



EXERCISE 7 – TUTORIAL

Spatio-temporal mapping of deforestation using Sentinel-2 data, comparison with high-resolution orthophoto imagery, using SNAP software

1 | Exercise outline

In this exercise, we will:

- Learn the basic steps to calculate the deforestation area based on S2 images
- Download images of the same area of interest over a period of 4 years
- Perform preprocessing for the 4 images using SNAP software
- Perform image classification based on the created training region, resulting in forest/non-forest masks
- Export the resulting masks to QGIS and colour the masks to better explore deforestation areas

2 | Background

Mapping deforestation using Sentinel-2 data

The presence of forests is crucial for preserving ecological balance, combating climate change, and ensuring a sustainable future for both the Earth and its inhabitants. Despite serving numerous essential functions, these ecosystems have faced significant threats to their condition, and overall quality in recent decades.

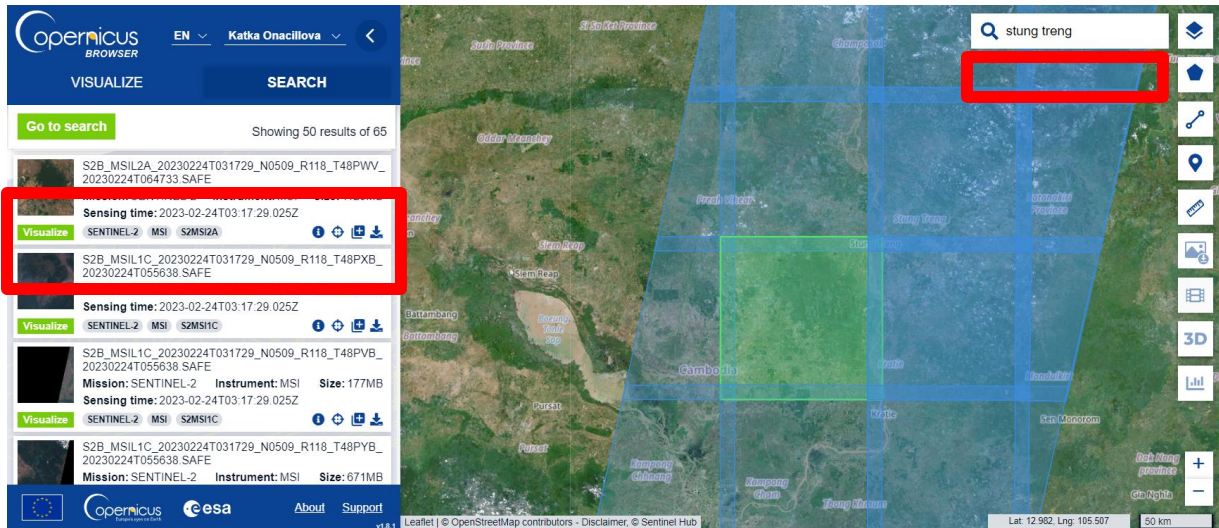


While various regions globally are undergoing deforestation, the reasons driving this phenomenon vary among countries. Data from Global Forest Watch's Dashboards reveals that, e.g. since 2001, Cambodia has seen a reduction of approximately 24 percent in its tree cover—an alarming percentage compared to more extensive, forested countries like Brazil and Indonesia. Protected Planet reports that around 26% of Cambodia's land is designated as protected areas for ecological or cultural conservation. However, GFW data from 2001 to 2018 indicates a loss of 557,000 hectares of tree cover in these areas, comprising 11.7% of Cambodia's total protected area. Many protected areas notably lost its protected status due to extensive deforestation for rubber and cashew plantations. This widespread forest loss contributes to increased flooding and erosion, impacting water storage, fishing, and agriculture during droughts.

Presently, the majority of countries regularly conduct forest inventory or remote sensing (RS) surveys every few years to observe alterations and assess the quality of forest cover. Over the last decade, the Sentinel-1 and Sentinel-2 satellite imagery from the European Space Agency's Copernicus program has offered substantial potential for examining forest stands. This technology can efficiently track changes, even in expansive forest areas, with a high temporal and spatial resolution.

2.1 Study area and data used

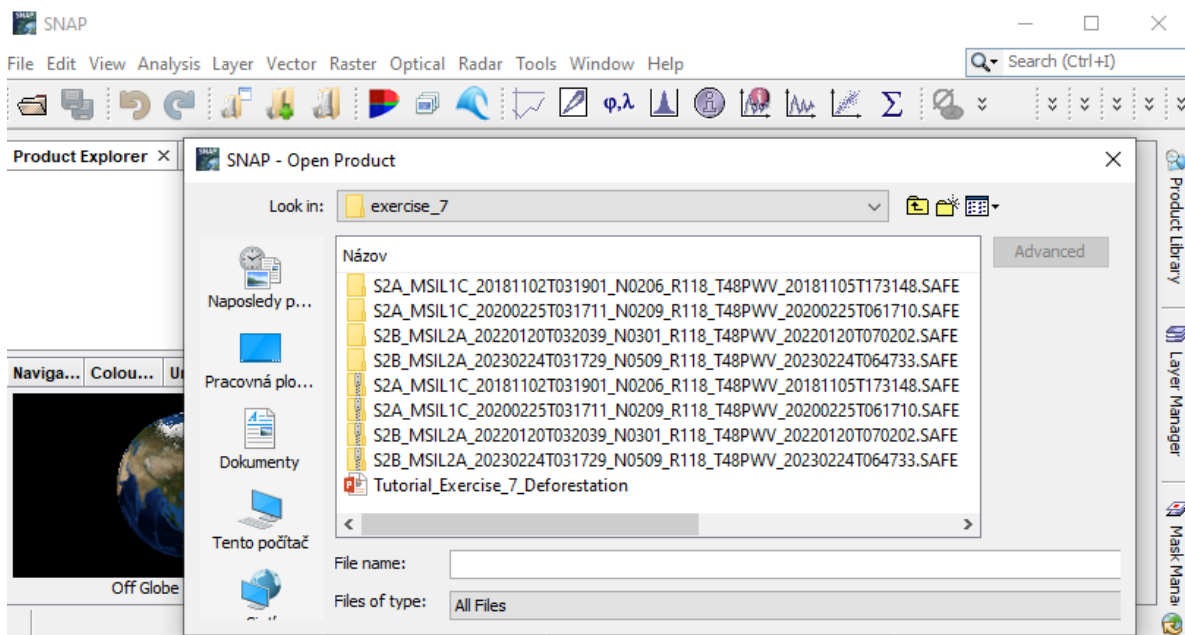
For this exercise, we will use three Sentinel-2 images of the same area in Stung Treng province, Cambodia, using the Tile Number *48PWV* downloaded for years 2018, 2020, 2022 and 2023 from the Dataspace Copernicus Open Access Hub [[@https://dataspace.copernicus.eu/](https://dataspace.copernicus.eu/)].



2.2. SNAP - Open and explore product

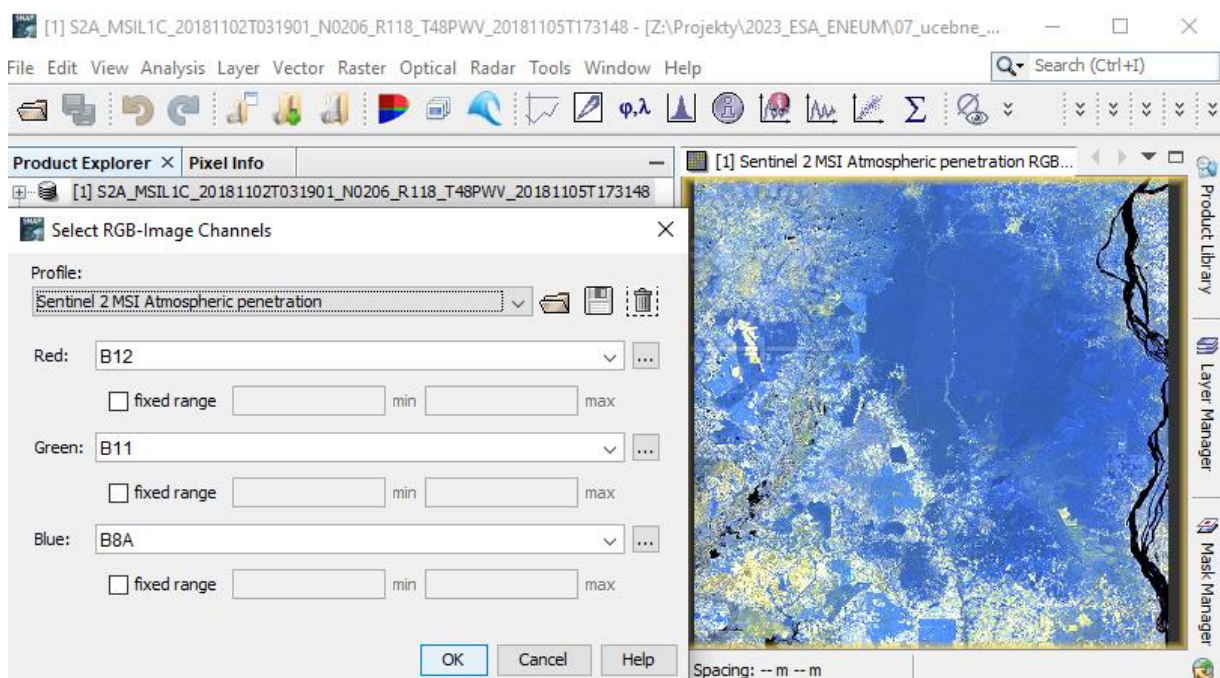
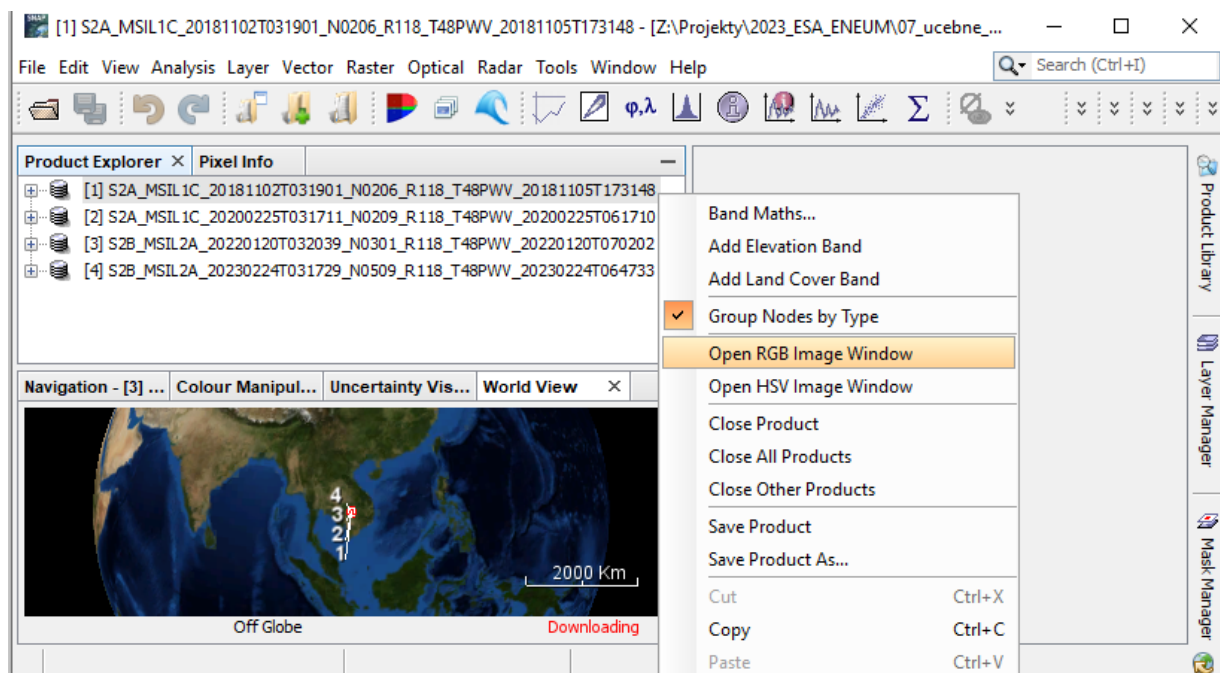
Open SNAP Desktop, click Open Product and open 4 downloaded products (unzipped) by double click on the metadata „MTD_MSIL2A.xml“ inside the folder. The opened products will appear in Product Explorer window.

S2A_MSIL1C_20181102T031901_N0206_R118_T48PWV_20181105T173148.SAFE
S2A_MSIL1C_20200225T031711_N0209_R118_T48PWV_20200225T061710.SAFE
S2B_MSIL2A_20220120T032039_N0301_R118_T48PWV_20220120T070202.SAFE
S2B_MSIL2A_20230224T031729_N0509_R118_T48PWV_20230224T064733.SAFE



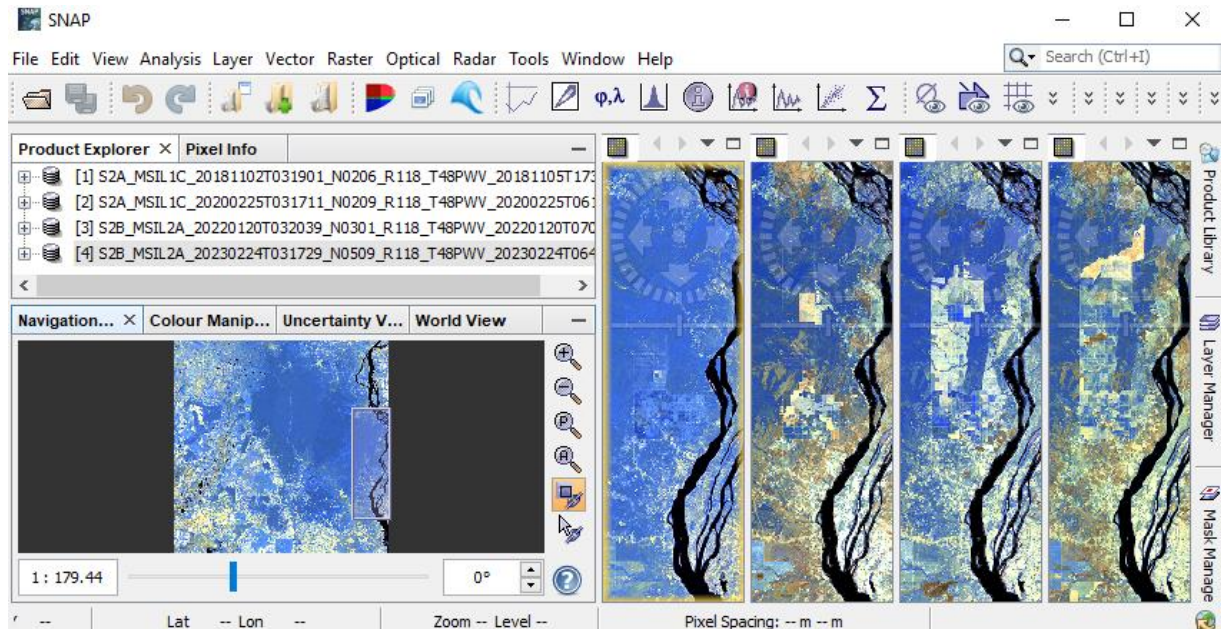
Display all products side by side using e.g. Atmospheric penetration band combination: Right click on the product – Open RGB Image Window – select Sentinel 2 MSI Atmospheric penetration. Repeat this step also for other three products.

The Atmospheric Penetration band combination (SWIR 2, SWIR 1, NIR) shows results similar to traditional false-color infrared color composition but with exceptional clarity. This method excludes visible bands, effectively penetrating atmospheric particles, smoke, and haze, thereby minimizing their impact on the image.



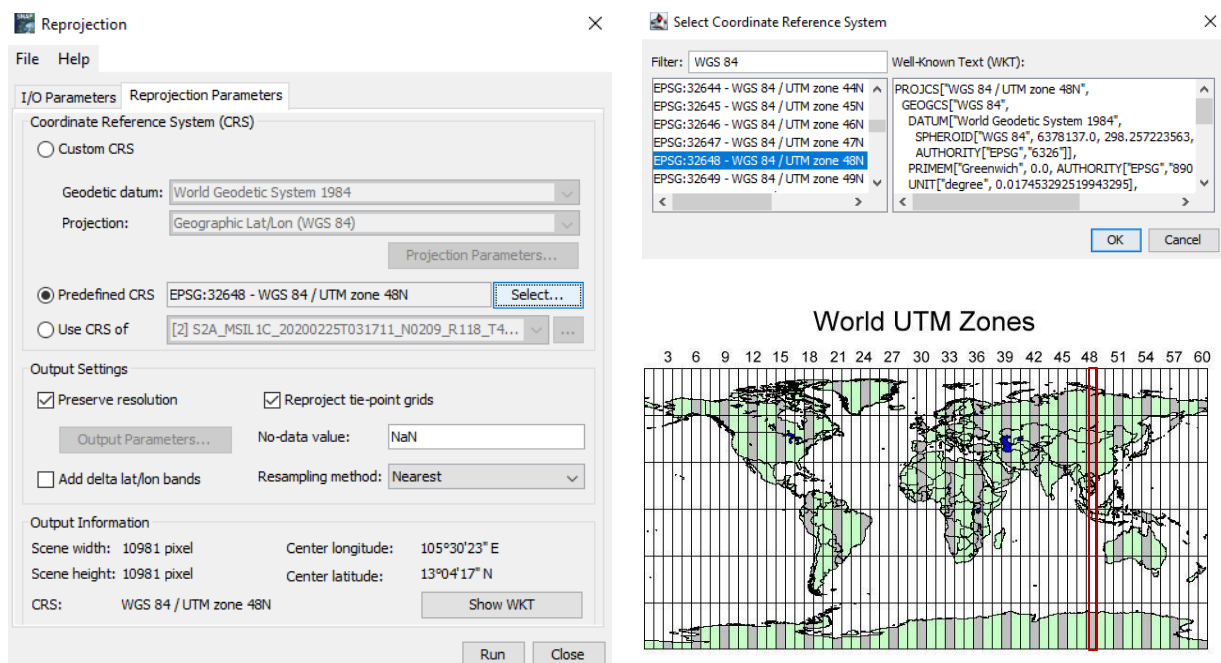
Then, tile windows horizontally. By opening and displaying all 4 images at once, we can take a first visual interpretation of deforestation in the years 2018, 2020, 2022 and 2023 - from the left.

In Navigation tab – Synchronise views across multiple image windows – Zoom into the eastern part of the image to explore deforestation.



2.3 Pre-processing

Firstly, it is advisable to reproject subsets to the system that corresponds to the area of interest (Cambodia) - WGS 84, UTM zone 48 North. Go to **Raster – Geometric - Reprojection** and reproject them to the system WGS 84, UTM zone 48N. Writing target product may take some time. At the end, 4 new reprojected products will be in the Product Explorer.

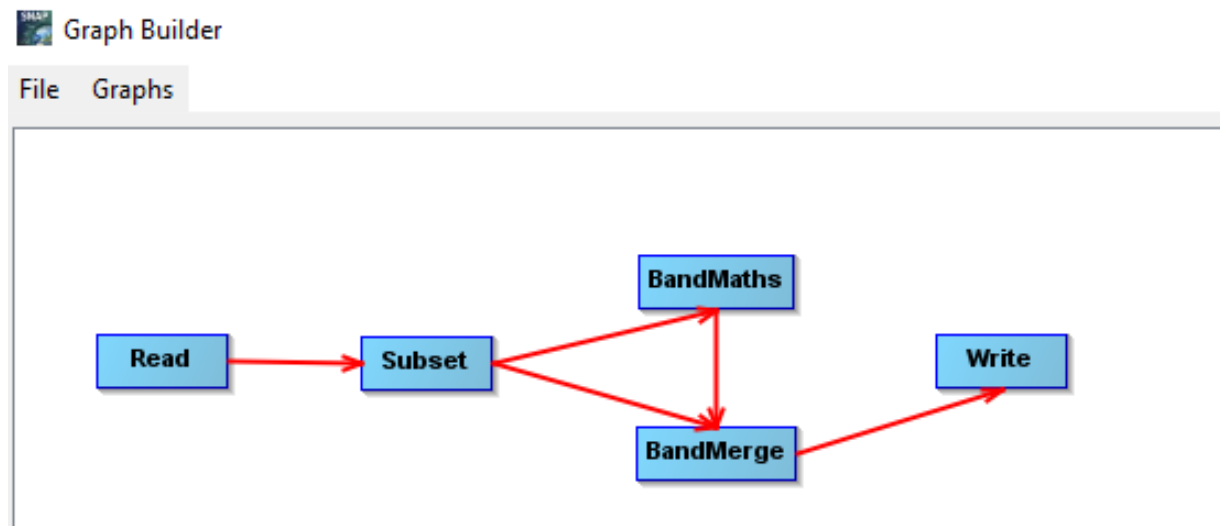


2.3.2 Create Processing Graph

Then, we need apply the same pre-processing steps for all our scenes. However, processing the data step by step and product by product could be time-consuming and impractical. Fortunately, the **Batch Processing** tool in SNAP allows us to apply all the steps to both images simultaneously, saving both time and disk space since only the final product is physically stored.

To use the tool, the initial step is to define the process we intend to apply along with all its corresponding steps. This can be accomplished by utilizing the GraphBuilder tool. Therefore, let's build our graph by navigating to **Tools** → **GraphBuilder**.

Through the GraphBuilder function, we build a processing graph, outlining the specific order of processing steps:



At the beginning, the graph has only two operators: **Read** (to read the input) and **Write** (to write the output). To add the new operator right-click the white space between the existing operators and select the desired operators:

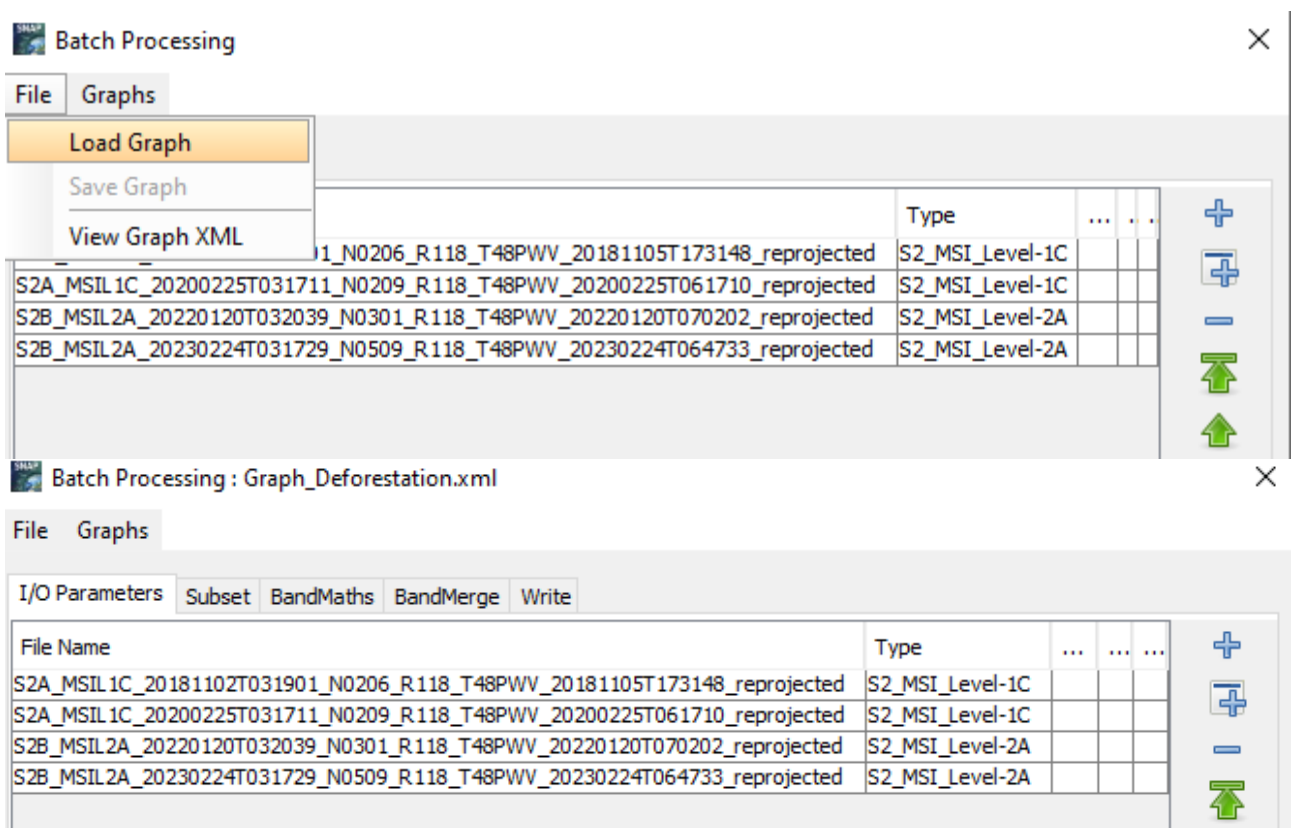
- **Subset** – export only bands that we will need for further analysis to calculate NDVI – select only B4 and B8
- **Band Maths** – to calculate NDVI using selected bands B4 and B8
- **Band Merge** – to combine the resulting bands into the resulting file

For the moment, do not change anything in the parameter tabs and save the graph (File – Save Graph) as „Graph_Deforestation.xml to your working folder. After you have saved it, close the GraphBuilder window.

2.3.3 Batch Processing

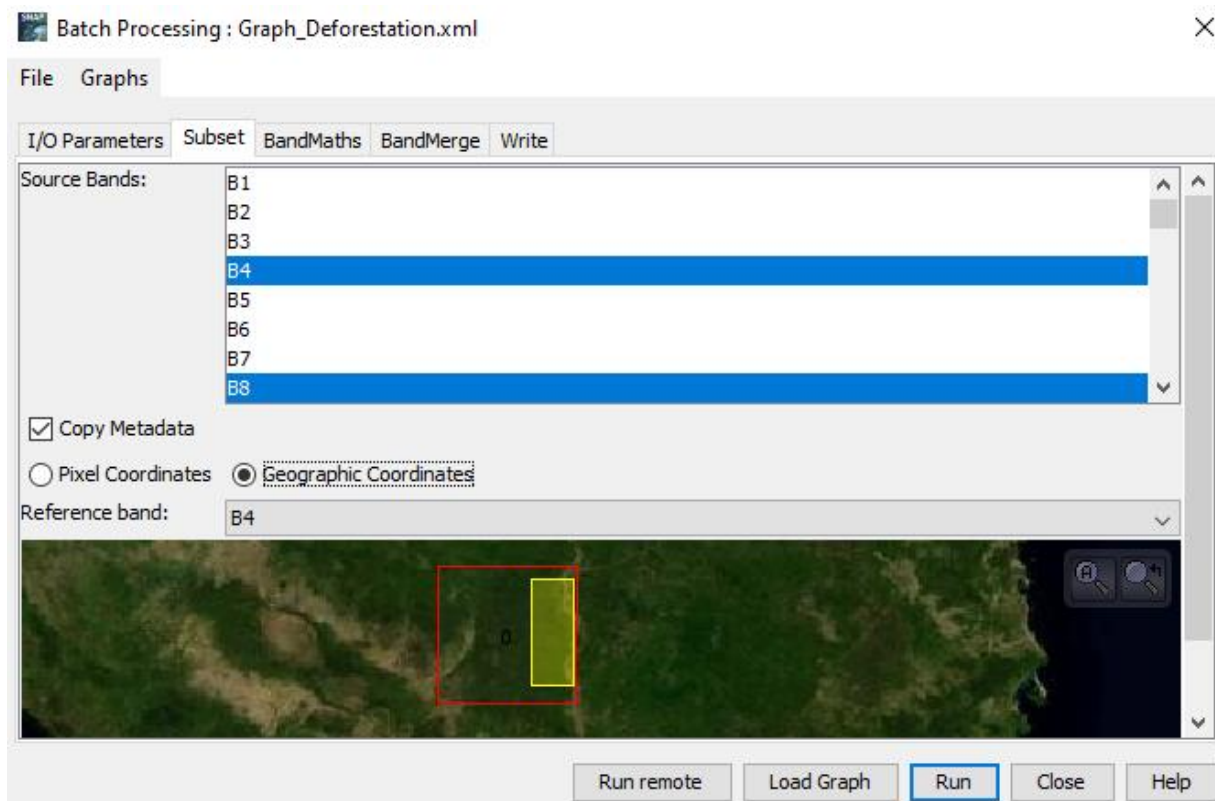
Open the **Batch Processing tool** (Tools → Batch Processing).

We will add all opened products by clicking Add Opened on the upper right (second icon from the top). Then, we delete original = not projected products by selecting them and clicking Delete (third icon from the top left only reprojected products). Then, when we have only 4 reprojected products, we click File - **Load Graph** at the top of the window and navigate to our saved graph „*Graph_Deforestation*“ and open it. We see that new tabs have appeared at the top of window corresponding to our operators with the exception of Read; this is correct as these parameters will be set in the I/O Parameters tab.



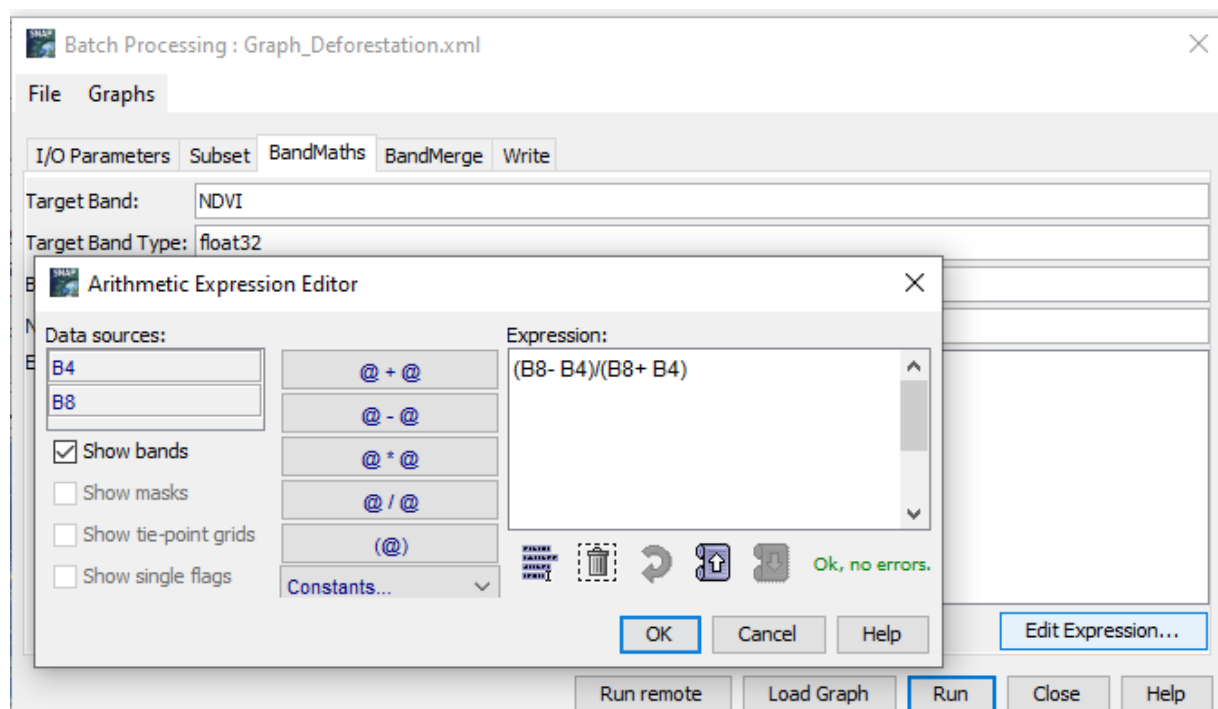
In the next step it is advisable to create **Subset** of these products for faster processing:

- **Source bands** – select only bands that we will need to calculate NDVI - B4 and B8
- **Geographic Coordinates** – create the subset of the area also by clicking on zoom into the area of image (red rectangle) and draw smaller (yellow) polygon inside it that includes only eastern part of the images where we observed deforestation
- **Reference band** – select Reference band according which all the Source Bands will be resampled

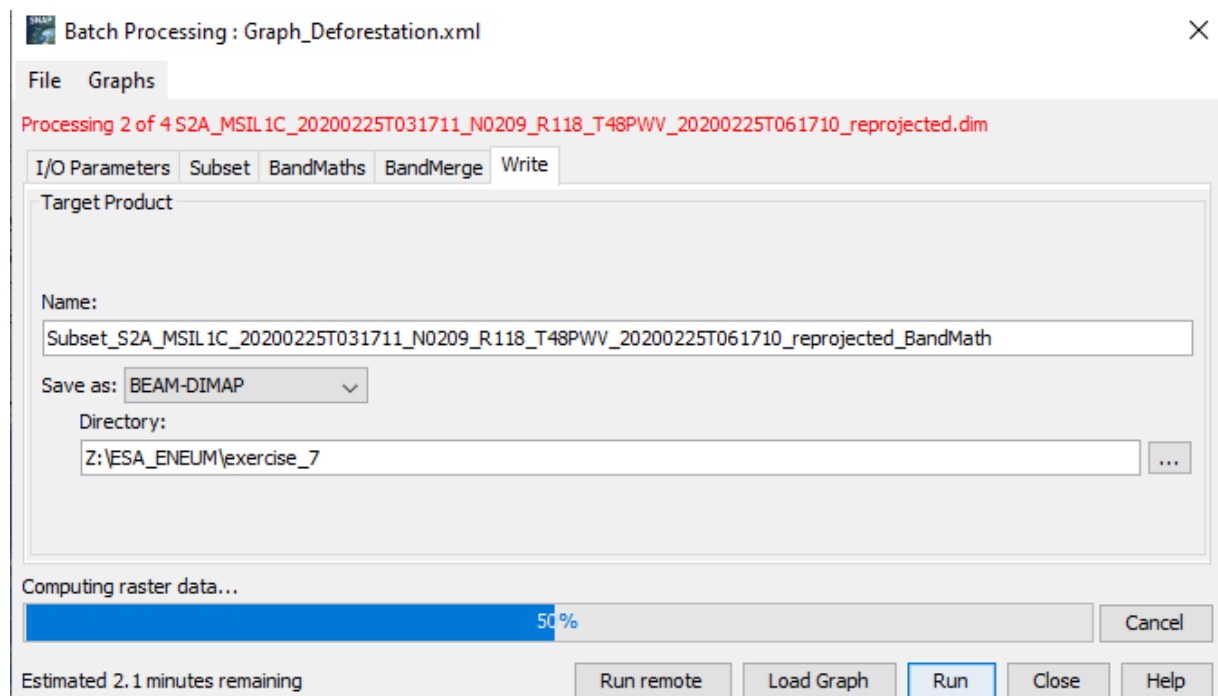
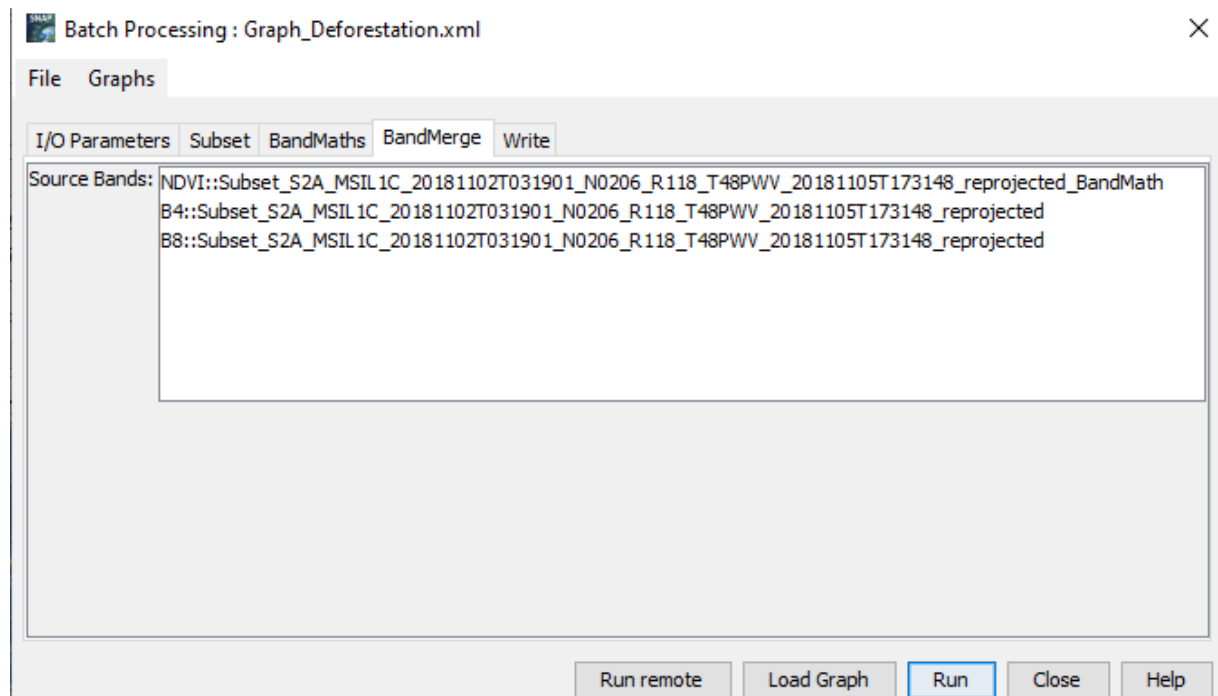


In BandMath, we enter the formula for NDVI calculation. The NDVI is calculated as a normalized difference of visible infrared (B8) and visible red (B4) bands, using the following equation (Rouse et al. 1974):

$$(B8-B4)/(B8+B4)$$



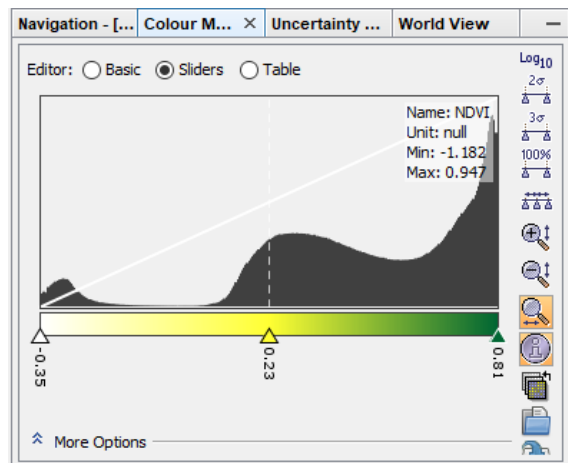
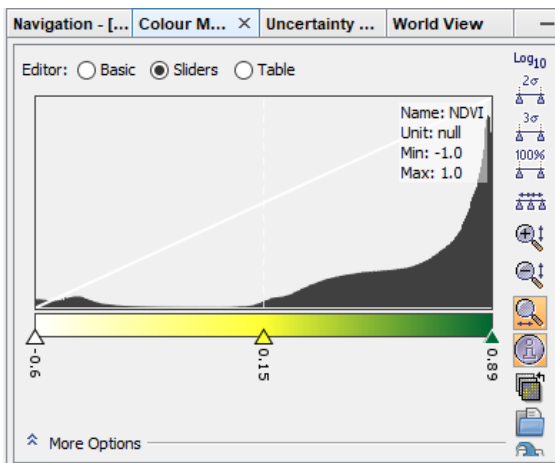
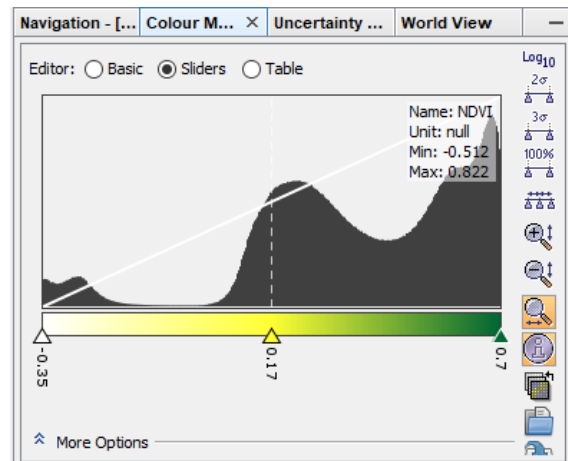
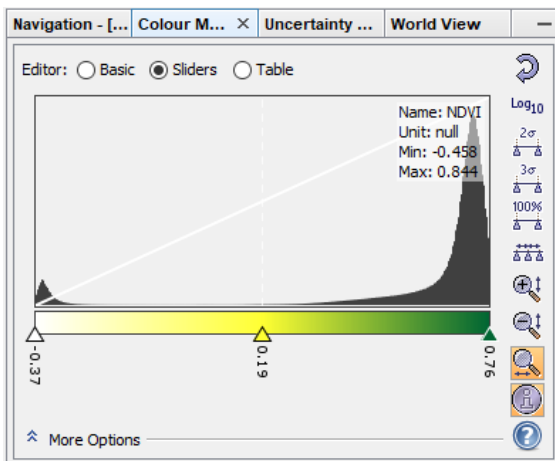
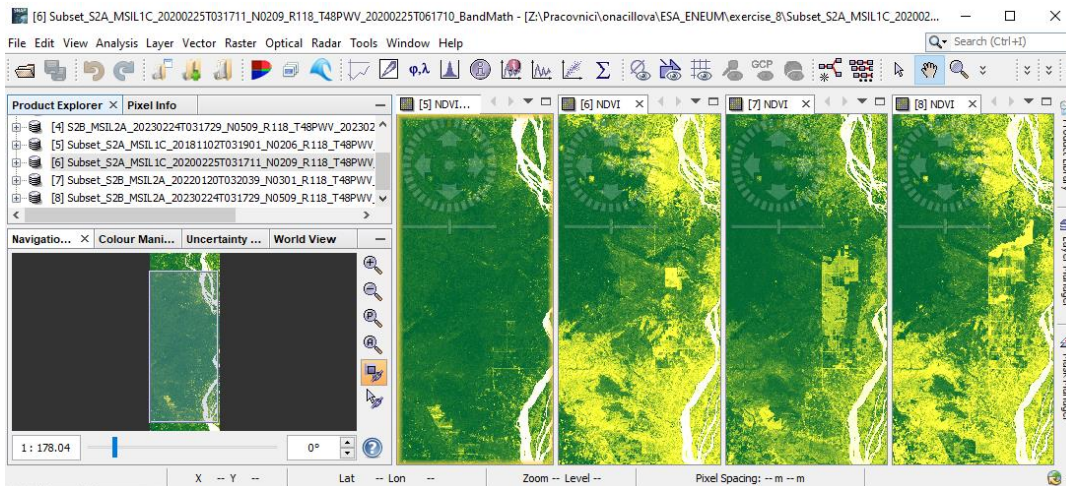
Then, in **BandMerge** tab we can combine the resulting bands into the resulting file and set the directory for the output file in **Write** tab. The common processing can be monitored. Writing target product may take some time.



3. Image analysis

Open the output NDVI images side by side for all processed years – **Window – Tile Horizontally**. In Colour Manipulation select Colour ramp derived from meris pressure.

NDVI image - have values from $< -1, 1 >$, where forested areas are displayed in values higher than 0. The peaks of the histogram point to 2 extremes - forested and logged area.



THANK YOU FOR FOLLOWING THE EXERCISE!