



EXERCISE 1 – TUTORIAL

Radar Earth Observation – ESA EO Data Access and resources, applications, Copernicus OA Hub

1 | Exercise outline

In this exercise, we will:

- acquire skills in retrieving satellite imagery from both ESA and third-party missions
- conduct specific analyses utilizing the EO Browser
- install ESA SNAP and execute fundamental image operations
- explore the spectral curve of various surface types

2 | Background

Most of the ESA's Earth observation datasets are easily accessible online, free of charge. Users can acquire access by completing a simple registration process.

The Copernicus Data Space Ecosystem provides full, free and open access to large amount of Earth observation data, along with scalable interfaces integrated with the Copernicus Sentinel satellites. This includes a range of both new and historical Sentinel images, commercial datasets, as well as Copernicus Contributing Missions.

Sentinel data is also accessible through Copernicus Data and Information Access Services (DIAS), which are platforms designed to facilitate the discovery, retrieval, and use of Copernicus satellite data, including data from the Sentinel missions. There are several DIAS platforms available, each offering a user-friendly interface and tools for working with the data.

The ESA Hub allows checking searches online by browsing and viewing product metadata and measurements without downloading them. Sentinel products are provided for download over HTTP in *.ZIP archive file format.

Sentinel Hub is a cloud-based platform that provides access to satellite data, particularly from the ESA Sentinel missions. The platform offers a variety of services and tools for the retrieval, processing, and analysis of satellite imagery. It is commonly used by researchers, developers, and businesses to access Earth observation data for various applications, including environmental monitoring, agriculture, urban planning, and more. EO Browser is an online platform developed by Sentinel Hub that allows users to visualize and explore satellite imagery, particularly from the Copernicus Sentinel missions. Sentinel Hub provides the backend infrastructure and access to the satellite data, while EO Browser serves as the user interface for interacting with that data.

ESA not only provides satellite data from its own Earth Observation (EO) satellite resources, but also facilitates access to Third Party Missions (TPMs), which are non-ESA EO missions. Integrating data from these diverse sources is crucial for enhancing the sustainability of satellite services, expanding the scope of monitored parameters, and promoting scientific development. Researchers and students alike can request third-party data, but it's important to be aware of licensing conditions, especially for users in certain countries, where national legislation on data access may apply.

3 | How to access ESA data

To access data from the European Space Agency (ESA), user can use various platforms and tools provided by ESA. Here are some key sources:

Earth Online Portal

The Earth Online Portal serves as a gateway to a diverse range of Earth observation resources. It includes a directory for discovering missions and datasets, offering convenient access to satellite data, operational updates, events, and tools to enhance data utilization.

Sentinel Online

The Sentinel online platform offers technical details about the Copernicus Sentinel missions and allows systematic access to processed data, which is readily accessible on the website. User registration is required for access.

Copernicus Contributing Missions Online

To obtain data with higher resolution, users can visit the Copernicus Contributing Missions website. This platform offers comprehensive information on all Contributing Missions that provide data complementing the Copernicus Sentinels, addressing the requirements of the Copernicus Services. Eligible users can access the data for free upon registration and confirmation of their user category.



4 | Copernicus Data Space Ecosystem

<https://dataspace.copernicus.eu/>

- Since 24 January 2023 a new [Copernicus Data Space Ecosystem](#) has been launched to provide free and open access to Earth Observation data from all Sentinel satellites with new features for visualisation and data processing.

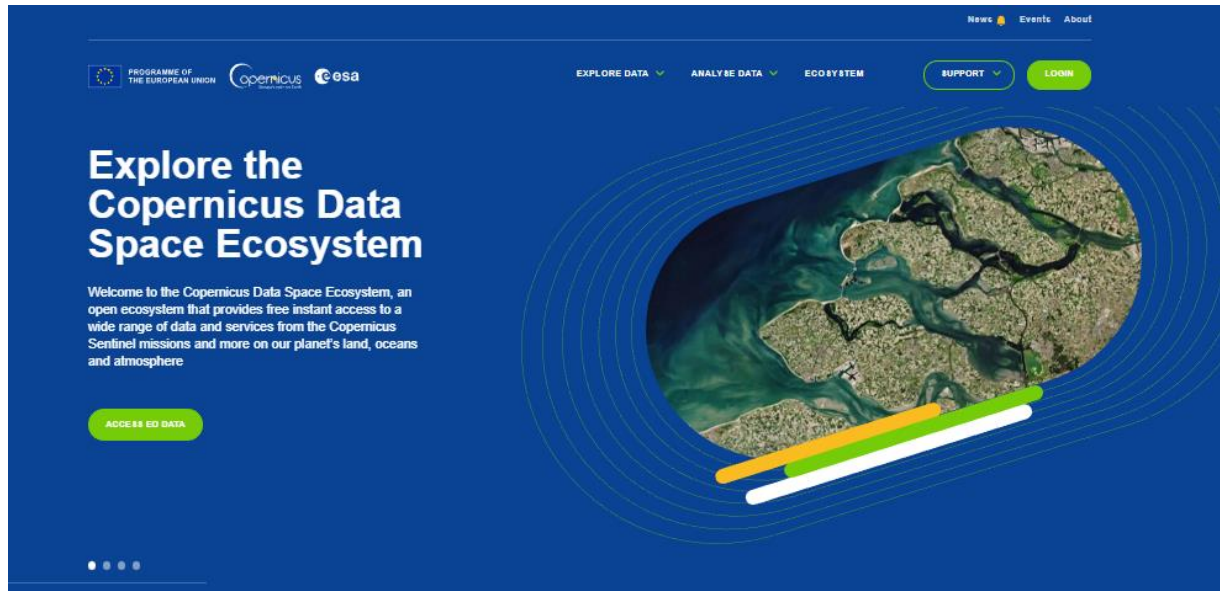


- The previous [Copernicus Data Hub](#) distribution service that has been providing access to Copernicus data is offering access to Sentinel data with a gradual ramp-down of the operations capacity and data offering.

A screenshot of the Copernicus Open Access Hub website. The header includes the Copernicus logo, the text "Copernicus Open Access Hub", and the ESA logo. The main content area has a "Welcome to the Copernicus Open Access Hub" section with text explaining the transition to the new ecosystem and the gradual ramp-down of the previous Data Hub service. It also mentions that Sentinel data is available via DIAS services. A "Reports & Stats" section shows 38,892 products published and 338,550 downloads in the last 24 hours. A "Resources" section lists links to the DHUS Open Source Portal, Copernicus Portal, Sentinel Online, and Sentinel Vision Stories. At the bottom, there are four buttons: "Open Hub", "API Hub", "S-5P Pre-Ops", and "POD Hub".

- Sentinel Data are also available via the Copernicus Data and Information Access Services (DIAS) through several platforms.

The Copernicus Data Space Ecosystem allows us to access a wide range of Earth observation data from the Copernicus Sentinel missions and more. The Copernicus Data Space Ecosystem provides tools for easy discovery, visualization and download which will be continuously upgraded.



Discover our services

Explore data

Access a wide range of Earth observation data from the Copernicus Sentinel missions and more. The Copernicus Data Space Ecosystem provides tools for easy discovery, visualization and download which will be continuously upgraded.

[DISCOVER THE DATA](#)

Analyse

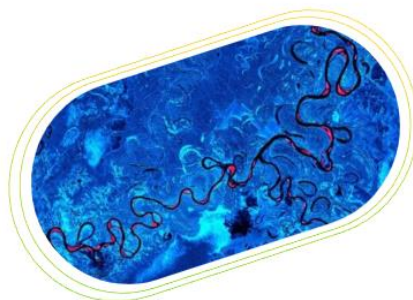
The service provides a powerful data analytics environment. Access a set of high-quality data processing tools to extract information valuable to conduct public, private or commercial activities. The Copernicus Data Space Ecosystem is set to be the next level of user data processing and distribution infrastructure.

[ACCESS THE TOOLS](#)

Ecosystem

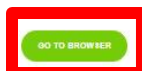
The Copernicus Data Space Ecosystem is the next step in the evolution of Earth observation data. The Ecosystem aims to gather tools and resources to unlock the full potential of this data. This allows to build a thriving, open and expanding Ecosystem to increase the impact of Earth Observation data for a sustainable society.

[FIND OUT MORE](#)



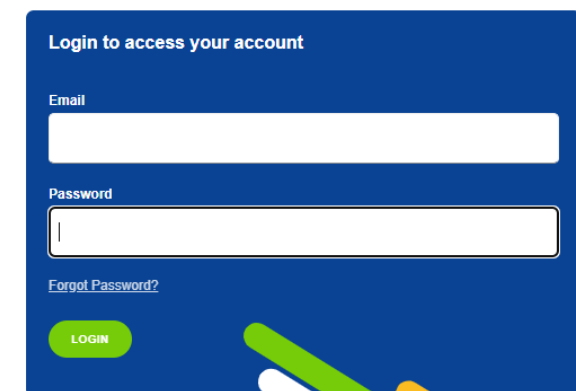
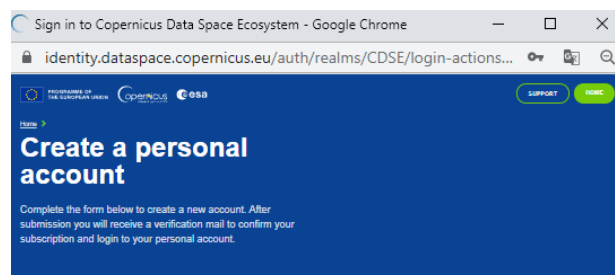
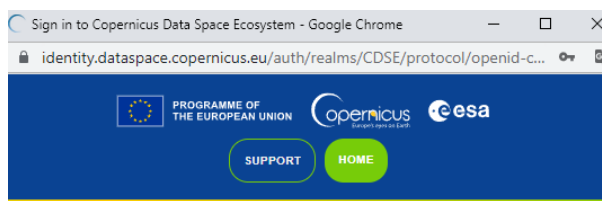
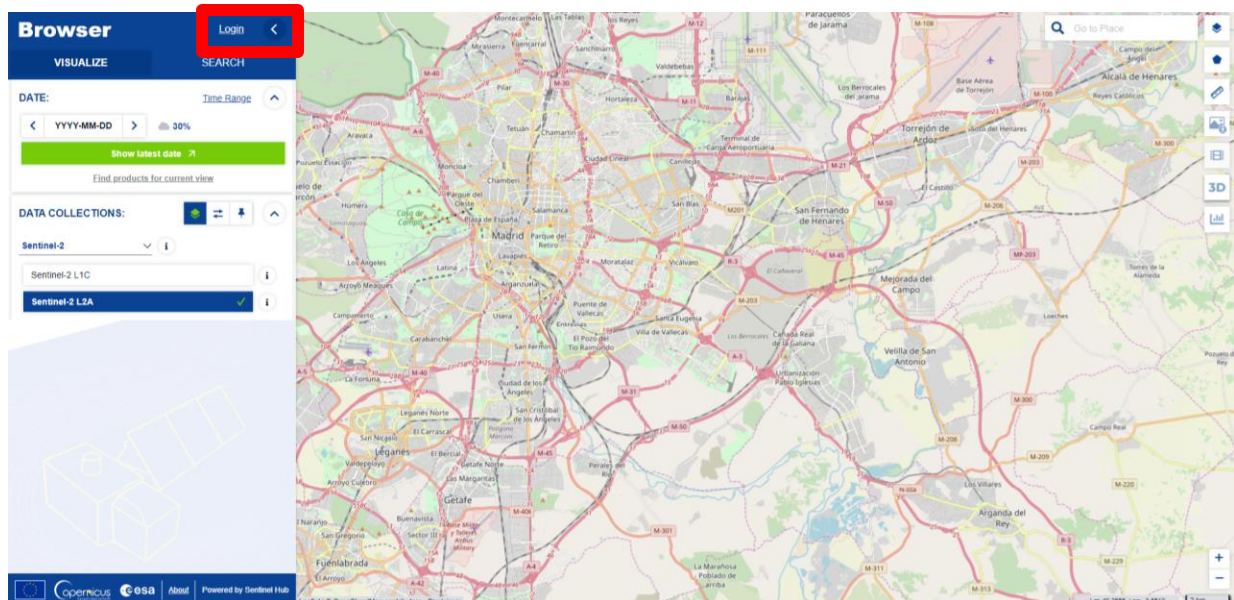
Copernicus Browser

Explore and engage with satellite imagery, using our user-friendly and intuitive browser. Open to all and easy to navigate.



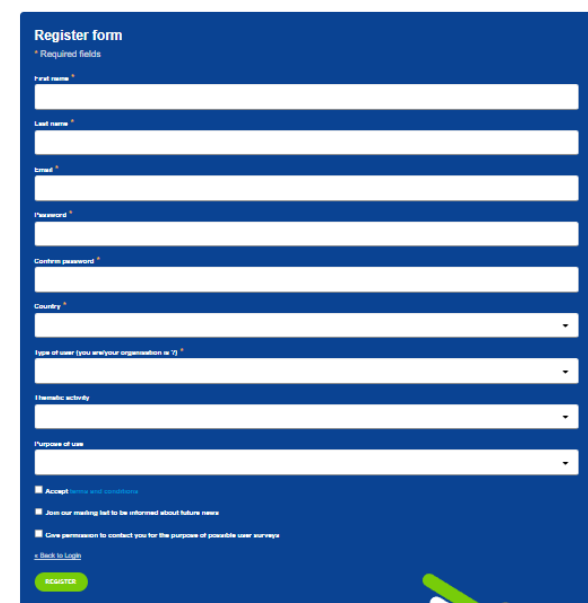
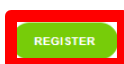
4.1. Registration and login

- We can register a new user or log in as an existing user to the portal.
- The Copernicus Data Space Ecosystem allows us to browse and visualize satellite images freely, but we need to register and create an account to be able to download them.



Register and create an account for free in 60 seconds

- ✓ Access a variety of Earth observation data
- ✓ Manage your personal settings
- ✓ Follow your credits and orders



After registration and login, it is possible to visualize or search EO data products within portal. We can choose various satellite platforms, product types, polarizations, and sensing modes for individual satellites:

Browser Login

VISUALIZE **SEARCH**

2023-04-26 30%

DATA COLLECTIONS:

Sentinel-2

Sentinel-2 L1C

Sentinel-2 L2A

LAYERS:

- True color
- False color
- Highlight Optimized Natural Color
- NDVI
- False color (urban)
- Moisture Index
- SWIR
- NDWI
- NDSI
- Custom

Visualize or Search options

Search area of interest

Select Map background

Select area of interest

Advanced options for analysis and visualization

Search by Date, select % of the cloud cover

Choose Sentinel mission and data product

Visualize data as color composition or spectral index

Or create your own color composition or spectral index

Browser Katarina Onačilová

VISUALIZE **SEARCH**

SEARCH CRITERIA:

Product name

DATA SOURCES:

SENTINEL-1

C-SAR

Level-0 RAW

Level-1 SLC

Level-1 GRD

Level-2 OCN

SENTINEL-2

SENTINEL-3

SENTINEL-5P

TIME RANGE:

2023-04-11 - 2023-05-11

filter by months

Jan Feb Mar Apr May Jun

Jul Aug Sep Oct Nov Dec

SENTINEL-1

SATELLITE PLATFORM: S1A S1B

ORBIT DIRECTION: Ascending Descending

RELATIVE ORBIT NUMBER: 1-175

ACQUISITION MODE: SM IW EW WV

BEAM ID: Beam id

POLARISATION: HH HV VV VH VV-VH HH+HV

RESET FILTERS

Search by Product ID

Select data source and set advanced filters (see slide X)

Search by date of image sensing or filter by months

E.g. Sentinel-1 C-SAR - SAR Instrument that provides an all-weather, day and night imagery at C-band at high and medium resolutions for land, coastal zones and ice observations.

- SENTINEL-1
 - C-SAR
 - Level-0 RAW
 - Level-1 SLC
 - Level-1 GRD
 - Level-2 OCN

Levels of product types

- unprocessed raw data
- (Single Look Complex) contains complex images with amplitude and phase in the slant range by azimuth imaging plane, in the image plane of satellite data acquisition
- (Ground Range Detected) consists of focused SAR data that has been detected, multi-looked and projected to ground range using an Earth ellipsoid model
- (Ocean) provide geo-located geophysical products derived from Level-1 for wind, wave and currents applications

Filters → **SENTINEL-1** ←

SATELLITE PLATFORM ⓘ

S1A S1B

ORBIT DIRECTION ⓘ

Ascending Descending

RELATIVE ORBIT NUMBER ⓘ

1-175

ACQUISITION MODE ⓘ

SM IW EW WV

BEAM ID ⓘ

Beam id

POLARISATION ⓘ

HH HV VV VH VH+VV

VV+VH HH+HV

RESET FILTERS

The available Sentinel-1 data includes products from the Sentinel-1 satellite constellation, including Sentinel-1A (operational since 2014) and Sentinel-1B (operational from 2016 to 2022)

Determines whether the data was recorded during a descending orbit (flight direction: north-south) or an ascending orbit (flight direction: south-north)

The Relative Orbit Number is the number of full orbits since the relative orbit 1 to the end of a cycle

Sentinel-1 operates in 4 instrument acquisition modes: Stripmap (SM), Interferometric Wide Swath (IW), Extra-Wide Swath (EW), Wave (WV)

Depending on the acquisition mode, different swaths and identifiers are possible

Determines with which polarisation the data was acquired. The first letter indicates the polarisation when sending the signal, the second letter when receiving the signal. Data can be acquired in single polarisation HH or VV or in dual polarisation HHHV or VVVH depending on the instrument mode

4.2. Search results

After defining the search criteria, we get the results that can be further viewed, analysed or downloaded.

Image download

Image preview (if available)

Main product information

Metadata information

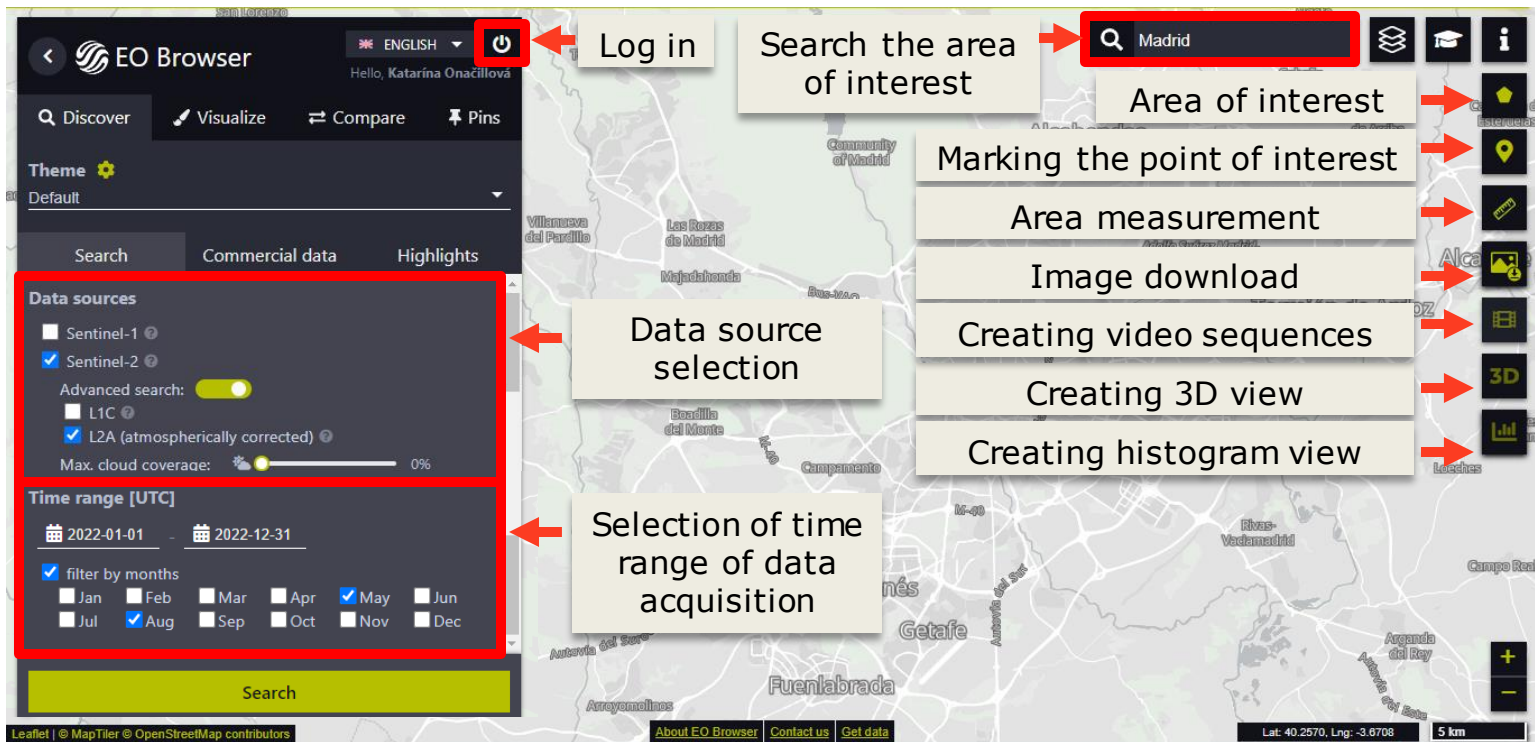
5 | Sentinel Hub - EO Browser

<https://apps.sentinel-hub.com/eo-browser/>

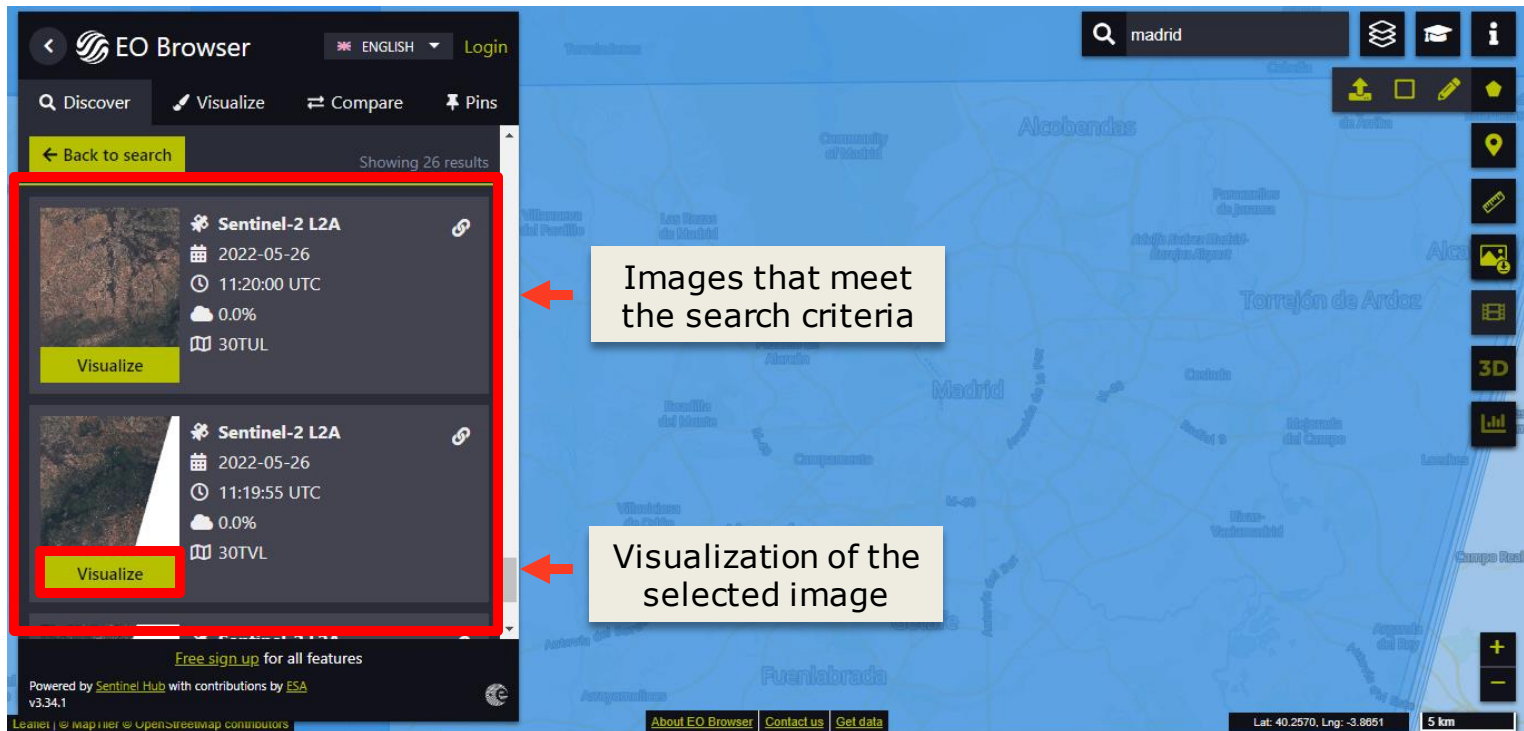
EO Browser, developed by Sentinel Hub, is an online platform that empowers users to explore and visualize satellite imagery from Earth observation (EO) missions, with a focus on the Copernicus program. Offering an intuitive and user-friendly interface, the platform is widely utilized for educational, research, and environmental monitoring purposes. Key features encompass direct access to Copernicus Sentinel data, enabling users to visualize and analyze imagery within the browser. Customization options allow users to tailor their view by adjusting parameters like date and cloud cover, catering to specific research needs. The platform's educational utility is evident in its use in educational settings, introducing students to Earth observation and remote sensing through its accessible interface. Additionally, EO Browser facilitates time-lapse creation for monitoring changes in the Earth's surface over time. EO Browser is a valuable tool for those interested in exploring and understanding satellite imagery for a wide range of applications, including environmental monitoring, agriculture, forestry, and urban planning.



Registration or Log in



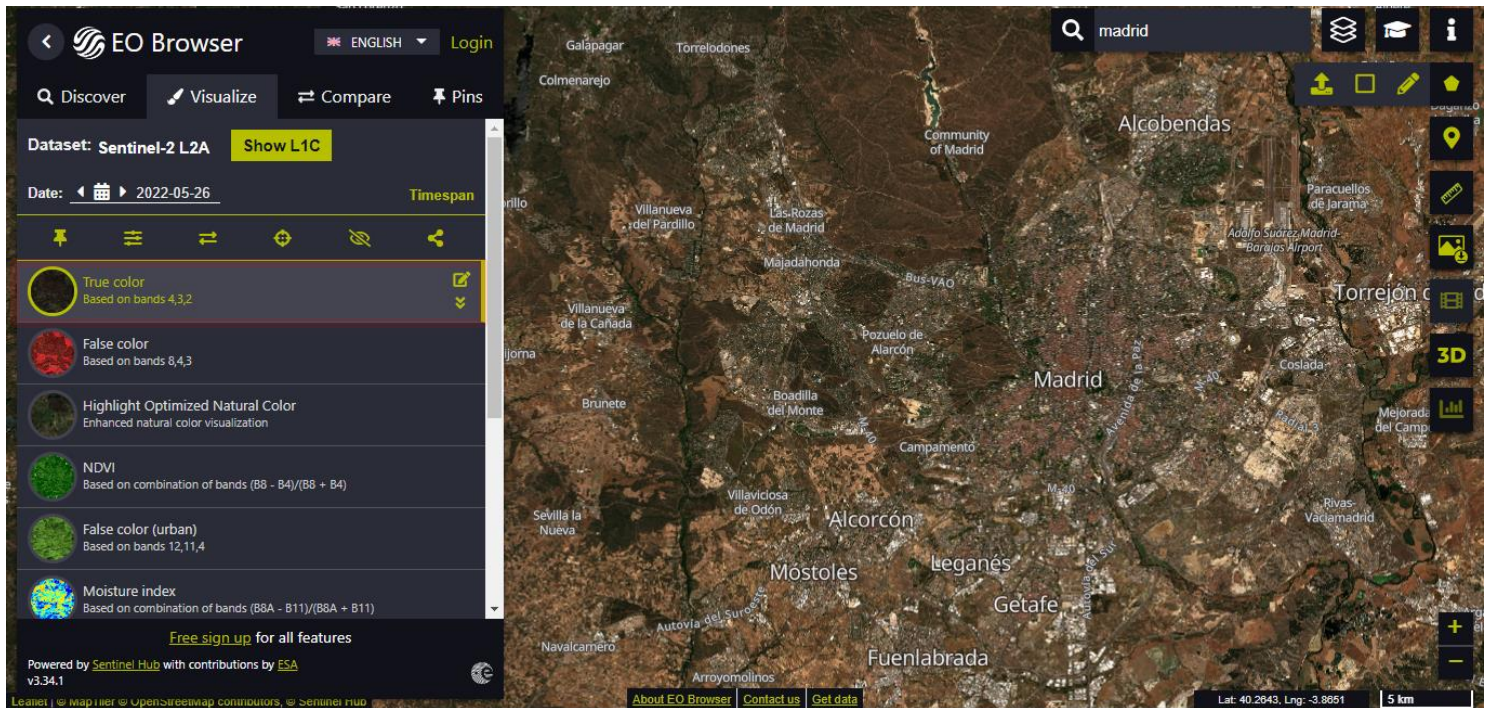
After the search, the selected image can be visualised in the browser.



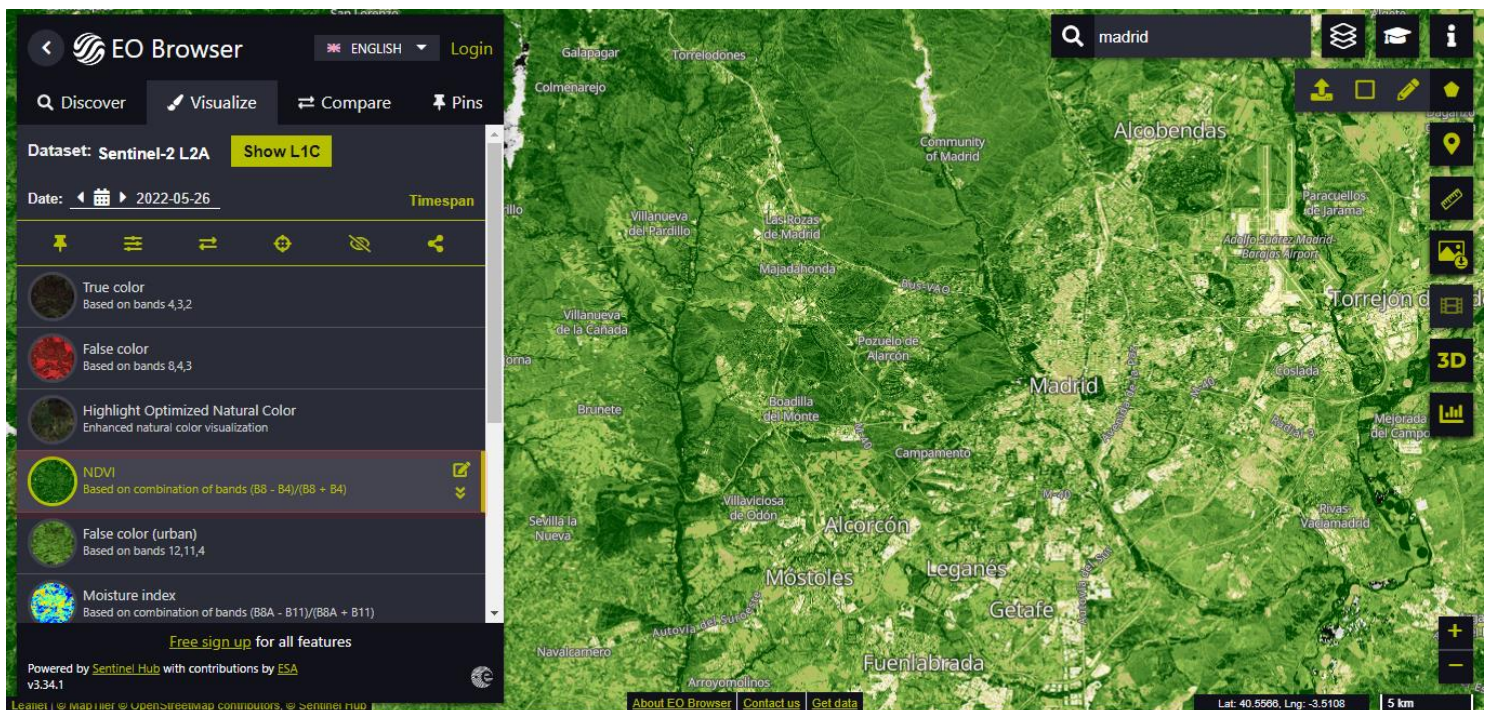
5.1 Optical data

In the visualisation tab, we can change the view mode (available are visualization options in the form of color compositions and spectral indices).

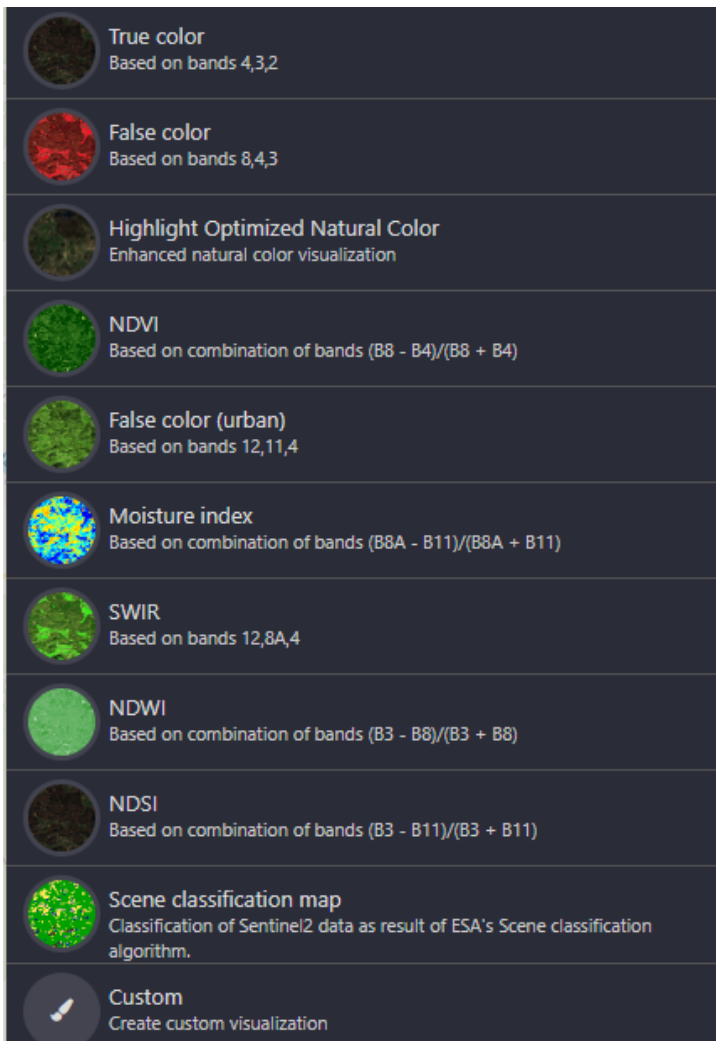
True color composition (R-G-B)



Normalised difference vegetation index (NDVI)



Other visualization options



Available color compositions:

- True colour (bands: Red-Green-Blue)
- False colour (bands: NIR-Red-Green)
- Highlight Optimized Natural Color
- False colour (urban) (bands: 12-11-4)
- SWIR (bands: 12-8A-4)

Available spectral indices:

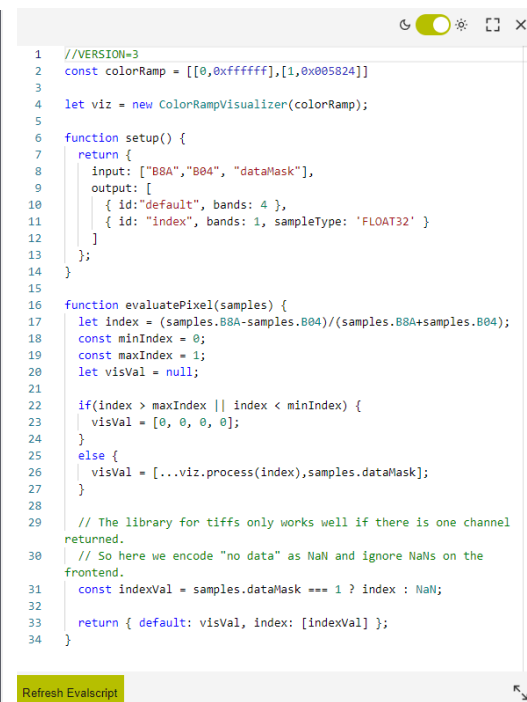
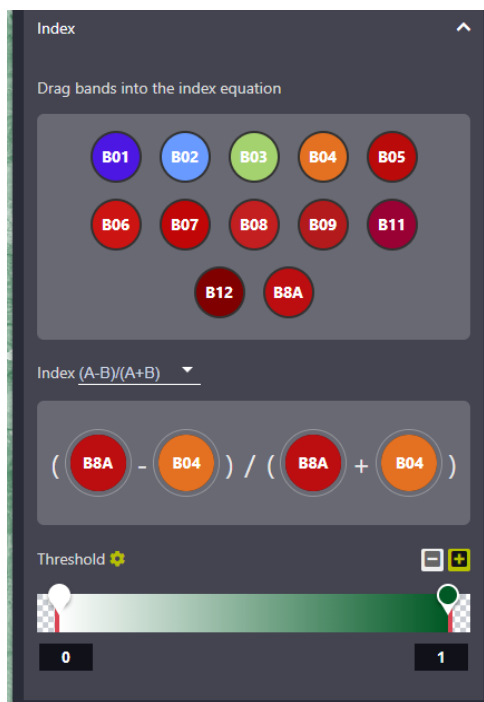
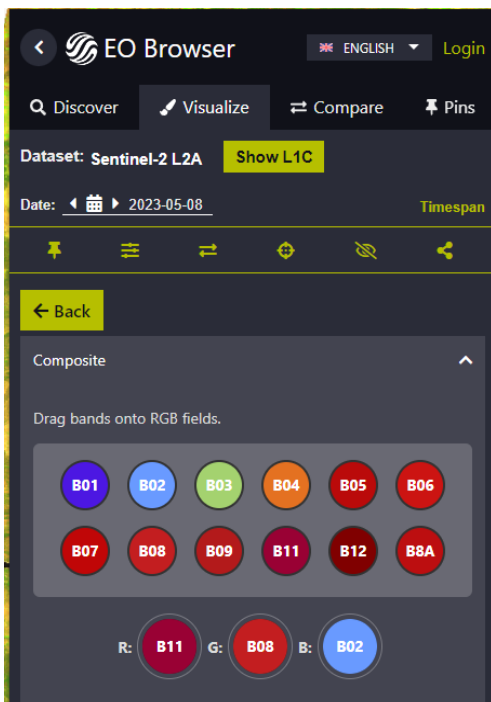
- NDVI - for vegetation monitoring
- NDWI - for water monitoring
- NDSI - for snow monitoring
- Moisture index - for moisture monitoring

Available classifications:

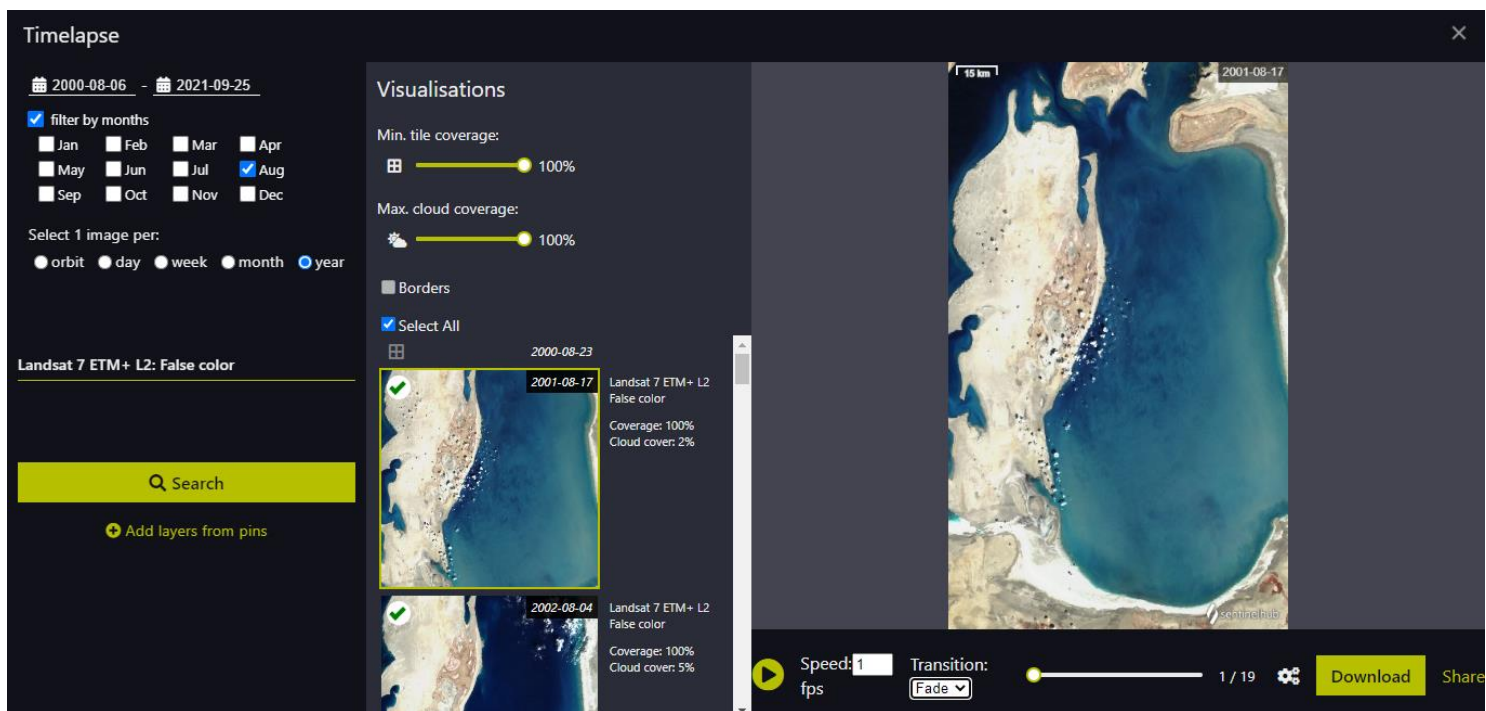
- Scene classification map - classification display based on ESA algorithms

+ Available custom visualization

We can also use a visualisation for custom color combinations or spectral indices of default bands or the scripting tool and use additional datasets.



An important visualisation tool of EO Browser is the *Timelapse* function. We can choose multiple images filtered by date or month and select one image per orbit, day, week, month or year. We can set preferred tile coverage and % of cloud cover. Then we can select all or only some images and play the timelapse visualisation.



Select time range

Select/deselect image

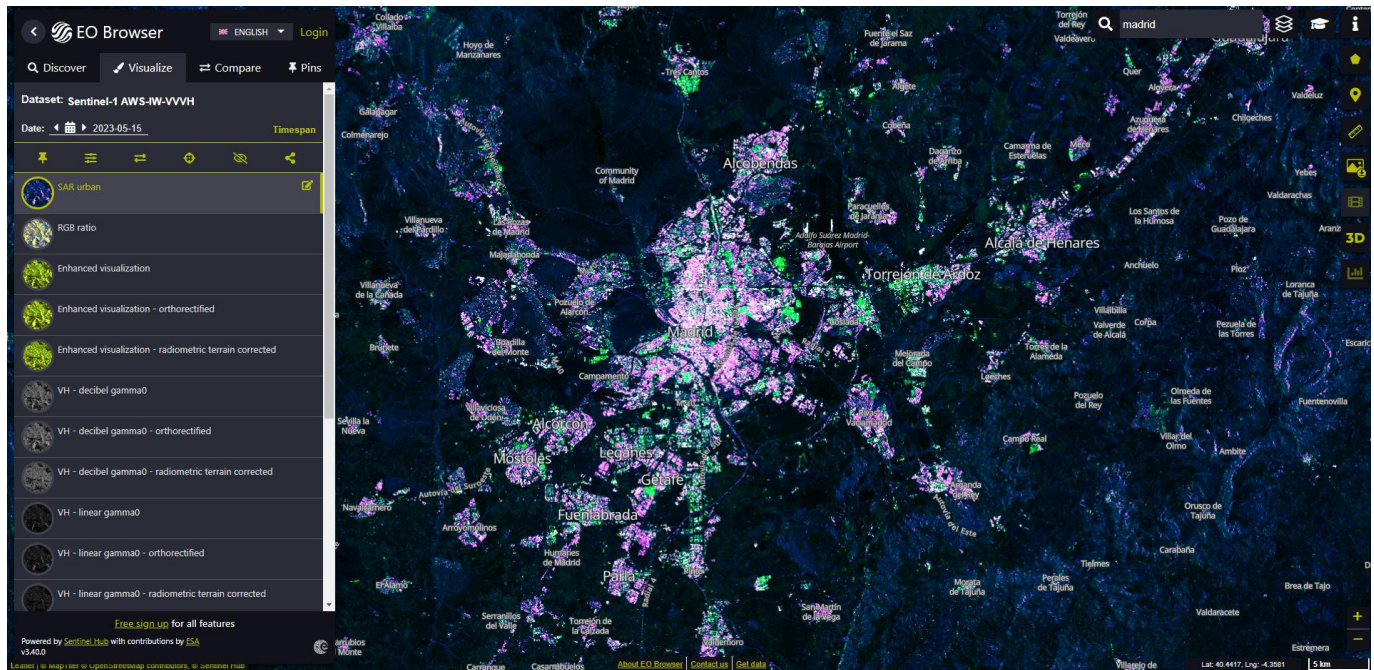
Play a video, select transition mode, download or share your created timelapse



The resulting timelapse of images from the Landsat 7 satellite showing the disappearance of the Aral Sea by 2020

5.2. Radar data

When displaying radar data, we have the option to choose from various types of visualizations.



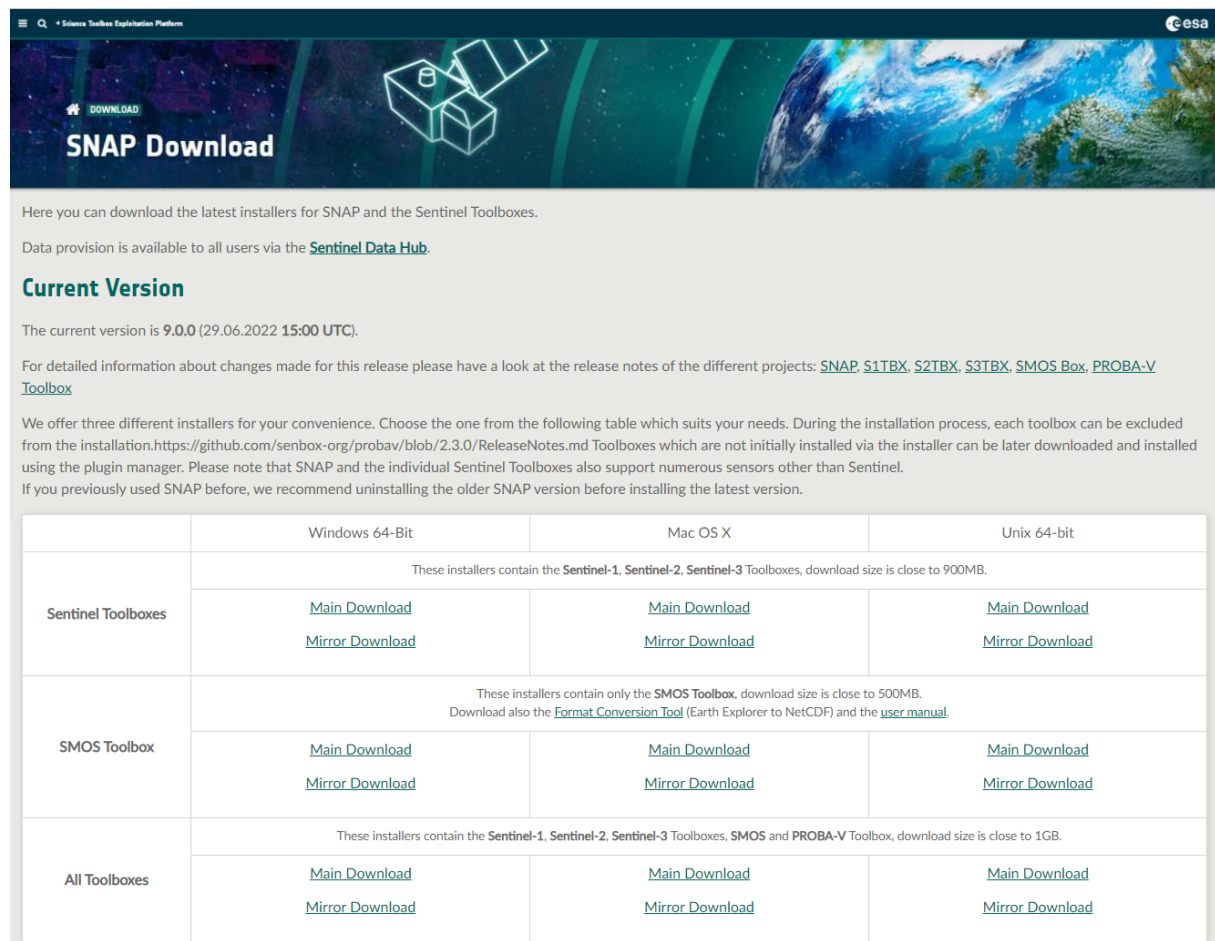
In accordance with specific requirements, the terrain can be displayed using different polarizations, cross-polarizations, and corrections.



6 | Sentinel Application Platform (SNAP)

<https://step.esa.int/main/download/snap-download/>

ESA Sentinel Application Platform (SNAP) is a software toolkit developed by the European Space Agency (ESA) for processing and analyzing Earth observation data, particularly data from the Sentinel satellites. SNAP is part of the Sentinel Toolbox and is freely available to the public. It provides a user-friendly interface and a comprehensive set of tools also for working with a variety of other remote sensing data.



Here you can download the latest installers for SNAP and the Sentinel Toolboxes.

Data provision is available to all users via the [Sentinel Data Hub](#).

Current Version

The current version is **9.0.0** (29.06.2022 15:00 UTC).

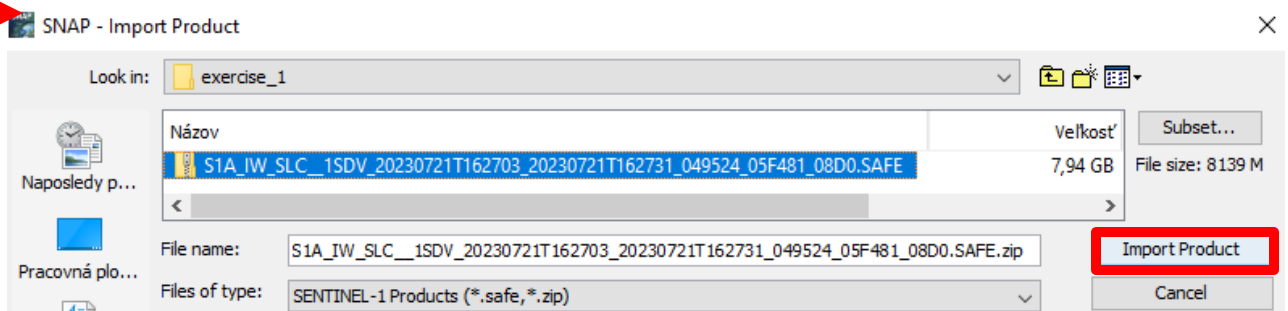
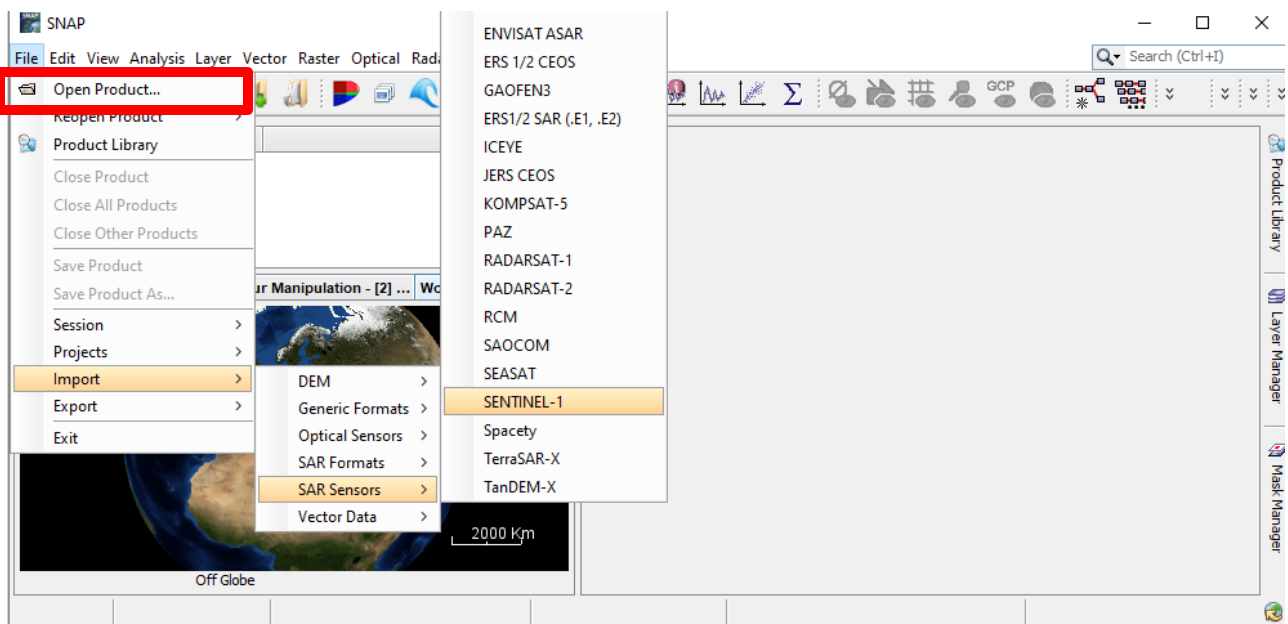
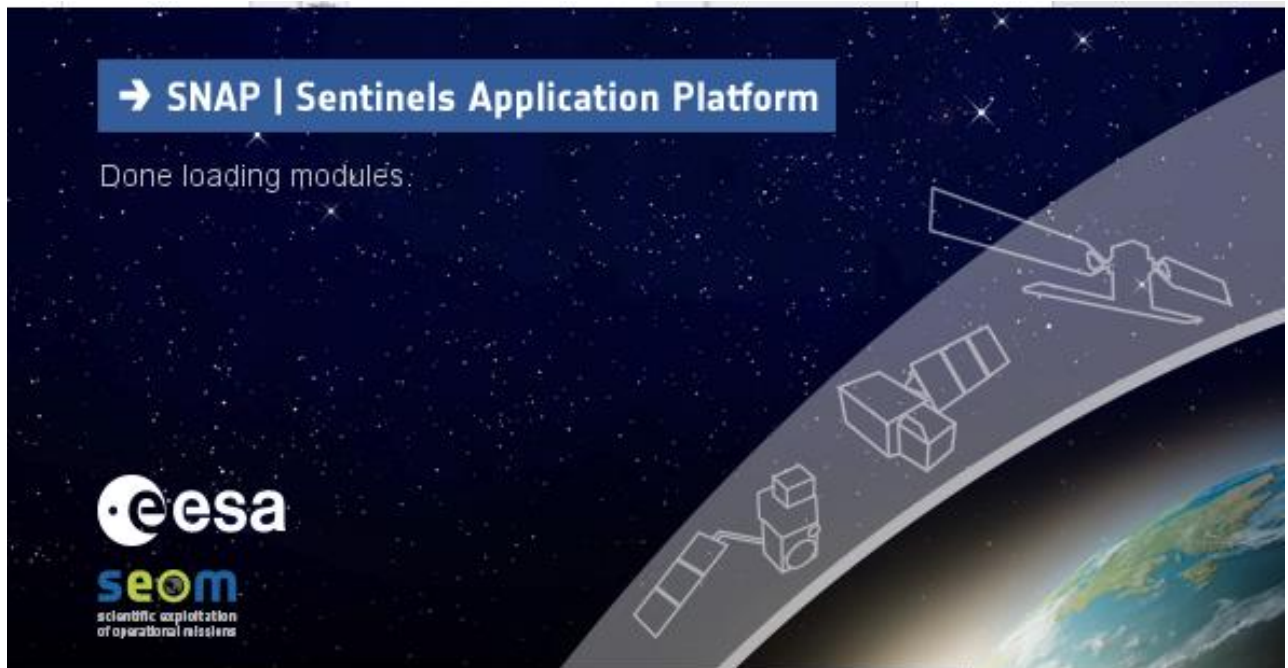
For detailed information about changes made for this release please have a look at the release notes of the different projects: [SNAP](#), [S1TBX](#), [S2TBX](#), [S3TBX](#), [SMOS Box](#), [PROBA-V Toolbox](#)

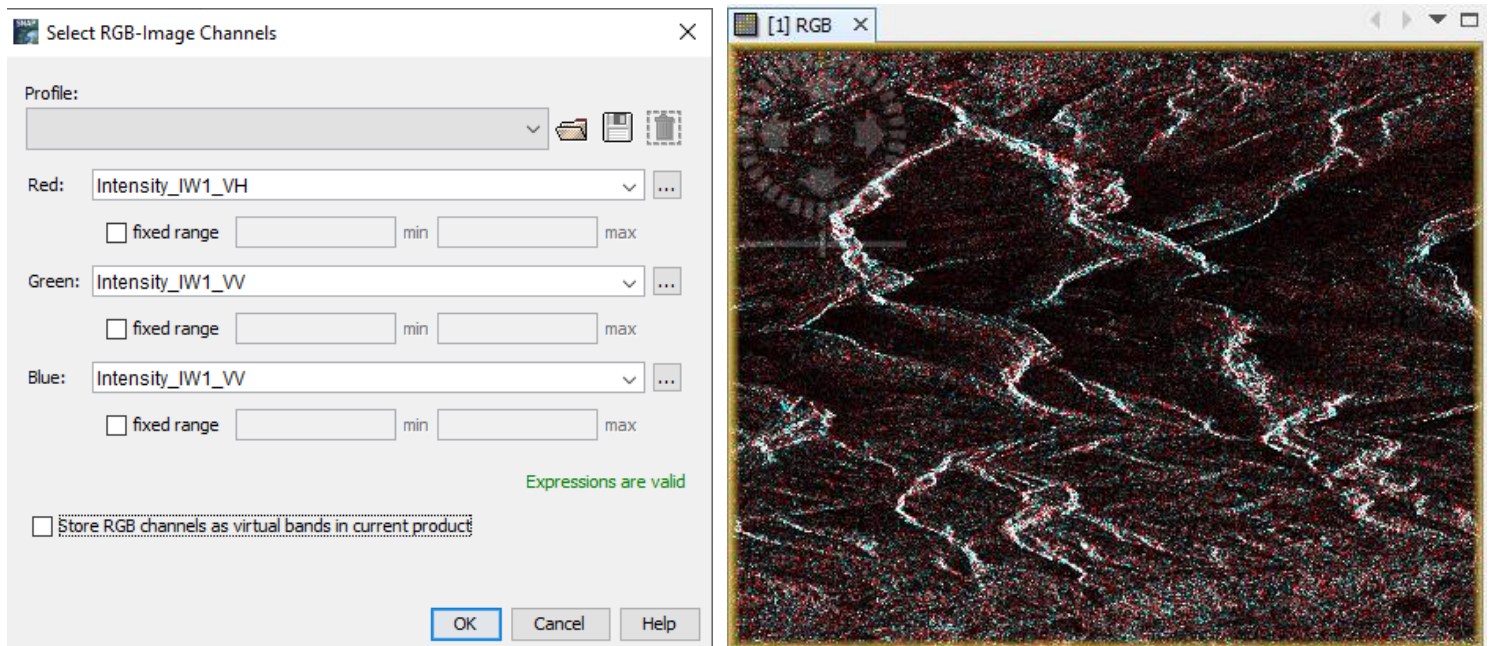
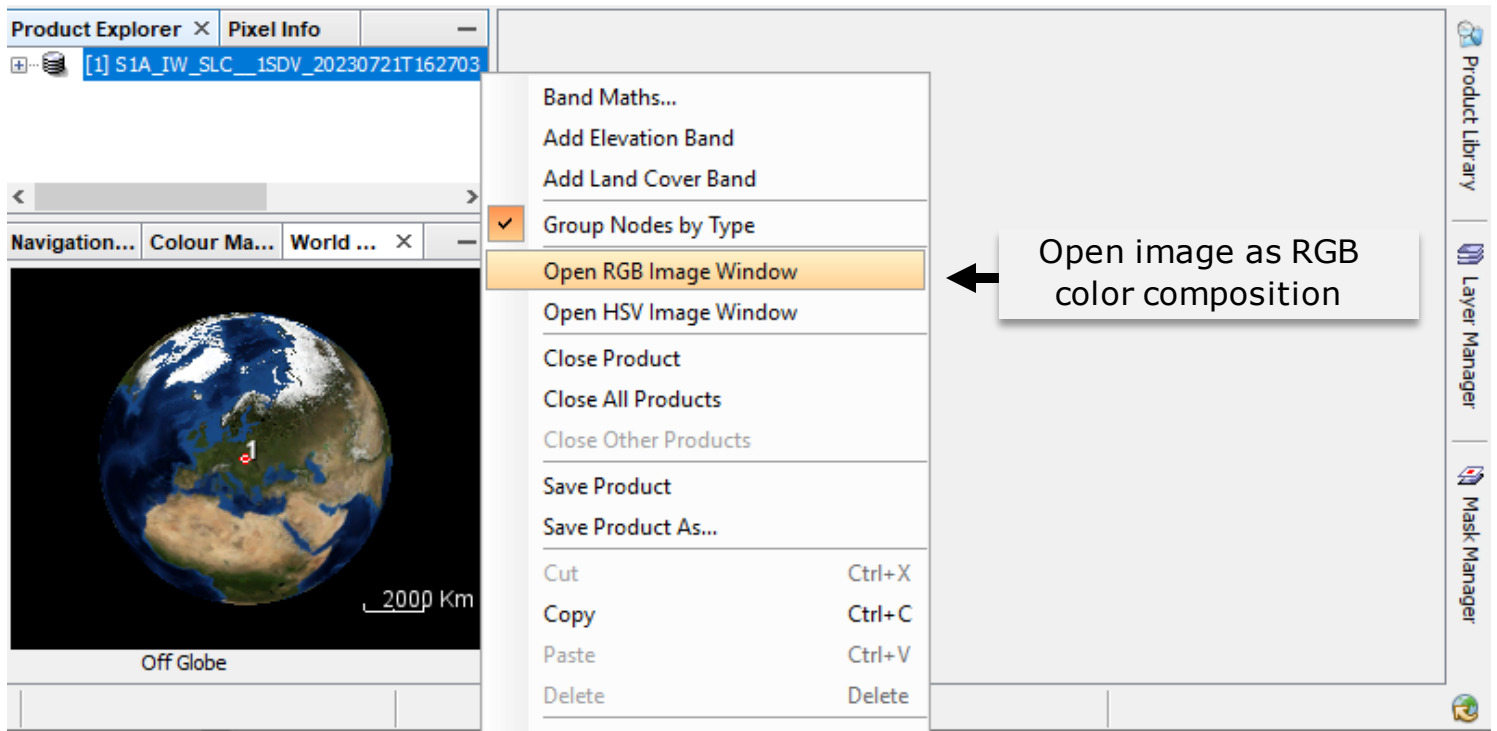
We offer three different installers for your convenience. Choose the one from the following table which suits your needs. During the installation process, each toolbox can be excluded from the installation. <https://github.com/senbox-org/probav/blob/2.3.0/ReleaseNotes.md> Toolboxes which are not initially installed via the installer can be later downloaded and installed using the plugin manager. Please note that SNAP and the individual Sentinel Toolboxes also support numerous sensors other than Sentinel. If you previously used SNAP before, we recommend uninstalling the older SNAP version before installing the latest version.

	Windows 64-Bit	Mac OS X	Unix 64-bit
Sentinel Toolboxes	These installers contain the Sentinel-1 , Sentinel-2 , Sentinel-3 Toolboxes, download size is close to 900MB.		
	Main Download	Main Download	Main Download
	Mirror Download	Mirror Download	Mirror Download
SMOS Toolbox	These installers contain only the SMOS Toolbox , download size is close to 500MB. Download also the Format Conversion Tool (Earth Explorer to NetCDF) and the user manual .		
	Main Download	Main Download	Main Download
	Mirror Download	Mirror Download	Mirror Download
All Toolboxes	These installers contain the Sentinel-1 , Sentinel-2 , Sentinel-3 Toolboxes, SMOS and PROBA-V Toolbox, download size is close to 1GB.		
	Main Download	Main Download	Main Download
	Mirror Download	Mirror Download	Mirror Download

SNAP is widely used in the scientific community and by remote sensing professionals for a variety of applications, including land cover mapping, environmental monitoring, and disaster response. It is an open-source tool, and its modular architecture allows for the integration of plugins and additional functionalities.

After installing and starting the software, we can open an image using File – Open Image or by Import option:

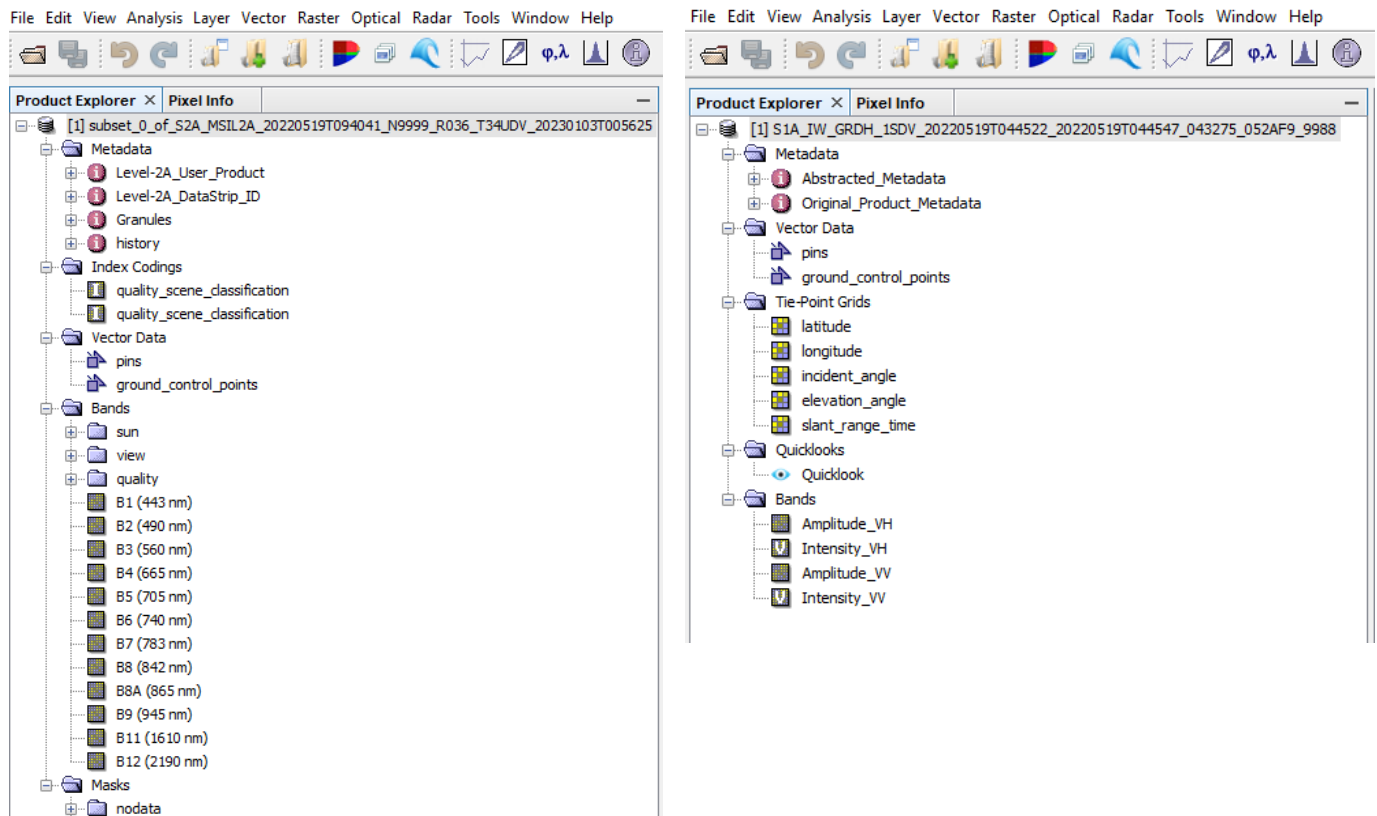




↑

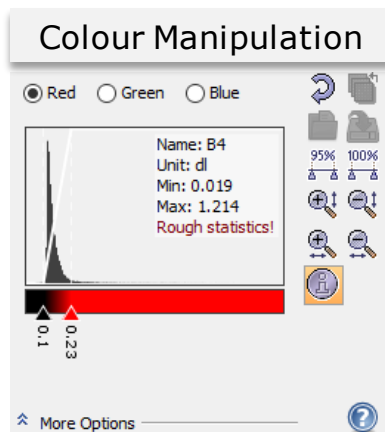
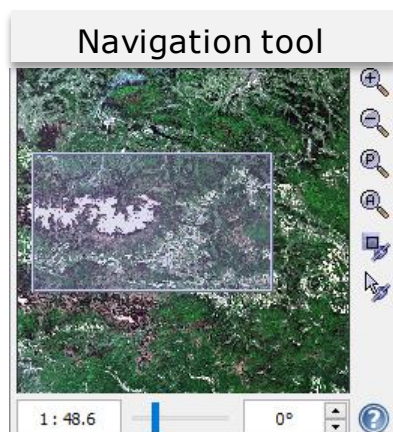
Display image in different polarizations

Upon opening an image, users can explore the image data through the Product Explorer window. This encompasses opening RGB composite images, navigating metadata, inspecting spectral bands, and reviewing image masks. In the case of radar images, amplitude or intensity can be visualized in various polarizations.





In the bottom-left Window Group, we can see 4 tools:

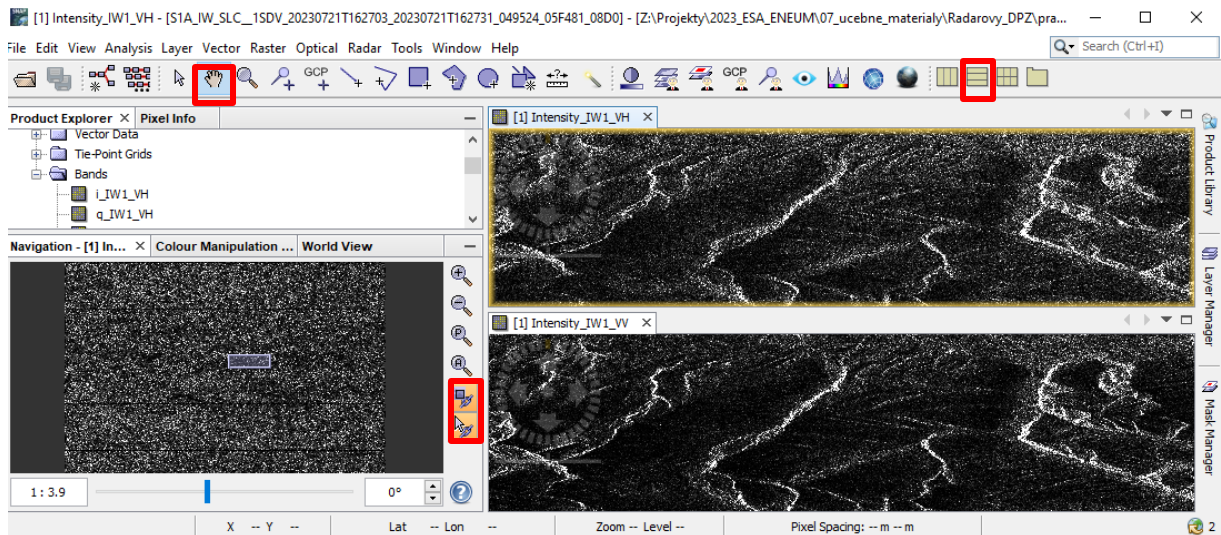
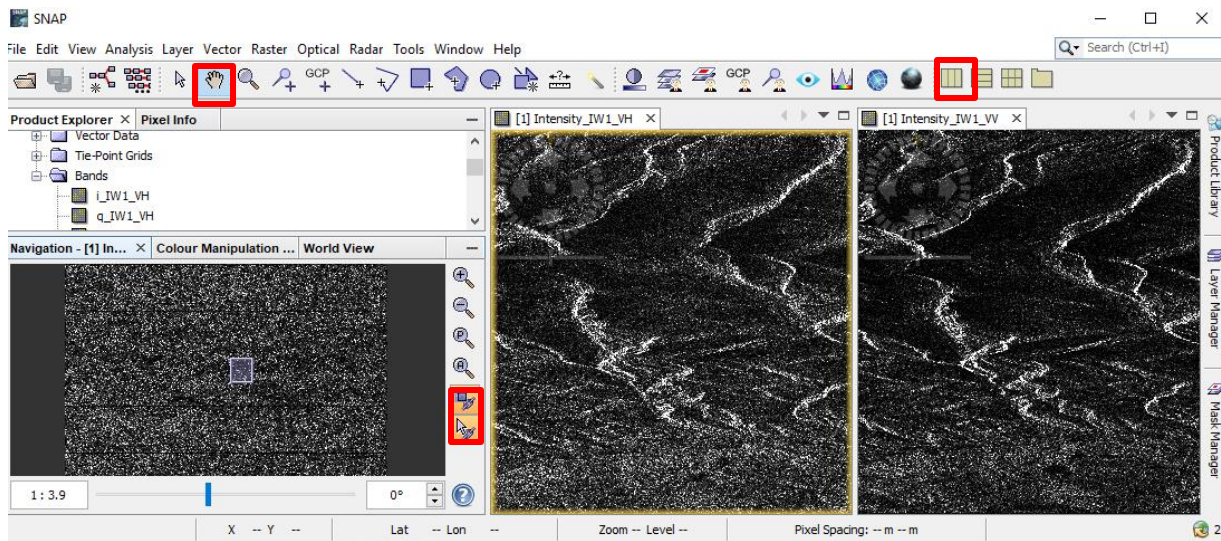
- *Navigation tool* – to navigate within the opened image
- *Colour Manipulation* – to view the histogram for the opened image and manipulate individual channels or assign new colours to the image
- *Uncertainty Visualisation* – to visualise the uncertainty information associated with a band shown in an image view
- *World View* – to see the position of our selected image




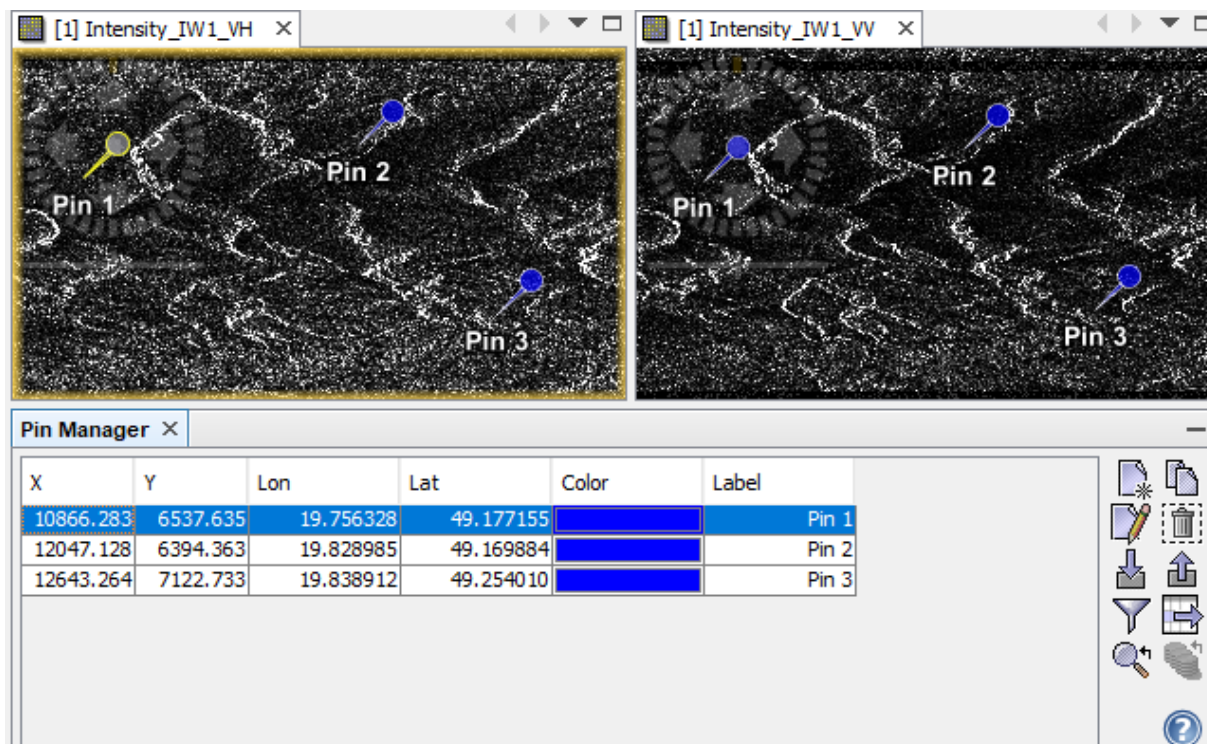
To simultaneously view and compare multiple opened images, utilize the *Tile* function (e.g. "*Tile Horizontally*" or „*Tile Vertically*”).

Ensure that the cursor is visible and that simultaneous manipulation of all images is possible by navigating to the Navigation tab and verifying that the following is checked:

-  *synchronises views across multiple image windows*
-  *synchronises cursor positions across multiple image windows*




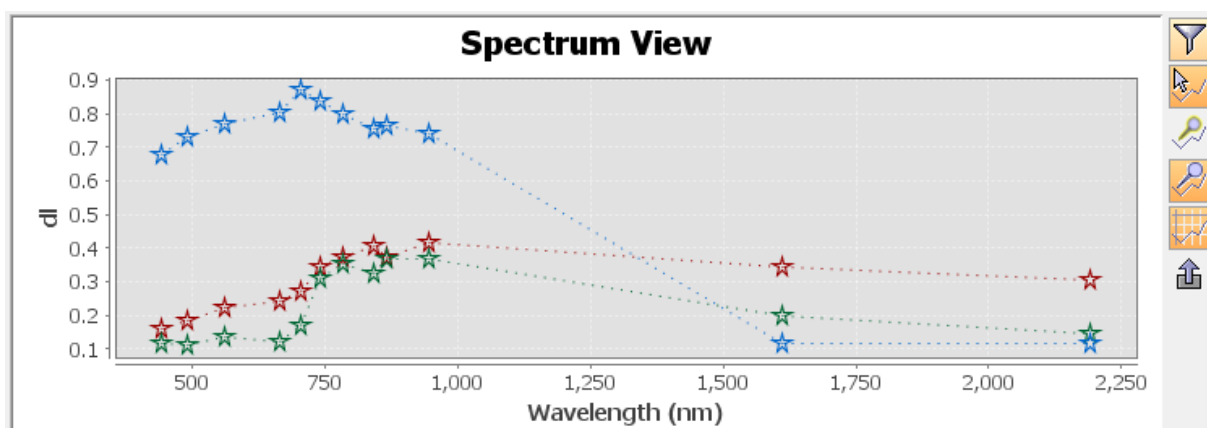
For localization purposes, we can add various pins to different pixels and add the description to them (View – Tool Windows – Pin Manager or by clicking on the icon of Pin placing tool )



The screenshot shows two windows titled "[1] Intensity_IW1_VH" and "[1] Intensity_IW1_VV" displaying satellite imagery with three pins labeled Pin 1, Pin 2, and Pin 3. Below the windows is the Pin Manager window, which contains a table with the following data:

X	Y	Lon	Lat	Color	Label
10866.283	6537.635	19.756328	49.177155		Pin 1
12047.128	6394.363	19.828985	49.169884		Pin 2
12643.264	7122.733	19.838912	49.254010		Pin 3

To observe spectral information of these various pins, we can use the tool Spectrum View 



7 | Third party missions

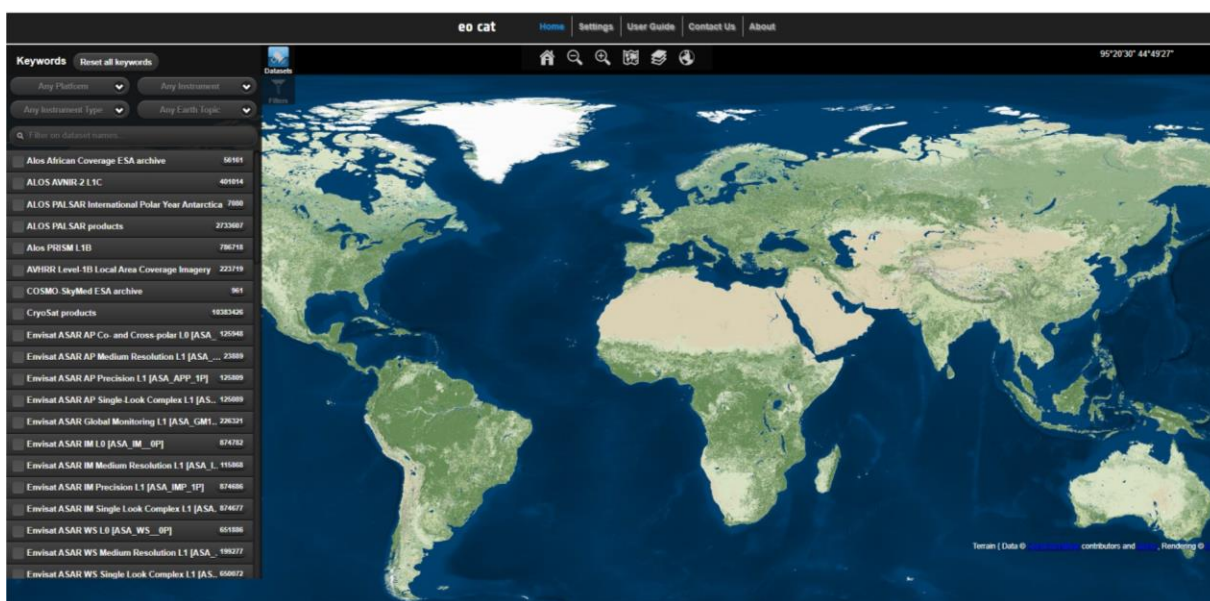
<https://earth.esa.int/eogateway/missions/third-party-missions>

In addition to providing users with data from its own Earth observing (EO) satellites, the European Space Agency (ESA) has played a significant role in providing access to Earth Observation missions not under ESA ownership or operation—referred to as Third Party Missions (TPM). With a history spanning over 45 years, the TPM program involves a series of Earth Observation-focused satellites owned by various commercial and public organizations worldwide. The TPM initiative currently includes over 50 missions, contributing data from more than 60 instruments to support users engaged in research and development endeavors.

7.1. Access to TPM data

Users have the ability to explore and download Earth Observation (EO) data from the extensive catalog of missions operated and supported by the European Space Agency through the ESA EO Catalogue (EO-CAT):

- <https://eocat.esa.int/sec/#data-services-area>



User can find here:

- mission, instrument and product news and descriptions;
- collection descriptions;
- data access links;
- information on selected Earth/environmental topics and applications of satellite data

Data are also accessible through the TPM L-OADS web interface:

- <https://tpm-ds.eo.esa.int/collections/>

THANK YOU FOR FOLLOWING THE EXERCISE!