



EXERCISE 5 – TUTORIAL

Crop Classification with S1 and S2 data using the SNAP software

1 | Exercise outline

In this exercise, we will:

- Use radar (Sentinel-1) and optical (Sentinel-2) data to classify and analyse different crop types and their health over an area
- Data pre-processing will be performed, and then the crop types will be estimated by classification of the data, based on the Random Forest algorithm
- Land crops growth and health will be observed using NDVI time series

2 | Background

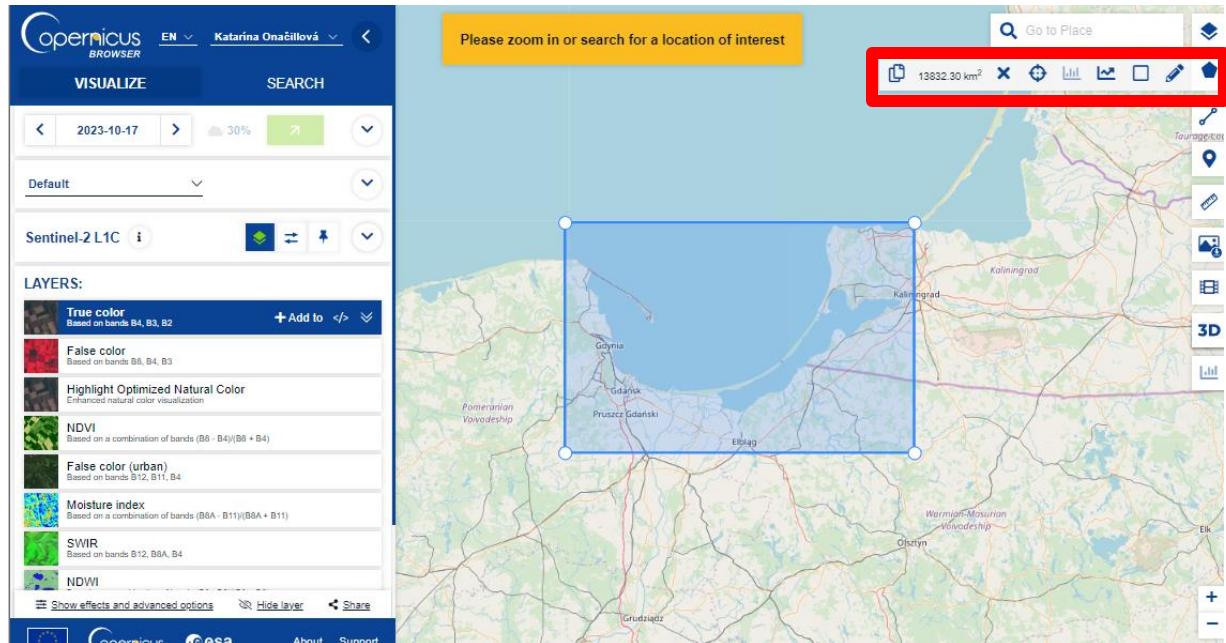
Crop classification using Sentinel-1 and Sentinel-2 data

Crop classification using Sentinel-1 data relies on the radar backscatter signals obtained from the satellite. The backscatter intensity, polarization, and texture of the radar imagery are analyzed to distinguish between different crop types.

Supervised classification methods involve training a classifier with labeled samples of land cover types, while unsupervised methods group pixels based on their spectral similarity without prior training. The accuracy of the land cover classification is validated using ground truth data, and the results can be refined iteratively to improve accuracy. The final land cover maps provide valuable information for various applications, including urban planning, agriculture, forestry, and environmental monitoring.

2.1 Study area and data used

For this exercise, we will use Sentinel-1 and Sentinel-2 images to explore fields in Kacik, near Gdansk and Baltic Sea coast northern Poland, downloaded for year 2023 from the Dataspace Copernicus Open Access Hub [[@https://dataspace.copernicus.eu/](https://dataspace.copernicus.eu/)].

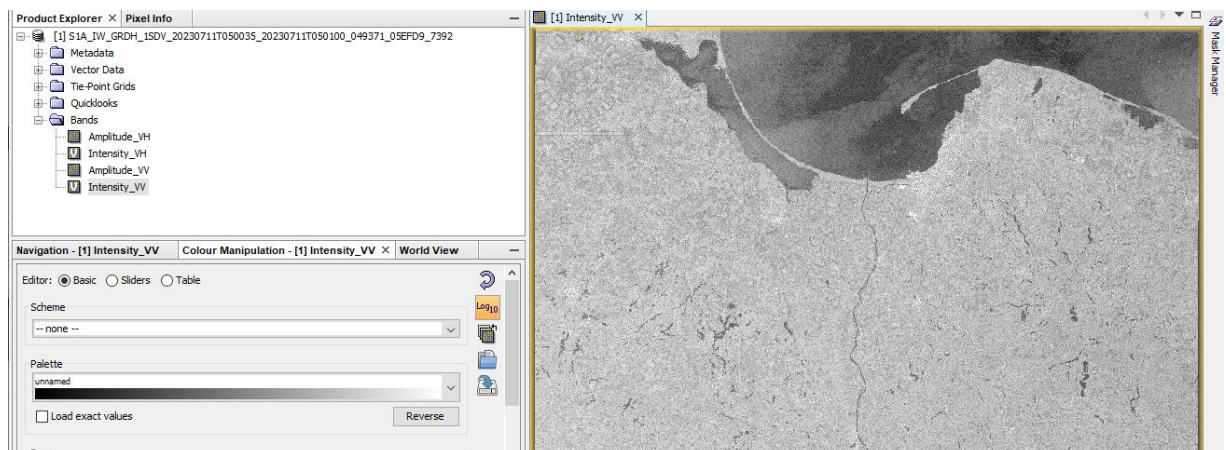


2.2. SNAP - Open and explore product

Open SNAP Desktop, click Open Product and open Sentinel-1 GRDH downloaded products with HH and HV polarizations acquired on 11 July 2023 by double click on the zipped folders. The opened products will appear in Product Explorer window:

S1A_IW_GRDH_1SDV_20230711T050035_20230711T050100_049371_05EFD9_7392.SAFE

Click + to expand the content of product, then expand Bands folder and double click on Intensity_VV band to visualize it. Depending on your computer's capabilities, this process could take some time. To minimize the data load, the next step involves creating a subset that encompasses only a portion of the dataset.



3. Pre-processing

For classification purposes, three bands are utilized per acquisition: VV (or HH for Sentinel-1), VH, and their ratio VV/VH (or HH/VH for PALSAR). Out of the 13 bands per Sentinel-2 data acquisition, only the 10 with spatial resolutions of 10 m or 20 m are utilized.

3.1 Sentinel-1 preprocessing

The Sentinel-1A data were obtained in IW mode and retrieved from the ESA Scientific Data Hub at <https://scihub.copernicus.eu/> in GRDH format. These data require calibration (converting from Digital Numbers to Radar Backscattering Coefficient s_0) and orthorectification (transforming from image geometry to a geographical projection) within a geographical subset. Subsequently, a filter is applied to mitigate Speckle noise, which is inherent in radar imagery.

Apply orbit file

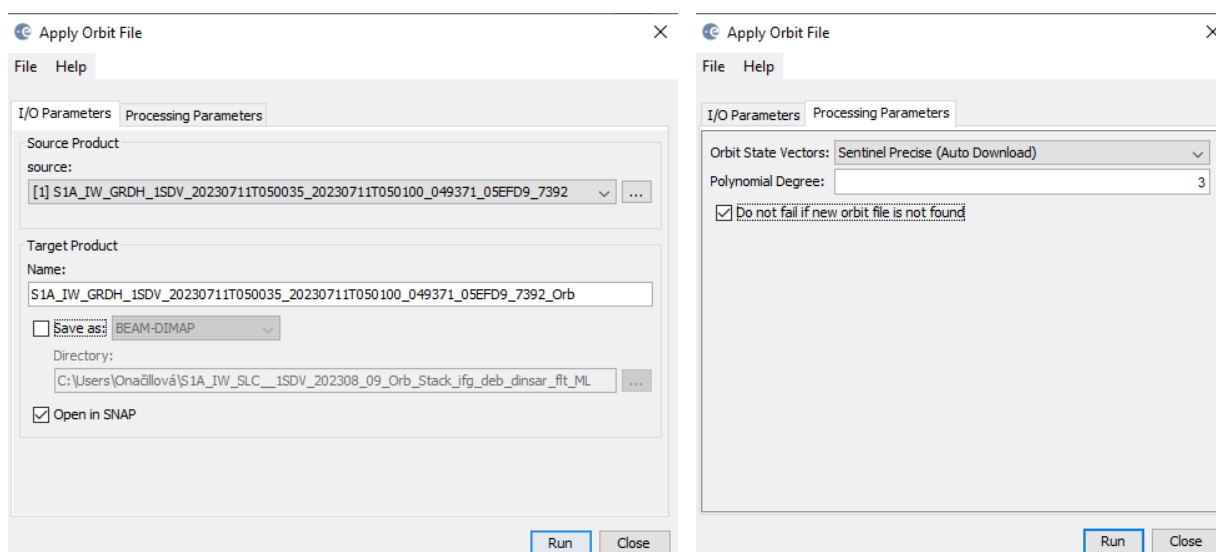
Satellite positions are recorded using a Global Navigation Satellite System (GNSS). To ensure the fast delivery of Sentinel-1 products, orbit details produced by an onboard navigation system are included in the Sentinel-1 products. Subsequently, the Copernicus Precise Orbit Determination (POD) Service further enhances the accuracy of the orbit positions.

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 is not found“

Note: If precise orbits are not yet available for your product, restituted orbits can be selected which may not be as accurate as the Precise orbits but will be better than the predicted orbits available within the product.

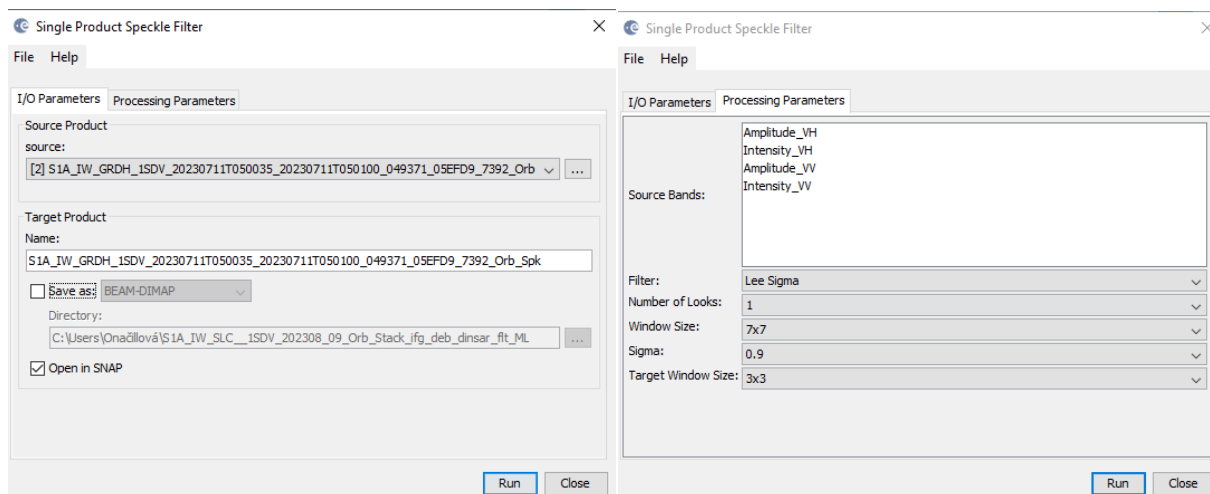


Speckle Filter

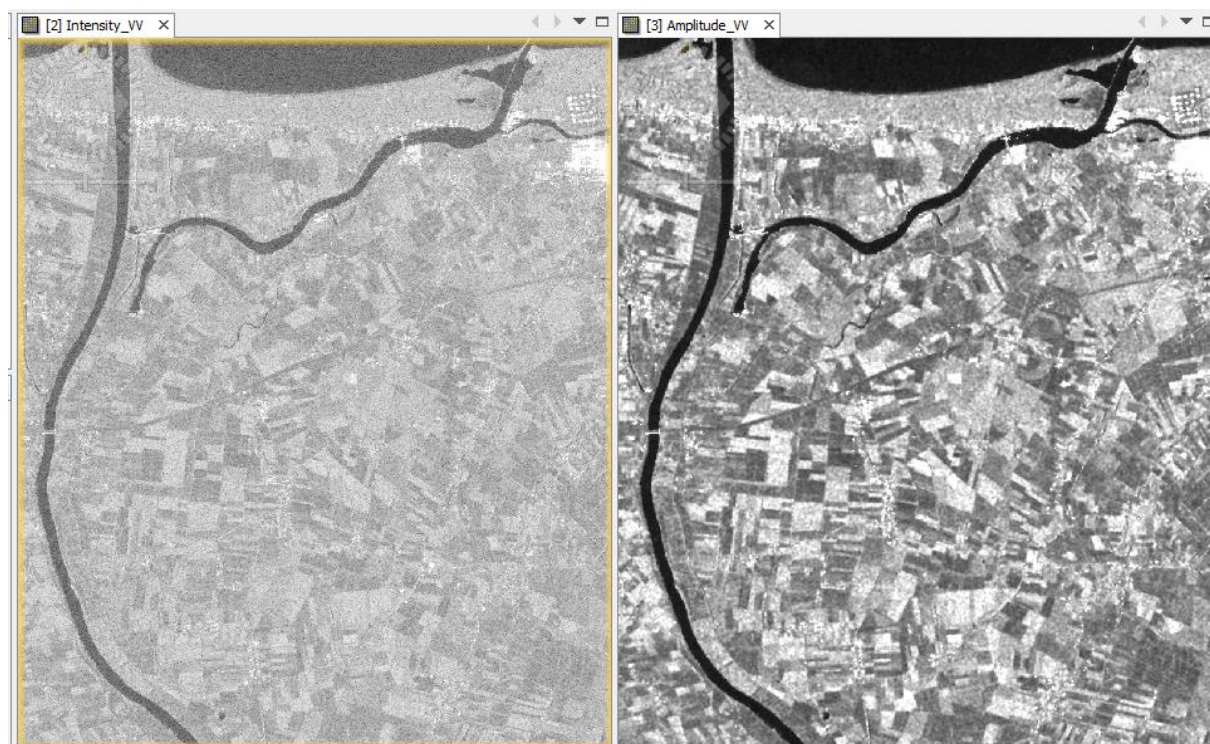
Despeckling removes thermal noise introduced by the sensor from the image to remove potential sources of error in analysis.

Navigate to Radar > Speckle Filtering > Single Product Speckle Filter:
In the Processing Parameters tab, choose the Lee filter with default window sizes and click Run.

Note: Selecting the size of the speckle filter depends on the targets (point target, distributed target) and the target size (for example field sizes).



Open the output of the Lee sigma filter and compare it with the image before Speckle filtering. Filtered image looks sharpened and without noise comparing with the image before applying Speckle filter.



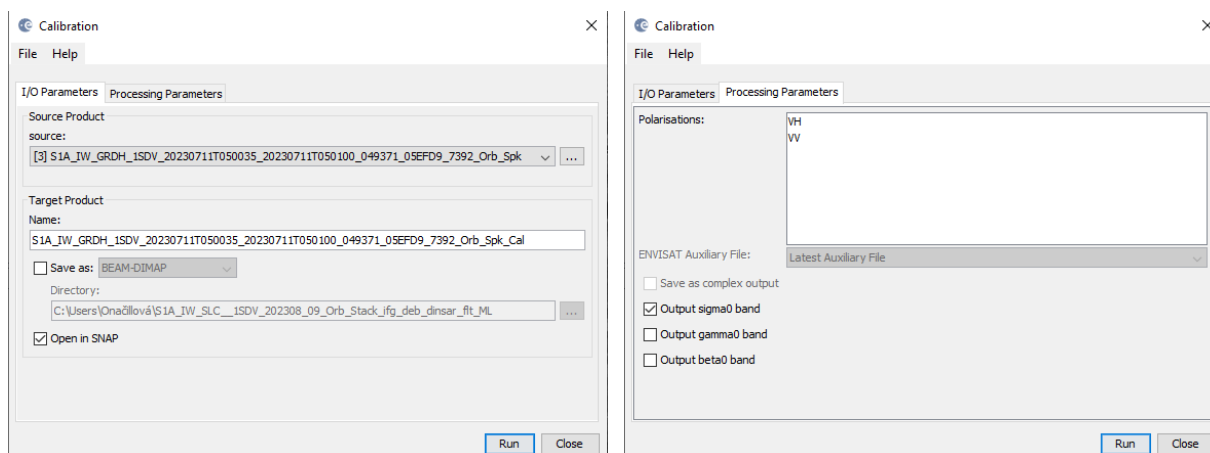
Calibration

S1 Level-1 products are not radiometrically corrected or calibrated, by default¹. Radar reflectivity is stored as Digital Numbers (DNs) in S1 products, and must be converted to physical units (radar backscatter).

Navigate to Main Menu – Radar – Radiometric – Calibrate

In the I/O Parameters tab, select the last filtered product and name the target product.

In the Processing Parameters you can select one or both polarization and accept all default settings and then click Run



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).

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

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

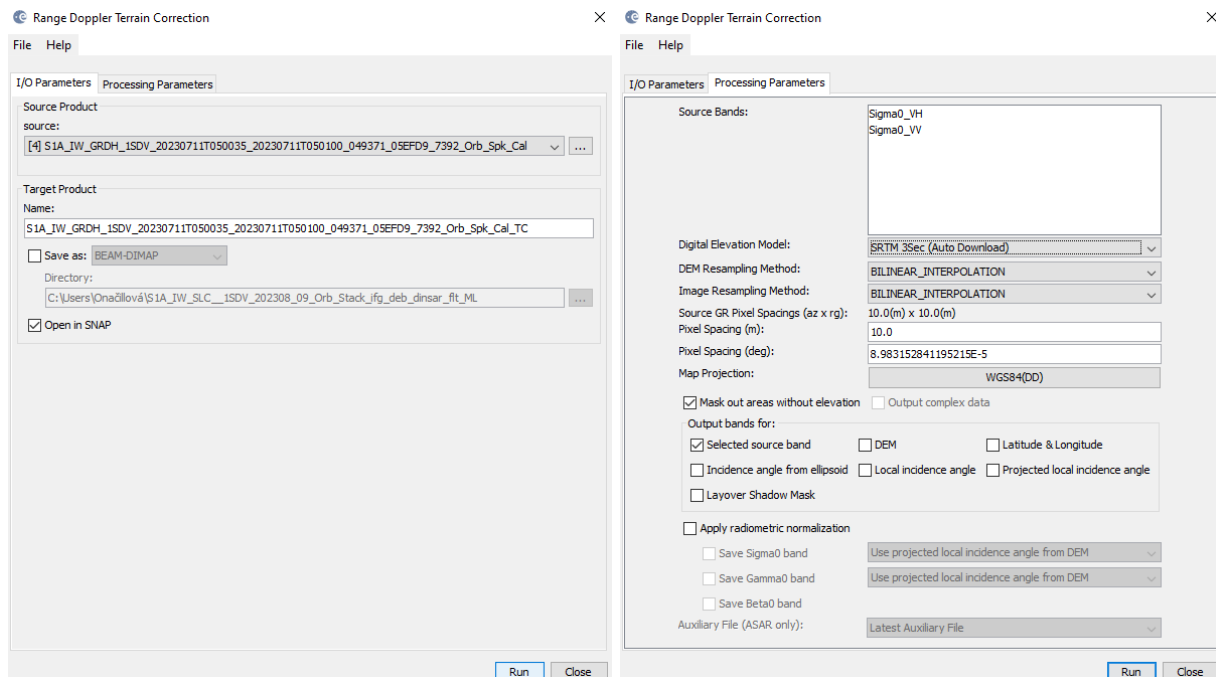
In "Target Product", keep the default name and set the Directory

In the Processing Parameters tab set:

Digital Elevation Model: SRTM 3Sec (Auto Download)

Map Projection: WGS84(DD)

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



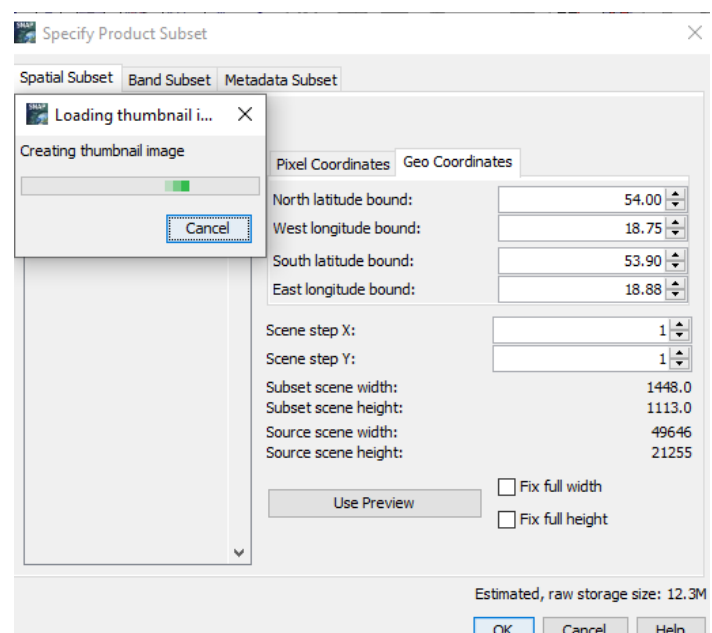
3.1 Create subset

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.

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

North latitude bound: 54.00
West longitude bound: 18.75
South latitude bound : 53.90
East longitude bound : 18.88

Note: There is no need to wait till thumbnail image will be created when entering coordinates.

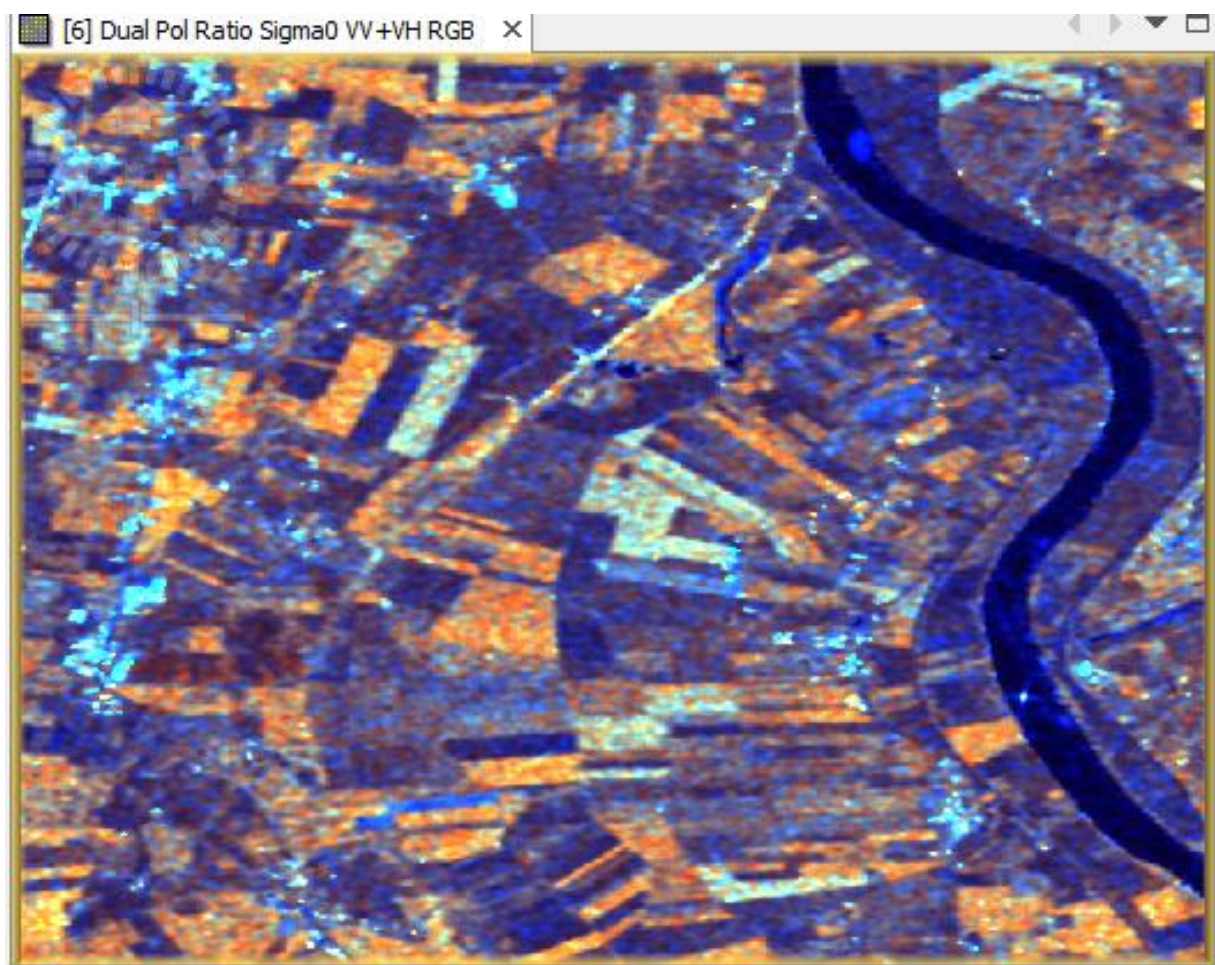


Visualize the output subset by double-click on VH and VV polarization.



Visualize the final subset image using RGB:

Go to Window > Open RGB Image Window (or right-click on the last product in the Product Explorer and Open RGB window) and select the band combinations for final RGB image: VH, VV, VV/VH.



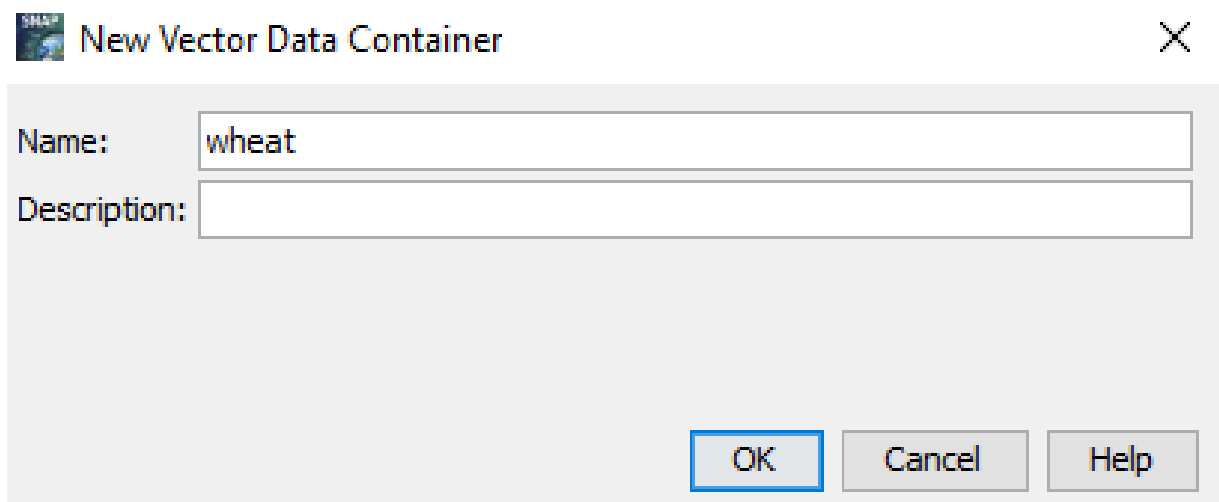
2.4 Image classification

We will perform a random forest classification. For this we will create some training data by identifying polygons containing the different crop/land cover types:

- wheat
- maize
- Rapeseed
- barley
- grassland
- river

Select the last subset product by clicking on it. Navigate to Vector > New Vector Data Container.

Create new data containers – separate for each type of ice mentioned above. Start with creating the data container for, e.g. „wheat“.Click OK.



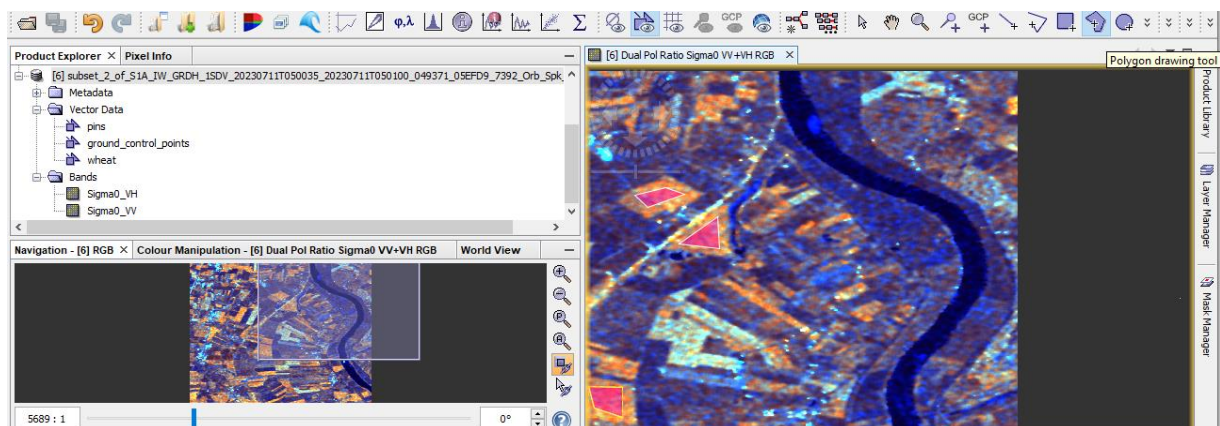
New Vector Data Container

Name: wheat

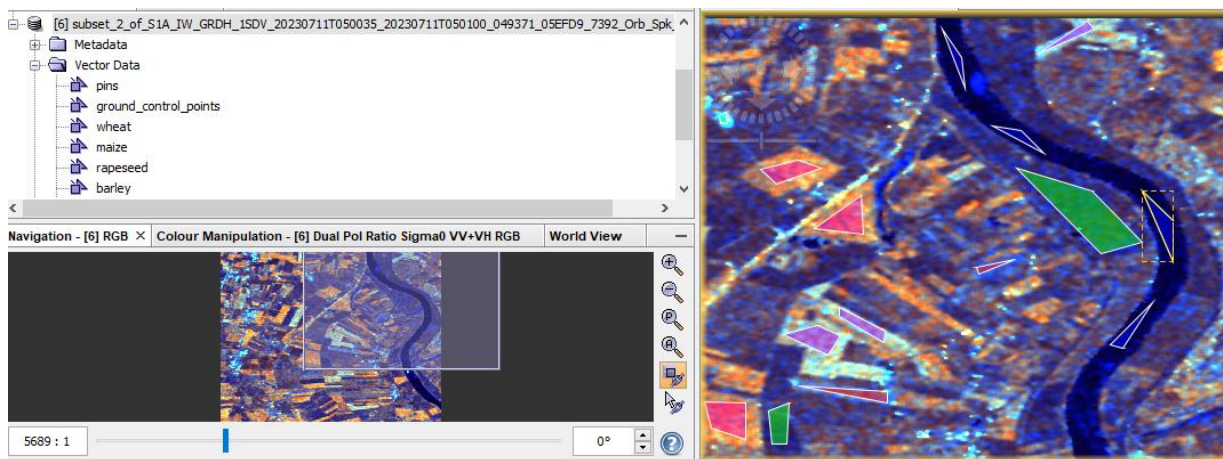
Description:

OK Cancel Help

The newly created vector data container should appear under "Vector Data" in the Product Explorer. Now let's start creating training polygons for these different containers on ice type using the Polygon drawing tool:



Repeat this step and create training polygons for all remaining classes.

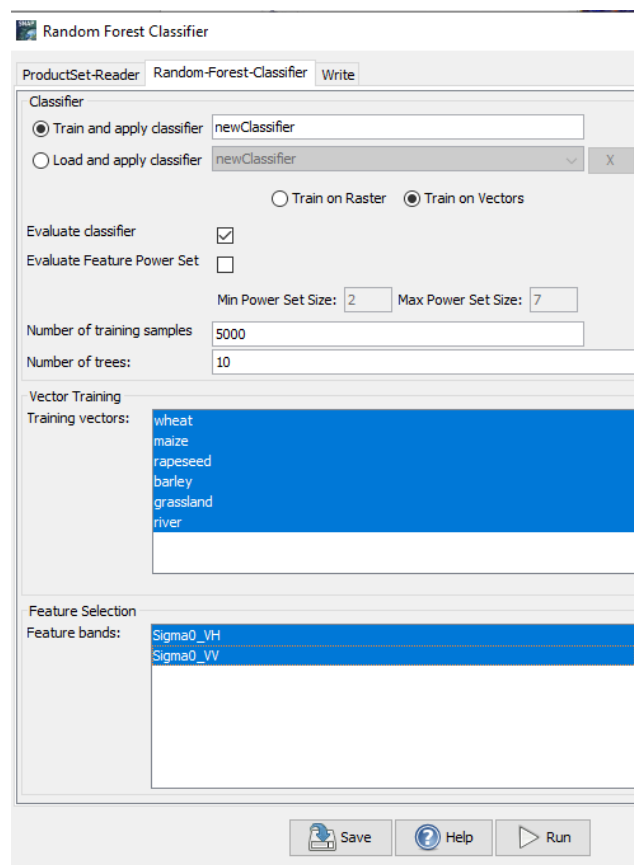


Wheat (red), maize (violet), rapeseed (light blue), barley (cyan), grassland (green) and water (blue) training polygons. Save the final product with your created vector data containers to your folder.

Random Forest image classification

Navigate to Raster > Classification > Supervised classification > Random Forest Classifier

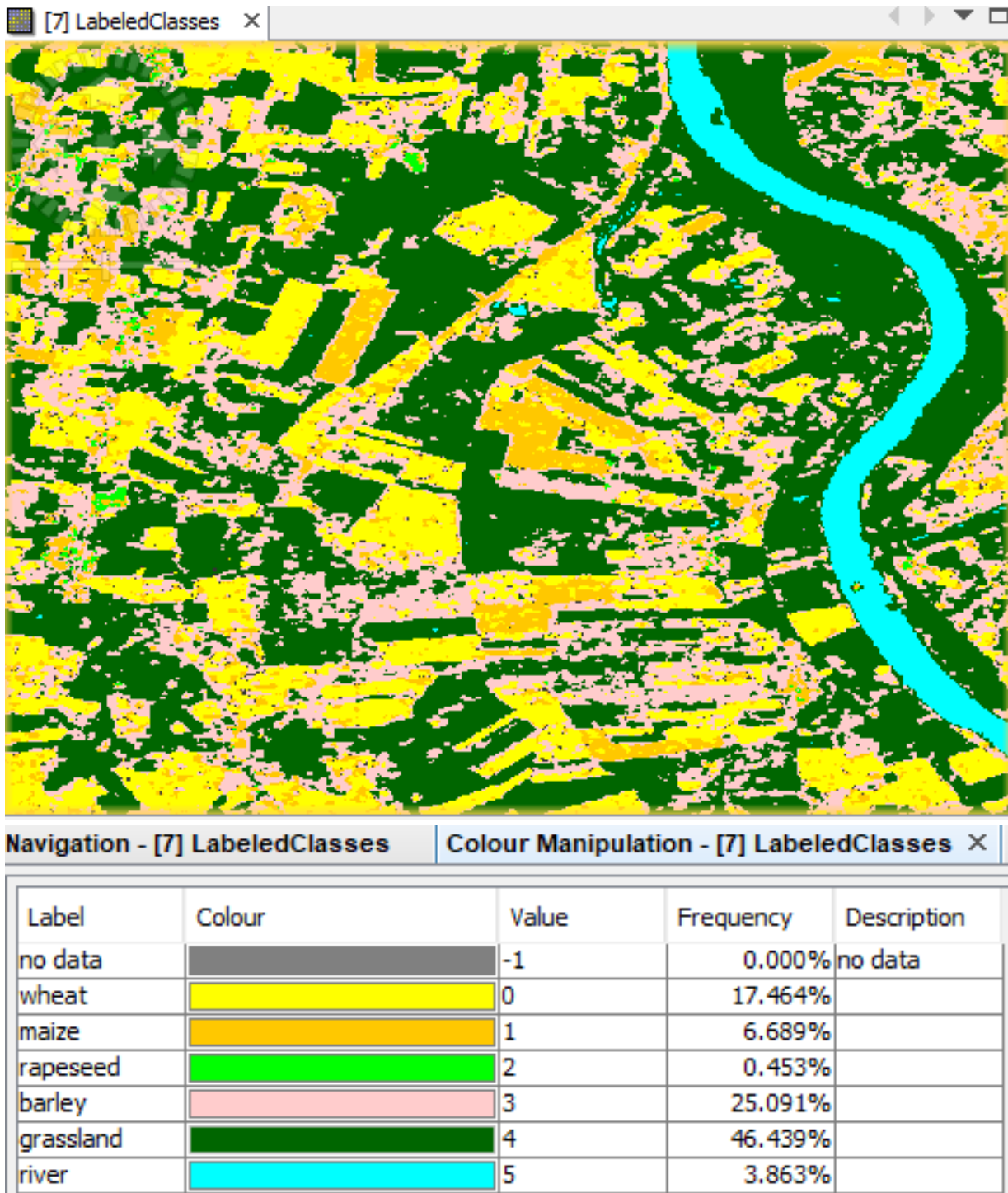
- In the ProductSetReader tab select the saved product with your training data.
- In the Random-Forest-Classifier select the classes/training vectors (all polygon vector containers) and feature bands (select both Sigma0_VH and Sigma0_VV polarisations) that you'd like to include into image classification.
- In the Write tab by default, the output target is set to the same directory and appends „RF" to the filename.
- Click RUN.



2.5 Post-processing

The final product should now appear in the ProductExplorer. Visualize this output classified image and classes by double-click on the layer „LabeledClasses“ under Bands folder in the Product Explorer.

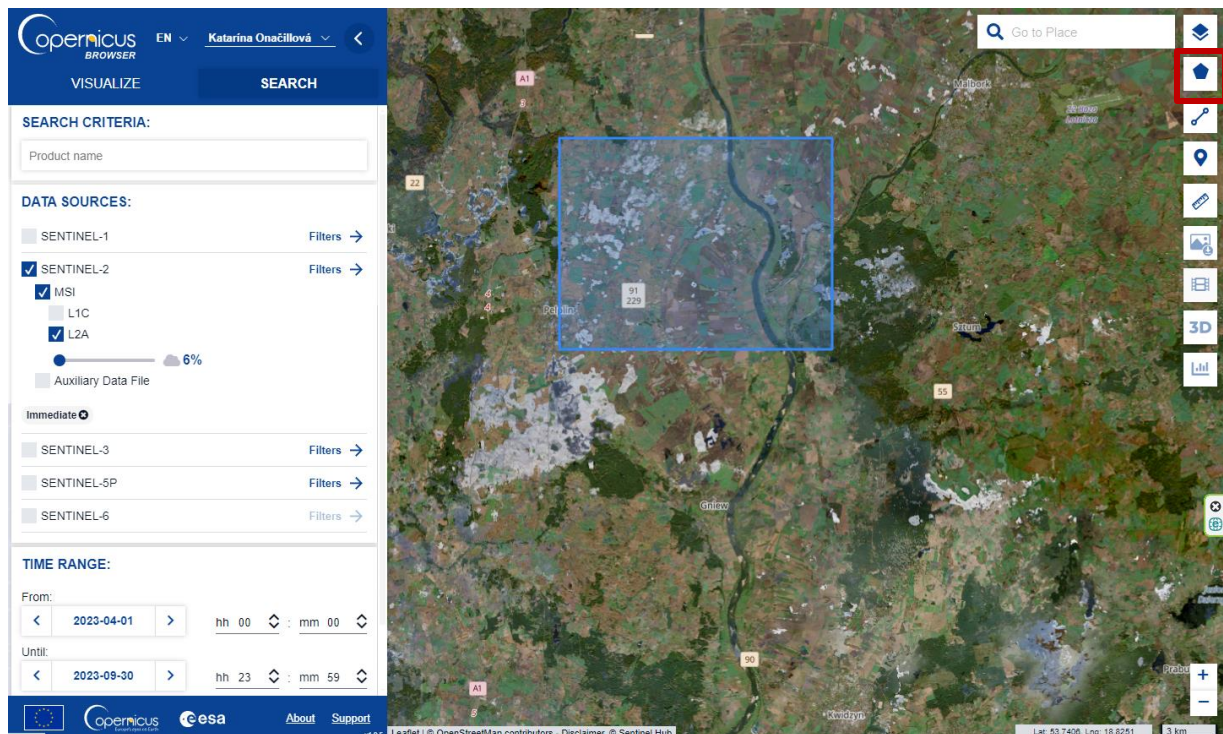
Navigate to Colour Manipulation tab to change the colours of individual crop type classes and other ones and explore the frequency and distribution of these classes through the classified image and table.



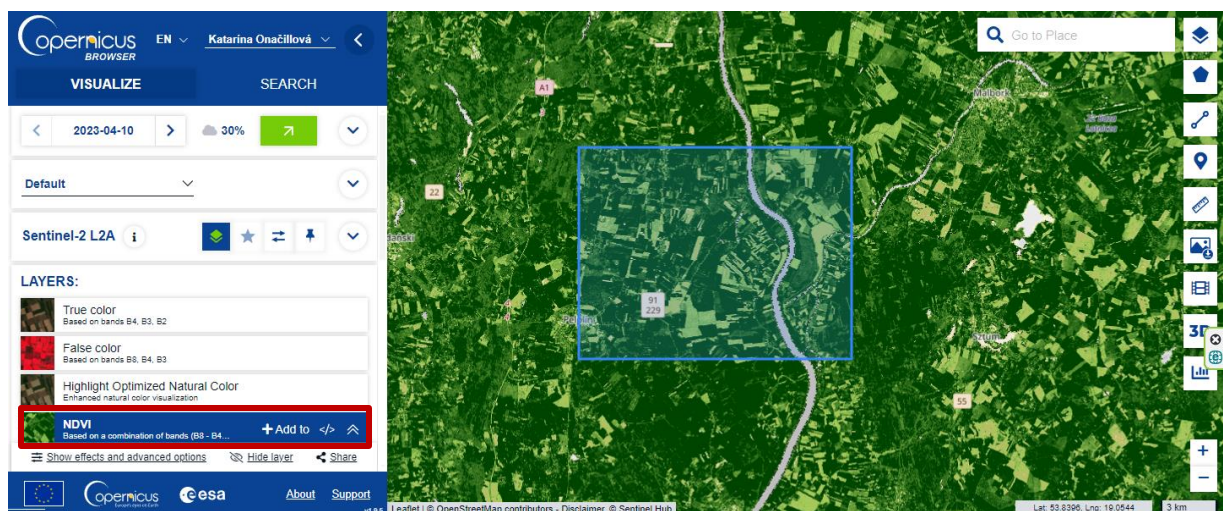
2.6 Crop types characteristics using spectral indices

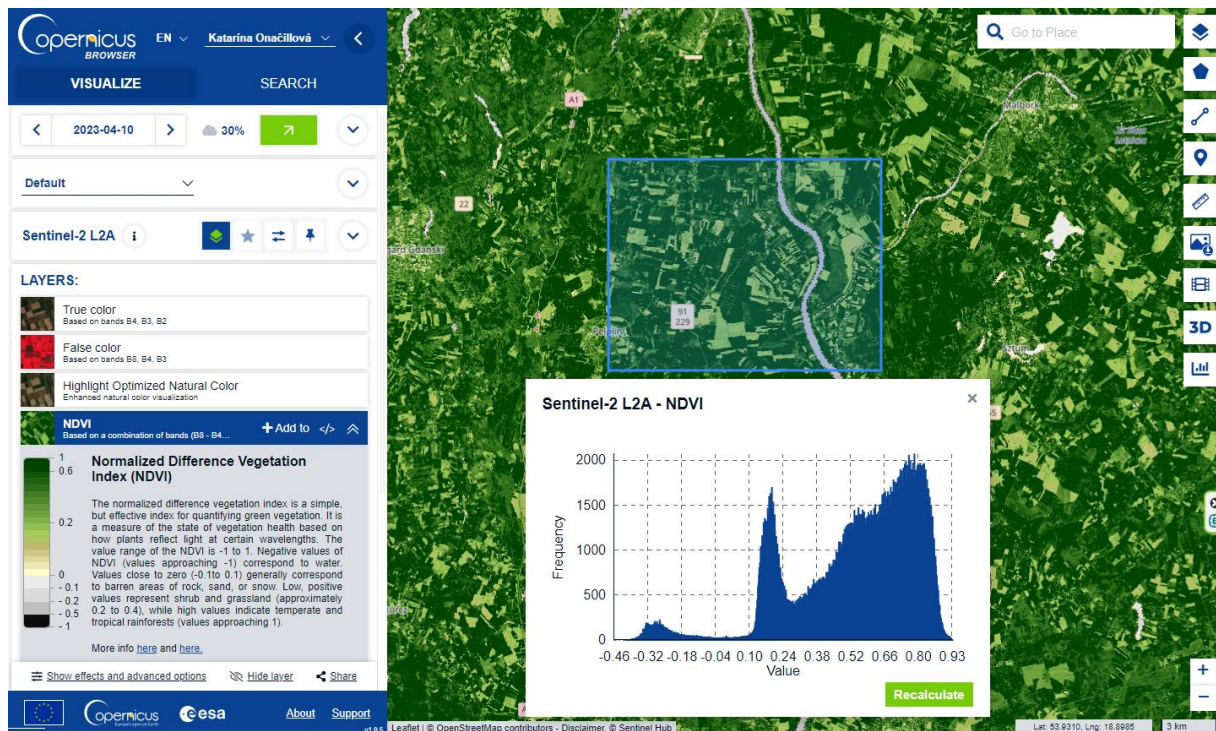
Now, let's explore also Sentinel-2 data for the same area.

- Navigate to the Copernicus Browser website:
- <https://browser.dataspace.copernicus.eu>
- Create the area of interest by using rectangle.
- For the best results, search for Sentinel-2 L2A products with low cloud cover, e.g. less than 6%.
- Set the time range from 01-04-2023 to 31-09-2023 to monitor crops during the growth season. And click on Search.

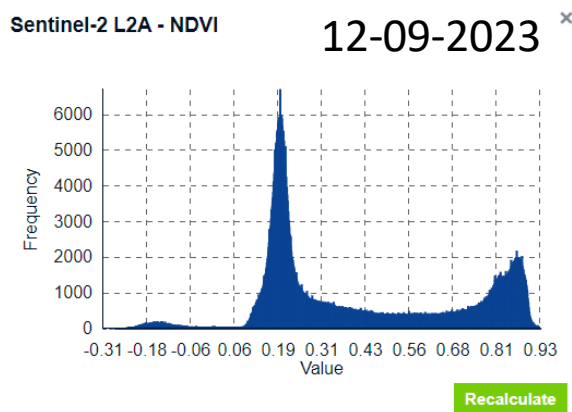
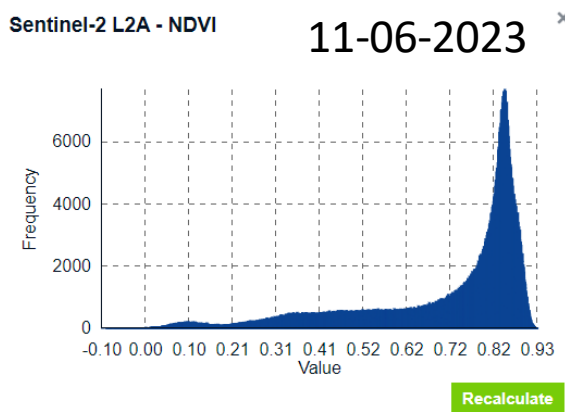
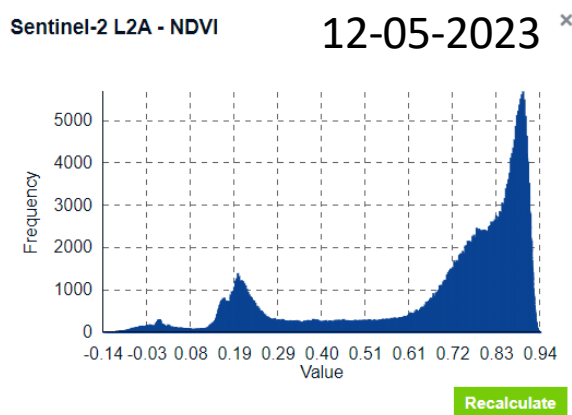
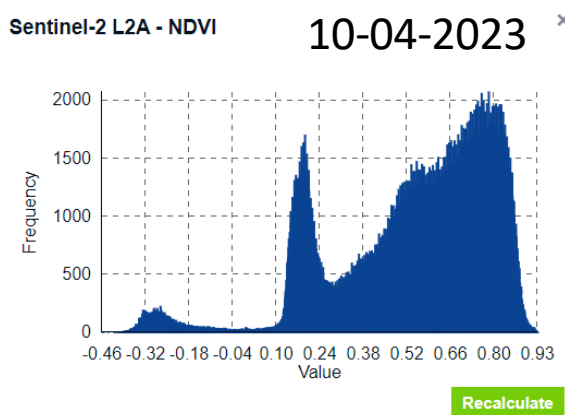


- Visualise at least one of the images – start e.g. from 10-04-2023 and select, e.g. NDVI layer.
- At the top right panel select Histogram option.
- Explore NDVI values for the selected image.





Then, move to another date, e.g. 27-05-2023 and click on „Recalculate“ to refresh the histogram values for this acquisition date. Explore the NDVI values during the growth season by visualising histogram for NDVI values of several dates.



During the growth season, NDVI (Normalized Difference Vegetation Index) values typically exhibit fluctuations reflecting changes in vegetation dynamics. At the beginning of the season (April), NDVI values may be relatively low as vegetation starts to emerge and develop. As the season progresses and vegetation becomes more abundant and healthier, NDVI values tend to increase, reaching their peak during the peak of the growing season when vegetation is at its fullest and most vibrant (May). This period is characterized by high NDVI values, indicating dense and healthy vegetation rich in chlorophyll and other nutrients. After reaching the peak, NDVI values may start to decline as vegetation undergoes senescence or experiences stress due to factors such as water scarcity or disease (June-September). Monitoring NDVI values throughout the growth season provides valuable insights into vegetation health, growth patterns, and overall ecosystem dynamics.

For more information, see the lecture: [5. SAR and optical remote sensing for precision agriculture 1](#)

THANK YOU FOR FOLLOWING THE EXERCISE!