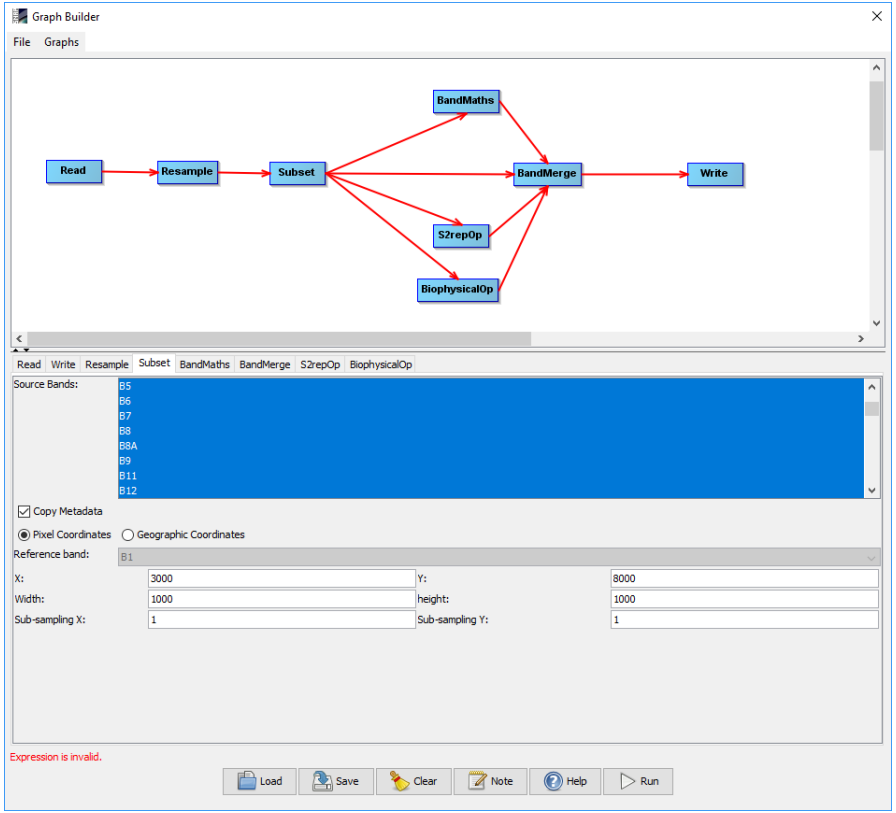
‘Raster’ → ‘BandMerge’



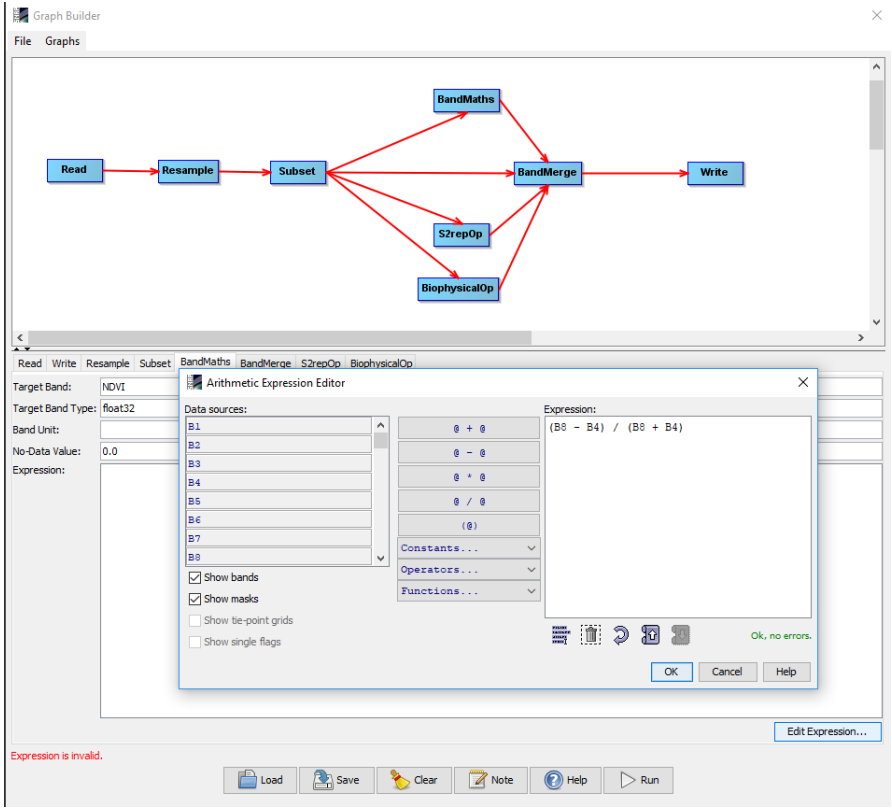
GraphBuilder (Resample module)



GraphBuilder (Subset module)



GraphBuilder (BandMaths module)

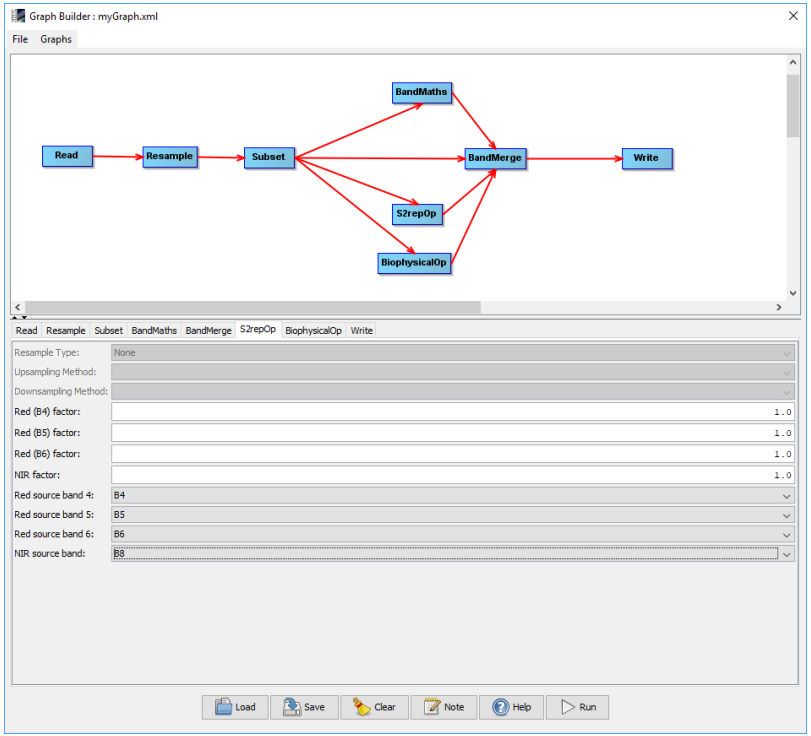


GraphBuilder (S2repOp module)

The Sentinel-2 Red-Edge Position Index algorithm is based on linear interpolation, as presented by Guyot and Baret (1988).
Red edge, as the inflection point of the strong red absorption to near infrared reflectance, includes the information of both crop (chlorophyll content) N and growth status.

$$705 + 35 \times \frac{\frac{(Red + NIR)}{2} - Red_2}{(Red_3 - Red_2)}$$

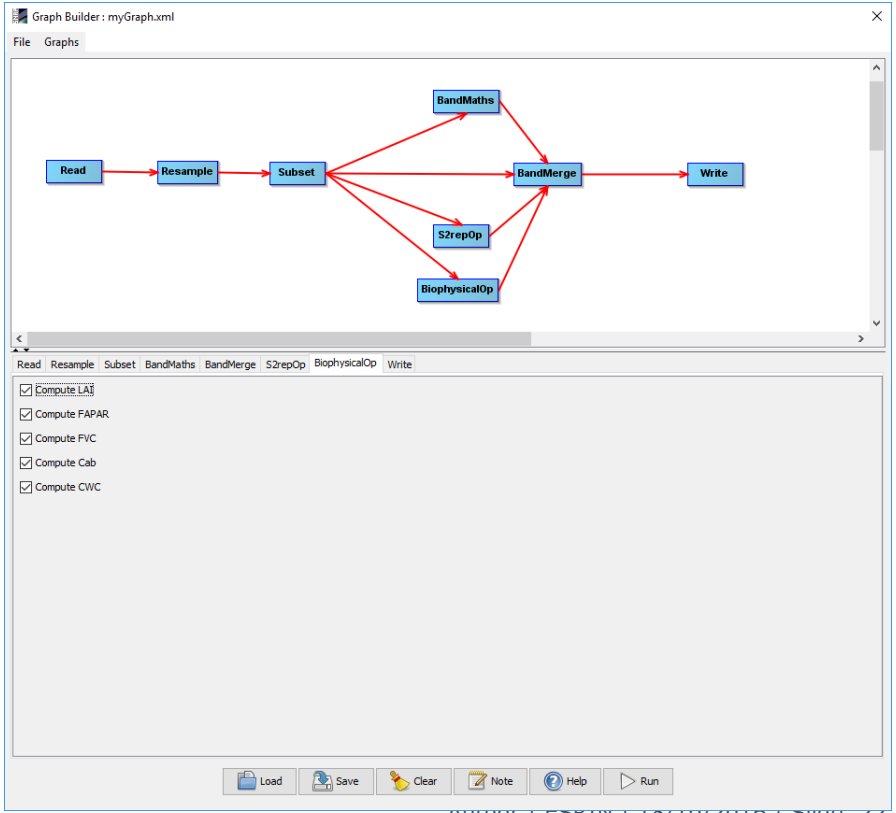
$$705 + 35 \times \frac{\frac{(B4 + B7)}{2} - B5}{(B6 - B5)}$$



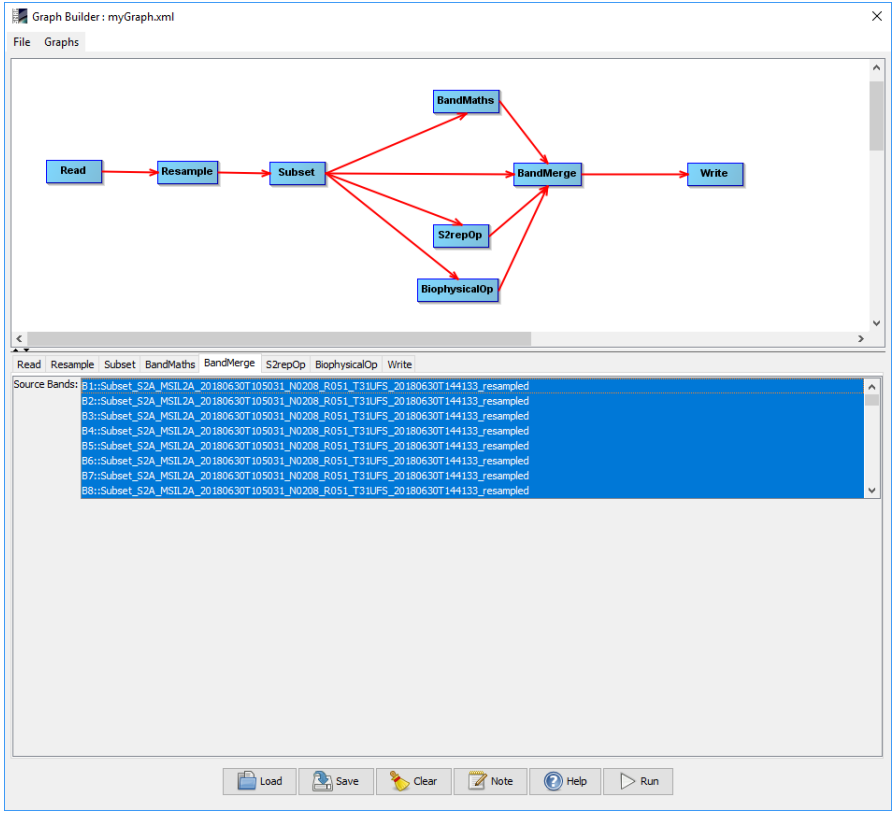
GraphBuilder (BiophysicalOp module)

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:

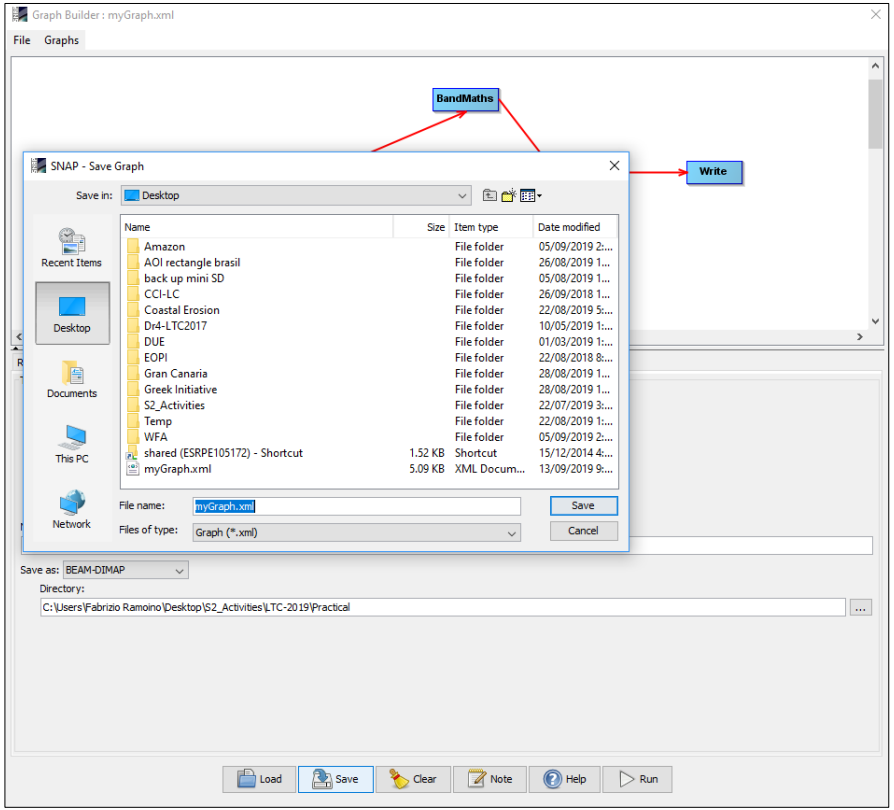
- ✓ LAI: Leaf Area Index
- ✓ fAPAR: Fraction of Absorbed Photosynthetically Active Radiation
- ✓ FVC: Fraction of vegetation cover
- ✓ Cab: Chlorophyll content in the leaf
- ✓ CWC: Canopy Water Content



GraphBuilder (Band Merge module)

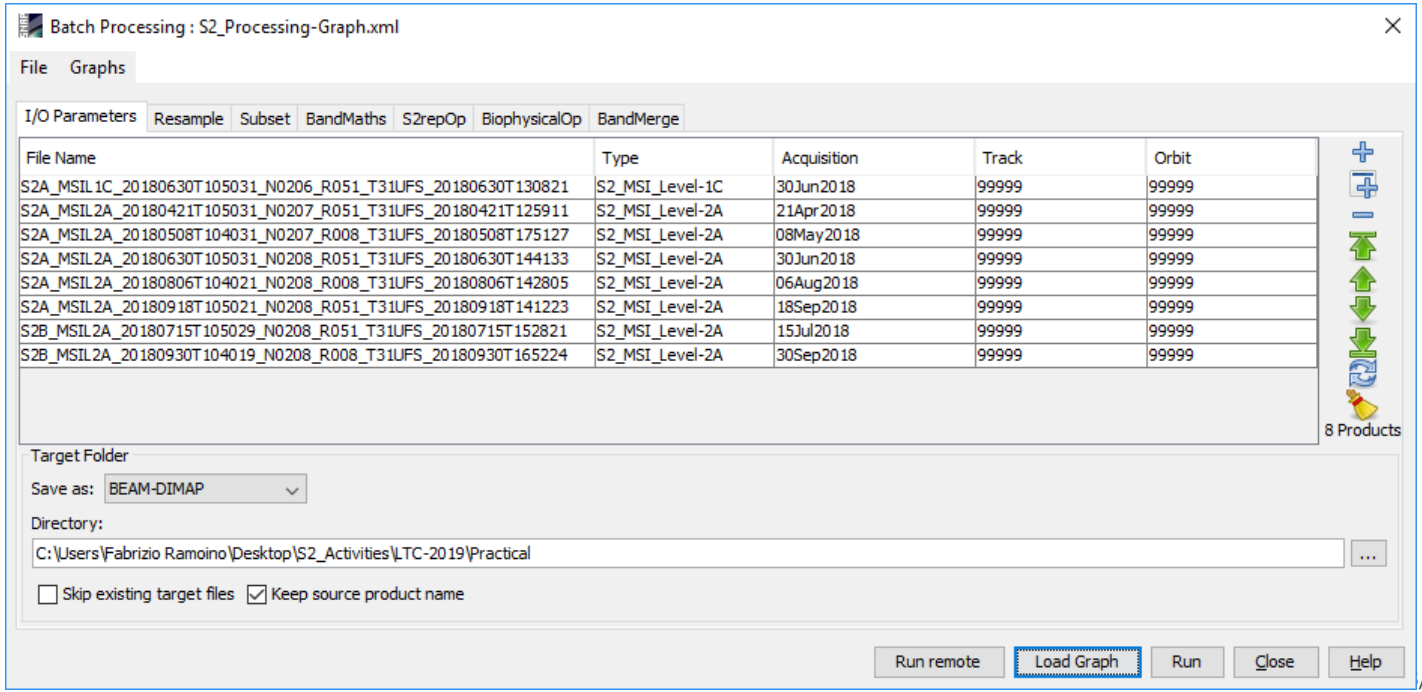


GraphBuilder (Save the graph)



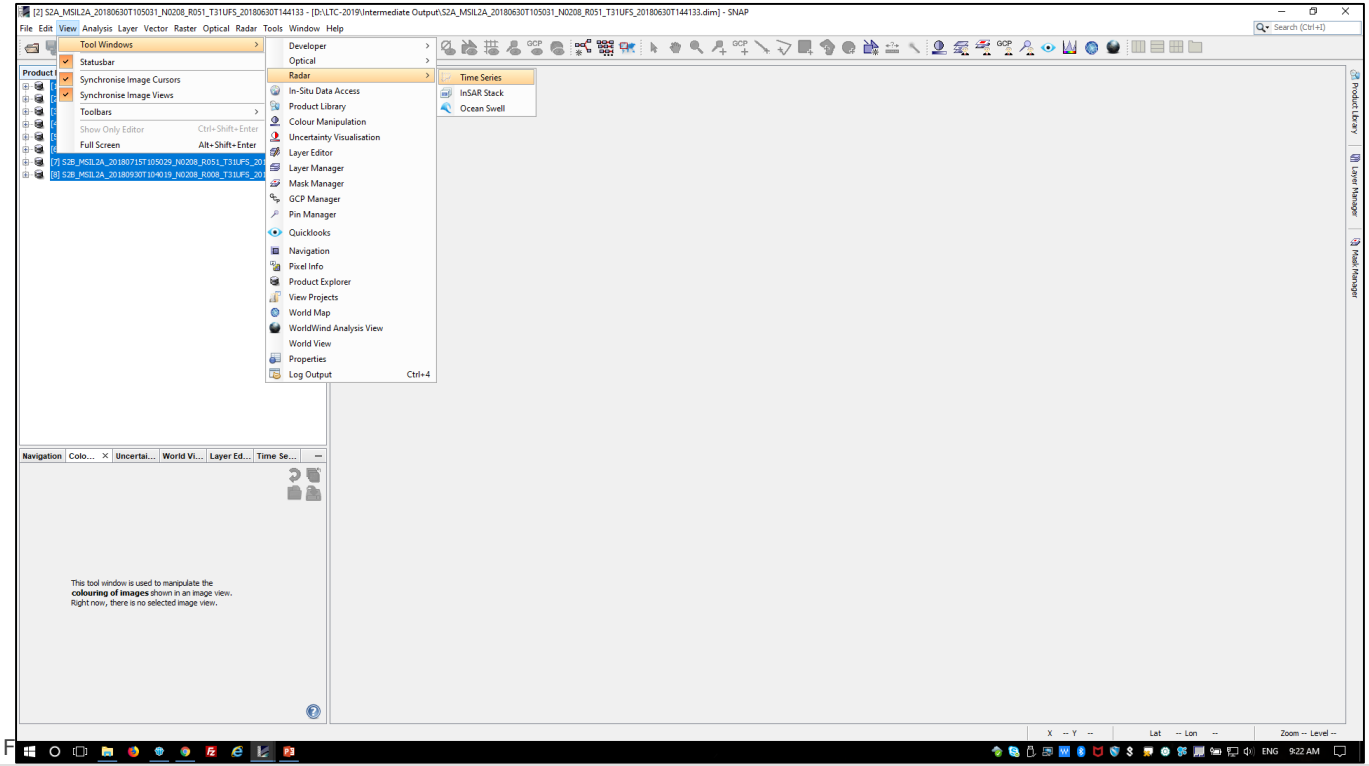
Batch Processing

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".



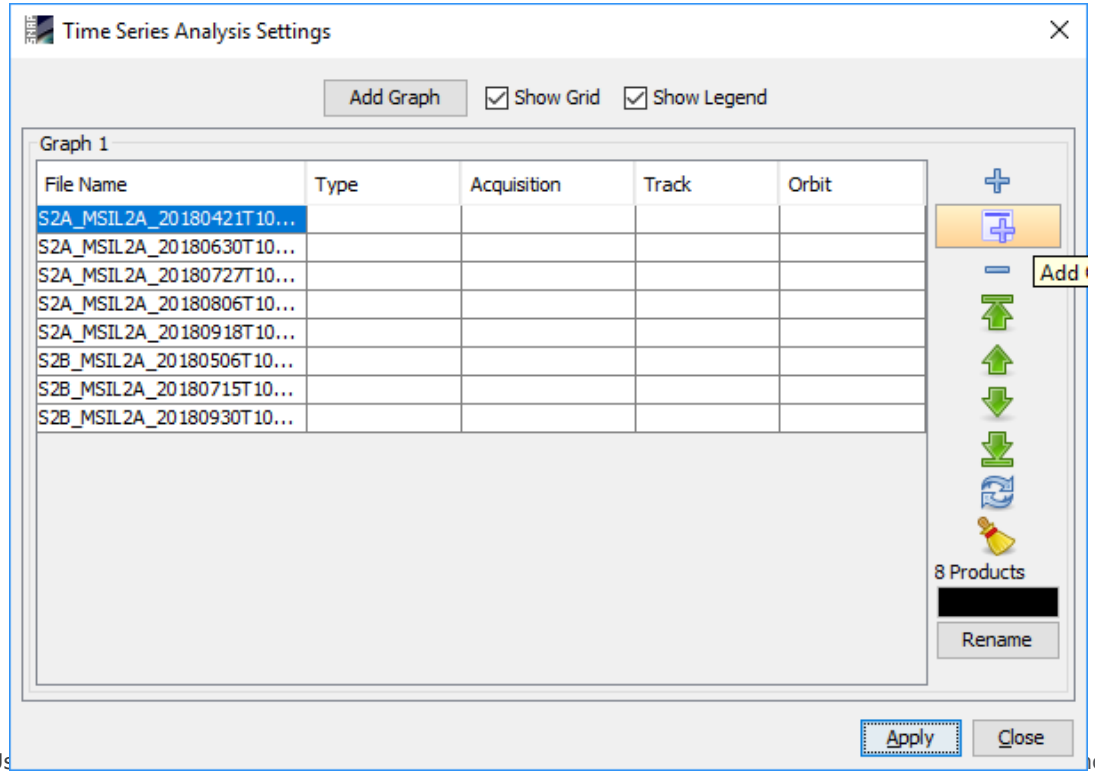
Time Series

Due to the short time you can find the batch processing output in the 'Intermediate Output' folder in DIMAP format. Open them in SNAP and then open the Time Series Window. 'View' → 'Tool Windows' → 'Radar' → 'Time Series'

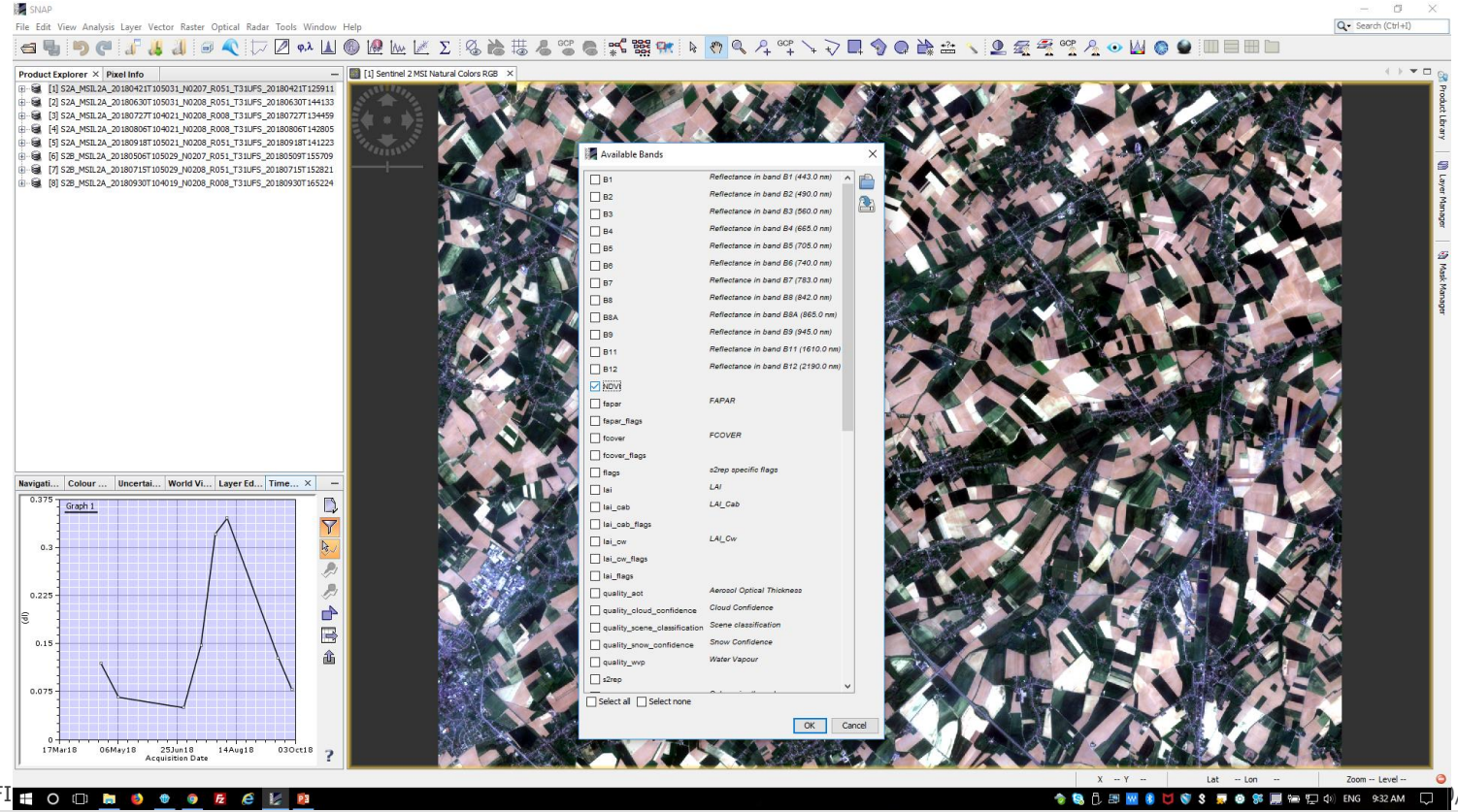


Time Series

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



Time Series


SNAP
File Edit View Analysis Layer Vector Raster Optical Radar Tools Window Help
Product Explorer
Pixel Info
[1] S2A_MSIL2A_20180421T105031_N0207_R051_T31UFS_20180421T125911
[2] S2A_MSIL2A_20180630T105031_N0208_R051_T31UFS_20180630T144133
[3] S2A_MSIL2A_20180727T104021_N0208_R008_T31UFS_20180727T134459
[4] S2A_MSIL2A_20180806T104021_N0208_R008_T31UFS_20180806T142805
[5] S2A_MSIL2A_20180918T105021_N0208_R051_T31UFS_20180918T141223
[6] S2B_MSIL2A_20180506T105029_N0207_R051_T31UFS_20180509T155709
[7] S2B_MSIL2A_20180715T105029_N0208_R051_T31UFS_20180715T152821
[8] S2B_MSIL2A_20180930T104019_N0208_R008_T31UFS_20180930T165224
[1] Sentinel 2 MSI Natural Colors RGB
Available Bands
B1 Reflectance in band B1 (443.0 nm)
B2 Reflectance in band B2 (490.0 nm)
B3 Reflectance in band B3 (560.0 nm)
B4 Reflectance in band B4 (665.0 nm)
B5 Reflectance in band B5 (705.0 nm)
B6 Reflectance in band B6 (740.0 nm)
B7 Reflectance in band B7 (783.0 nm)
B8 Reflectance in band B8 (842.0 nm)
B8A Reflectance in band B8A (865.0 nm)
B9 Reflectance in band B9 (945.0 nm)
B11 Reflectance in band B11 (1610.0 nm)
B12 Reflectance in band B12 (2190.0 nm)
NDVI
fapar FAPAR
fapar_flags
fcover FCOVER
fcover_flags
flags s2rep specific flags
lai LAI
lai_cab LAI_Cab
lai_cab_flags
lai_cw LAI_Cw
lai_cw_flags
lai_flags
quality_aot Aerosol Optical Thickness
quality_cloud_confidence Cloud Confidence
quality_scene_classification Scene classification
quality_snow_confidence Snow Confidence
quality_wvp Water Vapour
s2rep
Select all
Select none
OK
Cancel
Navigati...
Colour ...
Uncertai...
World Vi...
Layer Ed...
Time...
Graph 1
0.375
0.3
0.225
0.15
0.075
0
(dl)
17Mar18
06May18
25Jun18
14Aug18
03Oct18
Acquisition Date
Product Library
Layer Manager
Mask Manager
Search (Ctrl+I)
Lat
Lon
Zoom -- Level --
ENG
9:32 AM