

OPTICAL IMAGERY OF MARINE AREAS – 1 SENTINEL-3

Training Materials MO.1

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ADMISSION

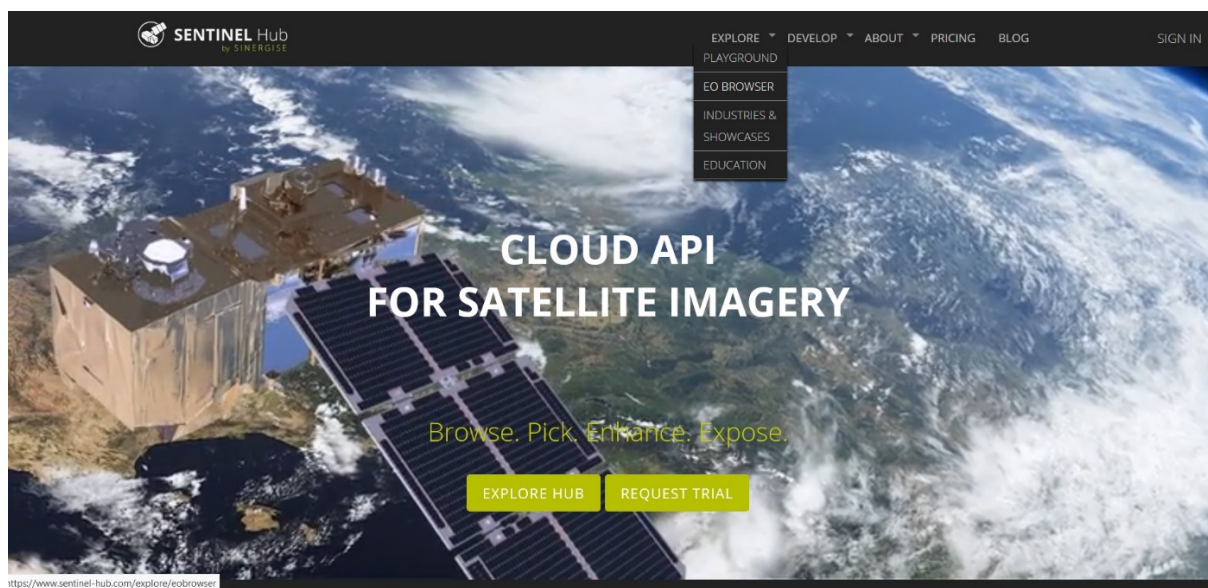
This guide will provide information on how to view and obtain OLCI sensor data (Sentinel-3) for the sea using websites such as [EOBrowser](#), [CODA EUMETSAT](#) and [Copernicus Access Hub](#) and how to prepare it for further GIS work with SNAP. EO Browser is a convenient browser with which you can see how many scenes in the period of interest we are interested in, whether the area remains cloudless, whether it is on the edge or at the center of the scanning path, as well as to notice the occurrence of mass bloom or run-off of cloudy waters e.g. flowing rivers. Sentinel-3 data without atmospheric correction (L1) is available through a standard SENTINEL satellite data source, i.e. Copernicus Access Hub and EUMETSAT services. Up to L2 level, the data are processed separately for the land and sea area. Products for the maritime area are only available through EUMETSAT services.

VIEW AND DOWNLOAD DATA

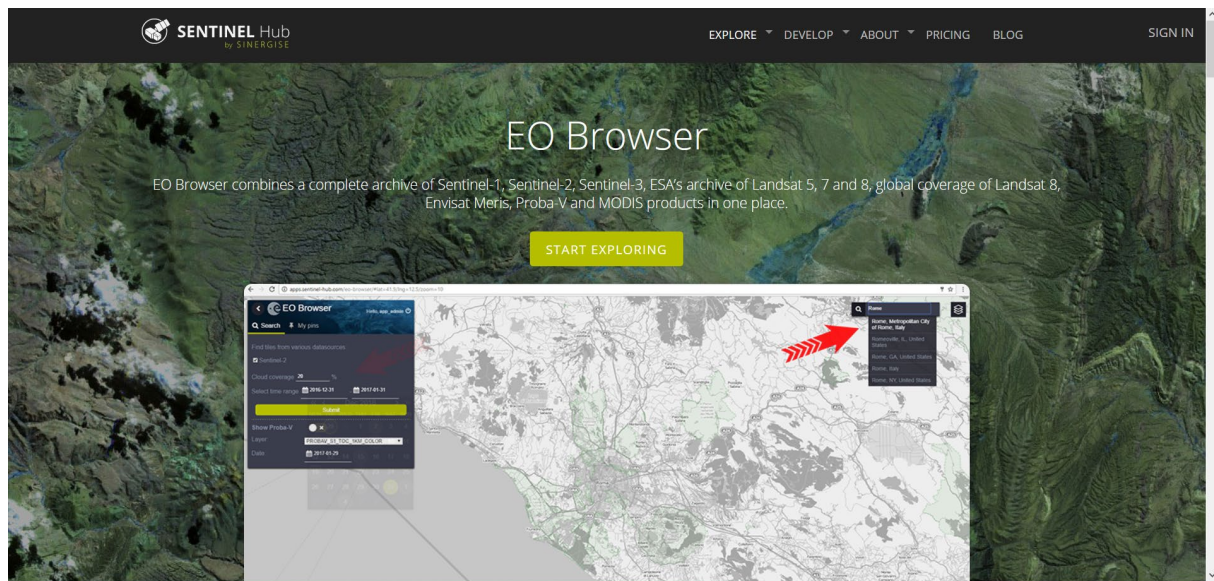
[EO BROWSER](#)

SIGN IN TO THE SITE

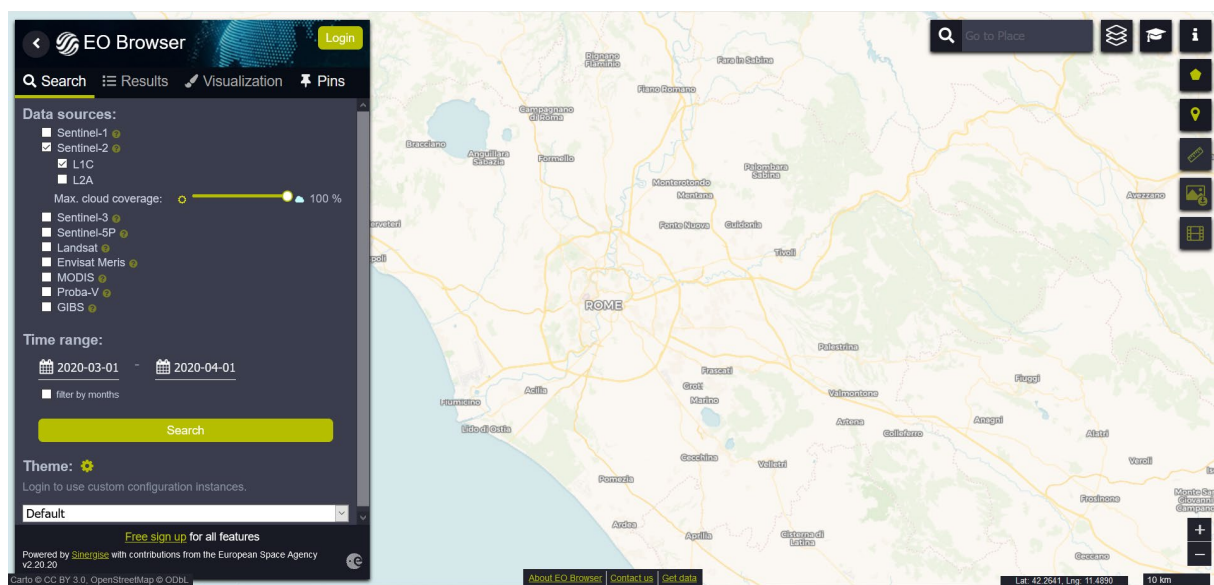
Go to the www.sentinel-hub.com and select EXPLORE tab, then EO BROWSER.



Then click START EXPLORING.



A new screen will appear and a "Login" button will appear on the left side of the screen.



If you do not have an account, you must create one by clicking on "Login" and then "Sign Up". The registration form appears. Without registration and login, it is possible to search and view data without the possibility of saving and using additional functionalities of the site.

SEARCH

To search for an image, move over the area of interest. In this case, move to the Baltic Sea region so that at least its central part and the Polish coast are visible. Scene search will be narrowed down to the area that is displayed on the monitor. Any imagery that includes, even a part, a visible area will appear in search results.

On the left, you can see a menu where you can define the scope of the search. When you select a field next to the names of subsequent satellites, additional search attributes are displayed.

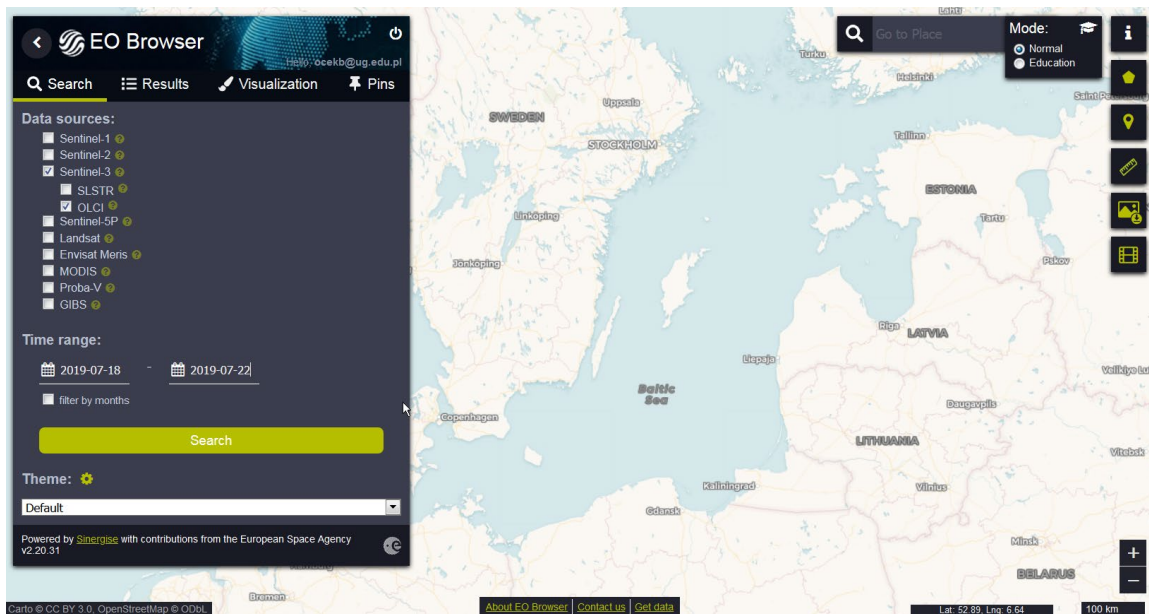
In the Sentinel-3 section, you can select the device from which you want to search for data:

- **SLSTR (Sea and Land Surface Temperature Radiometer)** – thermal data that can be used to create a sea surface temperature map;

- OLCI (*Ocean and Land Colour Instrument*) – data on the so-called "colour of the sea", i.e. data in the visible and near infrared range, on the basis of which it can be inferred the transparency of the waters, the particles suspended in them, including phytoplankton blooms, and dissolved matter.

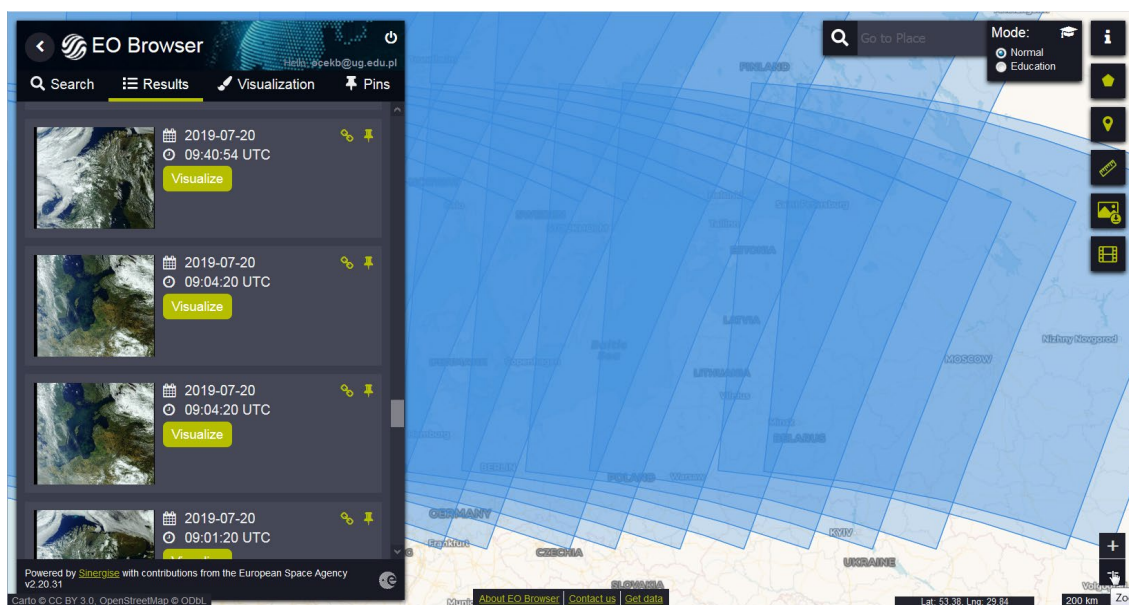
Time range allows you to define the period for which the data will be searched. It is also possible to select data only from specific months in a few years (**Filter by months** option)

The example will use the OLCI sensor data for the second half of July 2019, so select Sentinel-3, OLCI, from July 18 to July 22, 2019. Click **Search**.



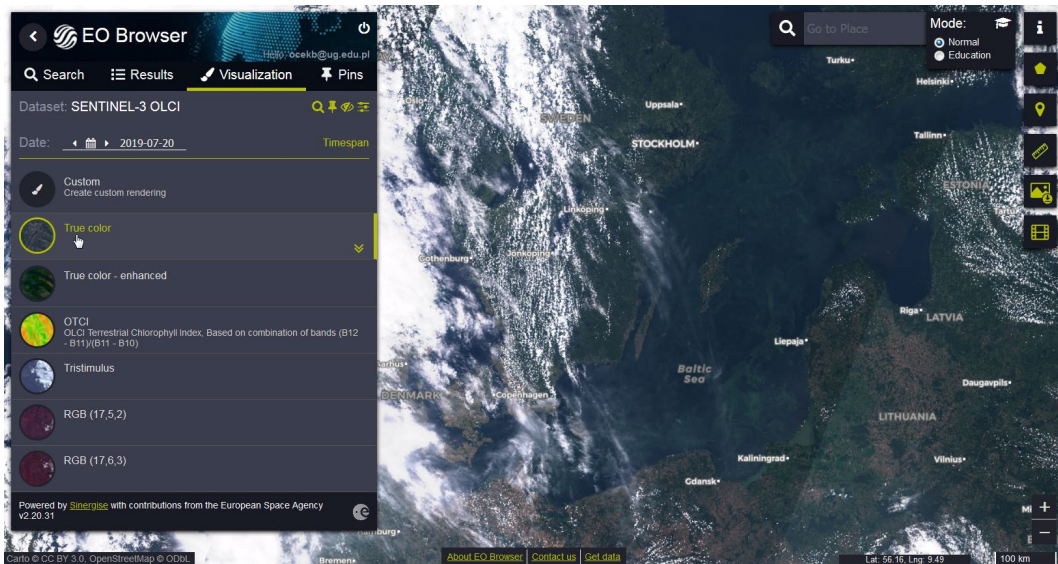
VIEW AND REVIEW RESULTS

To see a list of found scenes, go to the **Results** tab. It displays thumbnails of RGB composites to select granules (portions of paths) where the area of interest is not covered by clouds. At the same time, the map displays the strokes of all found granules (scenes).



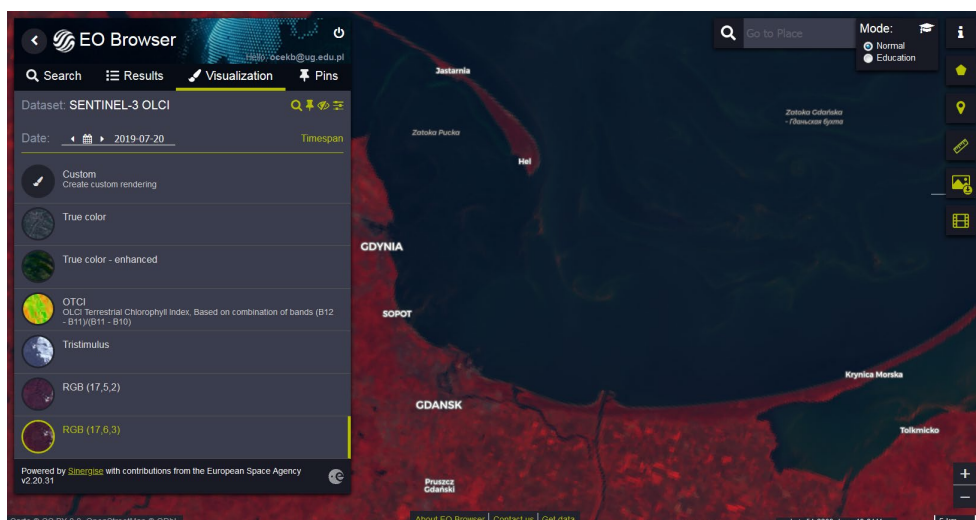
Select the scene from 07/20/2019 that shows a large area of the Baltic Sea. Click [Visualize](#). You will be automatically moved to the [Visualization](#) tab, where the selected image will be displayed as an RGB composite in colours similar to real ones.

On the left side of the screen, a list will appear where you can choose which composition or with which pointer you want to display the image:



- *True color* - colours similar to real ones, composite using channels lying in the spectrum ranges corresponding to the following colours: red (B08), green (B06) and blue (B04)
- *True color – enhanced* – multi-channel composition (channels B04-B07, B09, B14), enhancing color saturation
- *Tristimulus* – composition based on a combination of all channels in the visible light range, colors close to the real
- *OCTI* – chlorophyll index calculated on the basis of 3 channels from the red light range (range "Red Edge"), used to assess vegetation in the land area
- *RGB (17,5,2) and RGB (17,6,3)* – near-infrared compositions (false colours), allowing among others to distinguish inland waters from surrounding forest areas, but also algal blooms that persist on the surface of the water

Below is an image in false colours (RGB: 17,6,3))

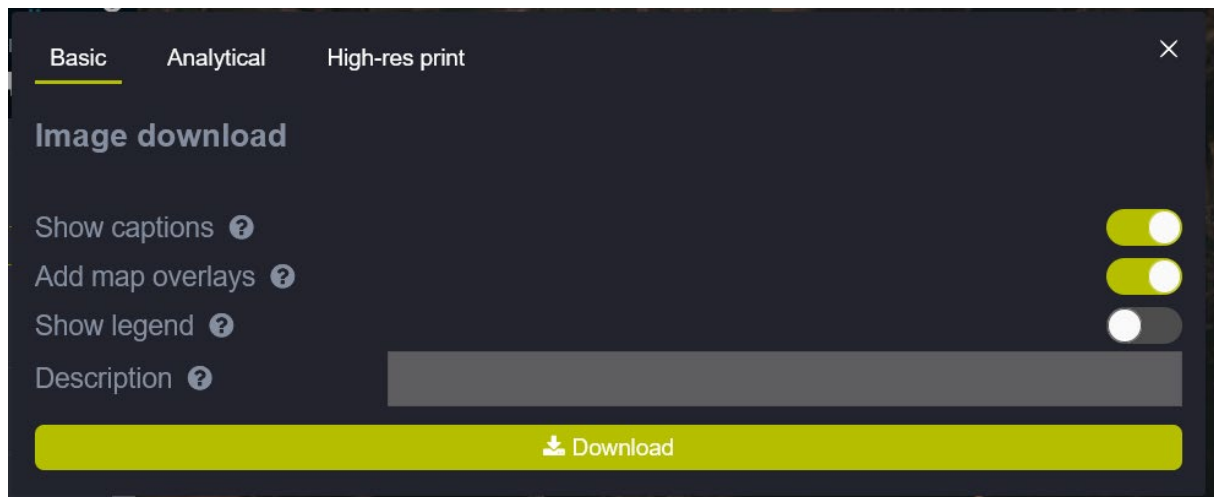


DOWNLOAD AN IMAGE OR DATA

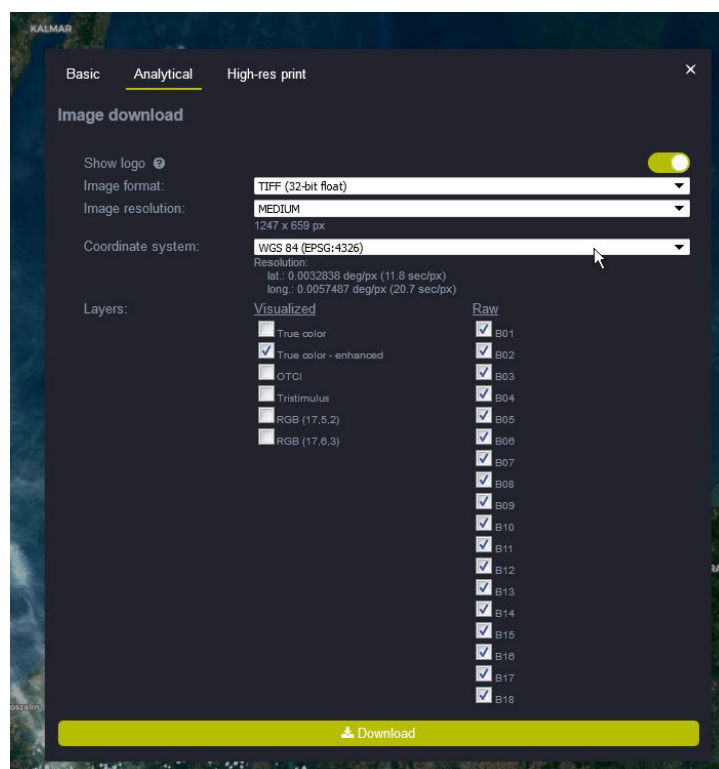
To download a visible image (selected artwork or index), click the [Download image](#) icon on the right side of the screen.



A new window appears. As the default, the [Basic](#) section appears. By selecting [Download](#) in this section, you can download the image in JPG graphic format, not useful for further analysis, but possible to use e.g. in presentations.

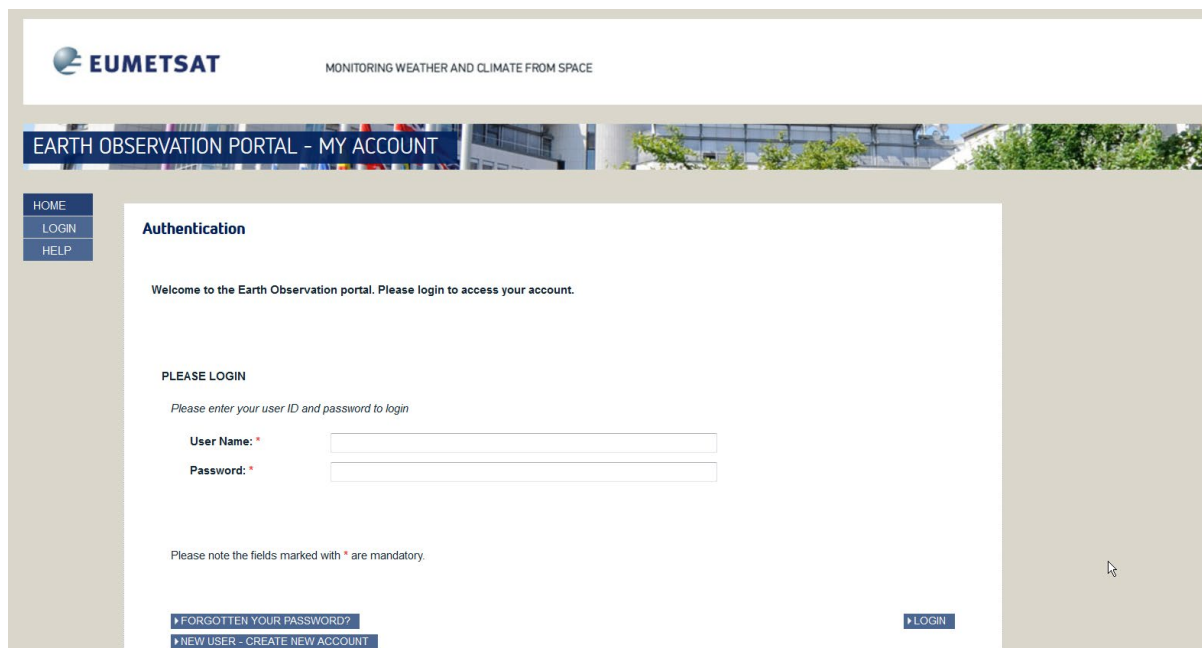


After going to the [Analytical](#) section, you can project the image to the selected projection and save it in TIFF format. This image can be used as a backing layer of the map created in GIS software. By clicking on the selected fields in the "Raw" column, you can also retrieve L1B data for the selected spectral channels. Keep in mind that data will only be retrieved for the restricted area in the display window, not the entire scene (hence the small file size). The pixel size will depend on the size of the area visible in the window and the resolution option selected (LOW, MEDIUM, HIGH), not the actual resolution of the data. Select any spectral channels and the selected composite. Click [Download](#).



SIGN IN TO THE SITE

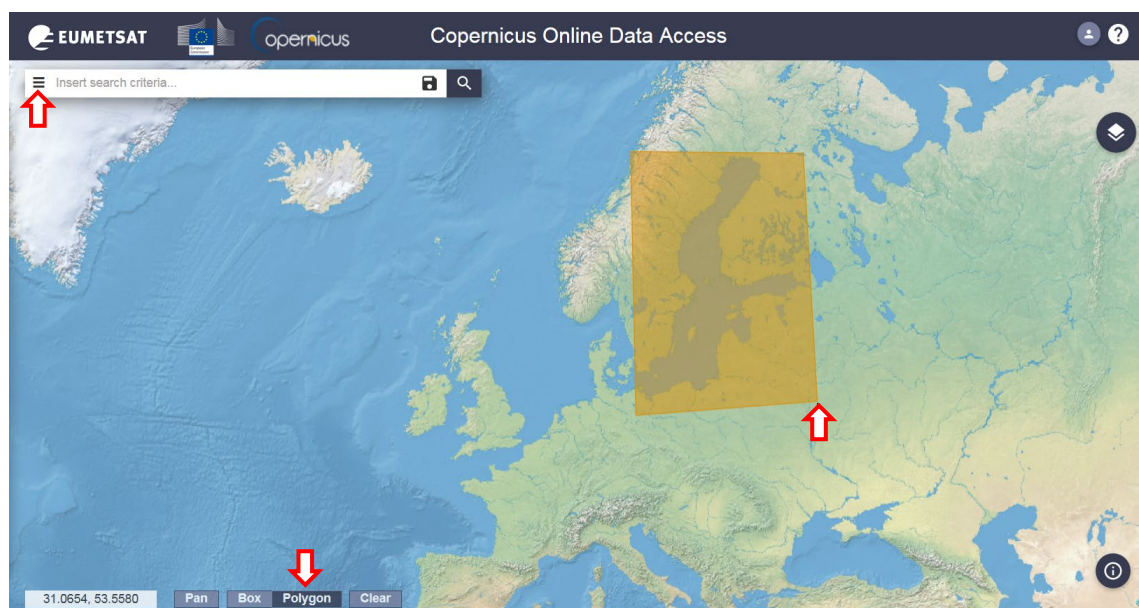
Enter the website address in your browser: <https://codu.eumetsat.int/>. You will be redirected to the login page. If you do not have an account, you must create one by clicking [NEW USER – CREATE NEW ACCOUNT](#). Without registration and login, it is not possible to use the functionality of the service. Registration is free and easy – requires only a few information about you. The obtained login and password are valid for all EUMETSAT services (CODA, CODAREP and DATA CENTRE).



The screenshot shows the EUMETSAT Earth Observation Portal - My Account login page. The header includes the EUMETSAT logo and the tagline "MONITORING WEATHER AND CLIMATE FROM SPACE". Below the header is a navigation bar with "HOME", "LOGIN", and "HELP" buttons. The main content area is titled "Authentication" and contains a welcome message: "Welcome to the Earth Observation portal. Please login to access your account." Below this is a "PLEASE LOGIN" section with a prompt: "Please enter your user ID and password to login". There are two input fields: "User Name: *" and "Password: *". A note below the fields states: "Please note the fields marked with * are mandatory." At the bottom of the login section are three buttons: "FORGOTTEN YOUR PASSWORD?", "NEW USER - CREATE NEW ACCOUNT", and "LOGIN".

DATA MINING

The CODA service allows you to search the database based on several criteria. **Note!!!** In different web browsers, the page may look different. The examples presented here have been prepared using *Mozilla Firefox*.



It's best to start defining search parameters by highlighting the area of interest. To do this, select **Polygon** (see the red arrow at the bottom of the image above). You draw a polygon by selecting points on the map with the left mouse button. To close the polygon and finish drawing, right-click. The polygon will be highlighted in yellow. To move the map while leaving the polygon, go to **Pan** mode. All data that at least partially covers the specified area will be searched. To limit the search further, click the icon to the left of the **Insert search criteria** pane. A list will expand to define the parameters for searching and displaying results:

Sort By - choose how you want to sort the images you're looking for:

- *Ingestion date* - by the date of "acceptance" of the data (product) into the database;
- *Sensing date* – by date of the imagery;
- *Cloud Coverage* – by degree of cloud coverage of the scene

Order by – selecting the direction in which the results are sorted

- *Descending*
- *Ascending*

Sensing period/Ingestion period – selection of dates within which the user performs the search.

Note!!! Data up to a year back is available on CODA. Previous data, from 26/04/2016 to 29/11/2017, is available on CODAREP (<https://codarep.eumetsat.int/>), to which you can log in with the same login and password. Its functionality is the same as described here for CODA. Data recorded after 29/11/2017 that are no longer available in CODA can be obtained at the L1 processing level using the Open Access Hub (see [next chapter](#)) and then processed to L2 by SNAP (see [chapter "Processing product L1 to L2 with case 2 water algorithm"](#)).

You can then refine your search by filling in information in one or more of the following filters:

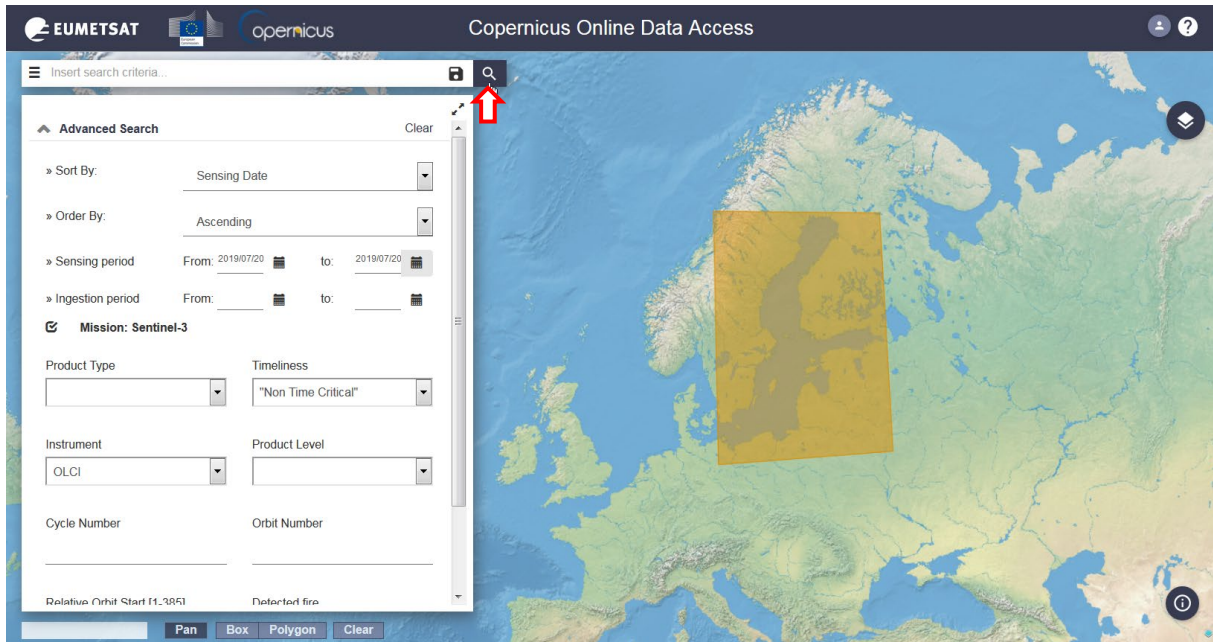
- **Instrument**
- **Product Level:**
 - L0 – raw data
 - L1 – data after instrumental correction and geolocation
 - L2 – data after atmospheric correction, geophysical values regarding water transparency and concentration of suspended solids, phytoplankton and dissolved organic matter, etc.
- **Timeliness** mode- *in the case of OLCI, data is shared in 2 modes*
 - NRT (*Near Real Time*) – products already made available within 3 hours after registration, but less precisely processed (in particular less accurate georeferential data) – stored in the database up to one month after registration
 - NTC (*Non Time Critical*) – products made available late, up to one month after registration (algorithms use more precise information for correction) - stored in the database up to a year after registration

and/or in more detail:

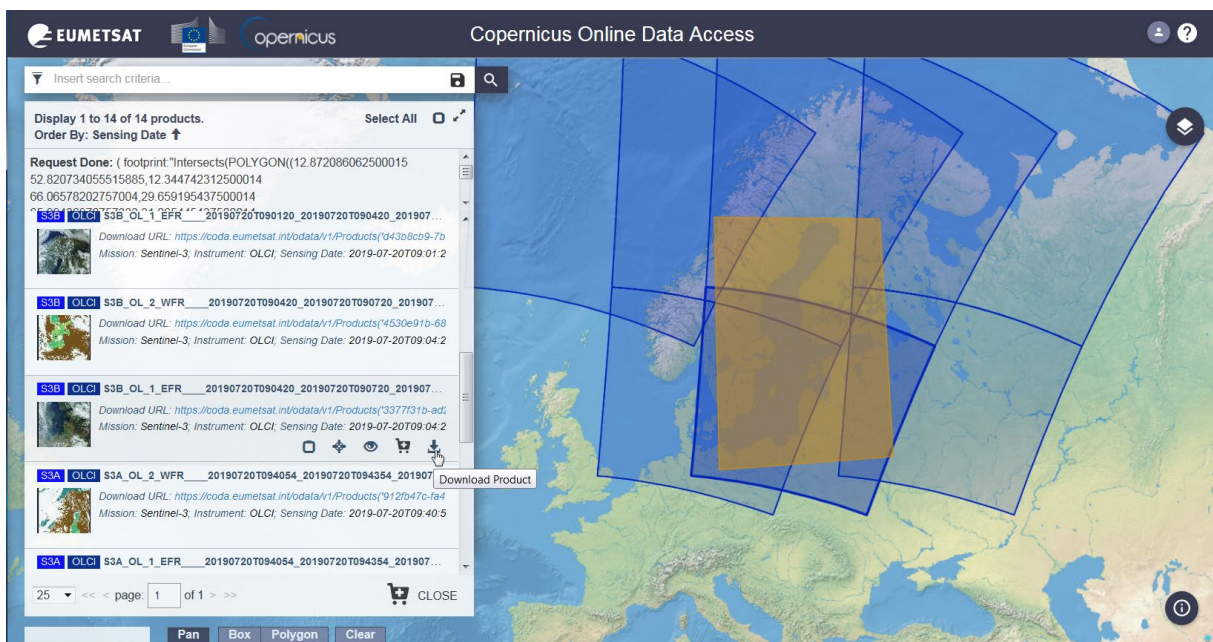
- *Product type* – OLCI sensor products have names beginning with "OL_", then 1 or 2 means the level of processing L1 or L2 (the letter "W" in L2 products means that they are marine products), "FR" or "RR" means the full resolution (300 m) and reduced (approx. 1,2 km) respectively.
- *Cycle Number* – number indicating for the first time since the beginning of the mission the satellite was exactly above the same point on Earth (in operational mode, the cycle length of the Sentinel-3 satellite is 27 days)
- *Orbit Number* – number indicating the next orbital circuit from the beginning of the mission

- *Relative Orbit Start*, that is, the imaging belt corresponding to the successive orbits of the satellite in one cycle.
- *detected fire* – allows you to select only those scenes where fires have been identified

To acquire L1 and L2 products for the previously selected scene from 20.07.2019, select the training ground covering the Baltic Sea, sorting after the registration date ascending, registration period from 20.07.2019 to 20.07.2019 and OLCI instrument and *Non Time Critical* mode. Leave the remaining filters blank. Click on the magnifying glass to start the search.



You will search for all scenes, some of which are in the set training ground. A list of found data and pellet strokes on the map appears in place of the filters.



DOWNLOAD DATA

Find L1 and L2 products for a scene recorded approx. 9 a.m., which covers most of the Baltic Sea (you can search the list for previews of the images or click on the map in the outline covering the Baltic sea to go to the corresponding list item). Click the [Download product](#) icon next to L1.



A save window appears. Select a path and download the file. This may take a few minutes due to the significant file size. Re-download for L2 product (position above in the results list).

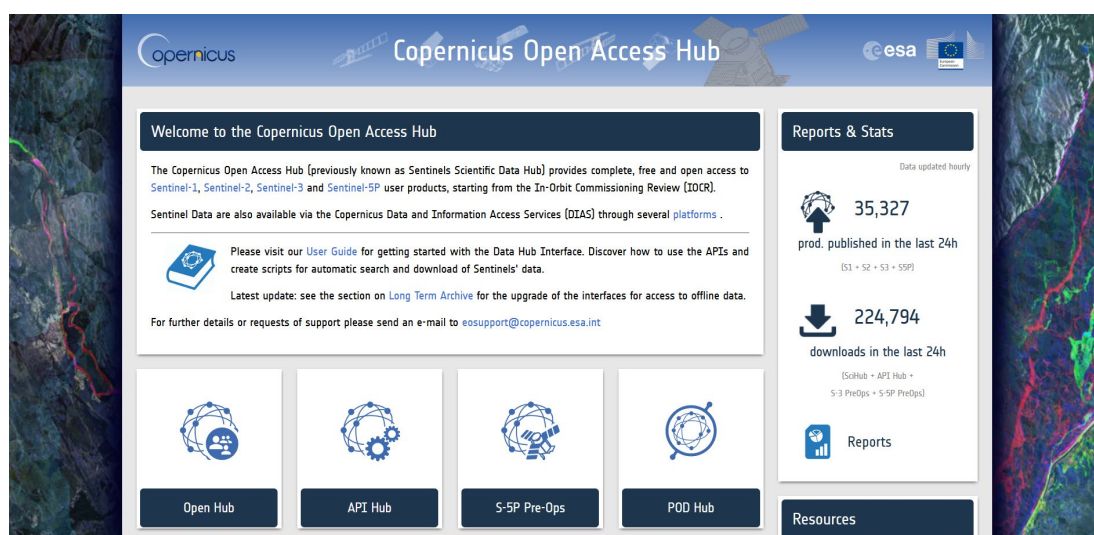
More about CODA functionality in [Sentinel 3 Marine Copernicus Data Access User Manual](#)

COPERNICUS ACCESS HUB

OLCI L1 data for the entire registration period, processed by the *Land Production Centre*, is independently available through Copernicus Open Access Hub (www.scihub.copernicus.eu).

LOGIN

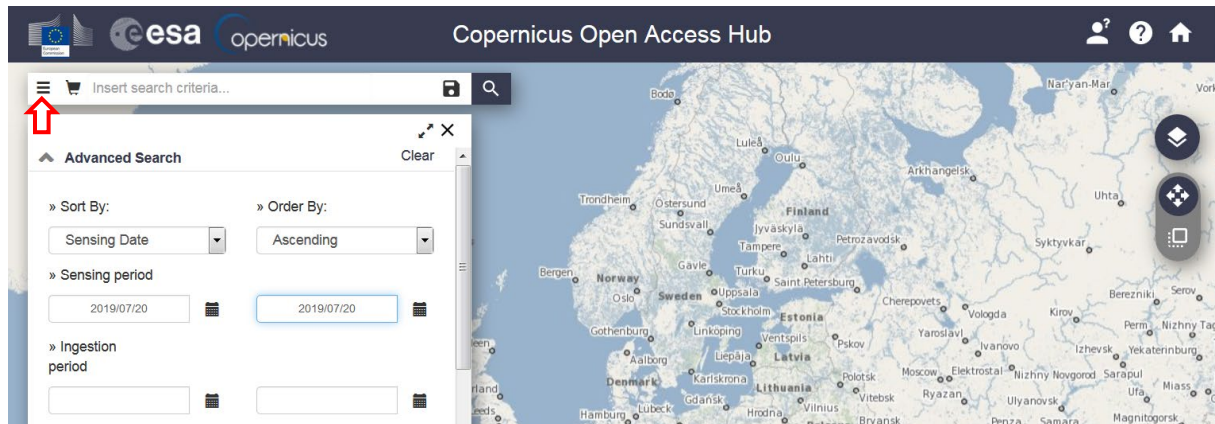
Go to Copernicus Access Hub and select "Open Hub"



After clicking on "Open Hub", the above page will be displayed. You must log in to be able to fully use the website. To do this, click the icon in the upper right corner of the page. Prior registration is required. To register, click "Sign up". After clicking "Sign up", the registration form will be displayed. After registering, enter your login (username) and password (password), and then press "Login".

DATA MINING

Copernicus Open Access Hub has functionality similar to CODA, but with a smaller filter list. Here, too, the appearance of the site may vary depending on the browser. The examples presented have been prepared using *Mozilla Firefox*.



To select search parameters, click on the icon on the left side of the "Insert search criteria" pane. A list will expand to define the parameters for searching and displaying results:

Sort By - choose how you want to sort the images you're looking for:

- *Ingestion date* - by the date of "acceptance" of the data (product) into the database;
- *Sensing date* – by date of the imagery;
- *Tile id* – by imagery order.

Order by – selecting the direction in which the results are sorted

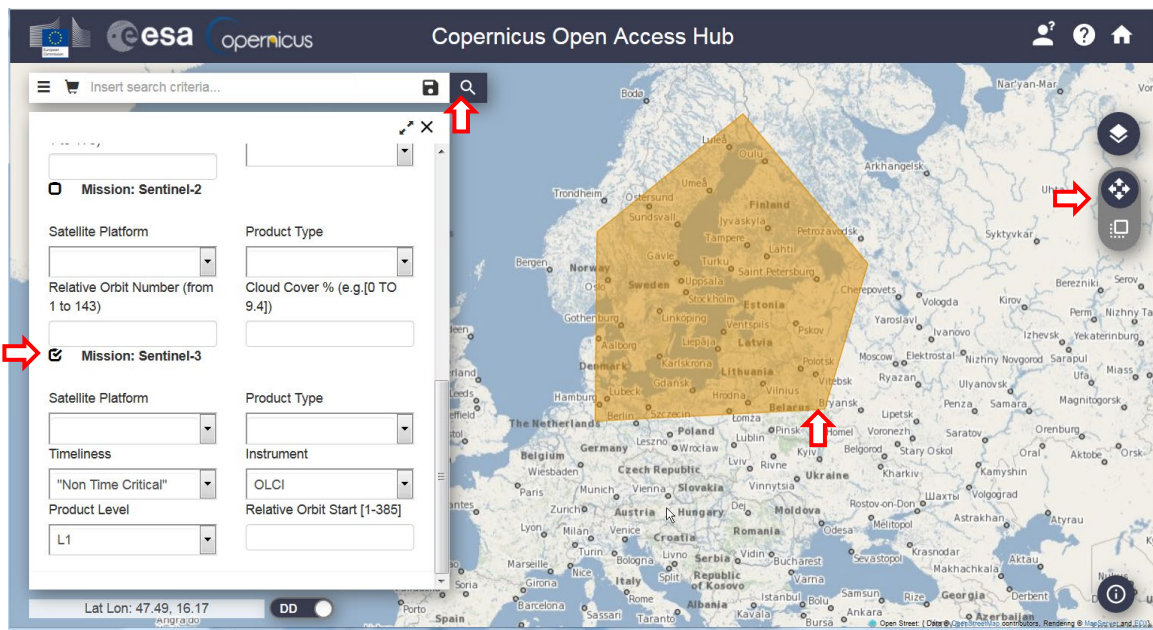
- *Descending*
- *Ascending*

Sensing period/Ingestion period – selection of dates within which the user performs the search.

These are the general search parameters that apply to each data source. To search for products from Sentinel-3 satellites, check the box next to Mission: Sentinel-3. You can then narrow your search by filling in information in one or more of the following filters:

- **Satellite Platform** – select the satellite that performs the imagery. These are satellites with the same parameters. To increase the search range, leave the field blank to search for images from both satellites:
 - S3A
 - S3B
- 1. **Product type** – OLCI sensor products have names beginning with "OL_", then 1 or 2 means the processing level L1 or L2 (the letter "L" in L2 products means that they are land-based products – marine products are only available on EUMETSAT services), "FR" or "RR" means full resolution (300 m) and reduced (1 km) respectively
- **Timeliness** - for OLCI, the data is made available in 2 modes:

- NRT (*Near Real Time*) – products already made available within 3 hours after registration, but less accurately processed (in particular less accurate georeferential data), possible acquisition of data from the last month
- NTC (*Non Time Critical*) – products made available late, up to one month after registration (algorithms use more precise information for correction), possible acquisition of data from the period of the last year
- **Instrument**
- **Product Level:**
 - L1 – data after instrumental correction and geolocation
 - L2 – data after atmospheric correction, land geophysical quantities.
- **Relative Orbit Start**, that is, an image strip corresponding to successive satellite orbits in one cycle.



Please refine your area before starting your search. To do this, select the "Switch to Area Mode" icon on the right side of the screen. Drawing a polygon is done by marking points on the map with the left mouse button. Double-click to close the polygon and finish drawing. The polygon will be highlighted in yellow.

To obtain the L1 product for the previously selected scene from 20/07/2019, select the training ground covering the Baltic Sea, sort by registration date in ascending order, registration period from 20/07/2019 to 20/07/2019 and the OLCI instrument, L1 level and *Non Time Critical* mode. Leave the other filters empty. Click on the magnifying glass to start the search. All images will be searched, at least some of which are in the given polygon.

DOWNLOAD DATA























Find a product for a scene registered at approx. 9 a.m., which covers most of the Baltic Sea (you can search the list for previews of the images or click on the map in the Baltic outline to go to the corresponding list item). Click the [Download product](#) icon next to the product. A save window appears. Select a path and download the file. This may take a few minutes due to the significant file size.



SENTINEL-3 DATA STRUCTURE / OLCI

DATA FROM [EO BROWSER](#)

After downloading the data from sentinel-hub.com site, open the folder where the downloaded file is located. It will be a compressed Zip.

Nazwa	Typ	Rozmiar po skompr...
 2019-07-20, Sentinel-3 OLCI, B01.tiff	Plik TIFF	1,882 KB
 2019-07-20, Sentinel-3 OLCI, B02.tiff	Plik TIFF	1,884 KB
 2019-07-20, Sentinel-3 OLCI, B03.tiff	Plik TIFF	1,941 KB
 2019-07-20, Sentinel-3 OLCI, B04.tiff	Plik TIFF	1,963 KB
 2019-07-20, Sentinel-3 OLCI, B05.tiff	Plik TIFF	1,952 KB
 2019-07-20, Sentinel-3 OLCI, B06.tiff	Plik TIFF	1,944 KB
 2019-07-20, Sentinel-3 OLCI, B07.tiff	Plik TIFF	1,929 KB
 2019-07-20, Sentinel-3 OLCI, B08.tiff	Plik TIFF	1,941 KB
 2019-07-20, Sentinel-3 OLCI, B09.tiff	Plik TIFF	1,942 KB
 2019-07-20, Sentinel-3 OLCI, B10.tiff	Plik TIFF	1,946 KB
 2019-07-20, Sentinel-3 OLCI, B11.tiff	Plik TIFF	2,068 KB
 2019-07-20, Sentinel-3 OLCI, B12.tiff	Plik TIFF	2,139 KB
 2019-07-20, Sentinel-3 OLCI, B13.tiff	Plik TIFF	1,871 KB
 2019-07-20, Sentinel-3 OLCI, B14.tiff	Plik TIFF	2,036 KB
 2019-07-20, Sentinel-3 OLCI, B15.tiff	Plik TIFF	2,129 KB
 2019-07-20, Sentinel-3 OLCI, B16.tiff	Plik TIFF	2,145 KB
 2019-07-20, Sentinel-3 OLCI, B17.tiff	Plik TIFF	2,152 KB
 2019-07-20, Sentinel-3 OLCI, B18.tiff	Plik TIFF	2,153 KB
 2019-07-20, Sentinel-3 OLCI, B19.tiff	Plik TIFF	2,101 KB
 2019-07-20, Sentinel-3 OLCI, B20.tiff	Plik TIFF	1,880 KB
 2019-07-20, Sentinel-3 OLCI, B21.tiff	Plik TIFF	2,149 KB
 2019-07-20, Sentinel-3 OLCI, True color - enhanced.tiff	Plik TIFF	8,059 KB

It contains only TIFF graphics files (or other files depending on the format selected when writing), one for each of the selected spectral channels and composites. A description of the spectral channels (spectral range and purpose) can be found on the ESA Sentinel Online portal (<https://sentinel.esa.int/web/sentinel/user-guides/sentinel-3-olci/resolutions/radiometric>) and in the training presentation on sensors used in satellite sea research. This data can be loaded as raster layers into GIS software. Before you start working, you must unpack them into a new folder. In the training materials "WORK ON SATELLITE DATA – BASICS" you can find suggestions on how to analyze this kind of data using QGIS (Sentinel-3 TIFF layers are loaded the same as those in JP2 format, which were presented in the Sentinel-2 materials).

[EUMETSAT AND SENTINEL ACCESS HUB DATA](#)

After you download data from CODA or the Open Access Hub, open the folder where the downloaded file is located. Unzip L1 and L2 products into separate folders:

L1:

- S3B_OL_1_EFR____20190720T090420_20190720T090720_20190721T150114_0179_027_378_1980_MAR_O_NT_002.SEN3 (product from the site EUMETSAT)
lub
- S3B_OL_1_EFR____20190720T090420_20190720T090720_20190721T125137_0179_027_378_1980_LN1_O_NT_002.SEN3 (product from Sentinel Access Hub)

L2:

- S3B_OL_2_WFR____20190720T090420_20190720T090720_20190721T172639_0179_027_378_1980_MAR_O_NT_002.SEN3

Product information is encoded in the name of folders unzipped from files:

- S3B – The satellite that provided the data – in the example of Sentinel-3B;
- OL – Sensor OLCI
- 1_E / 2_W - L1B / L2_water processing level
- FR - full resolution (300 m)
- 20190720T090420 – scene registration start time (first line) – July 28, 2019 at 9:04:20 AM
- 20190720T090720 – end time of scene registration (last line) – 28 July 2019 9:07:20
- 20190721T150114 – product creation time - July 21, 2019 at 15:01:14 (note that for each product a different)
- 0179 – time to record the entire scene in seconds
- 027 – cycle number
- 378 – path number (cycle orbit number)
- 1980 – no granules along the path
- MAR (*Marine Processing and Archiving Centre*)/ LN1 (*Land Production Centre*) – data processing centre
- O – operational phase of the satellite operation
- NT – mode: *non time critical*
- 002 – processing version number

The folder structure is similar, regardless of the level of processing. They include:

1. "xfdumanifest.xml" file containing metadata and product structure description
1. Files with raster data in netCDF format (*.nc):

DATASET L1

Despite processing in different centres, the content of the L1 product obtained from EUMETSAT (MAR) and the Open Access Hub (LN1) is the same

1. **Oa##_radiance** – radiation values [$\text{mW m}^{-2} \text{sr}^{-1} \text{nm}^{-1}$] at the upper limit of the atmosphere (TOA) in 21 spectral channels (##_ - channel no.), calculated on the basis of recorded data after georeference and radiometric correction and reaming into an 'ideal' instrumental grid (line and column coordinate system, without projection for cartographic mapping, coordinates in separate images)
 - **geo_coordinates** – pixel geographic coordinates
 - **qualityFlags** – results of cloud identification, surface type, information on detected errors and possible interpolation of values
1. additional data (*auxiliary data*) used in correction or useful for further correction, including information about the recording time of each line, sensor characteristics, imaging geometry, meteorological data from the ECMWF model (instrument_data, removed_pixels, tie_geo_coordinates, tie_geometries, tie_meteo, time_coordinates)

More information on [Sentinel Online](#)

DATASET L2

- **Oa##_reflectance** – reflectance values [-] at sea level (BOA) in 16 spectral channels (##_ - channel number), calculated on the basis of L1B radiation using the Baseline Atmospheric Correction (BAC) algorithm

- **chl_oc4me** – chlorophyll *a* concentration [mg m^{-3}] for clean waters (BAC algorithms and maximum band ratio, values on a logarithmic scale were used in the calculations)
- **chl_nn** - concentration of chlorophyll *a* [mg m^{-3}] for turbid waters (C2RCC algorithm, logarithmic values)
- **tsm_nn** – concentration of total suspended matter [g m^{-3}] for turbid waters (C2RCC algorithm, logarithmic scale values)
- **trsp** – diffusive attenuation coefficient for downward irradiance $K_d(\lambda=490 \text{ nm})$ [m^{-1}] (BAC and M07 algorithm, logarithmic scale values)
- **iop_nn** – absorption coefficient [m^{-1}] by dissolved organic substances and detritus for wavelength 443 nm (C2RCC algorithm, logarithmic scale values)
- **PAR** - instantaneous values of photosynthetically active radiation [$\mu\text{E m}^{-2} \text{ s}^{-1}$] in the range of 400-700 nm (BAC and *clear-sky ocean* algorithms);
- **w_aer** - aerosol optical thickness of the atmosphere $T(\lambda=865 \text{ nm})$ and Angström coefficient (*A*) expressing a spectral relationship of the optical thickness of the atmosphere for waves of 779 nm and 865 nm (BAC algorithm)
- **iwv** – water vapour content in the atmospheric column [kg m^{-2}] (1D-Var algorithm).

All of the above geophysical products contain, in addition to parameter values, error estimates. Green colour marks those processed with algorithms specific to Case 2 waters, including the Baltic Sea.

- **geo_coordinates** – pixel geographic coordinates
- **wqsf** – data quality and pre-classification flags
- additional data (*auxiliary data*) used in correction or useful for further correction, including information about the recording time of each line, sensor characteristics, imaging geometry, meteorological data from the ECMWF model (*instrument_data*, *tie_geo_coordinates*, *tie_geometries*, *tie_meteo*, *time_coordinates*)

More information on [Sentinel Online](#)

PRE-PROCESSING OF DATA IN SNAP

Free SNAP software will be used for the rest of the exercises. Download the software at <http://step.esa.int/main/download/snap-download/>. To perform the analysis presented here, you only need to install the Sentinel Toolboxes. At <http://step.esa.int/main/doc/tutorials/> there are short tutorials on the basic functions of the program. After starting the program, the main window and the contents of the menu and toolbar may differ depending on the installed toolbox set. If any window of the tools used in the exercise is not visible, it can be opened with the View> Tool windows [command](#).

DATA OPERATIONS L1

DISPLAY AND EXPORT A COLOR COMPOSITE

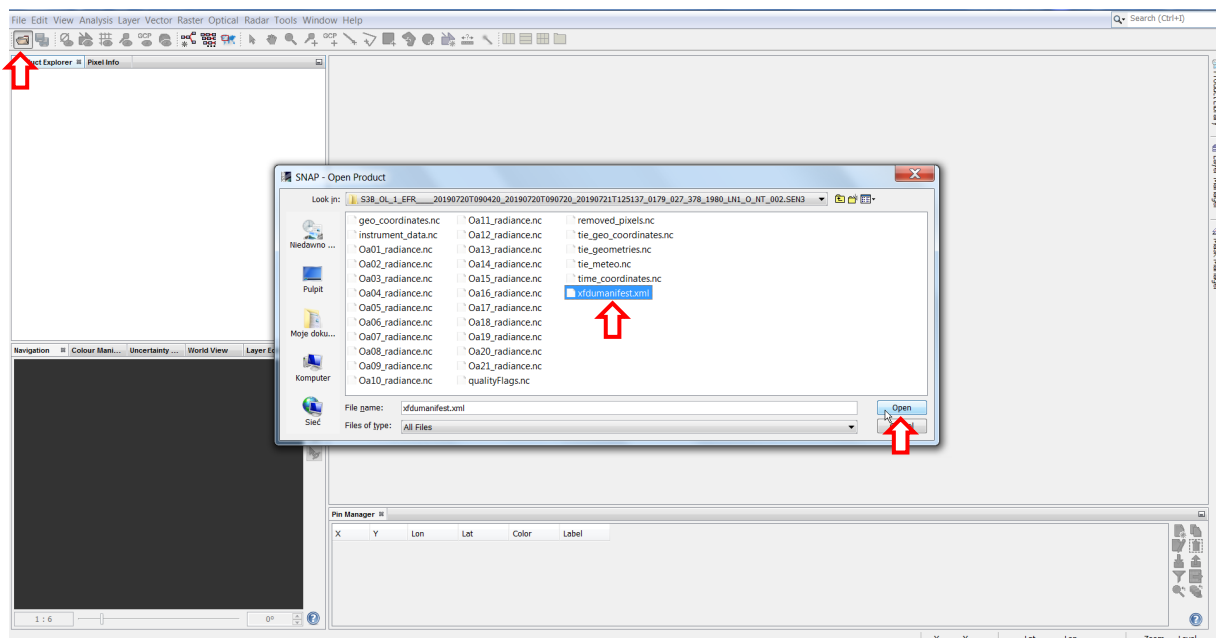
To load satellite data, select **File > Open Product**, then in the dialog box go to the folder where the data was unzipped, point to the *xfdumanifest.xml* file, and click **Open**.

Note!!! When unpacking Sentinel-3 data, keep the original folder name. For the analyzed example (data from the CODA website) it is:

S3B_OL_1_EFR____20190720T090420_20190720T090720_20190721T150114_0179_027_378_1980_MAR_O_NT_002.SEN3

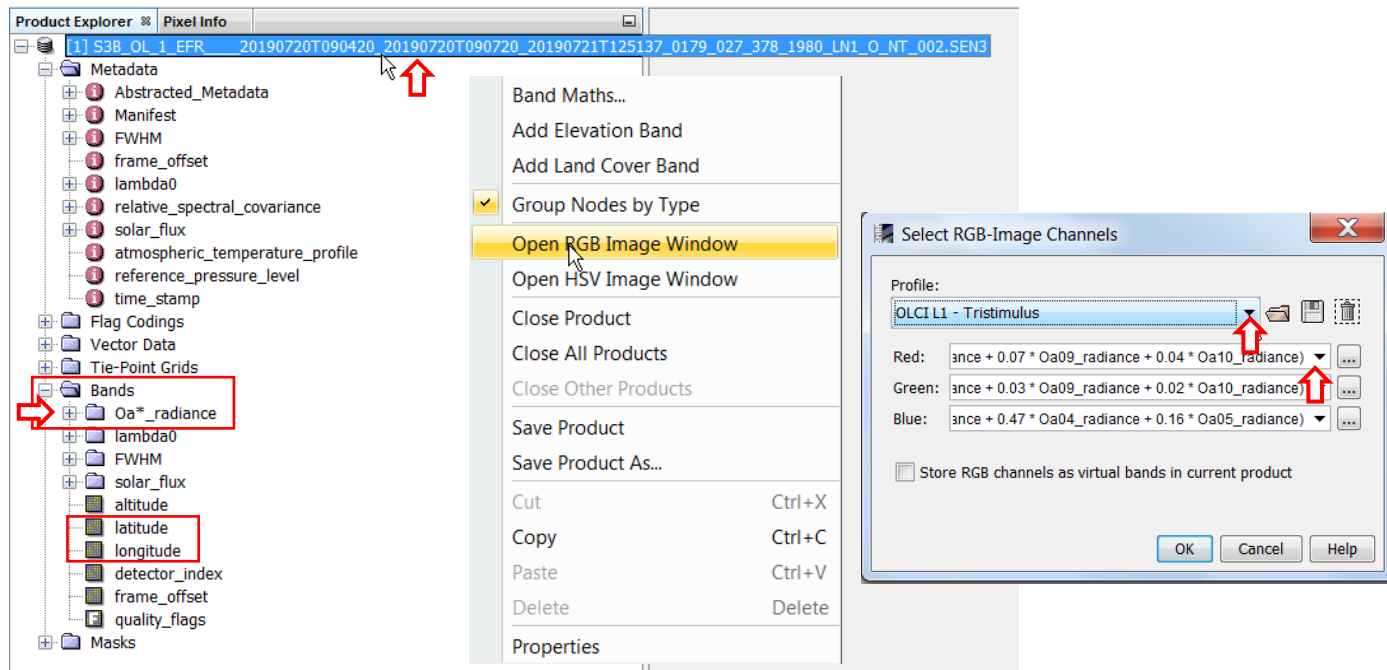
or (from Copernicus Open Access Hub website):

S3B_OL_1_EFR____20190720T090420_20190720T090720_20190721T125137_0179_027_378_1980_LN1_O_N_T_002.SEN3

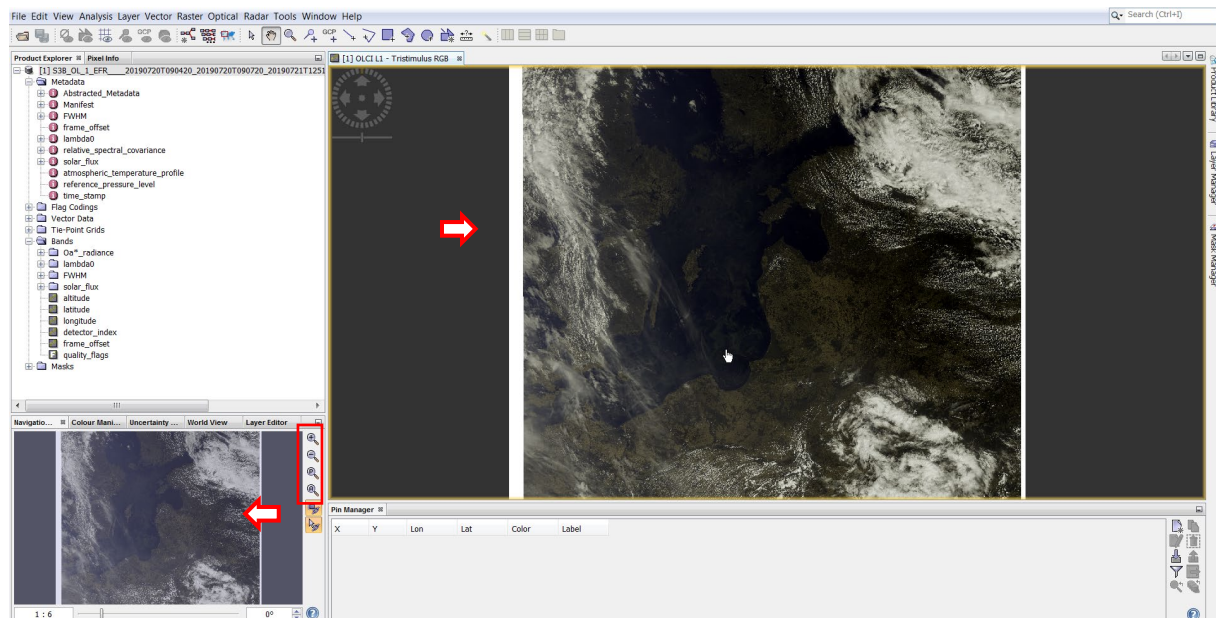


SNAP automatically loads all *.nc files contained in the product folder. The product structure can be viewed in the **Product Explorer** window (usually opened at the top left of the SNAP window). Content expands by clicking on the character to the left of the product name and each of its folders. Data from each spectral channel (radiation values at TOA) can be found in the Bands > *Oa*_Radiance*. Pixel coordinates in *latitude* and *longitude* raster layers.

To view the data as an RGB composite, right-click on the product name in the **Product Explorer** window. A context menu appears from which to select open **RGB Image Window**. In the composite creation dialog box, you can select one of the predefined **composites** (Profiles), or create your own by selecting for individual components R,G,B radiations from any spectral channels (▼) or their combination (creating a combination of channels with a button marked with three dots).

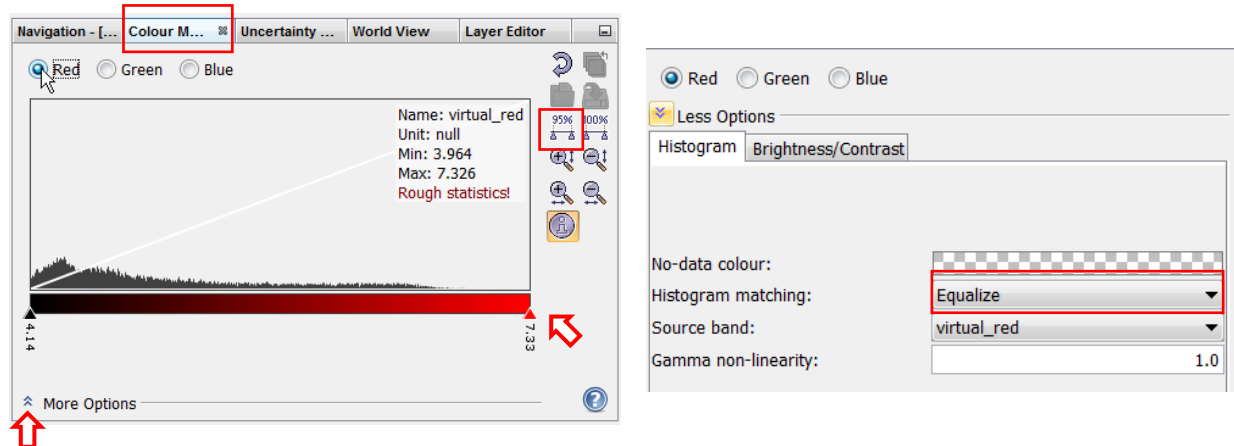


Select the **OLCI L1- Tristimulus** predefined composite and click **OK**. The image appears in the main part of the program window and in the **Navigation** pane. The set of magnifying glass in this second window allows you to zoom in/out of the area in the main window.

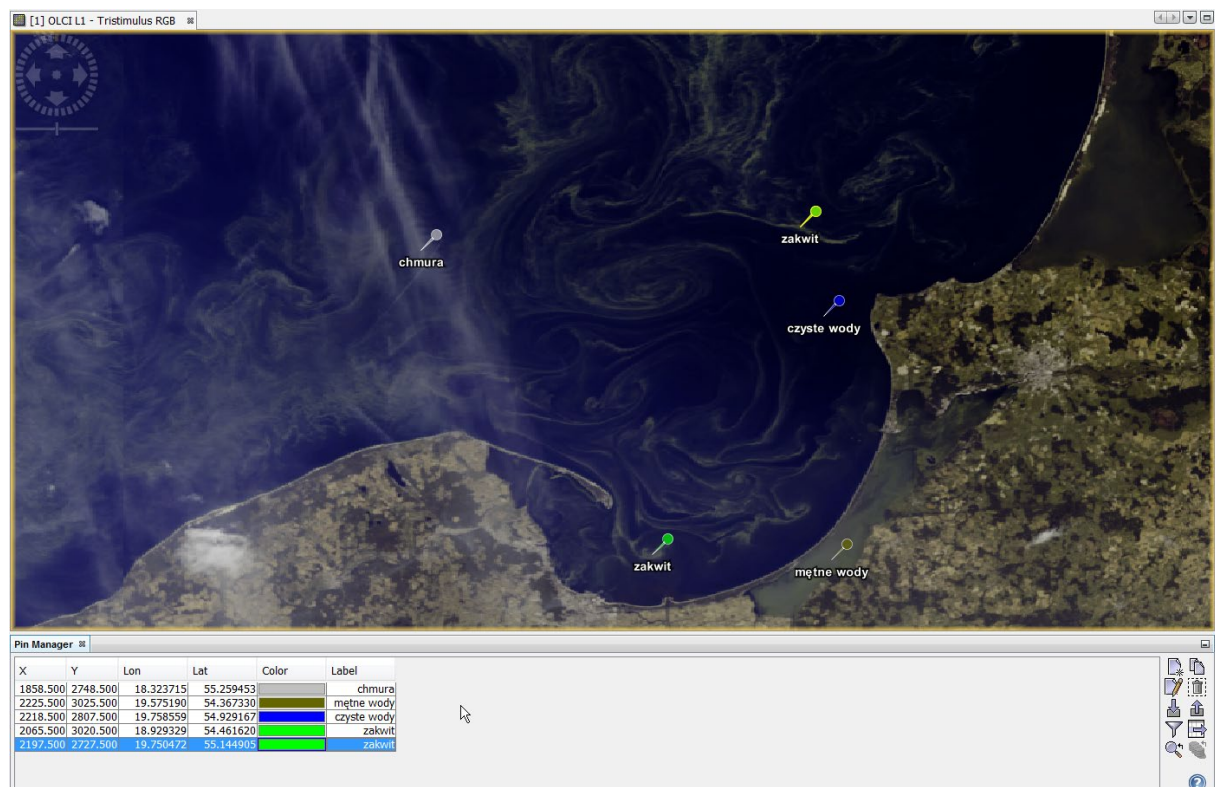


Zoom in on the Gulf of Gdansk. To enhance the contrast of an image, you can use the **Colour Manipulation** tool (the tab next to **Navigation**) to limit the range of values in which the shades of each color will be distributed. You can choose to automatically adjust the linear contrast with the 2.5% cut of the extreme values (option 95%) or

manually using the color scale slider. To keep the colors close to the real thing, you need to do it proportionally in each of the three color bands. You can also use other options that are available when you expand [More Option](#).



Select the option to align the [histogram matching](#): [Equalize](#). In the image, clean sea waters will have a dark navy blue color, waters with a large amount of suspending matter and those in the area of phytoplankton bloom – green to brown. Cloud streaks cause the image to brighten up when it occurs.



Note that by moving the mouse in the area that appears on the composition, you can read the position over which the cursor is placed in the SNAP status bar (lower-right corner of the program window). Displays the position in the XY coordinates of the original data grid, such as the column and row of the pixel position, as well as the geographic coordinates that SNAP automatically retrieves from the *latitude* and *longitude* rasters.

X	2070	Y	2968	Lat	54°35'33" N	Lon	18°59'53" E	Zoom	1.7:1	Level	0
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Places of special interest can be marked with "pins" in SNAP. To insert the pin, run the [Pin placing tool](#) and then click the location you want in the image. A pin symbol appears on it, and in the Pin Manager window (if it is not



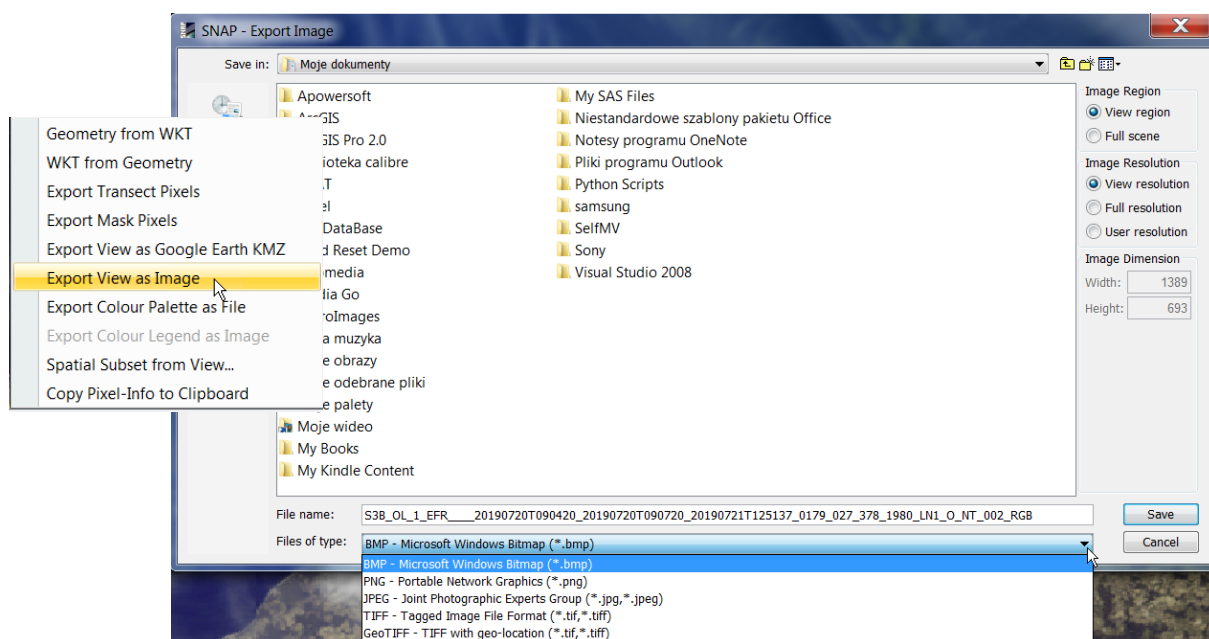
open, open it by selecting the coordinates of the marked location from the [View > Tool windows > Pin Manager](#) menu). In the pin manager table, you can edit individual fields by adjusting the color of the pin and its description. You can also modify the coordinates to move the tag. On the right side of the manager window there are a number of tools that, among others, you can remove the selected pin or save its properties in a file.

Mark with pins of the place: clean water, turbid waters in the lagoon, bloom and those where clouds can hinder interpretation. Describe the pins accordingly and diversify their colors. Select all pins in the manager table (the selected rows will be blue) and save to xml file ([Export Selected Pins To XML File](#))

After exporting the pins, exit their insertion mode by selecting a pointer from the toolbar. Click anywhere in the image to uncheck the pins.



You can save a visible image as a graphic file to include it, for example, in a report. To do this, right-click on the image and select [Export View as Image](#) from the context menu. In the export dialog box, select the destination folder and save format (available: BMP, PNG, JPEG, and TIFF). In the right part of the dialog box, you can change the resolution of the saved image, and you can choose to save the entire image ([Full scene](#)) instead of the visible portion ([View region](#)).



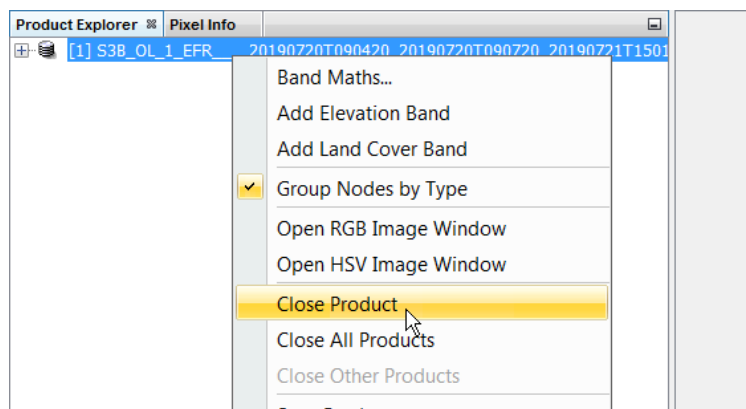
Save the magnified portion as a PNG image at the resolution at which it is displayed ([View resolution](#)). Insert the image into any document.

Selecting the entire image ([Full scene](#)) and full resolution ([Full resolution](#)) allows you to record the 3-channel image additionally in GeoTIFF format, along with coordinates, for further work in GIS.

Re-save the entire scene in full GeoTIFF resolution. Open QGIS and add the result as a raster layer. In the training materials "WORKING ON SATELLITE DATA – BASICS" you can find hints on how to display raster layers in QGIS (GeoTIFF layers load the same as those in JP2 format, which are presented in the materials for Sentinel-2).

If the image is to be presented in a specific cartographic projection, the scene can be projected in the SNAP program. The procedure is described in the following chapters using the example of the L2 product.

To close the analyzed product in SNAP, right-click on its name in the [Product Explorer](#) window, and then select the [Close Product](#) option.



OPERATIONS ON L2 DATA

SELECTION OF GEOPHYSICAL PARAMETERS

To load satellite data, as with L1, select [File > Open Product](#), then in the dialog box go to the folder where the data was unzipped, point to the *xfdumaniest file.xml* and click [Open](#).

Note!!! When unpacking Sentinel-3 data, keep the original folder name. For the example analyzed (CODA data) this is:



S3B_OL_2_WFR____20190720T090420_20190720T090720_20190721T172639_0179_027_378_1980_MAR_O
_NT_002.SEN3

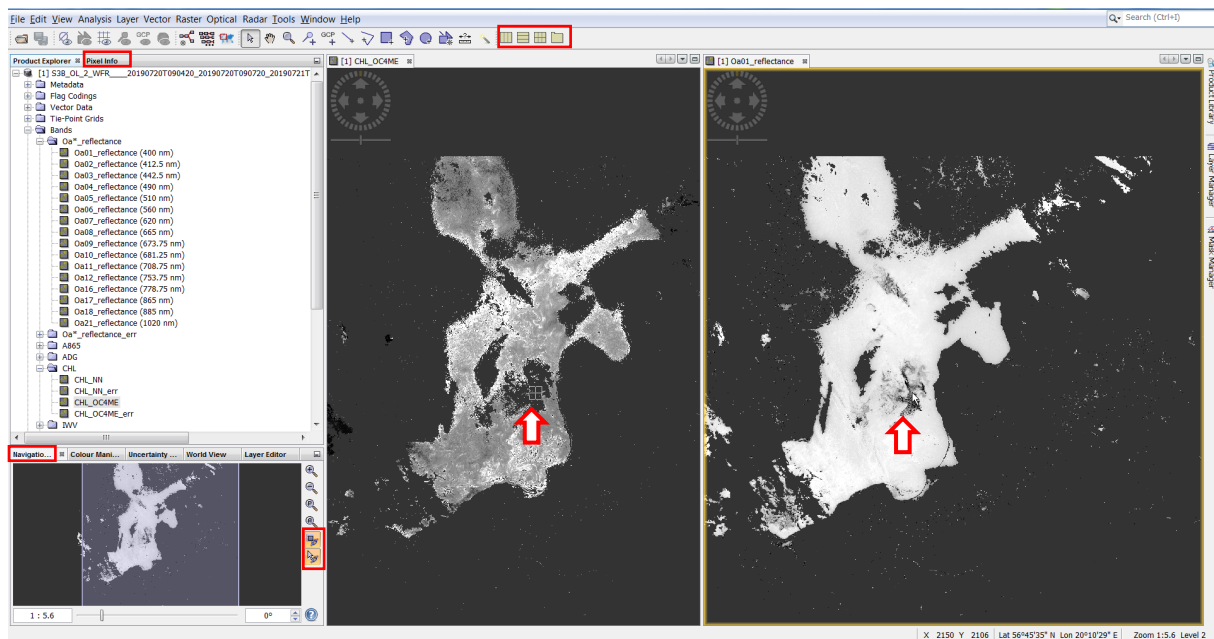
SNAP automatically loads all *.nc files contained in the product folder. The product structure can be viewed in the [Product Explorer](#) window (usually opened at the top left of the SNAP window). Content expands by clicking on the character to the left of the product name and each of its folders. Data from each spectral channel (BOA reflectance values) can be found in the *Bands > Oa*_Reflectance* folder. Pixel coordinates in *latitude* and *longitude* raster layers. Geophysical products calculated on the basis of spectral data in the relevant catalogues (see description of the products of [set L2](#)).

To display an image of a single screen (reflectance in the selected channel, chlorophyll concentration, etc.) Just double-click on the screen name.

Display, for example, the reflectance calculated from channel 1 data (*Oa01_reflectance (400 nm)*) and the concentration of chlorophyll calculated using the OC4ME algorithm (*CHL_OC4ME*). The toolbar has icons



that allow you to organize the panes where the images are displayed differently. Choose to make both images visible at the same time. The icons in the [Navigation](#) window allow you to synchronously zoom in/out of images in open windows (option  enabled) and track cursor position (enabled ).



In the [Pixel Info](#) pane, you can see the coordinates of the indicated pixels and the values of geophysical parameters. A NaN value indicates that the pixel is marked with a no data code. Note that in the area indicated in the image above, the reflectance values are negative and the chlorophyll concentration values are indicated by the no data code (in the images, all NaN pixels have the same color as the window background). When you expand the flags, you can see that the indicated pixel in the flag WQSF_Isb_OC4ME_FAIL is set to "true", which means that OC4ME returned an error calculating the chl_a value.

Product Explorer		
Pixel Info		
Position		
Image-X	2174	pixel
Image-Y	2054	pixel
Longitude	20°20'02"	E degree
Latitude	56°52'43"	N degree
Time		
Bands		
Oa01_reflectance	-0.02963	
CHL_OC4ME	NaN	mg.m-3
Tie-Point Grids		
Flags		
WQSF_Isb.INVALID		false
WQSF_Isb.WATER		true
WQSF_Isb.LAND		false
WQSF_Isb.CLOUD		false
WQSF_Isb.CLOUD_AMBIGUOUS		false
WQSF_Isb.CLOUD_MARGIN		false
WQSF_Isb.SNOW_ICE		false
WQSF_Isb.INLAND_WATER		false
WQSF_Isb.TIDAL		false
WQSF_Isb.COSMETIC		false
WQSF_Isb.SUSPECT		false
WQSF_Isb.HISOLZEN		false
WQSF_Isb.SATURATED		false
WQSF_Isb.MEGLINT		false
WQSF_Isb.HIGHGLINT		false
WQSF_Isb.WHITECAPS		false
WQSF_Isb.ADJAC		false
WQSF_Isb.WV_FAIL		false
WQSF_Isb.PAR_FAIL		false
WQSF_Isb.AC_FAIL		false
WQSF_Isb_OC4ME_FAIL		true
WQSF_Isb.OCNN_FAIL		false
WQSF_Isb.KDM_FAIL		true

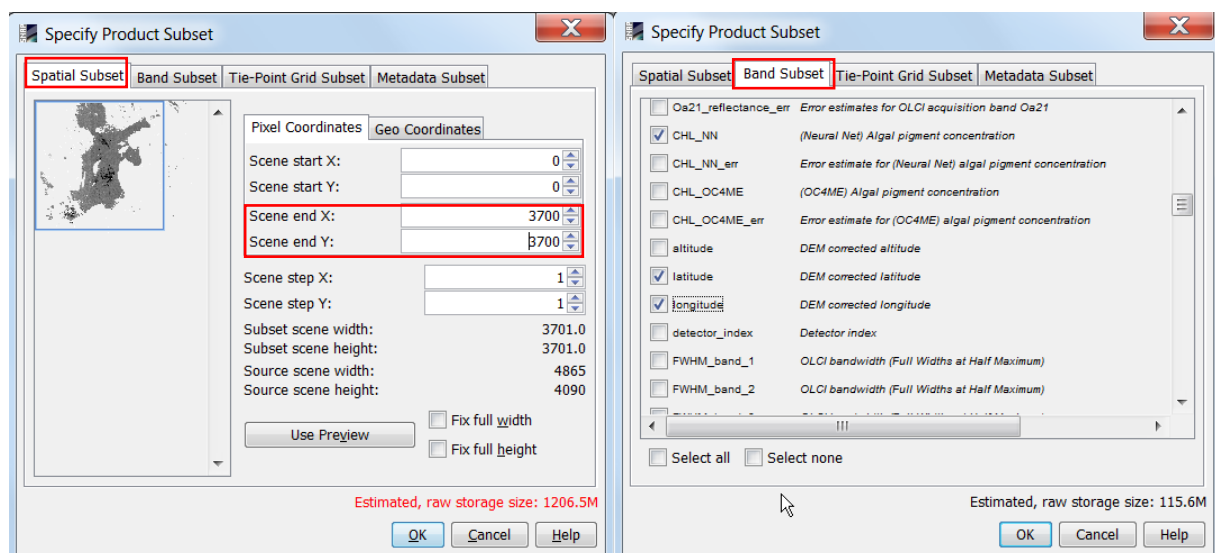
The error in calculating the concentration value of chlorophyll in this case is due to incorrect reflectance values. It expresses the ratio of radiation energy coming out of the sea towards the satellite to the sea surface, so it cannot take negative values. Negative values are the result of atmospheric correction, the assumptions of which are true for ocean waters, but can generate such errors for *Case 2* waters to which the Baltic sea belongs. All

products based on this correction in the Baltic area can be fraught with big errors. Of the geophysical sizes contained in the standard L2 product, only those indexed with *nn* are processed with a *Case 2* specific water algorithm.

To create a subset containing only a part of the original data (here products specific to the Baltic Sea) in SNAP use the Raster> Subset function. It allows you to create a subset both narrowing the area (Spatial Subset) and the content of the data set:

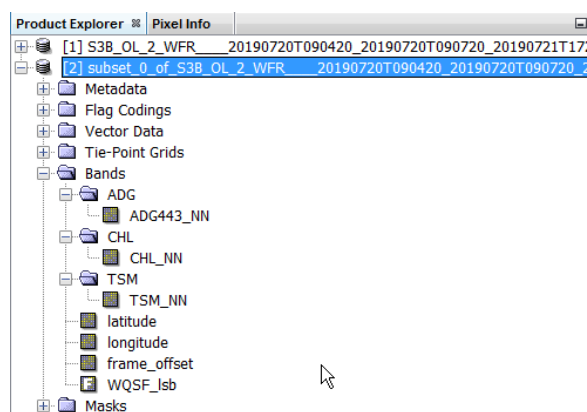
- spectral and designated geophysical parameters, geolocation data, flags, masks ([Band subset](#))
- additional data (auxiliary data) that can be used for further correction and interpretation ([Tie-Point Grid Subset](#))
- [Metadata Subset](#)

Spatially limit the dataset to columns and rows with numbers 0-3700 (truncating the part of the image covering the land) and to images: CHL_NN, ADG443_NN, TSM_NN, latitude, longitude, WQSF_Isb. Delete all additional data (Tie-Point Grid), leave the metadata. Press **OK** to accept the settings



In the [Product Explorer](#) window, another product will be created that contains the selected subset of data. Actually, it is a virtual product, containing only the appropriate definitions, the launch of which loads certain data from the original product. Therefore, the original product must remain open in [Product Explorer](#). View the raster CHL_NN the new product.

The selected data can be further processed in SNAP (see subsequent chapters) or exported for further work in GIS ([information on data export](#)).

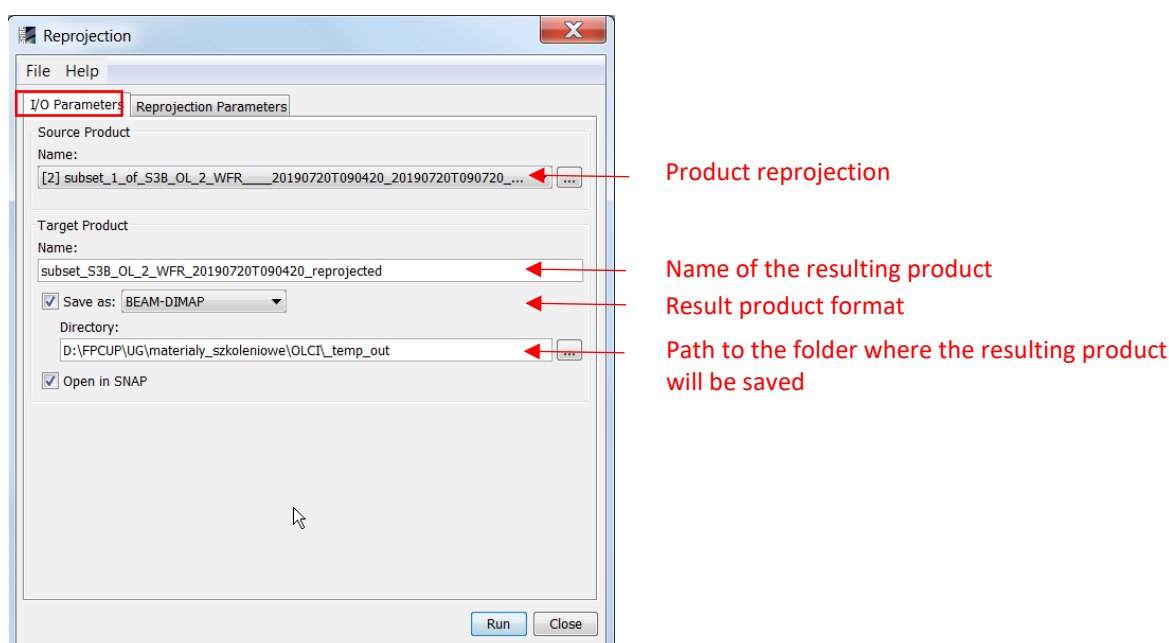


PROJECTION FOR CARTOGRAPHIC REPRODUCTION

The shape and position of the Baltic Sea in SENTINEL-3 images depends on the satellite's direction of flight (path), as the data has not been projected for any mapping. They are made available in an instrumental grid (after correction of geometric distortions resulting from sensor characteristics). This makes it difficult to compare images captured at different times, so it's a good idea to project the data before the next stages of visualization. Snap uses [Raster > Geometric Operations > Reprojection](#), which can be used to project L1 data in the same way.

In the [I/O Parameters](#) tab, select:

- previously created subset as a product that has been reprojected
- enter the name of the product that will be created after the projection
- select BEAM-DIMAP recording
- enter the path to the folder where you want to save the product after projection
- select [Open in SNAP](#) to have the program load the data automatically after the projection

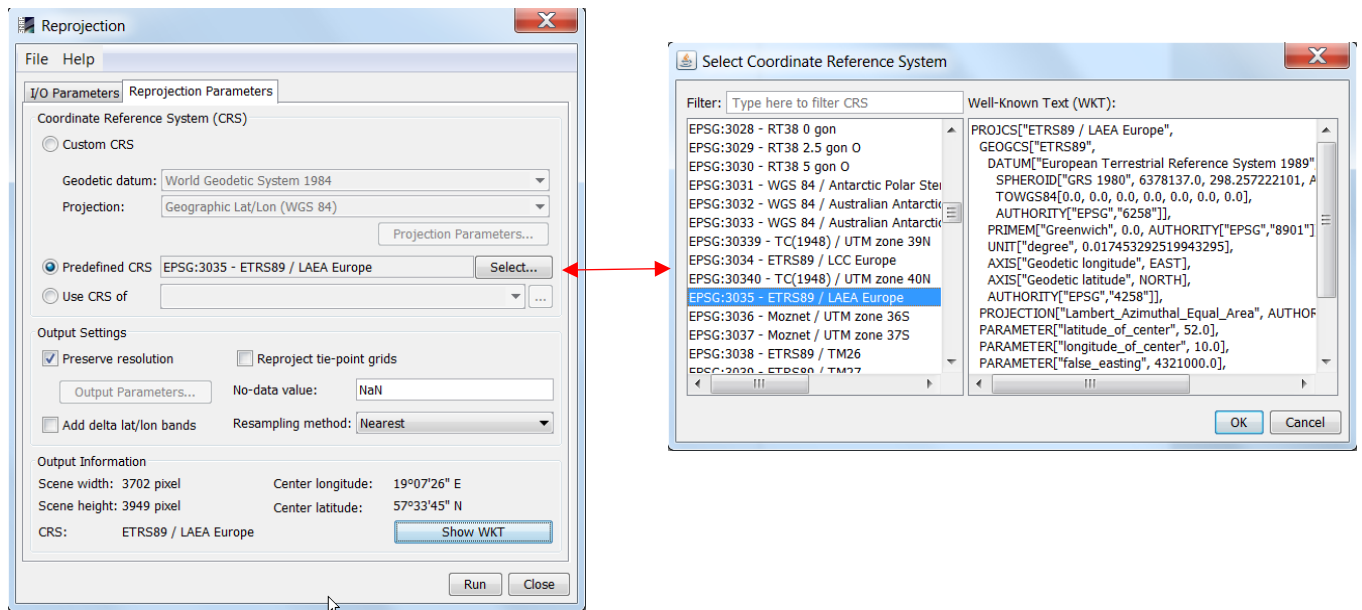


The reprojection function allows you to save the resulting product in different formats. BEAM-DIMAP format is a convenient form of recording when working in SNAP, because it allows you to save with data also selected color palettes for visualization, contrast settings, properties of added pins, etc.

In the [Reprojection Parameters](#) tab, select the projection to which the projection will be performed, define the raster mesh in the selected mapping, and select the resampling method.

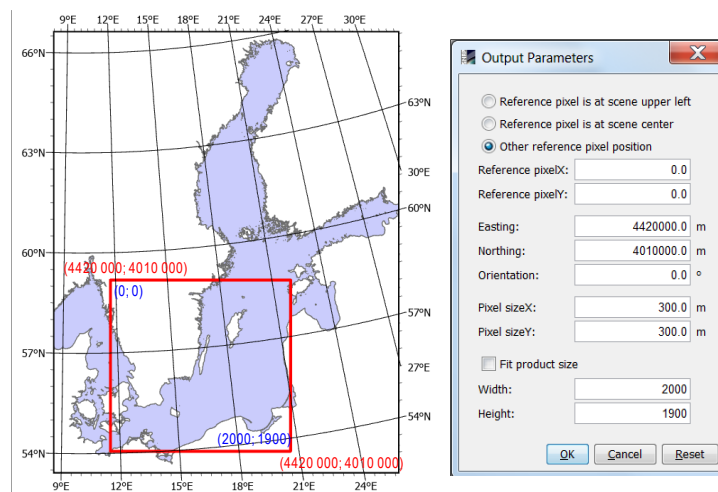
The projection can be selected in 3 ways:

- defining your own mapping ([Custom CRS](#)) by selecting DATUM, projection, and defining projection-specific parameters
- selection of defined projections ([Predefined CRS](#))
- indication of another product to be reproduced as a standard ([Use CRS of](#))



There are 2 ways to define a raster grid in a selected mapping:

- automatically (**Preserve resolution** selected) – adjusts the grid boundaries to fit the entire data area of the input product and the pixel size to match the average size of the original pixels
- 1. manually (unchecked **Preserve resolution** option, defining grid parameters in **Output Parameters**)– the following is an example of a grid definition in EPSG:3035, with a pixel size of 300x300 m, covering the selected Baltic area (coordinates of the upper-left and lower-right corners of the new grid are shown on the map in EPSG:3035 coordinate system – red and row/column – blue)



You can choose one from 3 resampling methods (calculating the pixel value in the new grid):

- *Nearest* – assigning a value using the "nearest neighbor" method
- *Bilinear* – interpolation of values based on the 4 closest pixels
- *Bicubic* – interpolation of values based on the 16 closest pixels (recommended when the pixel size changes large from the original image)

Because the new grid may contain an area outside the imaging range, you must also specify the value that will be assigned to pixels in this situation in the **No-data value** field (this can be any value that does not appear among parameter values, such as -9999 or NaN)

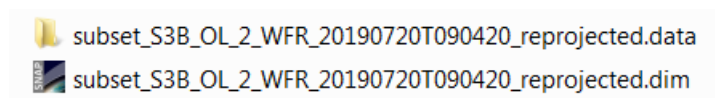
For the exercise in the [Reprojection Parameters](#) tab, select:

- Predefined CRS: EPSG:3035 – ETRS89 / LAEA Europe (use the EPSG number in the [Filter](#) window to make it easier to find the mapping)
- [Preserve Resolution](#)
- Resampling by the nearest neighbour method
- NaN as code of no data

Start processing with the [RUN button](#).


When a new product appears in [product explorer](#), you can close the product that contains the subset before the projection and the original S3 L2 product (in that order).

In the [windows explorer](#), you can see the structure of files stored in BEAM-DIMAP format.

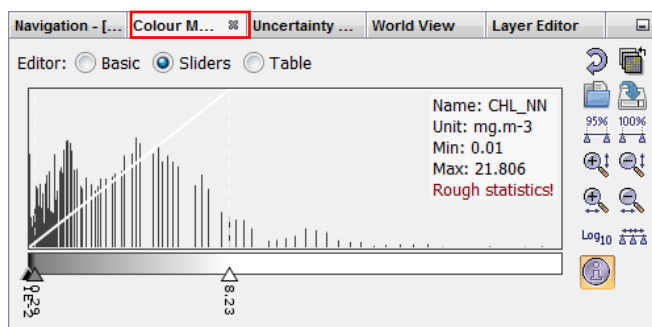


This will always be the *ProductName.data* folder that contains the data and the *ProductName file. Dim* in which the data structure is stored. The DIM file is used to open the data in SNAP. Do not rename or delete some of the data from the [windows explorer](#) – you must perform the necessary operations in SNAP.

MAP VISUALIZATION

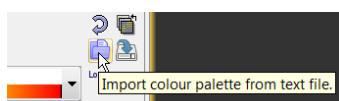
View the chlorophyll *a* concentration map by double-clicking on the CHL_NN (in [Product Explorer](#), the Bands folder > CHL>CHL_NN). Zoom in on the entire area ([Zoom All](#)  in [Navigation](#) window).

The [Colour Manipulation](#) window displays a histogram of pixel values (omitting those marked as no data) and information about the range of values and units. The color scale also tells you what shades of gray are represented in different ranges of values. The diagonal white line on the histogram indicates the extent to which shades no. 1-254 are linearly distributed. A shade of No. 0 (black here) is assigned to a value below this range, and shade No. 255 (here white) to the value above.

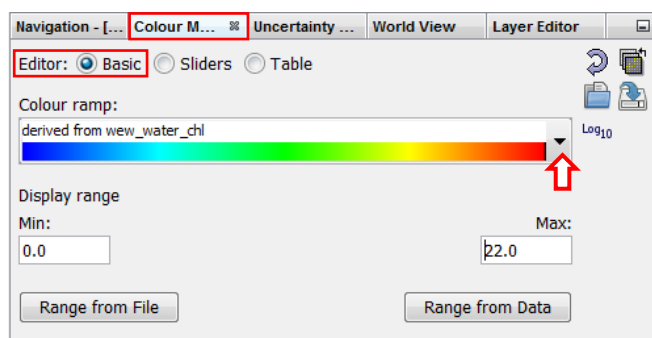


In this window, you can change the color palette and adjust the distribution of selected colors to the range of most common values.

Go to [Editor: Basic](#) mode, expand the [Colour ramp](#), and select a palette called *wew_water_chl*. If such a pallet is not listed, use the option to import the pallet:




The pallets are located in the folder:

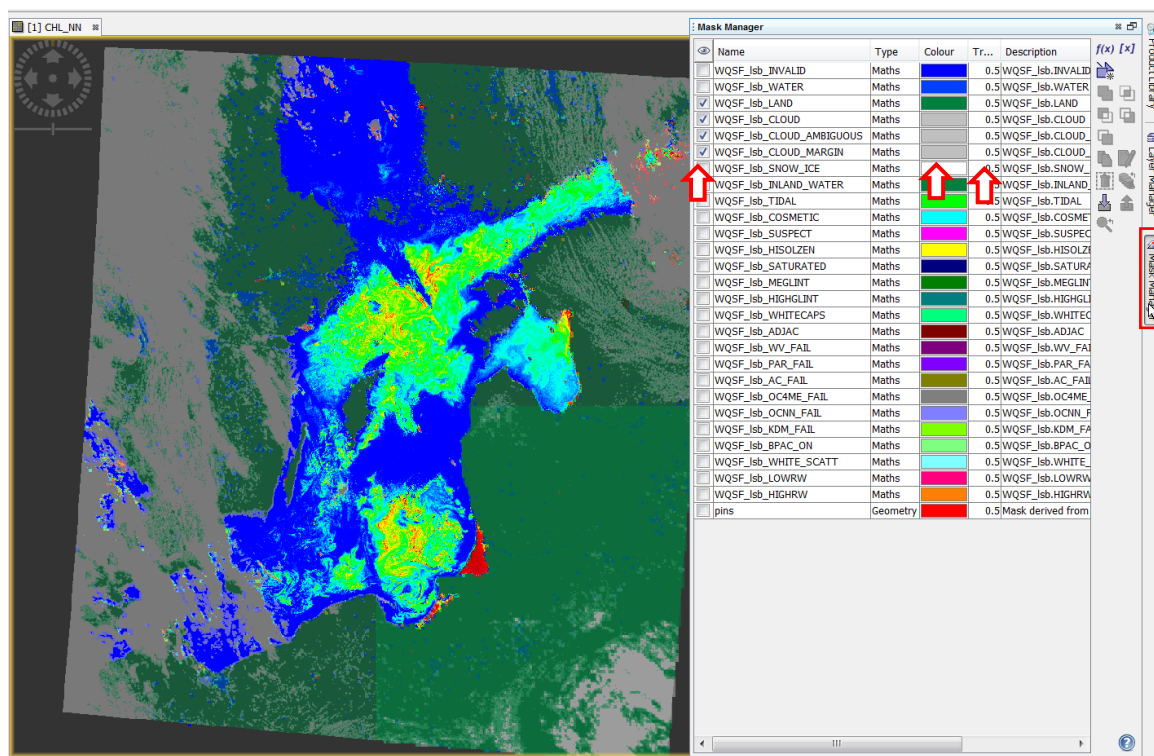
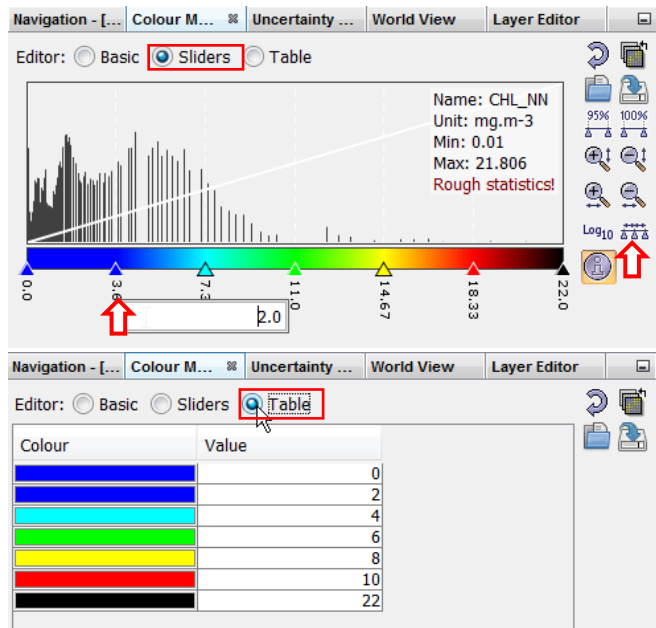


C:\Users\Name\.snap\auxdata\color_palettes

Select the range of values to include the palette: 0-22 to cover the entire range of chlorophyll concentration values of the analyzed map.

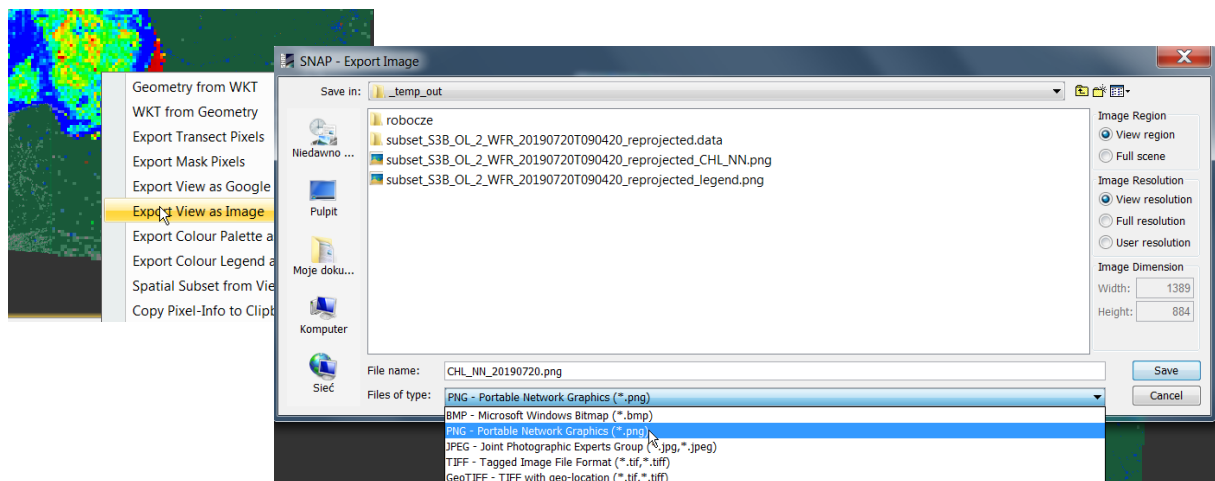
Return to **Sliders mode**. Distribute the color markers on the scale evenly . Then modify their position by moving the mouse or editing the values they represent. Set the markers to 0-10 every 2, leaving a wide last range of 10-22. You can do the same by editing the values corresponding to the colors in **Table mode**.

Data quality and pre-classification flags can be used to mark on the map e.g. land area, cloud-covered area, etc. To use them at the visualization stage, expand the **Mask Manager** window (usually it is collapsed into a bookmark on the right side of the program window, if there is no such bookmark, open it with the **Command View > Tool windows > Mask Manager**).



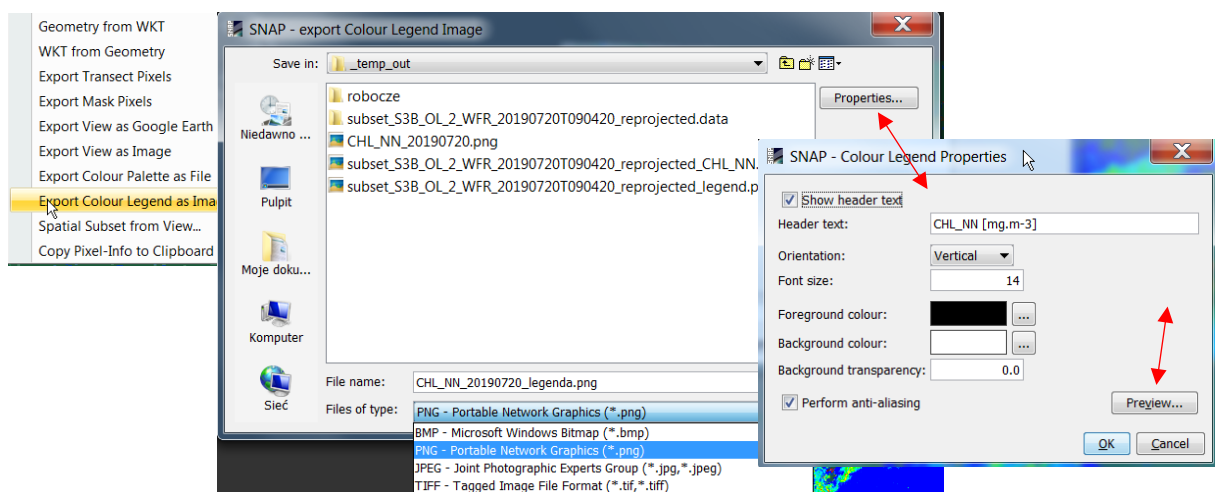
EXPORT AN IMAGE OR DATA

You can save the created map as a graphic file to include it in a report, for example. To do this, right-click on the map and select **Export View as Image** from the context menu. In the export dialog box, select the destination folder and save format (available: BMP, PNG, JPEG, and TIFF). In the right part of the dialog box, you can change the resolution of the saved image, and you can choose to save the entire image (**Full scene**) instead of the visible portion (**View region**).



Selecting the entire image ([Full scene](#)) and full resolution ([Full resolution](#)) allows you to record a 3-channel image in addition to GeoTIFF format, along with coordinates that can be used in GIS. However, pixel values do not correspond to chlorophyll concentration values, they only allow similar colors to be reproduced in GIS.

To export a color scale with a description of the value, right-click again on the map and select [Export Colour Legend as Image](#) from the context menu. In the export dialog box, select the destination folder and save format (available: BMP, PNG, JPEG, and TIFF). In the right part of the dialog box, the [Properties](#) button allows you to go to the window to define the appearance of the legend (heading, landscape or portrait orientation, font size of an descriptions, etc.). The button in the parameter window allows you to see the end result.



Save the entire chlorophyll *a* concentration map as a PNG image at the resolution at which it is displayed ([View resolution](#)). Save the color scale as a vertical legend. Insert both images into any document.

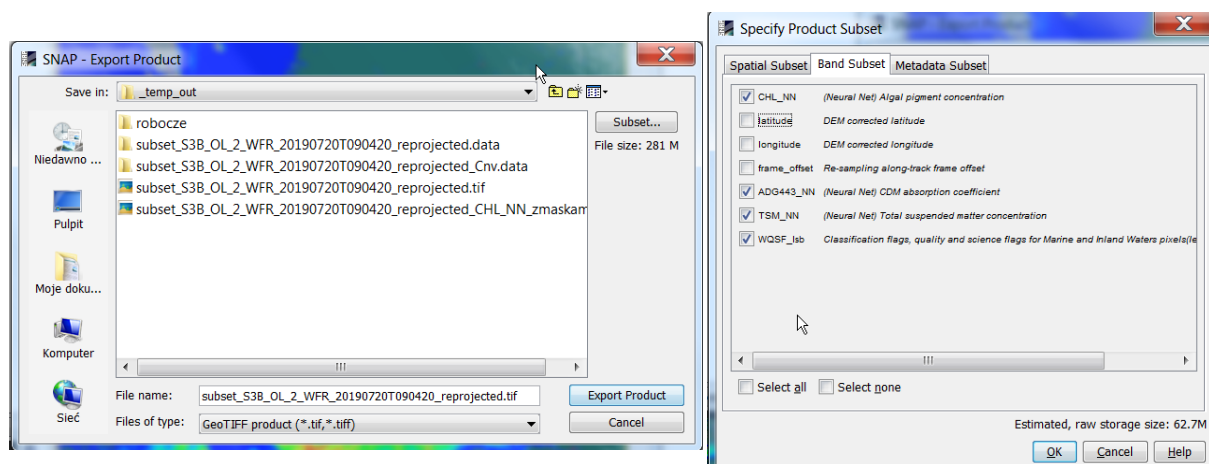
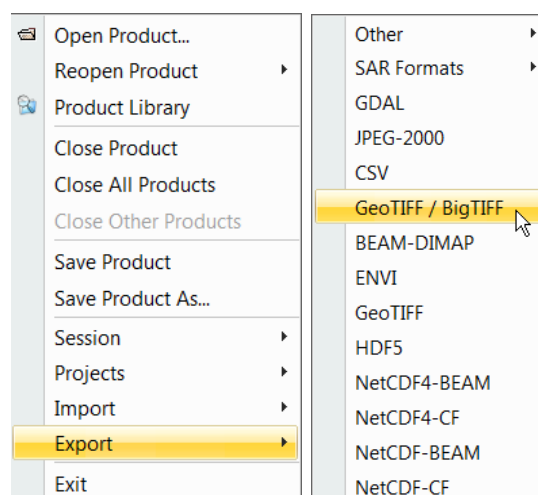
To export data for further analysis (e.g. calculating chlorophyll concentration statistics, creating change charts along lines, comparing with data measured *in situ*, etc.), call **File > Export**, which allows you to export any raster from a product that is open in Product Explorer. Then select the format of the target file. GeoTIFF is mostly the most convenient.

In the export window, you must first select the dataset that you want to export by opening the additional window with the **Subset** button on the right. It opens another window with similar functionality as the **Subset** function used earlier.

You can restrict a dataset because of:

- area (**Spatial Subset** tab)
- raster layers (**Band subset**)
- metadata (**Metadata Subset**)

The selected subset must be accepted by pressing **OK**. Then, in the export window, select the destination path and give the export file a name.



Export L2 data after projection for the entire area, limiting to CHL_NN, ADG443_NN, TSM_NN, WQSF_Isb, without metadata.

The SNAP program, when displaying or analyzing data from individual rasters, dynamically calculates the values of geophysical parameters in the given units or logical values of individual flags based on the *digital numbers* (DN) values stored in the file. The DN values are exported. The values of any parameter *X* can be calculated on their basis according to:

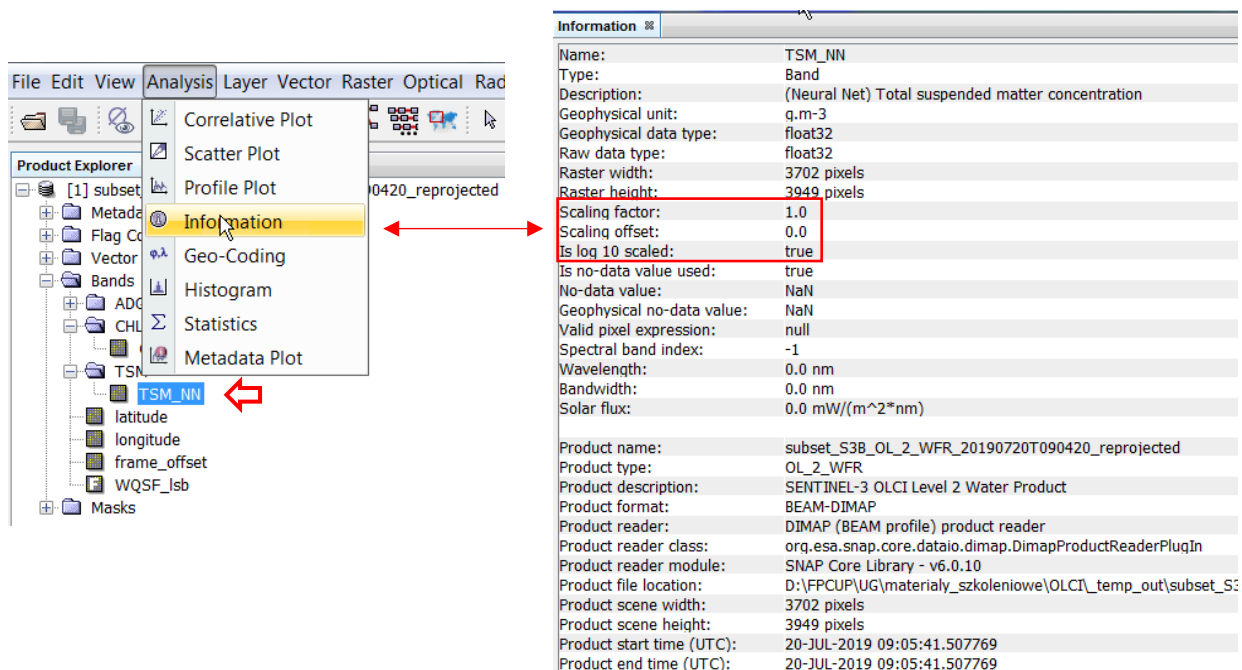
$$X = factor \cdot DN + offset$$

or

$$X = 10^{(factor \cdot DN + offset)},$$

when encoding to DN contains log scaling.

To read the information about encoding *X* to *DN* values necessary for conversions (including *scaling factor* and *scaling offset* values), select the raster layer in the Product Explorer window. Then start **Analysis > Information** from the menu.



PROCESSING PRODUCT L1 TO L2 LEVEL WITH CASE 2 WATER ALGORITHM

A limited number of products determined by algorithms specific to *Case 2* waters in the original L2 product necessitates the independent processing of L1 to L2 data. Likewise, when only L1 product is available in the databases for the selected scene. In SNAP, you can perform correction of OLCI L1 data with [C2RCC](#) algorithm. It uses the auxiliary data included with the S3 L1 product in the process of atmospheric correction.

Close previously processed products in SNAP (**File > Close All Products**). Open L1 (**File > Open Product**) using the *xfdumanifest.xml* file from the folder where the L1 product downloaded from CODA was unpacked:

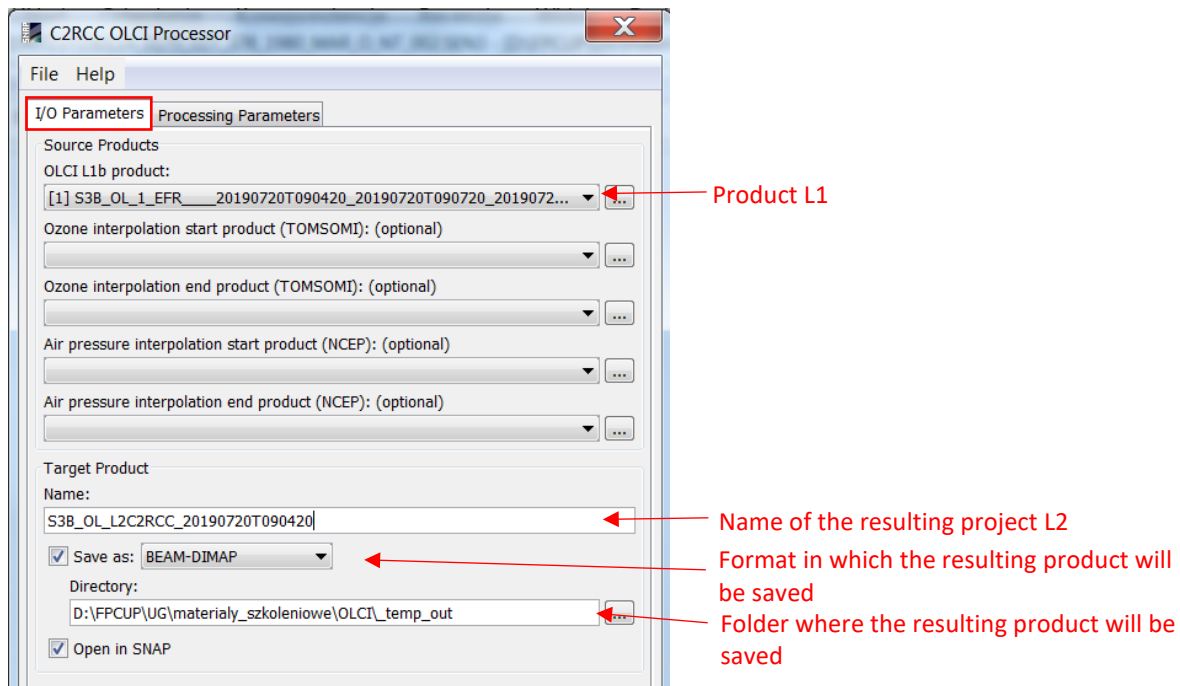
S3B_OL_1_EFR____20190720T090420_20190720T090720_20190721T150114_0179_027_378_1980_MAR_O_NT_002.SEN3

or from the Copernicus Open Access Hub website:

S3B_OL_1_EFR____20190720T090420_20190720T090720_20190721T125137_0179_027_378_1980_LN1_O_NT_002.SEN3

Run the C2RCC algorithm with **Optical > Thematic Water Processing > C2RCC Processors > OLCI**. In the **I/O Parameters** tab, select:

- product L1 to be processed
- enter the name of the product that will be created after the projection
- select BEAM-DIMAP recording
- enter the path to the folder where you want to save the product after projection
- select **Open in SNAP** to have the program load the data automatically after the projection



In the **Processing Parameters** tab, you must specify the input parameters of the C2RCC algorithm and select optional products.

Enter the following input parameters:

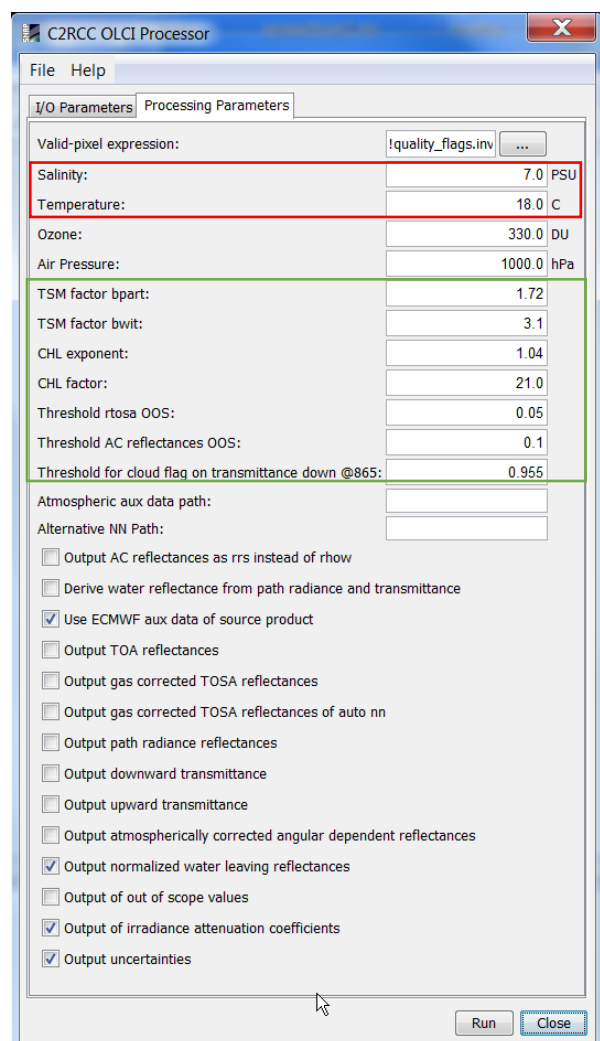
- salinity – approximate average salinity for the Baltic 7 PSU
- temperature – approximate average water temperature in July 2019 18°C
- „Use ECMWF aux data of source product” – selecting this option ignores the above-mentioned average ozone concentration and air pressure values

Leave the parameters for calculating TSM, CHL and pre-classification thresholds unchanged

Optional products are worth noting:

- *Normalized water leaving reflectances* – reflectance in spectral channels, which can be used, for example, to calculate the concentration of phyocyanineⁱ
- *Diffusive irradiance attenuation coefficient*
- *Uncertainties*


Start processing by clicking **Run**. Calculations may take several minutes.

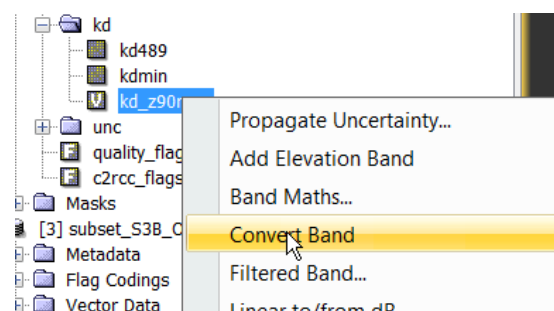
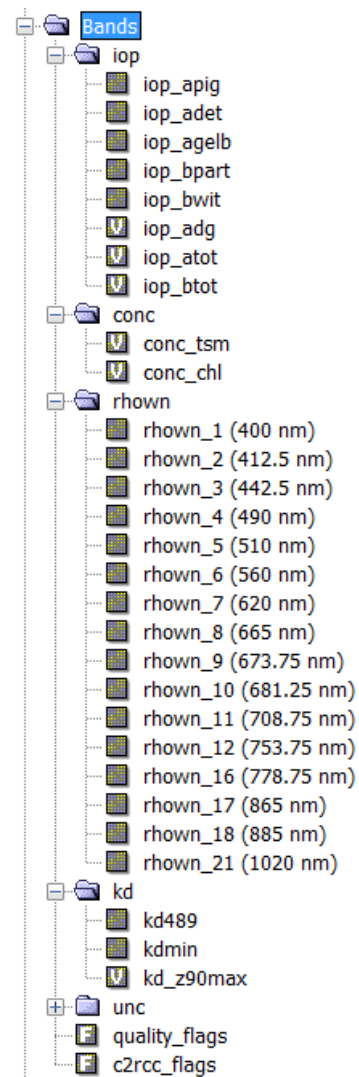


The resulting product contains the standard parameters generated and selected optional:

- absorption coefficients for wavelengths of 443 nm by: phytoplankton pigments (iop_apig), detritus (iop_adet), yellow substances (iop_agelb), detritus and yellow substances together (iop_adg), total (iop_atot)
- scattering coefficients for wavelengths of 443 nm by: suspended particles (iop_aptot), suspended limestone particles (iop_bwit), total (iop_btot)
- concentration of suspended matter (conc_tsm) and chlorophyll *a* (conc_chl)
- reflectance at the lower limit of the atmosphere (*normalized water leaving reflectance*) in 16 spectral channels (rhown_#, where # - number of OLCI spectral channel).
- diffusive irradiance attenuation coefficient for wavelength 489 nm (kd489), mean coefficient of weakening calculated on the basis of 3 spectral channels in which the weakening is the smallest (kadmin), the height of the water column from which 90% of the radiation coming out of the water (kd_z90max)
- product-specific uncertainties (unc)
- data quality flags and pre-classification (including cloudiness detection)

The **conc_tsm**, **conc_chl** and **iop_adg** correspond to the parameters of the standard S3 L2 product: **TSM_NN**, **CHL_NN**, **ADG443_NN**.

Data subset creation, mapping projection, mask visualization, and data export are as described for the standard L2 product in the "[L2 Data Handling](#)" chapter. Virtual raster marked with a symbol  must be converted before exporting. A virtual raster contains only a formula that dynamically calculates pixel values from other images. The conversion writes values to a raster. To convert, select the virtual raster, right-click on it, and select [Convert Band](#).

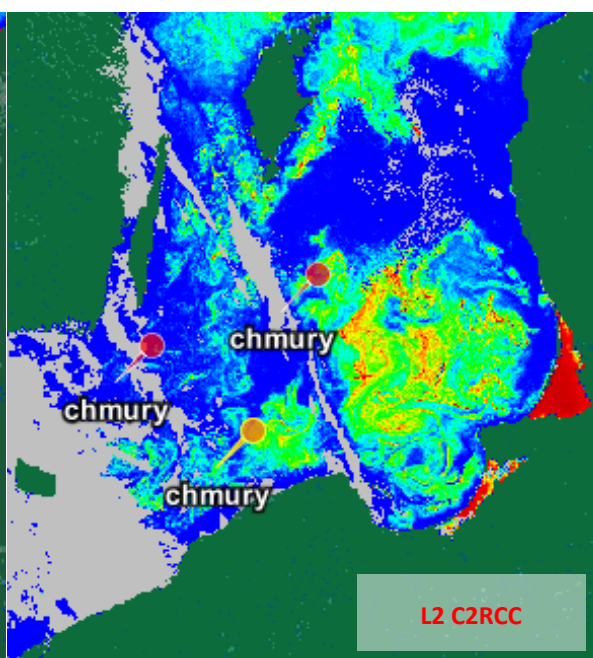
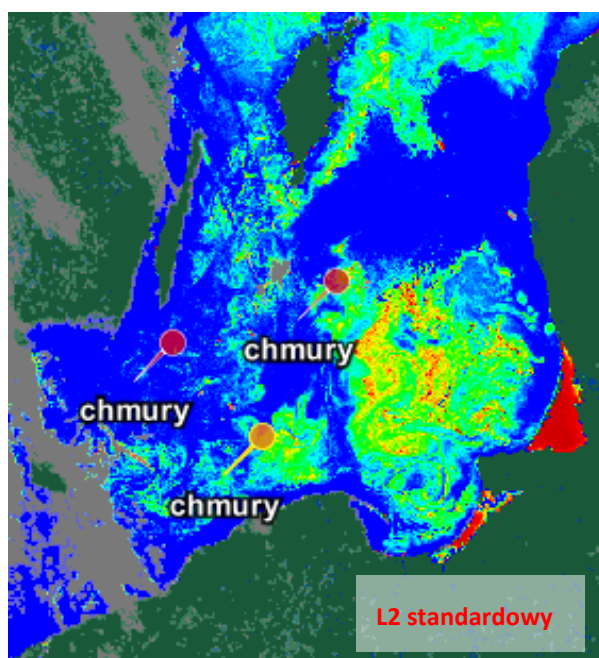


Similarly to the "[L2 data operations](#)" chapter, project the L2 C2RCC product (it may take several minutes to project the entire product to limit processing time, precede the operation by creating a subset containing only selected rasters and flags). Visualize the selected parameter by adjusting the color scale yourself, add a display of the land mask and overcast areas. Export the map to a graphic file and the selected data to a GeoTIFF file.

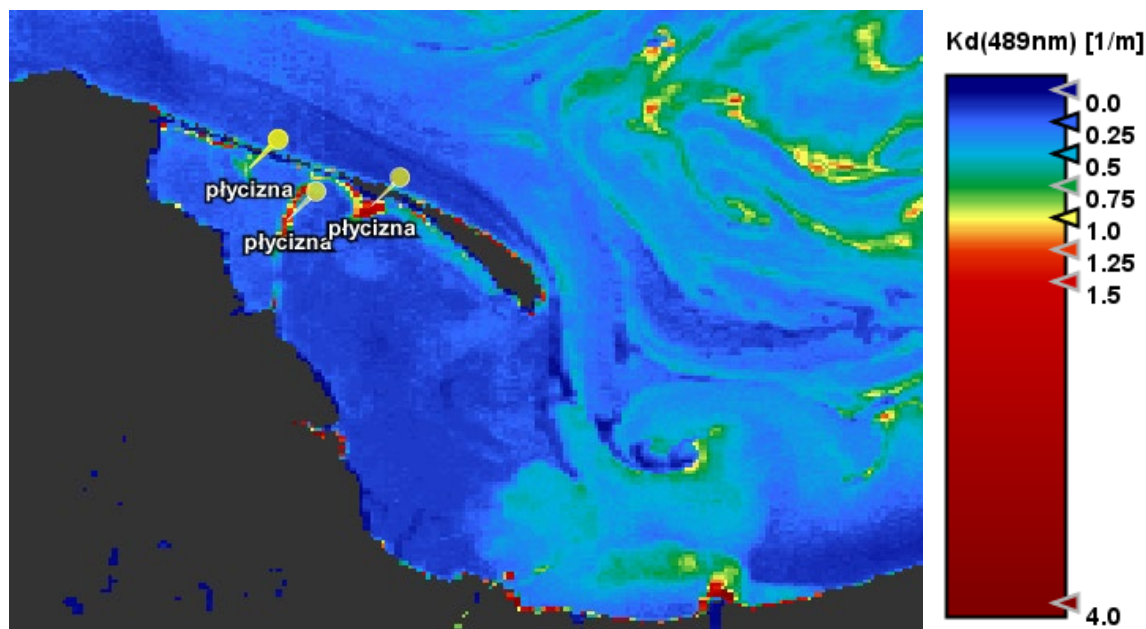
INTERPRETATION OF DATA – POTENTIAL PROBLEMS

Satellite algorithm products are validated against in situ data for a wide range of optical conditions. Locally, during the growing season, the composition of substances that affect the amount of radiation reaching the satellite and its spectral distribution is sometimes so specific that obtaining correct concentration or optical properties assessments requires additional calibration and validation by the data user.

Standard algorithms do not always correctly identify clouded areas, especially in the case when the cloud is not full. Comparing the RGB (L1) composite with the chlorophyll *a* (L2) concentration map, it can be seen that the cloud detection algorithm used in the standard L2 product did not detect thin, translucent clouds. In the region of their occurrence, the concentration of chlorophyll *a* determined on the basis of the NN algorithm may be burdened with a large error. The *cloud risk* flag generated by the C2RCC algorithm better identifies these types of clouds, but also does not fully solve the problem.



Another problem in the interpretation of OLCI products are shallow areas with relatively clean waters, where reflection from the bottom amplifies the signal recorded by the satellite and causes overestimation of the suspended matter concentration and the irradiance attenuation coefficients in these areas, and thus underestimating the transparency of the waters. It is clearly visible on the map of the diffuse irradiance attenuation coefficient, $K_d(489)$, in the area of Puck Bay, the high values of which coincide with the areas of the shallows.



SUMMARY

The materials present Sentinel-3 / OLCI data sources, the structure of downloaded files and the basic functions of SNAP to prepare quick data visualizations as well as export data to work in GIS. In further materials on optical imagery of marine areas you will find tips on how to use sentinel-2 / MSI data.

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ⁱWozniak M., Bradtke K.M., Darecki M., Krężel A., 2016, *Empirical Model for Phycocyanin Concentration Estimation as an Indicator of Cyanobacterial Bloom in the Optically Complex Coastal Waters of the Baltic Sea*, Remote Sens. 2016, 8(3), 212