



EXERCISE 10 – TUTORIAL

Flood Monitoring with Sentinel-1 & Sentinel-2 using the SNAP software

1 | Exercise outline

In this first exercise for mapping floods, we will:

- Detect floods on Sentinel-1 images
- Develop a graph for automated processing using Batch processing
- Create binary mask for flood mapping

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.



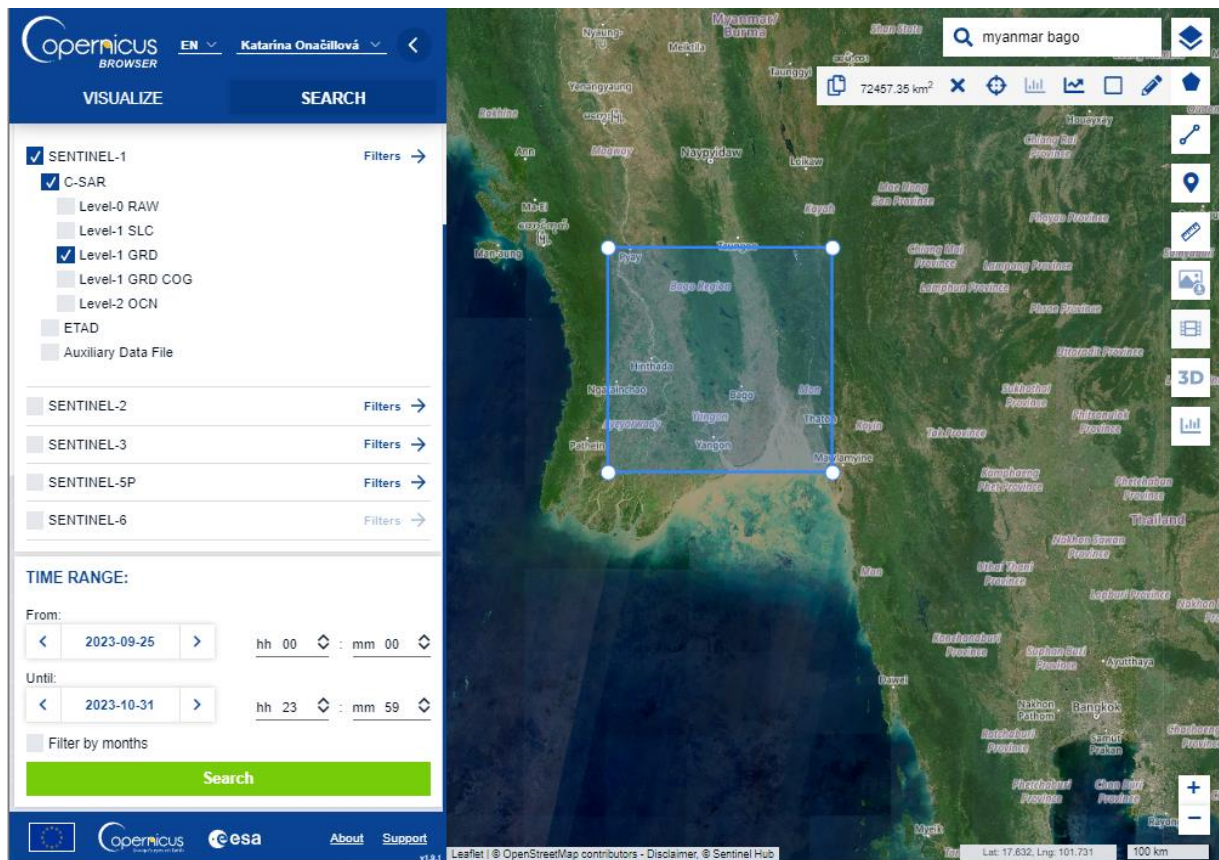
However, during severe weather conditions with heavy rainfall and intense cloud cover, optical remote sensing may struggle to provide accurate information due to a lack of cloud-free, high-quality images and difficulty in detecting water under vegetation cover.

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)

Synthetic Aperture Radar (SAR) datasets offer significant benefits in flood observation as they emit electromagnetic waves that are unaffected by weather and time of day. The Sentinel-1 satellite, which provides extensive global data coverage, can effectively detect flooding in vegetated or urban areas due to its high penetration capability.

2.1 Study area and data used

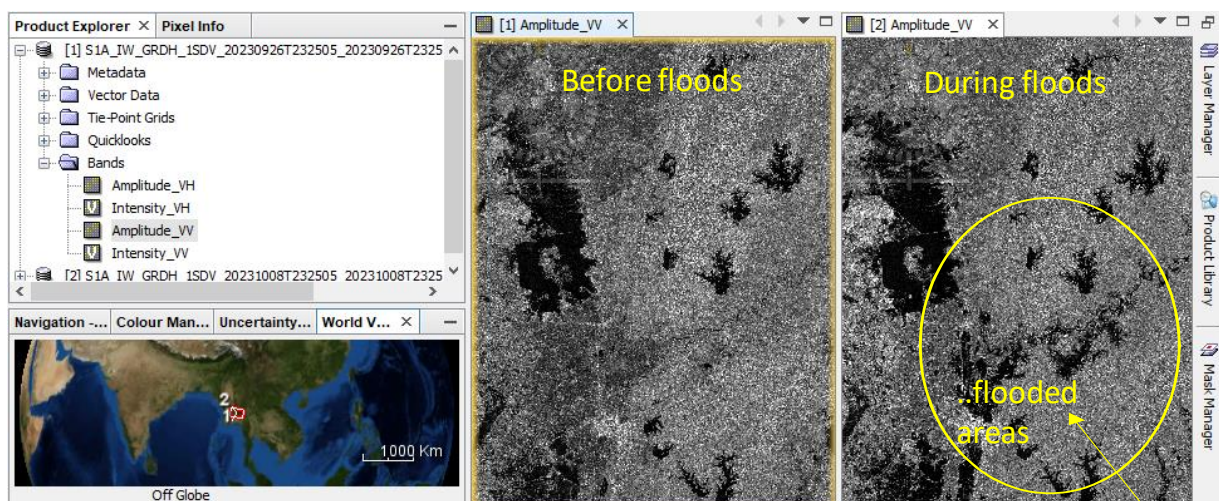
For this exercise, we will use two Sentinel-1 GRD images of the same area near Bago city, Myanmar, downloaded from the Dataspace Copernicus Open Access Hub [[@https://dataspace.copernicus.eu/](https://dataspace.copernicus.eu/)].



2.2. SNAP - Open and explore product

Open SNAP Desktop, click Open Product and open 2 downloaded products by double click on them. The opened products will appear in Product Explorer window. Go to Windows – Tile them e.g. Horizontally.

S1A_IW_GRDH_1SDV_20230926T232505_20230926T232530_050505_061540_C745.SAFE.zip
S1A_IW_GRDH_1SDV_20231008T232505_20231008T232530_050680_061B43_DCF8.SAFE.zip



3.1 Pre-processing

We need to apply identical pre-processing steps to both of our scenes:

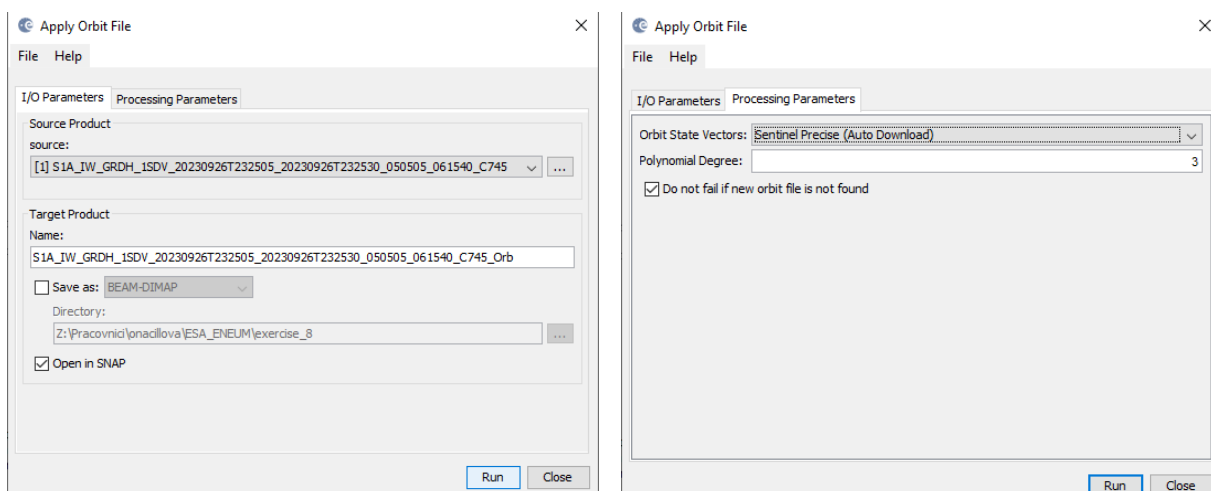
Apply orbit file

Navigate to Main Menu – Radar – Apply orbit file

In the I/O Parameters tab, select the first product and name the target product. There is no need to save the output as BEAM-DIMAP (we will save the time this way)

In the Processing Parameters accept the default settings and select the option „Do not fail if new orbit file not found“

Repeat for the second image.



Create subset

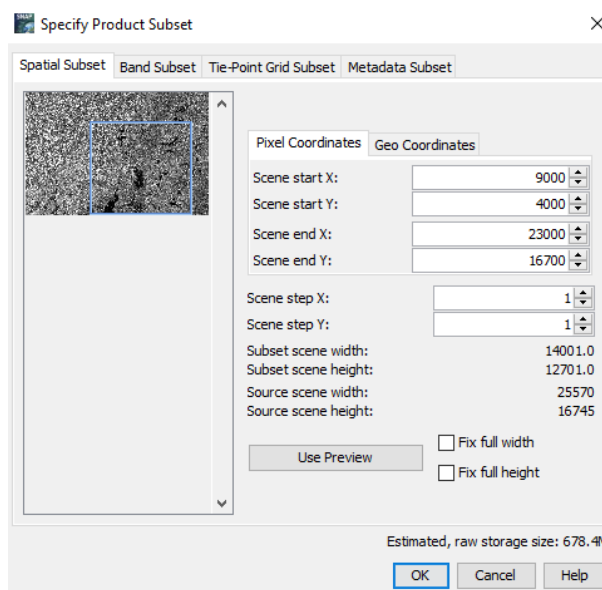
There is no need to process the whole image, instead, we can begin by narrowing down the scene to a more manageable size – creating subset. This approach will decrease processing time in subsequent stages, especially when the analysis is concentrated on a specific area rather than the entire scene.

Select the last product with applied orbit file.

Go to the Subset tab and at “Pixel Coordinates” set:

- Scene start X: 9000
- Scene start Y: 4000
- Scene end X: 23000
- Scene end Y: 16700

Repeat for the second image.

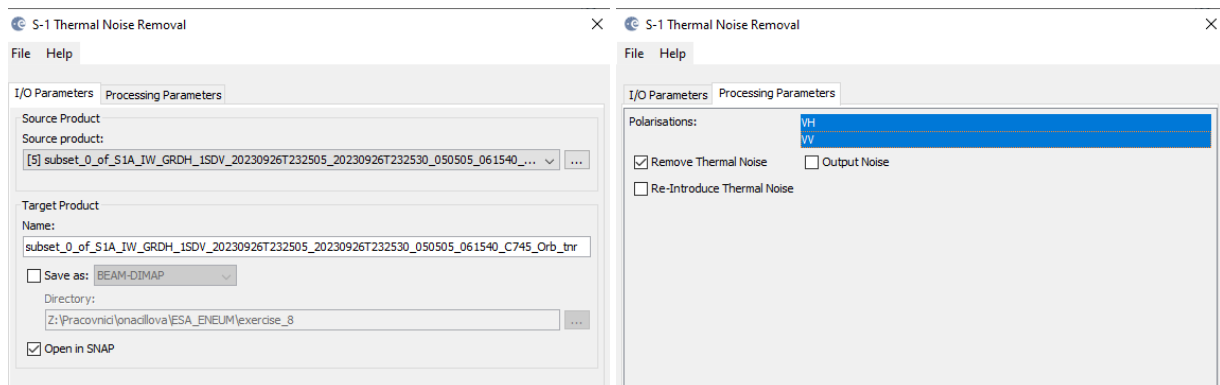


Thermal noise removal

Navigate to Main Menu – Radar – Radiometric – S-1 Thermal Noise Removal
In the I/O Parameters tab, select the last subset product with applied orbit file and name the target product. There is no need to save the output as BEAM-DIMAP (we will save the time this way)

In the Processing Parameters you can select both polarization and make sure that the “Remove Thermal Noise” option is selected.

Repeat for the second subset image.



Calibration

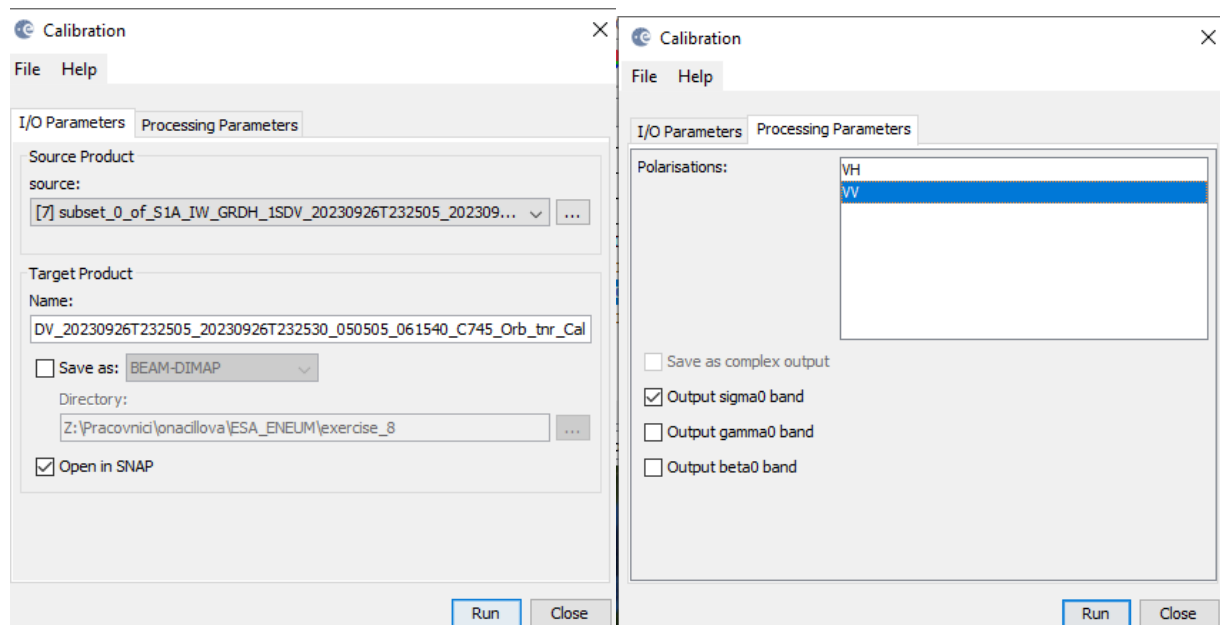
With our image now subsetting and with TNR, we must apply image calibration. This step is necessary to normalize the values in the image into backscatter values so we can compare multiple images in a time series.

Navigate to Main Menu – Radar – Radiometric – Calibrate

In the I/O Parameters tab, select the product with thermal noise removal and name the target product. In the case of this final product of preprocessing, please, save it to your folder for this exercise

In the Processing Parameters select the VV band as input and accept all default settings and then click Run

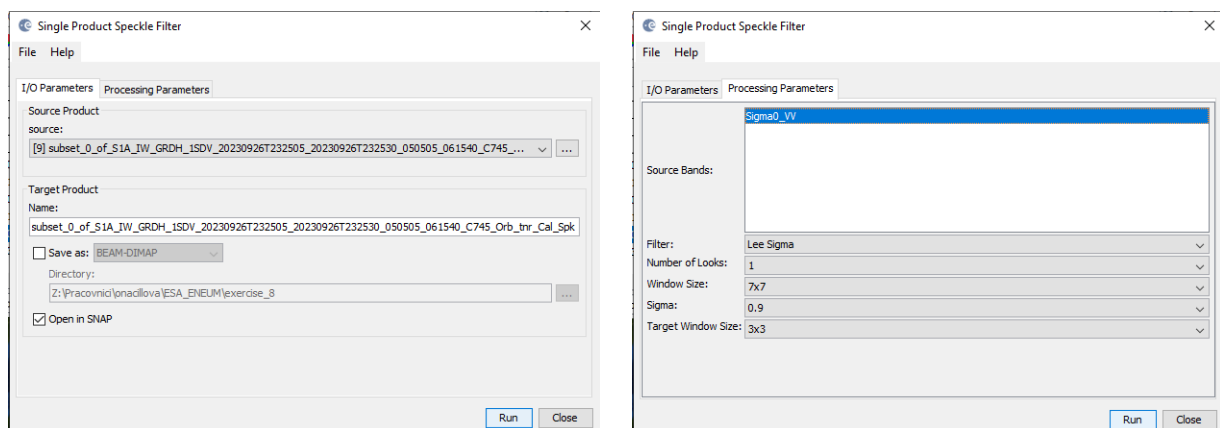
Repeat for the second image. The saving might take some time.



Speckle Filter

Despeckling removes thermal noise introduced by the sensor from the image to remove potential sources of error in analysis.

Navigate to Radar > Speckle Filtering Single Product Speckle Filter. In the Speckle-Filter tab, choose the simple Lee Sigma filter with default window sizes.



Terrain-Correction

Navigate to Radar – Geometric – Terrain Correction – Range Doppler Terrain Correction. The last step in our graph for image pre-processing is to apply terrain correction to the product, ensuring that all the pixels are moved to the right locations (eg if the nadir angle of the image is off, it will align the pixels correctly so it is closer to a top-down view of the imagery).

Our data are still in radar geometry, moreover due to topographical variations of a scene and the tilt of the satellite sensor, the distances can be distorted in the SAR images. We need to apply Terrain Correction to compensate for the distortions and reproject the scene to geographic projection.

Navigate to Main Menu: Radar - Geometric - Terrain Correction - Range-Doppler Terrain Correction

In the I/O Parameters tab set as "Source Product" the velocity product.

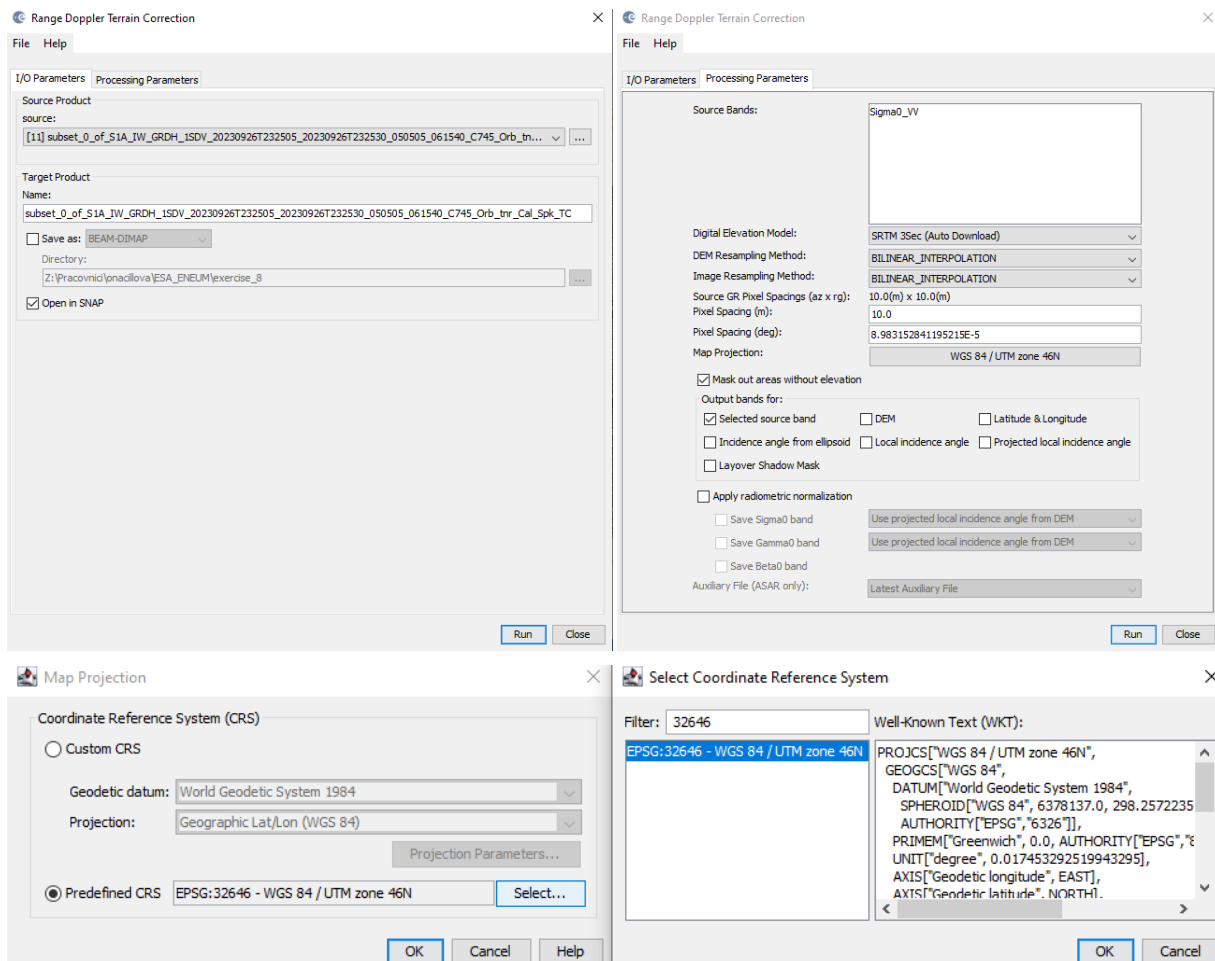
In "Target Product", keep the default name and set the Directory

In the Processing Parameters tab set:

Digital Elevation Model: ACE30 (Auto Download)

Map Projection: Click on the tab next to Map projection (WGS84(DD) – select Predefined CRS and click on "Select". In "Filter" search for 32621 (EPSG: 32646 – WGS84 / UTM Zone 46N) and when you find it click OK to both windows.

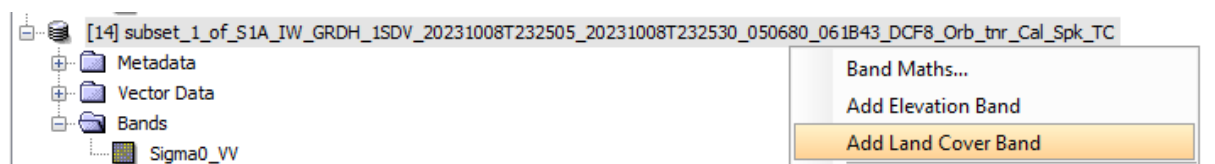
Keep default values for the other parameters. Click Run. Approximate processing time: 2.5 minutes.



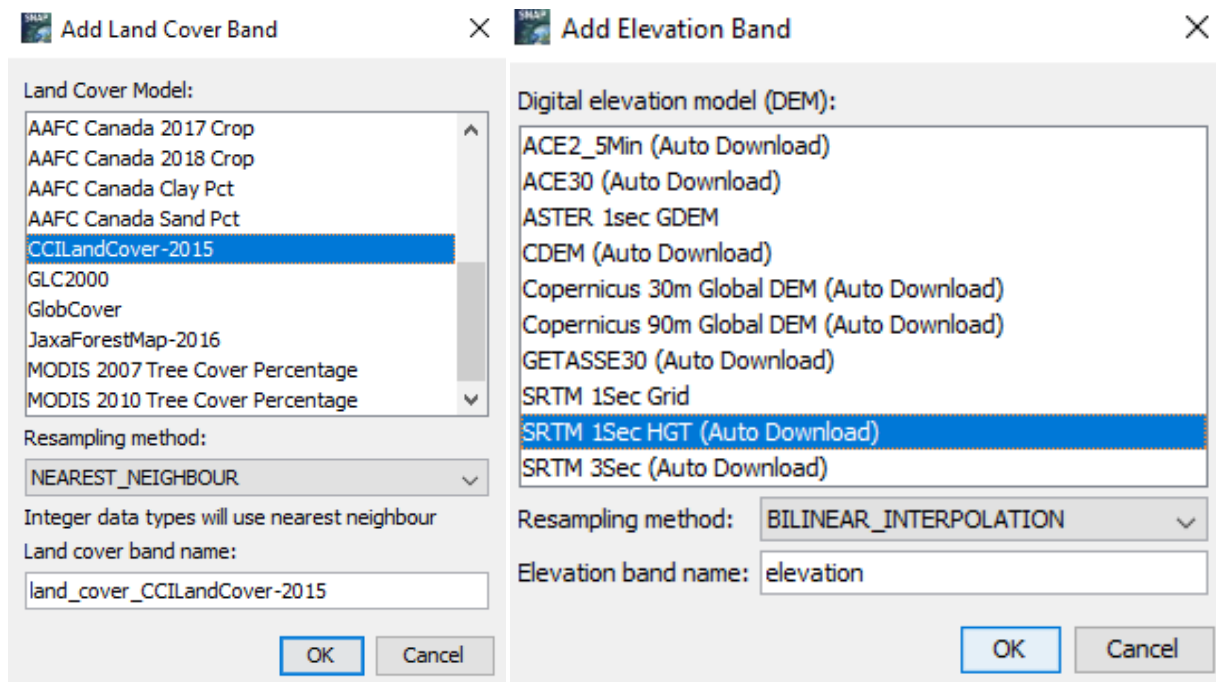
3.2 Flood assessment

After execution, your resulting two preprocessed products should contain a single bands called Sigma0_VV. Open all two (preprocessed) Sigma0_VVs in the View and then go to Window -> Tile Horizontally

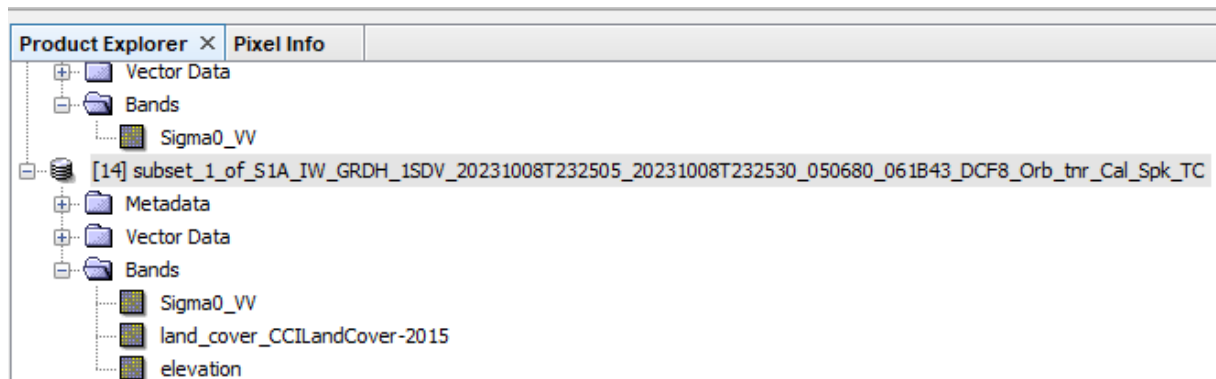
After ensuring that our products feature calibrated backscatter values, it's time to conduct flood assessments on the data to automatically ascertain the extent of flooding across the series of images. Areas with low backscatter indicate wet areas. Since our calibrated images contain calibrated backscatter coefficients, we can create a binary image from the products, highlighting areas below a cutoff threshold. Since the River traverses Bago city, it's crucial not to include recognized water sources in our flood mapping. To achieve this, we can incorporate the land cover band into our product in SNAP by right-clicking on the product in Product Explorer and selecting "Add Elevation Band."



Additionally, we aim to include an elevation band to prevent misidentification of high-elevation regions as flooded. To add an elevation band, right-click on the product and choose "Add Elevation Band," then select "SRTM 1Sec HGT (Auto Download)."



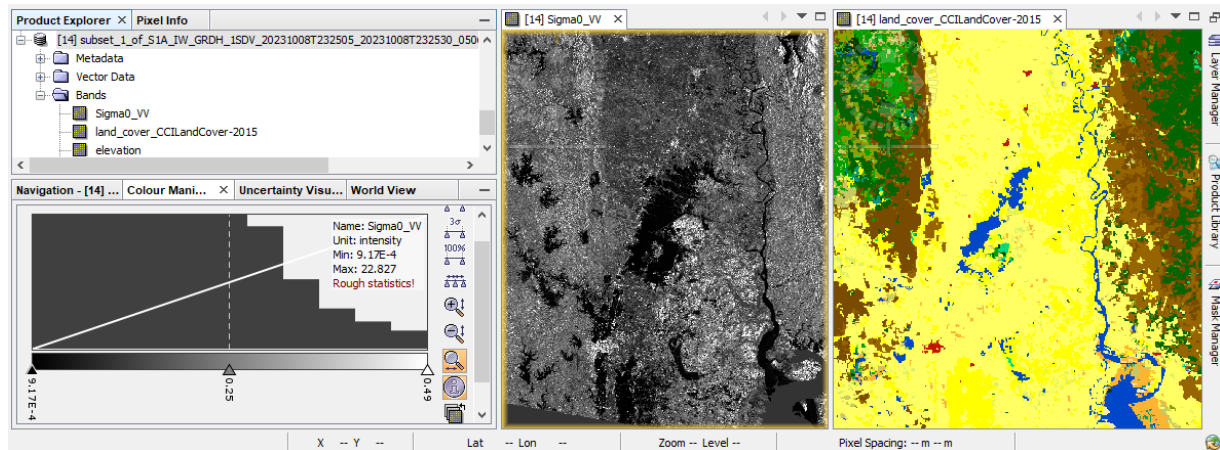
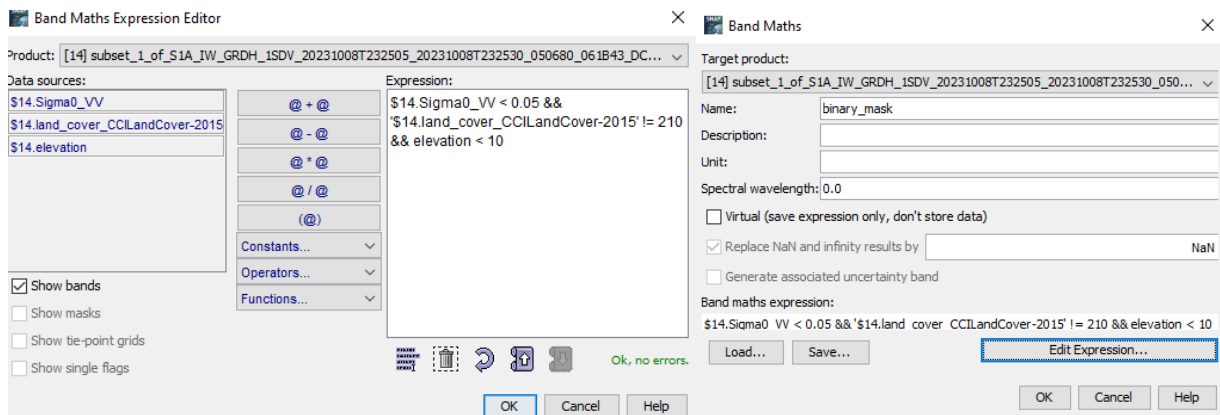
Your product now should include land cover band and also elevation band



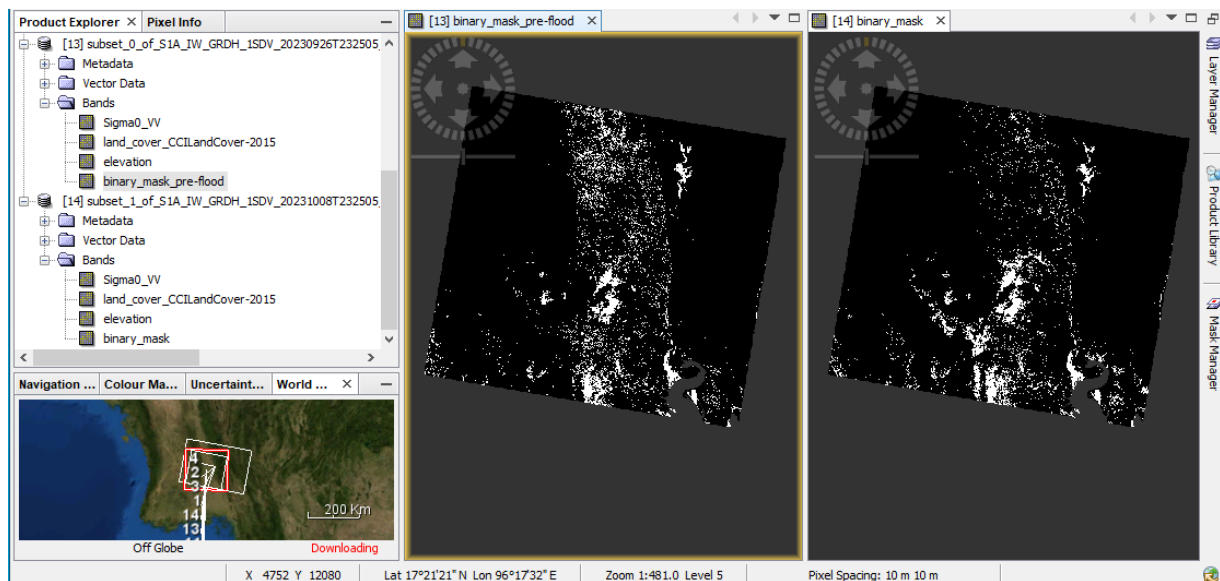
Now that we've added all the required bands, it's time to generate our new flooding band. Right-click on the product and choose "Band Maths." Enter the following expression into the text box:

Sigma0_VV < 0.05 && land_cover != 20 && elevation < 10

This will produce a binary mask indicating areas where the backscatter is below our threshold of 0.05, not categorized as water (Class 210) in land cover, and with an elevation below 10 meters above sea level.



Repeat the process for the second Sentinel product. Display the two masks to check they have been generated correctly. Our output flooding binary band should look like this (For September 26th – start of flooding and October 10th – peak of flooding):



3.3 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.

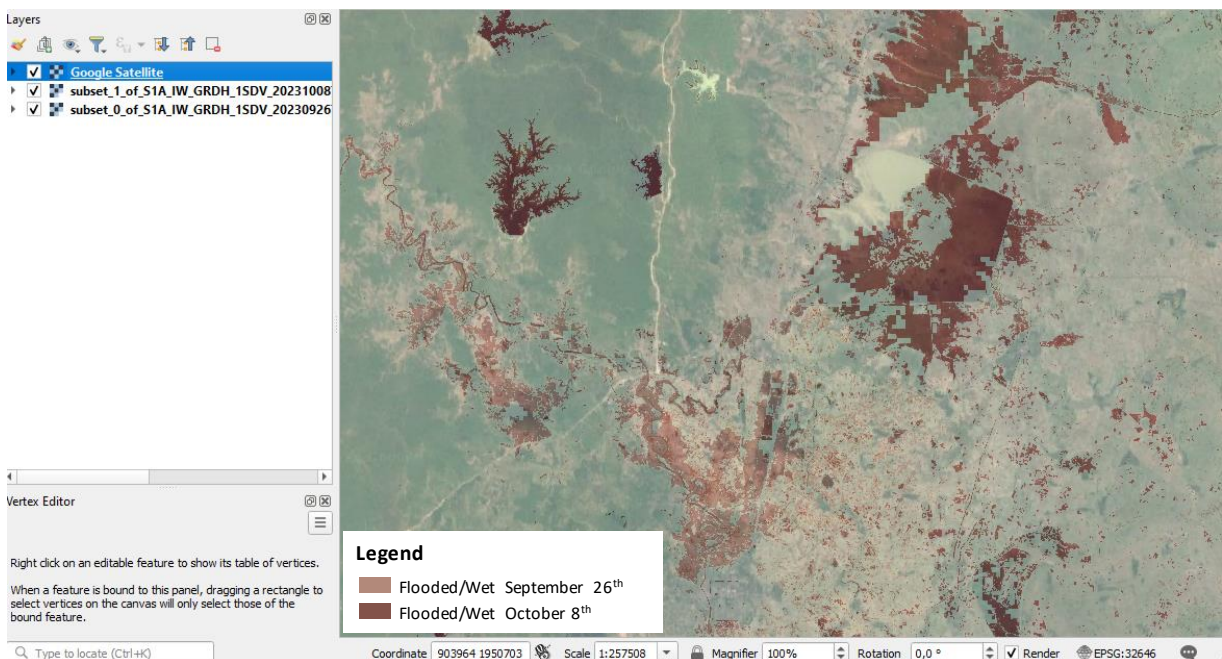
To visualize the output of our multi-temporal flood analysis, we will open the masks saved in GeoTIFF format using QGIS:

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.



THANK YOU FOR FOLLOWING THE EXERCISE!