



EXERCISE 11 – TUTORIAL

Flood Monitoring with Sentinel-1, Sentinel-2 data
using the SNAP software

1 | Exercise outline

In this second exercise for mapping floods, we will:

- Detect floods using Sentinel-2 images
- Create NDVI and NDWI spectral indices to explore floods
- Create binary water mask for flood mapping
- Compare results for flood mapping using Sentinel-1 and Sentinel-2 images

2 | Background

Floods, a commonly occurring natural disaster, result in significant damage to both lives and property. Timely information on floods is critical for emergency response. Rapid estimation of flood extent is essential for disaster risk assessment and spatial planning. Remote sensing and satellite imagery play pivotal roles in flood monitoring and mapping. Optical remote sensing, for instance, is utilized for dynamic flood monitoring by exploiting water's low reflectance in infrared bands and high reflectance in blue/green bands.



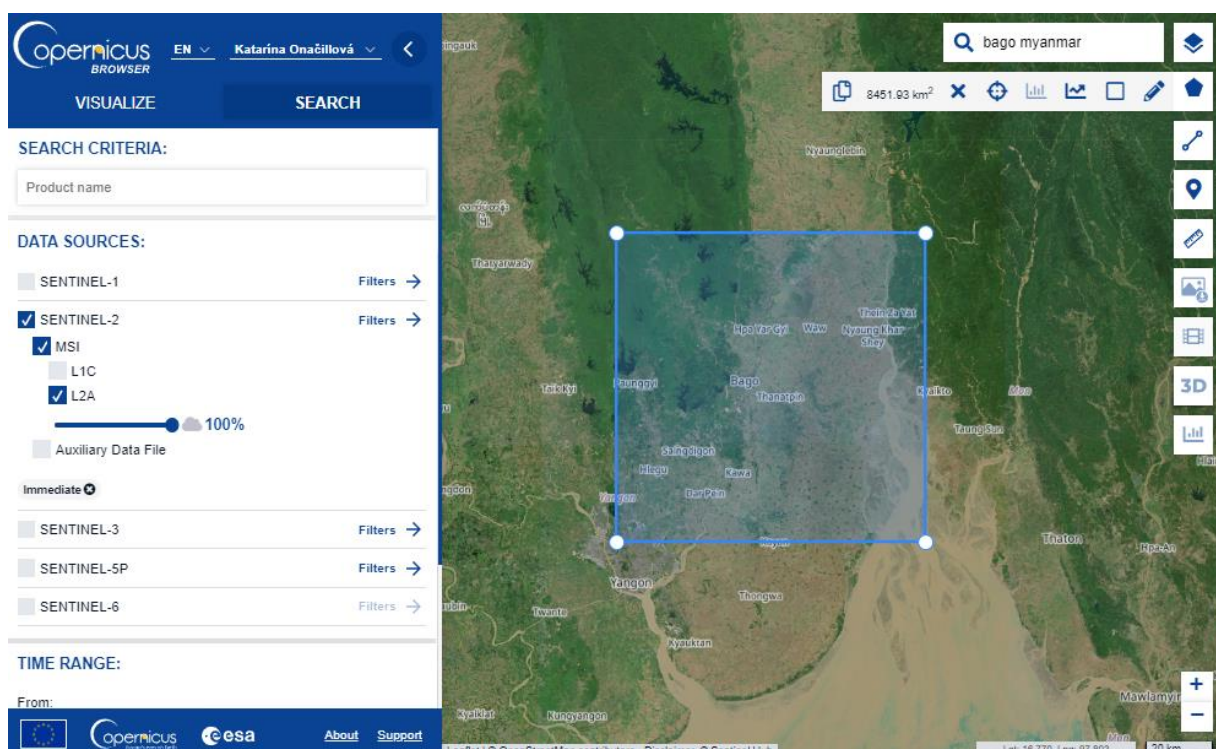
However, during severe weather conditions with heavy rainfall and intense cloud cover, optical remote sensing may struggle to provide accurate information due to a lack of cloud-free, high-quality images and difficulty in detecting water under vegetation cover.

Since October 4, 2023, the Myanmar Department of Meteorology and Hydrology (DMH) has been issuing flood advisory warnings and weather system alerts regarding water levels in major rivers. Between October 5 and 9, heavy rainfall during the late monsoon season resulted in extensive flooding in southern Myanmar. On October 9, the DMH reported that Bago township received an unprecedented 7.87 inches (200 millimeters) of rainfall, the highest recorded in 59 years. By October 10, the water level of the Bago River rose 4 feet above the danger level, leading to widespread flooding in urban and suburban areas. The impact of this flooding has been significant, affecting families, croplands, and causing displacement of people in areas including Bago City, Yangon, Taik Kyi, Hlegu, and Hmawbi townships. (DREF OPERATION Myanmar Flood 2023)

Besides Synthetic Aperture Radar (SAR) data that we used in the first part of the exercise for mapping floods, Sentinel-2 satellites are also extensively used for flood mapping due to their ability to capture high-resolution optical imagery of the Earth's surface. By analyzing these images, particularly before and after flood events, analysts can identify changes in water extent and detect flooded areas. The multispectral capabilities of Sentinel-2 allow for the differentiation of water bodies from other land cover types, enabling accurate mapping of flood-affected areas. Moreover, Sentinel-2's frequent revisits and openly available data make it a valuable resource for monitoring flood events in near real-time and supporting disaster response efforts.

2.1 Mapping floods with Sentinel-2 data

For the second part of this exercise, we will use two Sentinel-2 L2A images of the same area near Bago city, Myanmar, downloaded from the Dataspace Copernicus Open Access Hub [[@https://dataspace.copernicus.eu/](https://dataspace.copernicus.eu/)].

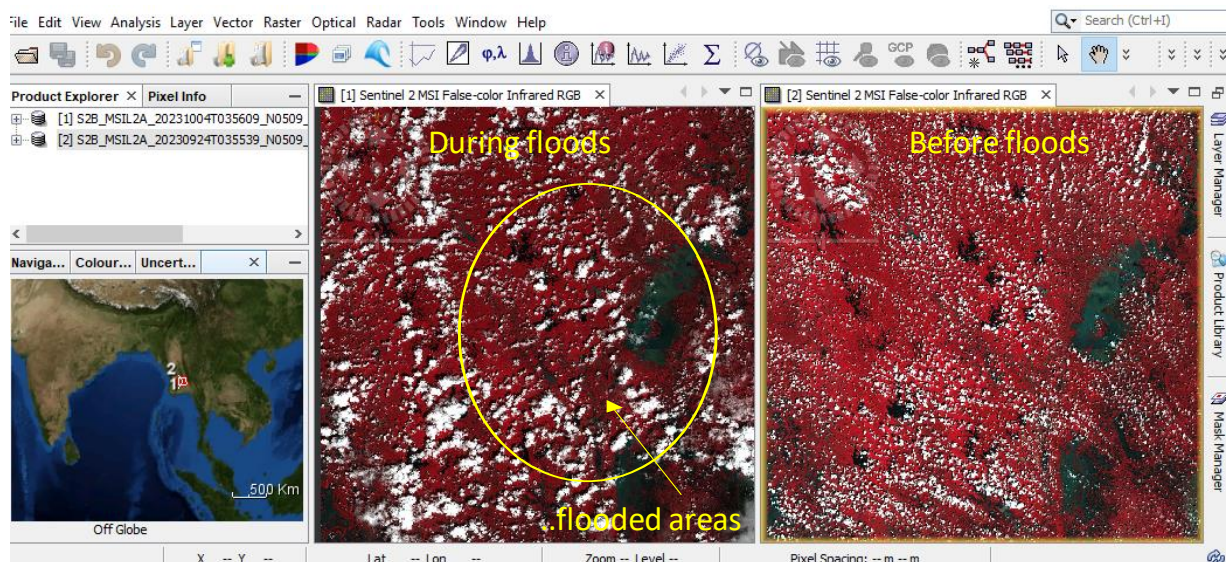


2.2. SNAP - Open and explore product

Open SNAP Desktop, click Open Product and open 2 downloaded products (unzipped) by double click on the metadata „MTD_MSIL2A.xml“ inside the folder. The opened products will appear in Product Explorer window. Go to Windows – Tile them e.g. Horizontally.

S2B_MSIL2A_20231004T035609_N0509_R004_T46QHE_20231004T070950.SAFE.zip
S2B_MSIL2A_20230924T035539_N0509_R004_T46QHE_20230924T071828.SAFE.zip

1. Select the first product in the Product Explorer window.
2. Right click on the product.
3. Open RGB Image Window.
4. In the pop-up window select e.g. 'Sentinel 2 MSI False-color Infrared (Red: B8; Green: B4; Blue: B3)'.
5. Repeat the process for the second product.
6. Tile two opened RGB Windows, e.g. horizontally
7. In the Navigation window, zoom in to the flooded region and synchronise views to see the same area



2.3 Preprocessing

Resample

Resample the bands to the pixel size of the VIS bands:

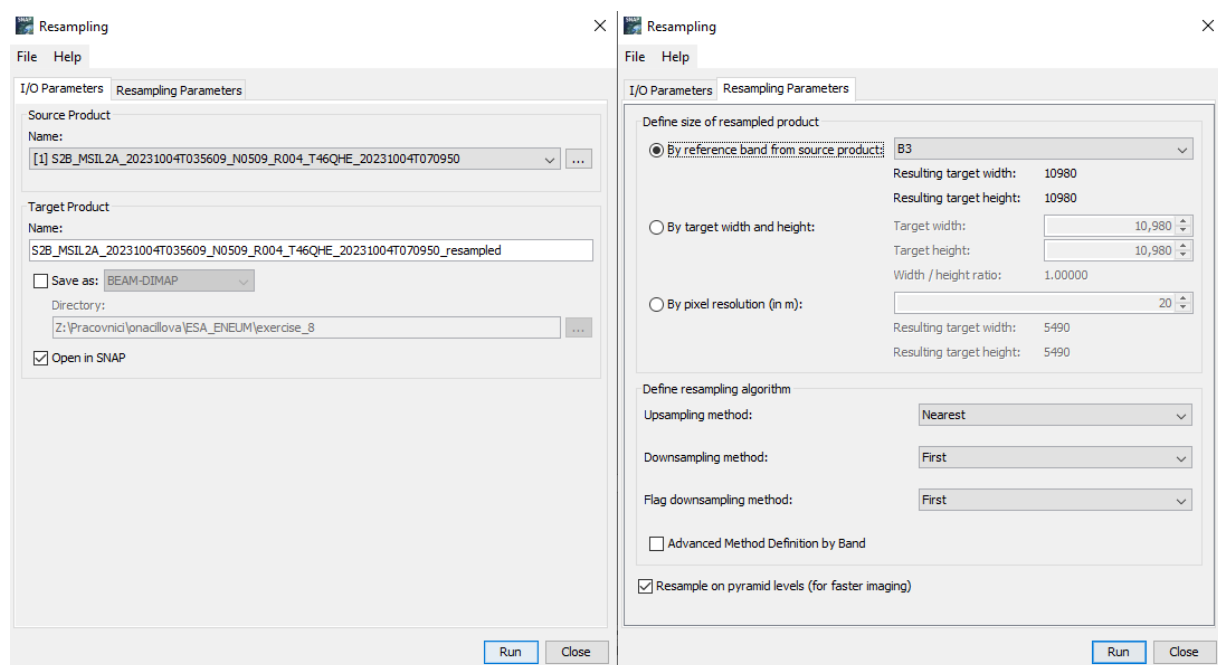
In the main SNAP menu, select Raster - Geometric - Resampling

In the I/O Parameters tab, the source product is set to our only product in the SNAP, change the name of the target resampled product if needed

Do not save the output product - disable the box "Save as:" (if selected).

In the Processing Parameters tab, use e.g. B3 with 10 m resolution to resample all the bands to 10 m as output spatial resolution.

Resample both of the products.



Create subset

Click on the resampled product in the Product Explorer, go to the main SNAP menu and select Raster - Subset...:

Create a subset with the following settings:

Spatial subset - Geo Coordinates:

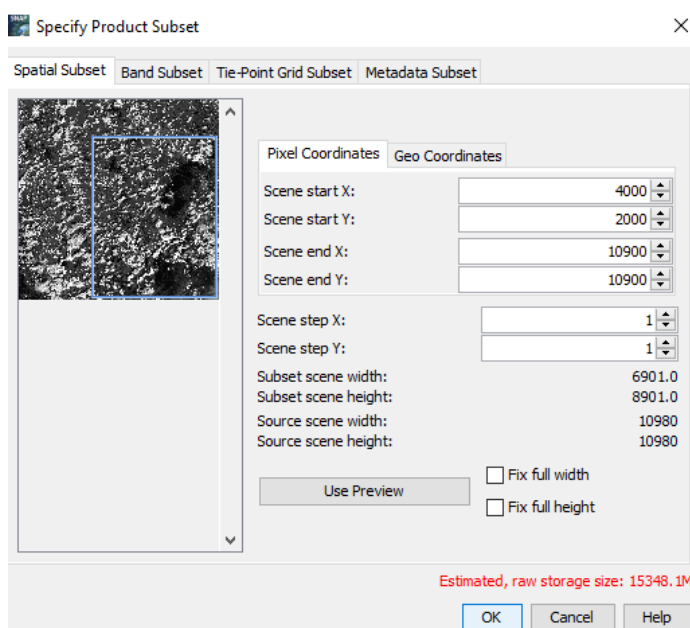
North latitude bound: 18.00,

West longitude bound : 96.20,

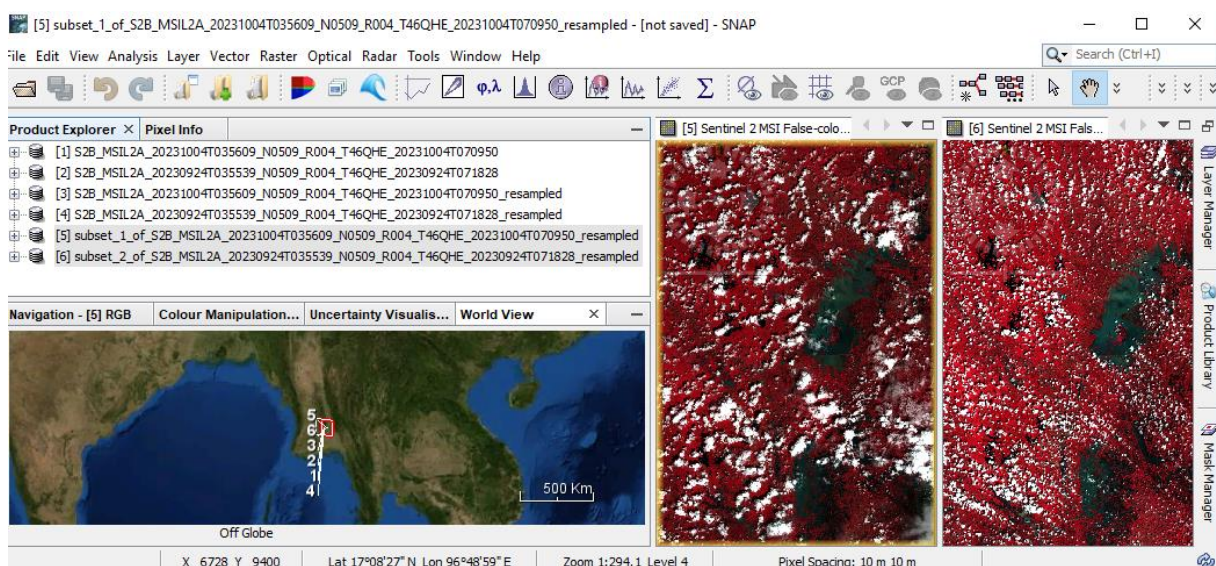
South latitude bound : 17.00,

East longitude bound : 97.00

Keep the remaining parameters as default and click OK



In the end, you should have two resampled subsets. Close original visualizations and display subsets in False color with Tile Horizontally option.

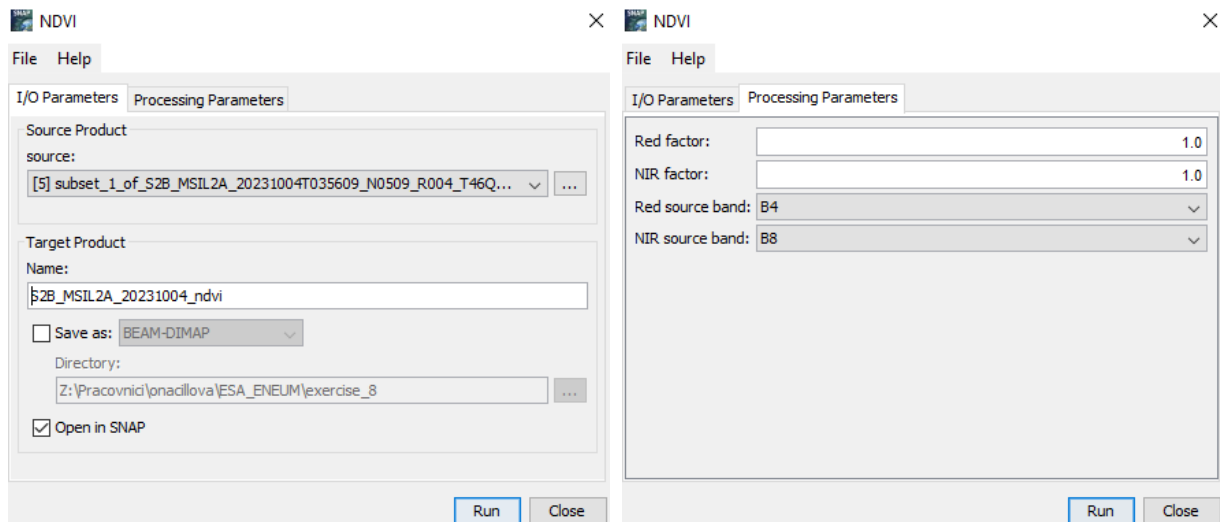


2.4 Image analysis

NDVI

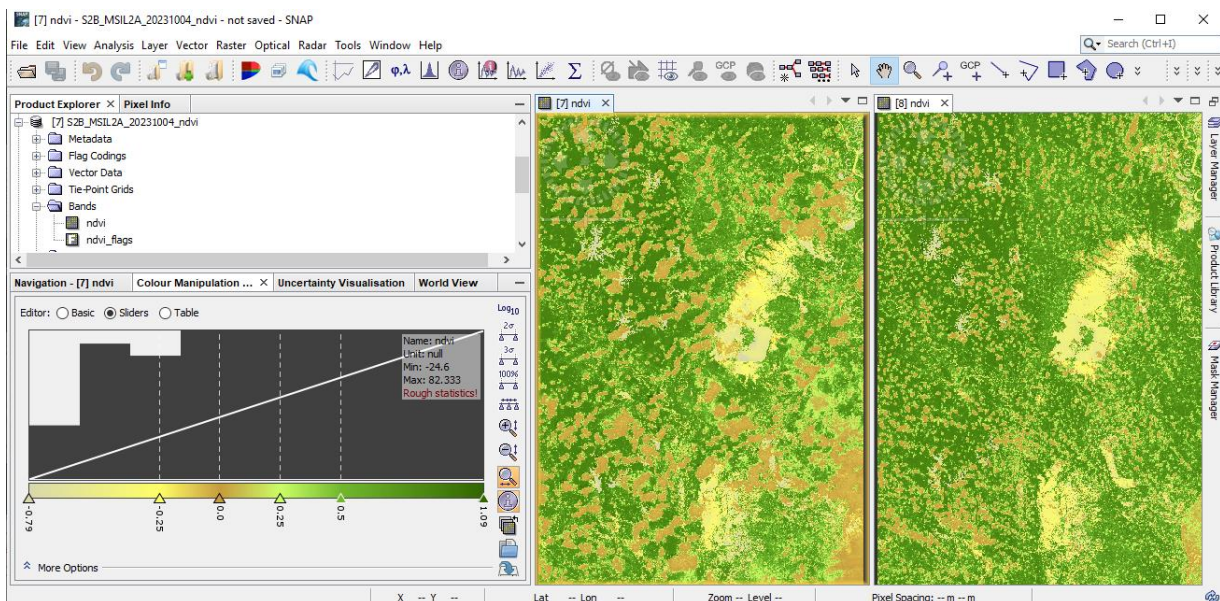
Let's calculate NDVI for the two subset images.

Navigate to Main Menu: Optical – Thematic Land Processing – Vegetation Radiometric Indices – NDVI Processor and set parameters:



In the Product Explorer tab double click to open resulted two new NDVI bands for each date.

Go to Colour Manipulation tab and select appropriate colour palette for vegetation index. Apply the same colour palette and set the sliders to the same values for both of the images. Synchronize Cursor Position and Views activating the two buttons in Navigation tab.

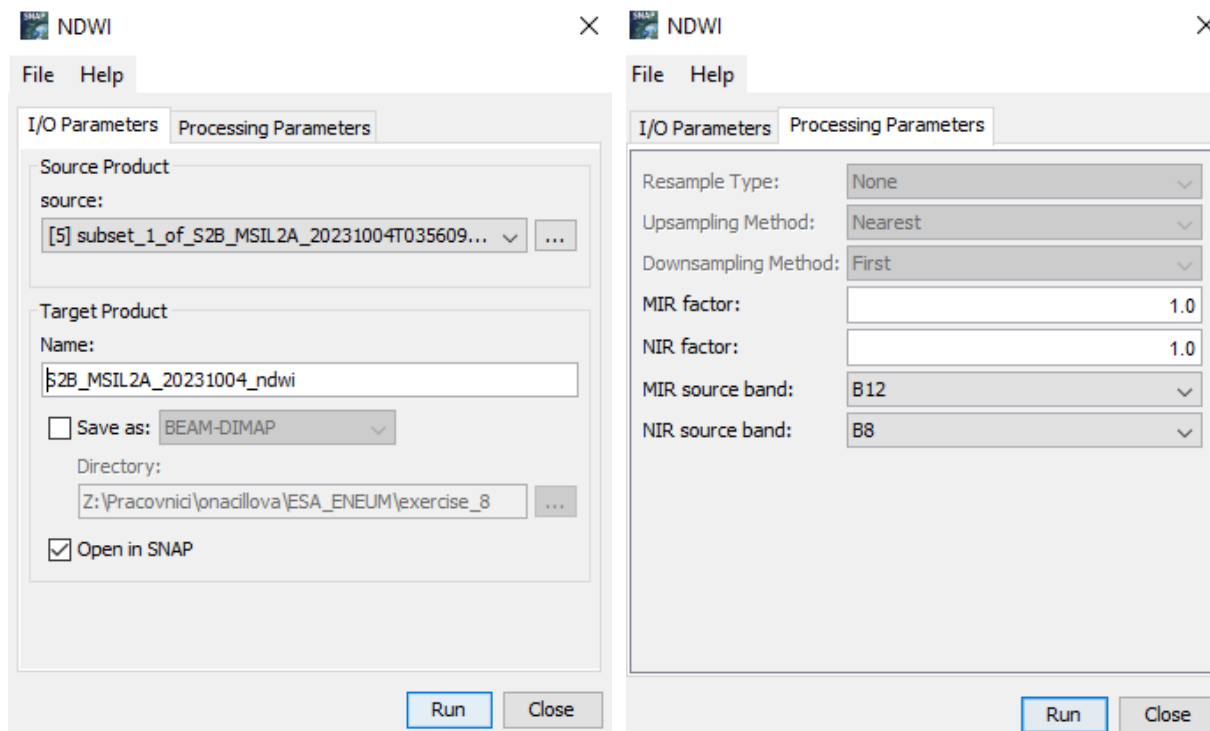


NDVI image has usually values from $< -1, 1 >$, where forested areas are displayed in values higher than 0.

NDWI

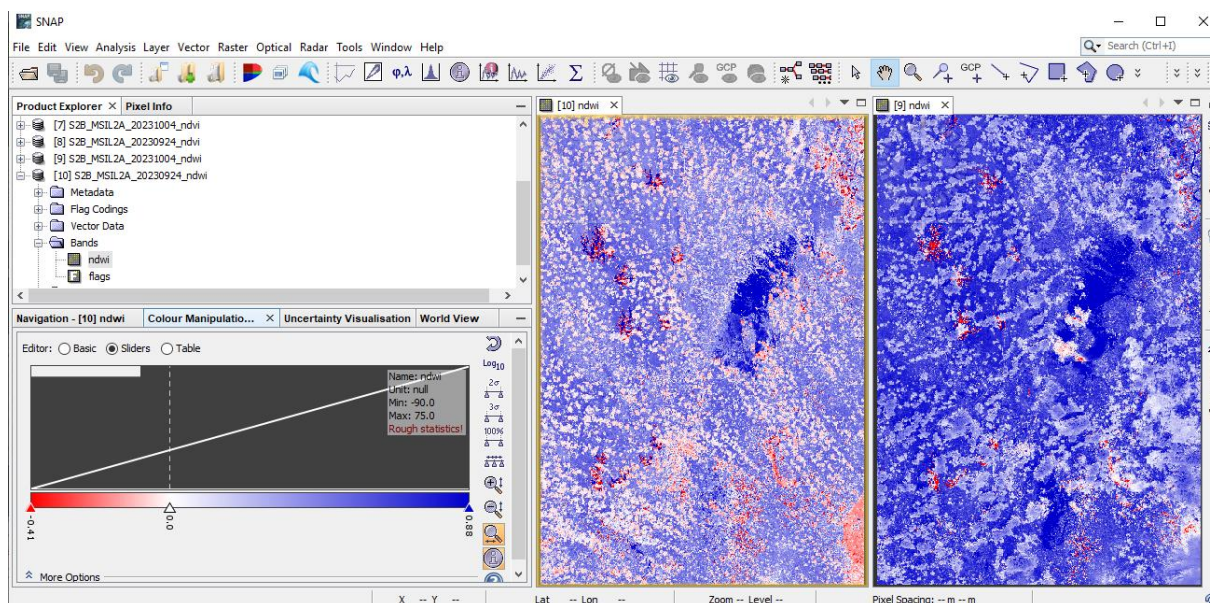
Let's calculate also NDWI for the two subset images.

Navigate to Main Menu: Optical – Thematic Land Processing – Water Radiometric Indices - NDWI Processor and set parameters:



In the Product Explorer tab double click to visualize resulted two new NDWI layers.

Go to Colour Manipulation tab and select appropriate colour palette for vegetation index. Apply the same colour palette and set the sliders to the same values for both of the images. Synchronize Cursor Position and Views activating the two buttons in Navigation tab.

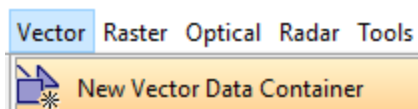


2.5 Water Mask Generation

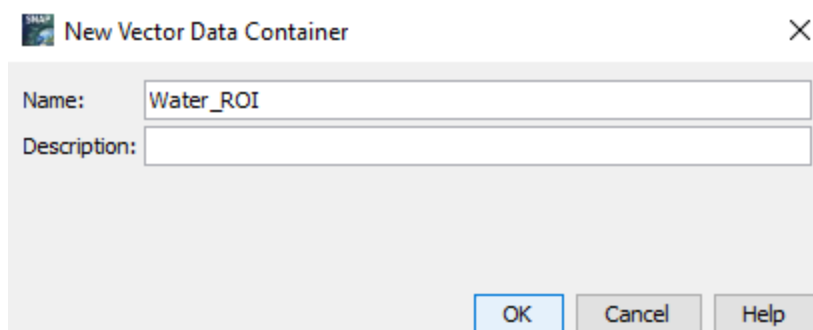
The utilization of both NDVI and NDWI together can be advantageous for specifically identifying water bodies.

Let's create a binary mask of water and non-water pixels with a thresholding condition. Open e.g. False-color composition and define a Waterbody Region of Interest (ROI)

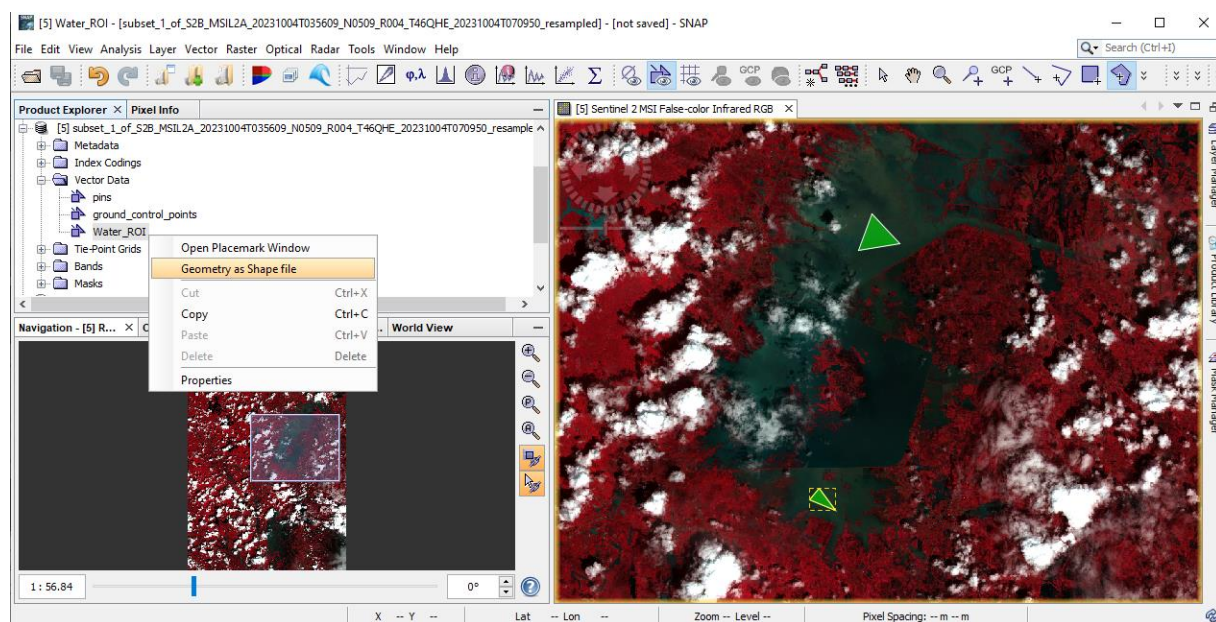
Define a new ROI (Vector->New Vector Data Container)



Define ROI name (f.e. Water_ROI) and description (optional)



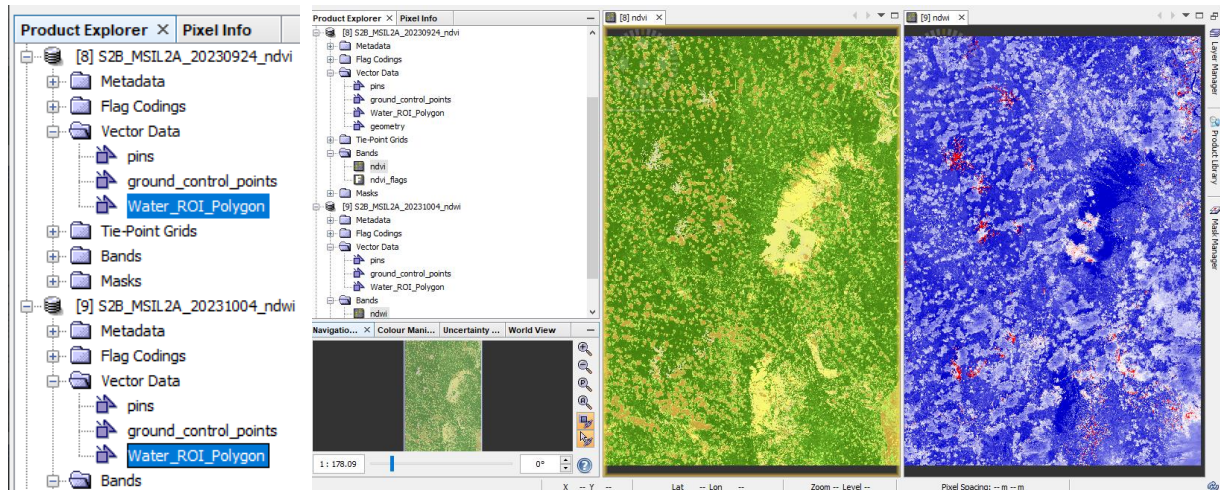
Check in VectorData folder corresponding to the active image to check the ROI has been created. Define Tool for ROI construction (Polygons Drawing Tool) and draw polygon over water area e.g. according False-color Infrared composition and double-click to close it



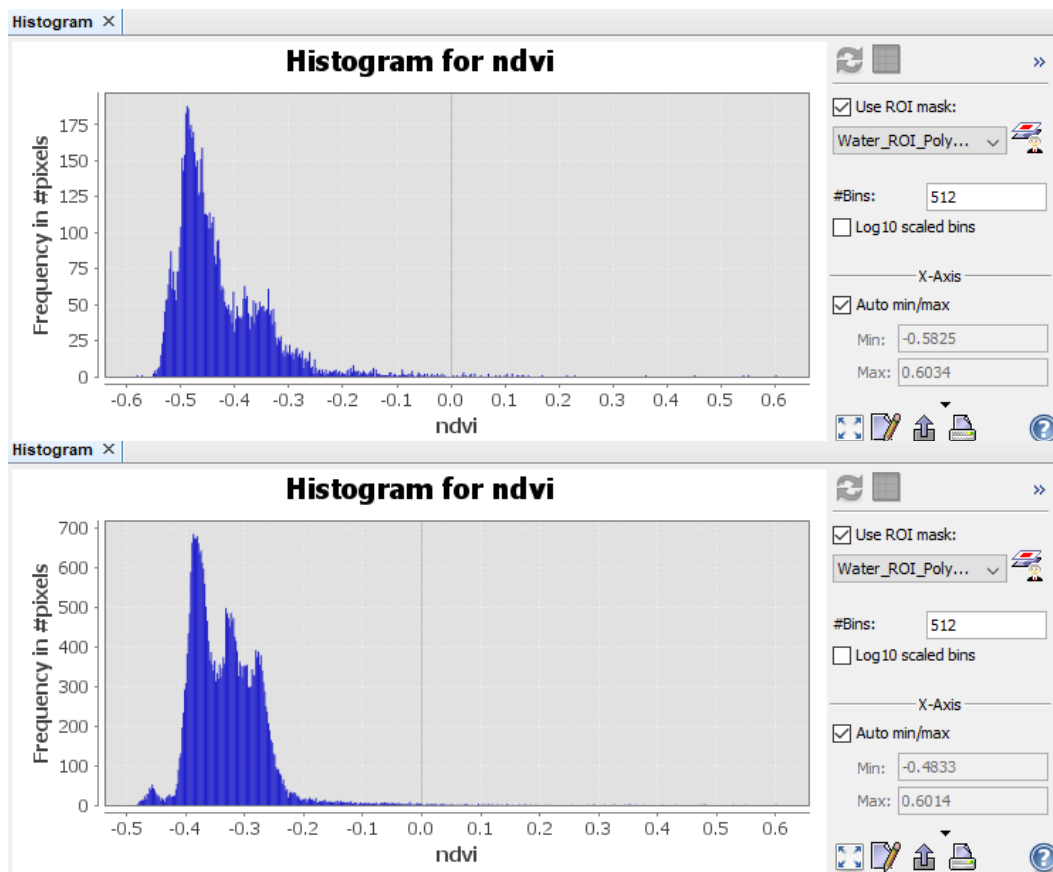
Export ROI as SHAPE file (f.i. as Water_ROI.shp) – right click on the layer – Geometry as Shapefile – set the directory for export and close the visualization

Import SHAPE file to make it available in NDVI and NDWI layers:
 Select NDVI product - File – Import- Vector data – ESRI Shapefile – and import your saved Water_ROI polygon

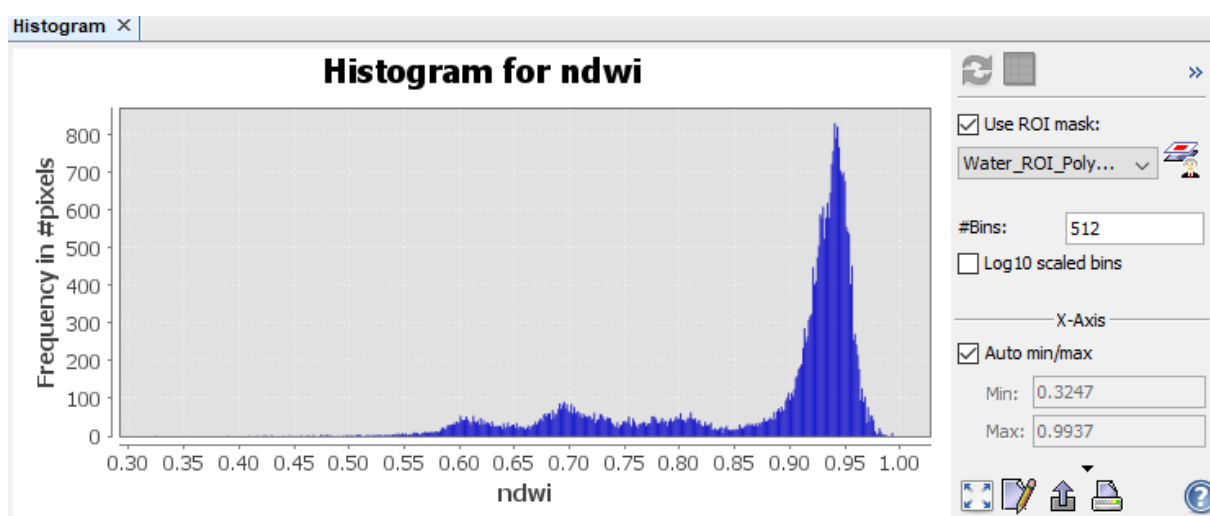
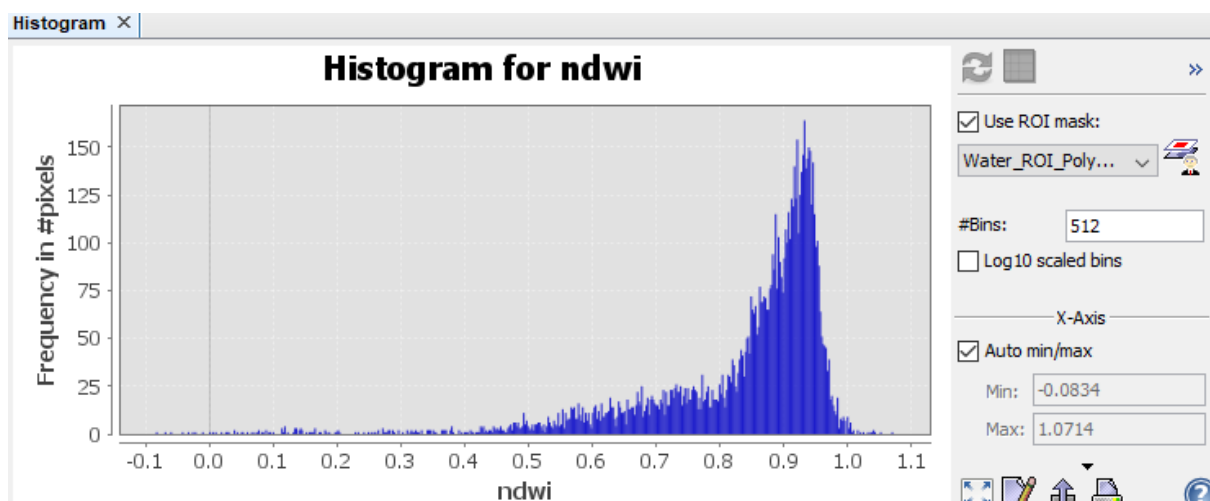
Select NDWI product - File – Import- Vector data – ESRI Shapefile – and import your saved Water_ROI polygon. Select NDVI and NDWI layers from Product Explorer panel and visualize them.



Calculate Histogram over ROI for NDVI and NDWI during pre-flood and during flood events:
 click on NDVI layer – Navigate to Analysis->Histogram – activate Use ROI Mask tab – select Water ROI Polygon mask and press refresh button.



Repeat for NDWI layer.

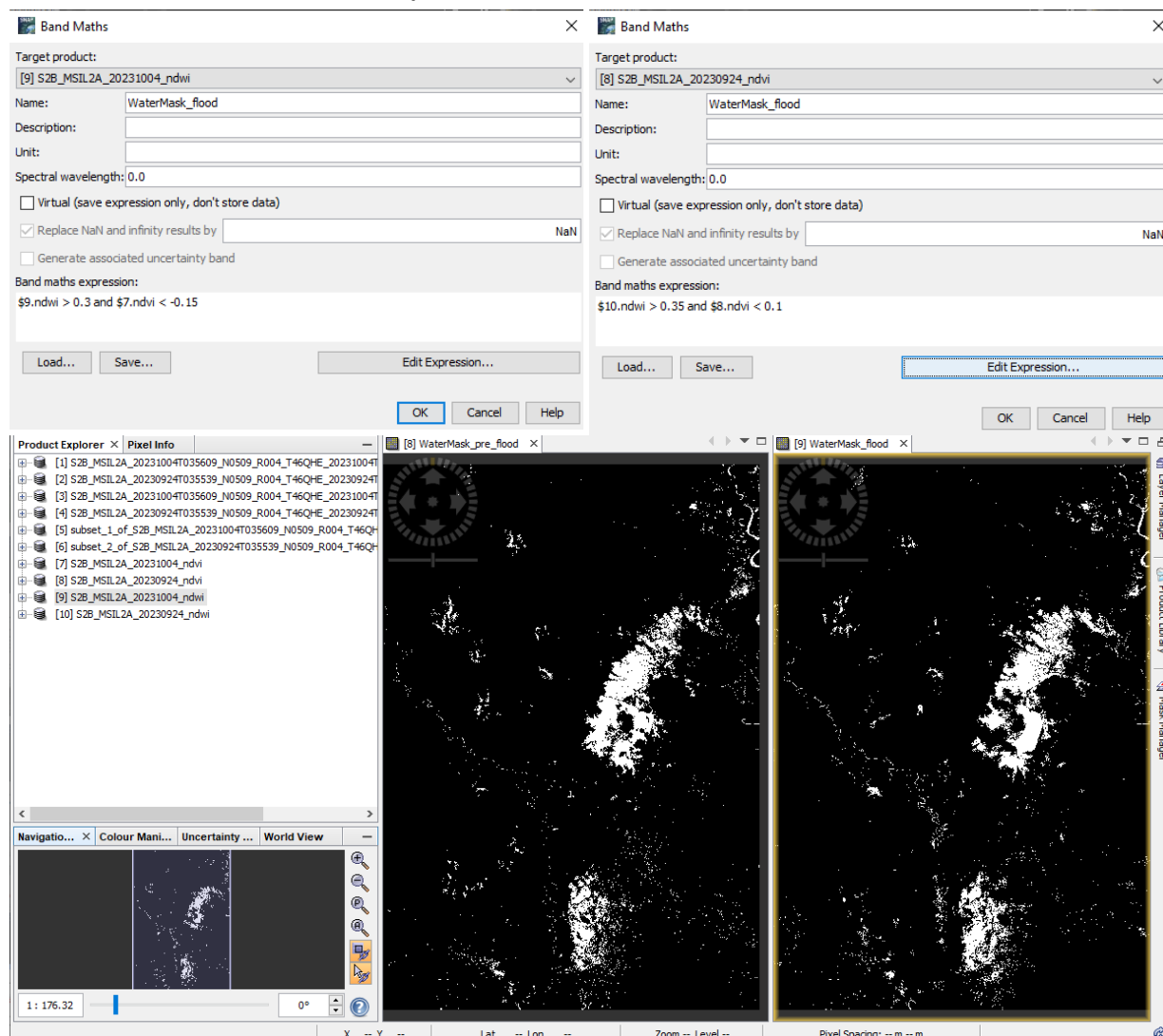


Proposed thresholding values

No-flooded	NDVI<-0.15 and NDWI > 0.3
Flooded	NDVI< 0.1 and NDWI > 0.35

Create masks for NDVI and for NDWI with a combined (AND) condition: Open Band Maths window from Raster>Band Maths or by selecting any available layer (f.i. NDWI) and clicking on the mouse's right button. Edit the formula by selecting the NDVI and NDWI properly (corresponding to the same acquisition) and applying the proper thresholds).

Calculate new masks for pre-flood and flood events.



2.6 Export and open binary masks in QGIS

To export this product for viewing in other GIS software and to map the changes in flooding over time, you need to save our two binary mask (start of floods and peak of floods) in TIF format in the proper folder using File-> Export->GeoTiff/BigTiff tool.

To visualize the output of our multi-temporal flood analysis, we will open the masks saved in GeoTIFF format using QGIS:

In QGIS click on the Add Raster Layer button located in the left panel, navigate to the folder containing the binary masks in TIFF format, and click Open (or drag&drop).

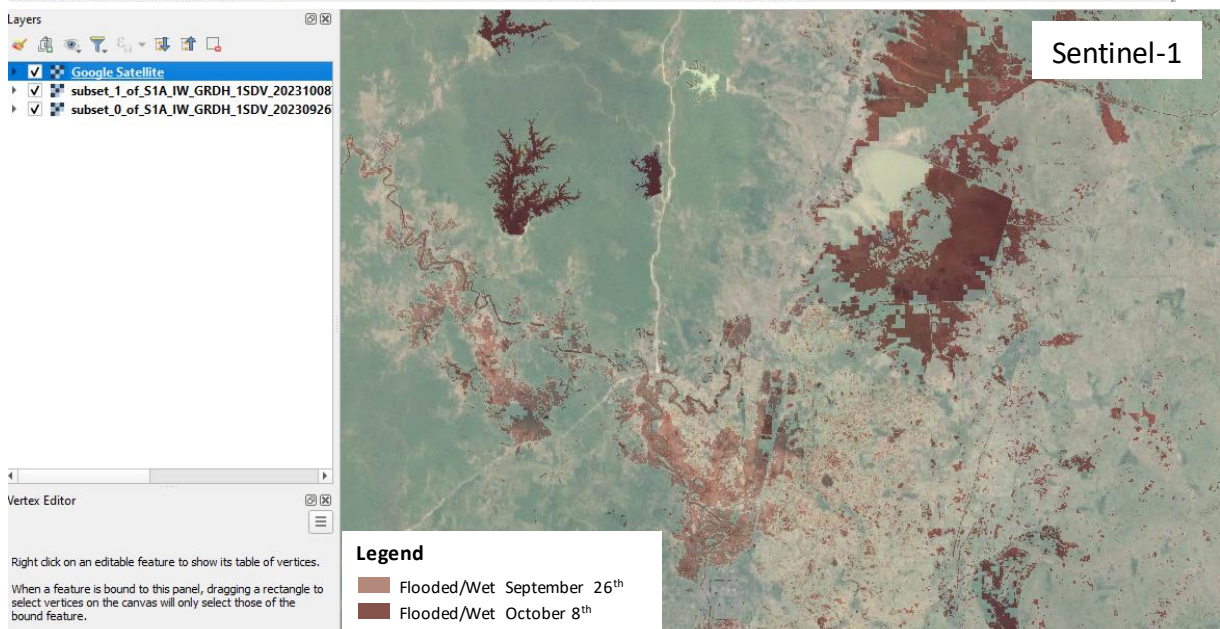
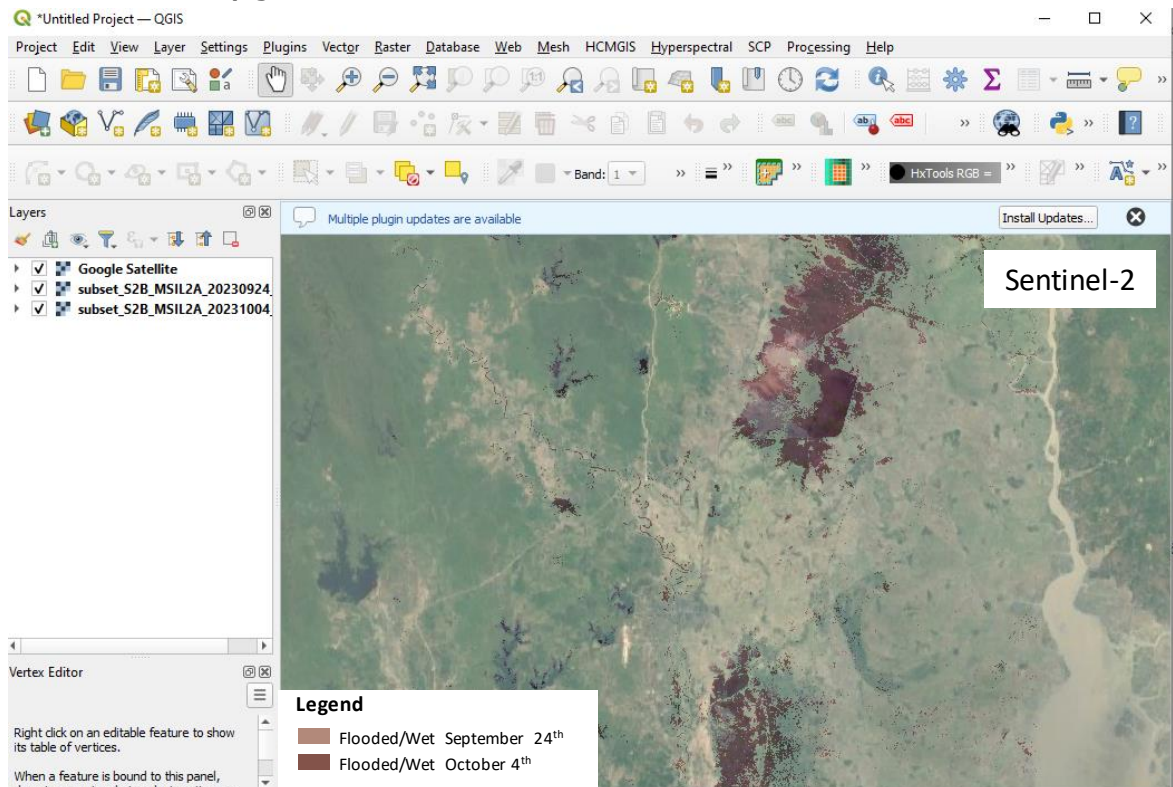
Now we open the output image in QGIS

- We can overlay it to e.g. Google Satellite or Bing aerial image:
- Web->OpenLayers plugin->Google Maps->Google Satellite
- Move the Subset above the satellite

- Play with Transparency: Properties->Transparency (e.g. 80%)

As observed, the floodwaters gradually subside over time, yet areas near the riverbanks remain saturated, displaying low backscatter and thus continuing to appear flooded.

Compare masks retrieved via S1 and S2 using S2-RGB data as (quasi simultaneous) ground truth.



For more information, see the lectures: [10. SAR and optical remote sensing for mapping floods](#), [11. SAR and optical remote sensing for post-flood assessment and recovery](#)

THANK YOU FOR FOLLOWING THE EXERCISE!