

1st INIOAS Training Course on Ocean Remote Sensing, 2023



17-21 Jun 2023 | Iranian National Institute for Oceanography and Atmospheric Science | Tehran, IRAN

<https://www.inio.ac.ir/ORSA>

Investigating the Ocean Color from Space

Masoud Moradi

Iranian National Institute for Oceanography and Atmospheric Science

moradi_msd@yahoo.com

Courtesy



European Space Agency

<https://www.inio.ac.ir>

Investigating the Ocean Color from Space

1. Sentinel data for water quality

1. Sentinel-3 OLCI display
2. Atmospheric effects
3. L2 processing and analysis: C2RCC
4. Simple retrieval of water quality parameters
5. Validation

Investigating the Ocean Color from Space

The aim of this exercise is to process an OC image (S3-OLCI) from L1 data to L3, going step by step and understanding the implications of each pre-processing and processing step necessary to retrieve water quality products.

We will use SNAP tools and processors for both processing and analysing the results.

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

Exercises

- 1.1 Sentinel-3 OLCI display
- 1.2 Atmospheric effects
- 1.3 L2 processing and analysis: C2RCC
- 1.4 Simple retrieval of water quality parameters
- 1.5 Validation

Material

S3B_OL_1_EFR____20190618T093412_20190618T093712_20190619T143145_0179_026_307_1980_MAR_O_NT_002.SEN3
S3B_OL_2_WFR____20190618T093412_20190618T093712_20190619T163055_0179_026_307_1980_MAR_O_NT_002.SEN3

Investigating the Ocean Color from Space

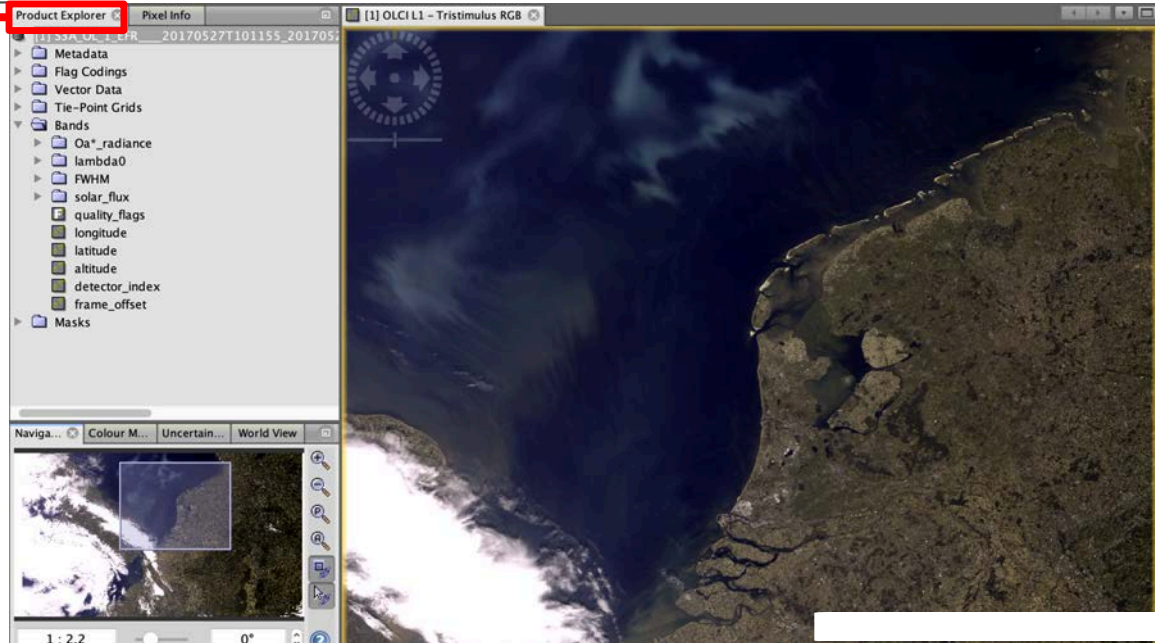
Import or open in SNAP the OLCI image (*xfdumanifest.xml*):

S3B_OL_1_EFR____20190618T093412_20190618T093712_20190619T143145_0179_026_307_1980_MAR_O_NT_002.SEN3

Product explorer shows the file content and detail information about the, metadata, bands, mask, flag coding, vector data and tie-point grids of the product.

Click on the (+) sign in each item and the different bands per folder will be shown.

Click in one of the bands of folder "Oa*radiance" and the image will be displayed in the right panel.



Investigating the Ocean Color from Space

The image shows a sequence of steps in the SNAP software interface. On the left, the 'File' menu is open, with 'Import' highlighted. A red arrow points from 'Import' to the 'Optical Sensors' category in the 'Generic Formats' tree. Another red arrow points from 'Optical Sensors' to the 'Sentinel-3' sub-category. A third red arrow points from 'Sentinel-3' to the 'Sentinel-3 SLSTR L1B (500m)' option. On the right, the 'SNAP - Import Product' dialog box is open, showing a file list. A red box highlights the 'xfdumanifest' file. A red arrow points from this file to the 'Import Product' button. A fourth red arrow points from the 'Import Product' button to a text box on the right. A fifth red arrow points from the 'xfdumanifest' file to a text box at the bottom.

File Edit View Analysis Layer V

- Open Product...
- Reopen Product >
- Product Library
- Close Product
- Close All Products
- Close Other Products
- Save Product
- Save Product As...
- Session >
- Projects >
- Import

DEM >

- Generic Formats >
- Optical Sensors
- Landsat
- RapidEye
- Seadas
- Sentinel-2
- Sentinel-3
- Sentinel-3 SLSTR L1B (1km)
- Sentinel-3 SLSTR L1B (500m)

Look in: S3A_OI_1_EFR_20180928T103827_20180928T104127_2018...

geo_coordinates.nc	Oa15_radiance.nc
instrument_data.nc	Oa16_radiance.nc
Oa01_radiance.nc	Oa17_radiance.nc
Oa02_radiance.nc	Oa18_radiance.nc
Oa03_radiance.nc	Oa19_radiance.nc
Oa04_radiance.nc	Oa20_radiance.nc
Oa05_radiance.nc	Oa21_radiance.nc
Oa06_radiance.nc	qualityFlags.nc
Oa07_radiance.nc	removed_pixels.nc
Oa08_radiance.nc	tie_geo_coordinates.nc
Oa09_radiance.nc	tie_geometries.nc
Oa10_radiance.nc	tie_meteo.nc
Oa11_radiance.nc	time_coordinates.nc
Oa12_radiance.nc	xfdumanifest
Oa13_radiance.nc	
Oa14_radiance.nc	

File name:

Files of type: All Files

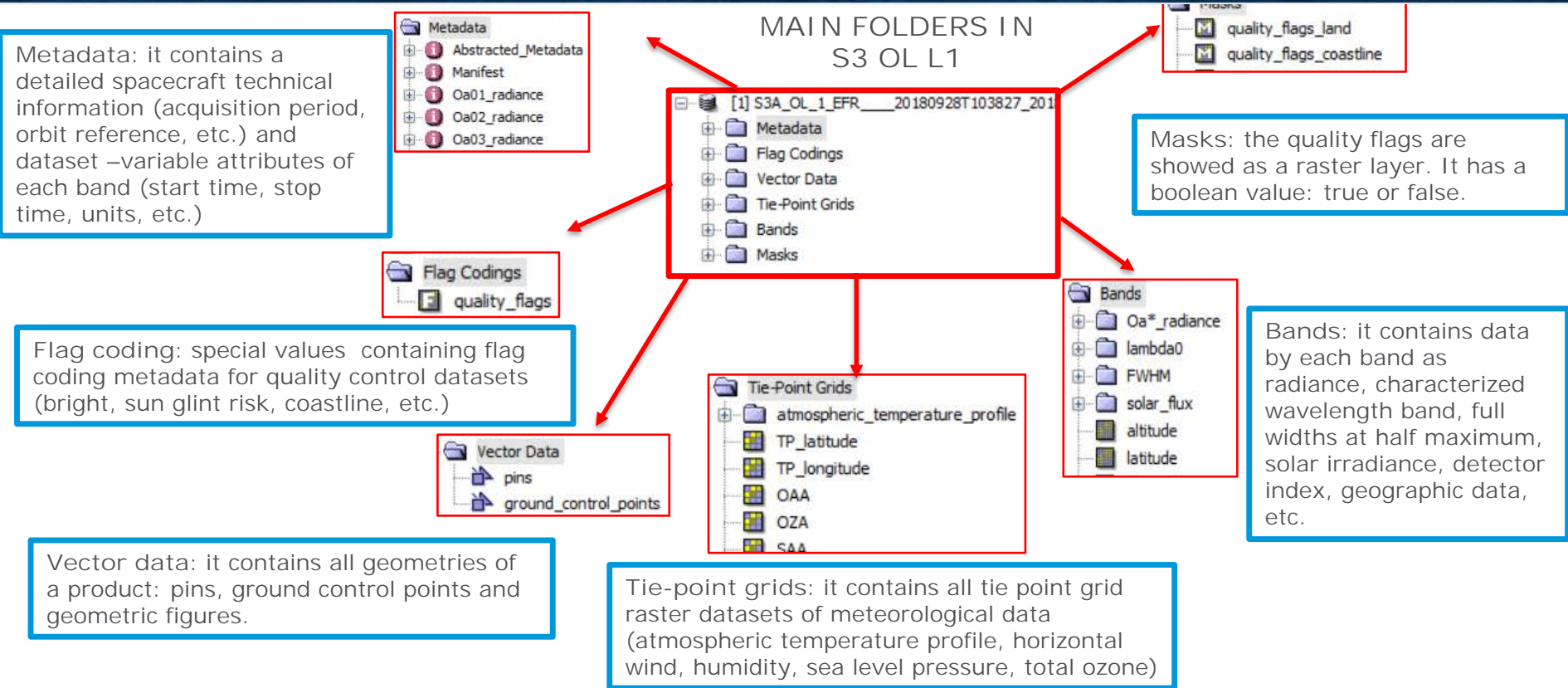
Import Product Cancel

Drag and drop: It allows to select a S3 image stored in an specific site.

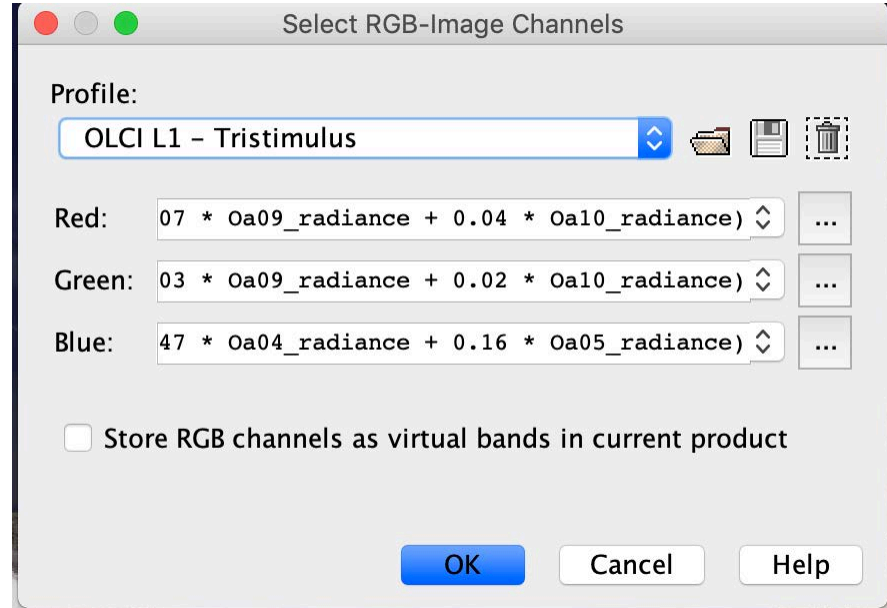
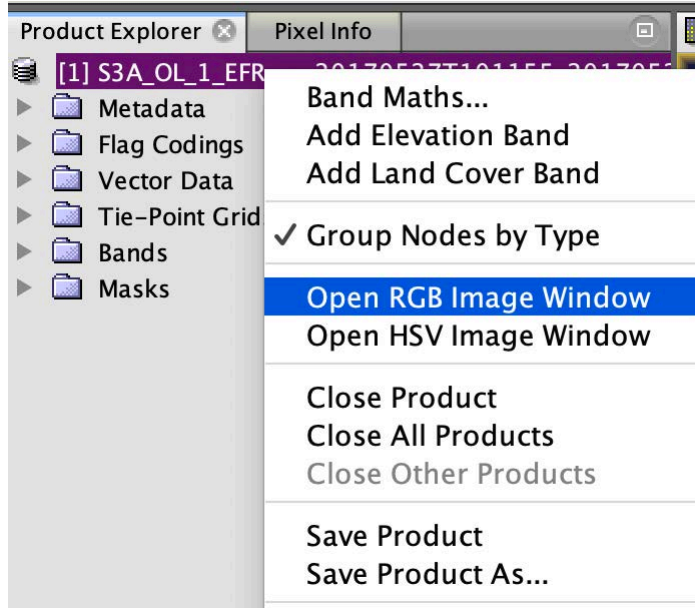
Once selected the xml file you must apply Import Product to open S3 image

xfdumanifest: S3 metadata file. It is on xml format. The file gathers together metadata associated with the instrument and file processing.

Investigating the Ocean Color from Space



Investigating the Ocean Color from Space

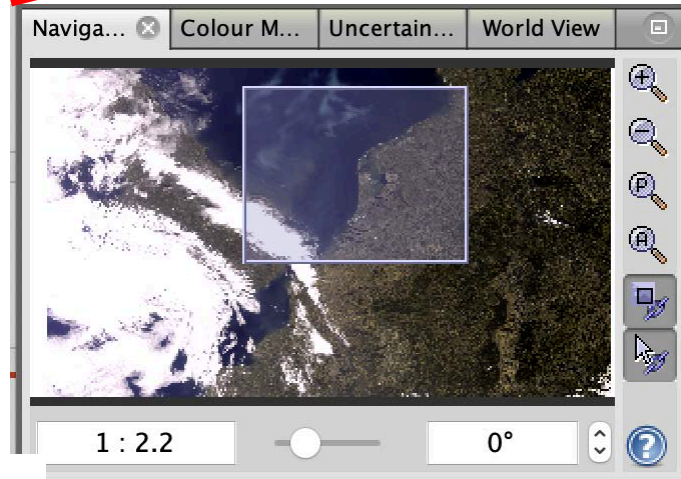
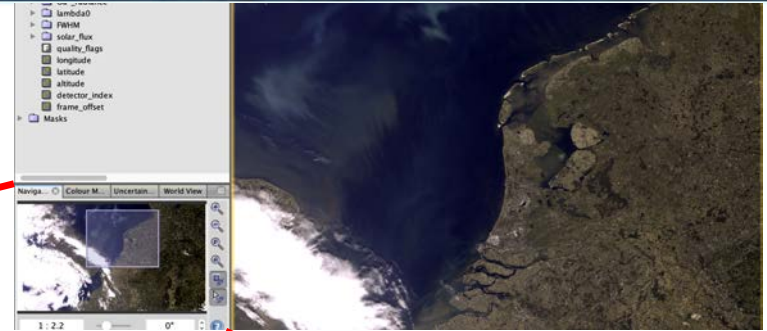


Create an RGB composition by right-clicking on the name of the products and selecting "Open RGB Image Window".

Select the profile by default (OLCI L1 - Tristimulus) since it contains the best band combination for each colour to be assigned.

Investigating the Ocean Color from Space

In the bottom left you will find the Navigation label, click on it to have an overview of the whole scene.



Zoom-in

Zoom-out

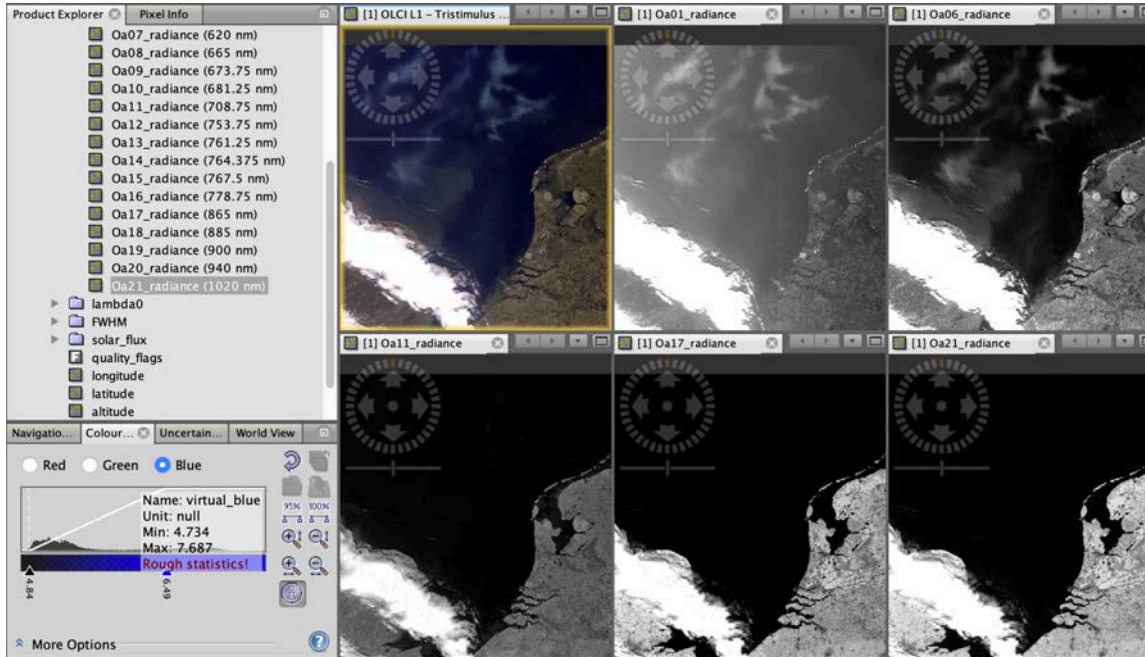
Central zoom

Show the whole image

Synchronization of view

Synchronization of

Investigating the Ocean Color from Space



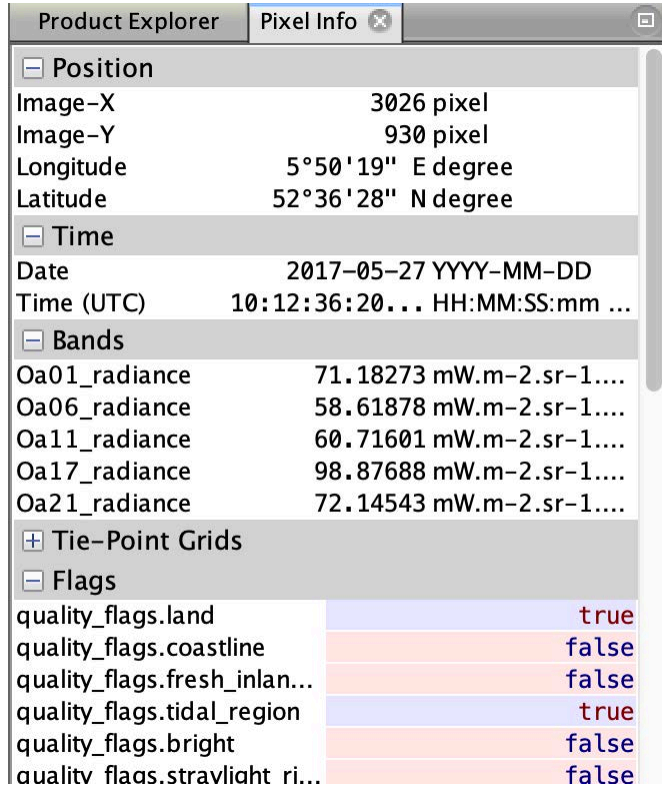
With the Windows Arrangement tools we can visualise side by side the different open bands: View → Toolbars → Window Arrangement.

Only if the views are synchronized the navigation tools will affect all open windows.

To see the cursors synchronized in all views, select the arrow with the chain label.



Investigating the Ocean Color from Space



The screenshot shows a window titled 'Product Explorer' with a sub-tab 'Pixel Info'. The window displays a list of parameters and their values, organized into several sections:

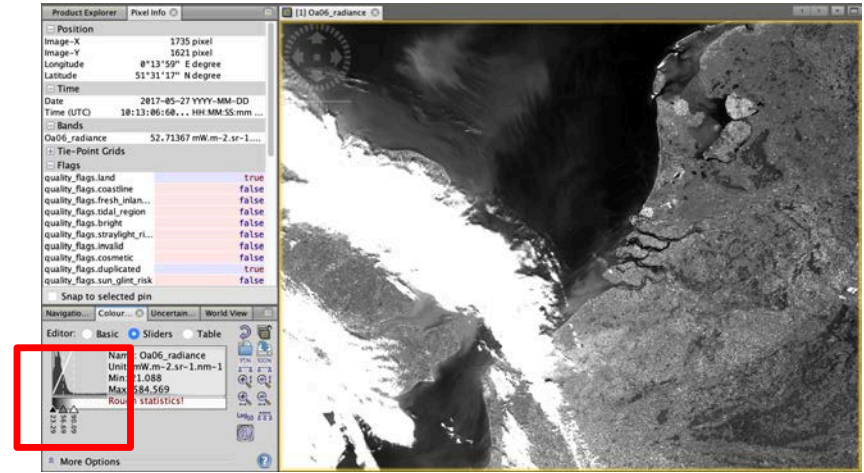
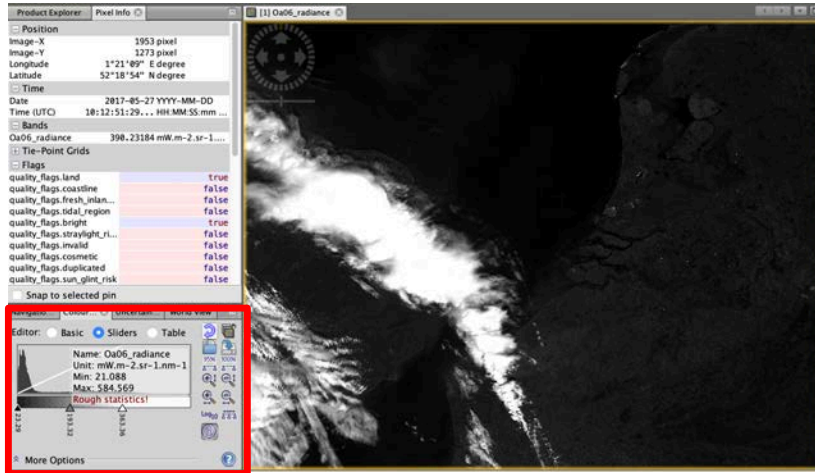
- Position:**
 - Image-X: 3026 pixel
 - Image-Y: 930 pixel
 - Longitude: 5°50'19" E degree
 - Latitude: 52°36'28" N degree
- Time:**
 - Date: 2017-05-27 YYYY-MM-DD
 - Time (UTC): 10:12:36:20... HH:MM:SS:mm ...
- Bands:**
 - Oa01_radiance: 71.18273 mW.m-2.sr-1....
 - Oa06_radiance: 58.61878 mW.m-2.sr-1....
 - Oa11_radiance: 60.71601 mW.m-2.sr-1....
 - Oa17_radiance: 98.87688 mW.m-2.sr-1....
 - Oa21_radiance: 72.14543 mW.m-2.sr-1....
- Tie-Point Grids:** (This section is currently collapsed)
- Flags:**
 - quality_flags.land: true
 - quality_flags.coastline: false
 - quality_flags.fresh_inlan...: false
 - quality_flags.tidal_region: true
 - quality_flags.bright: false
 - quality_flags.straylight ri...: false

The pixel information can be seen from the Pixel Info tab:

View → Tool Windows → Pixel Info

Moving the cursor over the image will continuously change the values in the Pixel Info

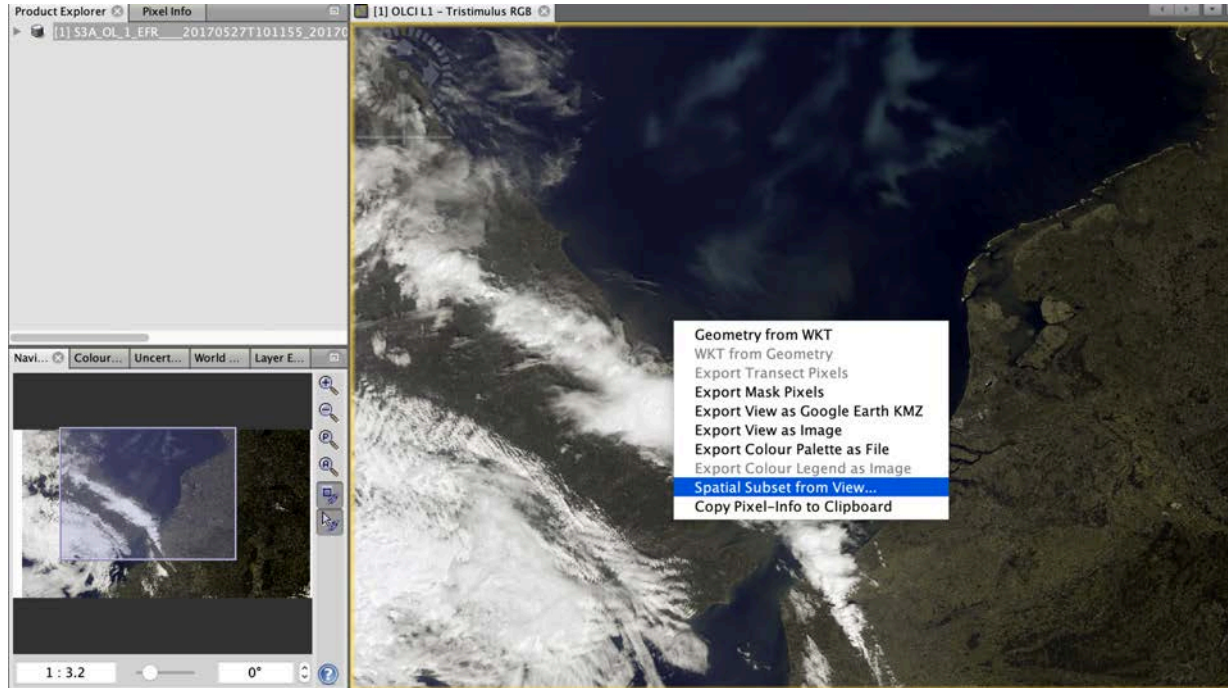
Investigating the Ocean Color from Space



It is possible to improve the visualisation of bands using the Colour Manipulation tool: View → Tool Windows → Colour Manipulation.

Stretching the histogram or normalized the contrast will enhance the visualization by 'stretching' the range of intensity values it contains to span a desired range of values (the range of the pixels in the current image).

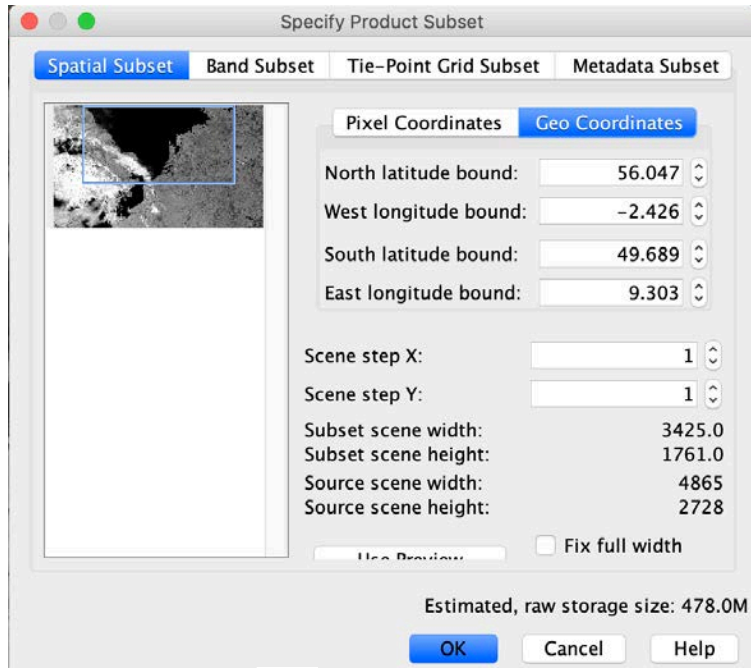
Investigating the Ocean Color from Space



Right click over the image and select → Spatial Subset from View...

Investigating the Ocean Color from Space

Modify the area to be subsetted using the rectangle on the view or introducing coordinates.



Specify Product Subset

Spatial Subset Band Subset Tie-Point Grid Subset Metadata Subset

Pixel Coordinates Geo Coordinates

North latitude bound: 56.047

West longitude bound: -2.426

South latitude bound: 49.689

East longitude bound: 9.303

Scene step X: 1

Scene step Y: 1

Subset scene width: 3425.0

Subset scene height: 1761.0

Source scene width: 4865

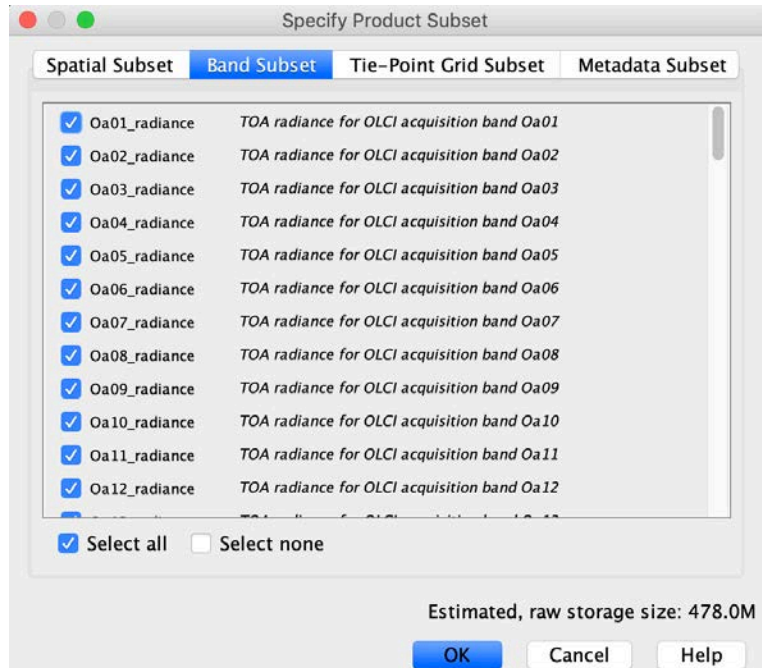
Source scene height: 2728

Use Preview Fix full width

Estimated, raw storage size: 478.0M

OK Cancel Help

It is possible to subset also for the bands, tie-point grids or metadata. We need everything this times.



Specify Product Subset

Spatial Subset Band Subset Tie-Point Grid Subset Metadata Subset

<input checked="" type="checkbox"/>	Oa01_radiance	TOA radiance for OLCI acquisition band Oa01
<input checked="" type="checkbox"/>	Oa02_radiance	TOA radiance for OLCI acquisition band Oa02
<input checked="" type="checkbox"/>	Oa03_radiance	TOA radiance for OLCI acquisition band Oa03
<input checked="" type="checkbox"/>	Oa04_radiance	TOA radiance for OLCI acquisition band Oa04
<input checked="" type="checkbox"/>	Oa05_radiance	TOA radiance for OLCI acquisition band Oa05
<input checked="" type="checkbox"/>	Oa06_radiance	TOA radiance for OLCI acquisition band Oa06
<input checked="" type="checkbox"/>	Oa07_radiance	TOA radiance for OLCI acquisition band Oa07
<input checked="" type="checkbox"/>	Oa08_radiance	TOA radiance for OLCI acquisition band Oa08
<input checked="" type="checkbox"/>	Oa09_radiance	TOA radiance for OLCI acquisition band Oa09
<input checked="" type="checkbox"/>	Oa10_radiance	TOA radiance for OLCI acquisition band Oa10
<input checked="" type="checkbox"/>	Oa11_radiance	TOA radiance for OLCI acquisition band Oa11
<input checked="" type="checkbox"/>	Oa12_radiance	TOA radiance for OLCI acquisition band Oa12

Select all Select none

Estimated, raw storage size: 478.0M

OK Cancel Help

Investigating the Ocean Color from Space

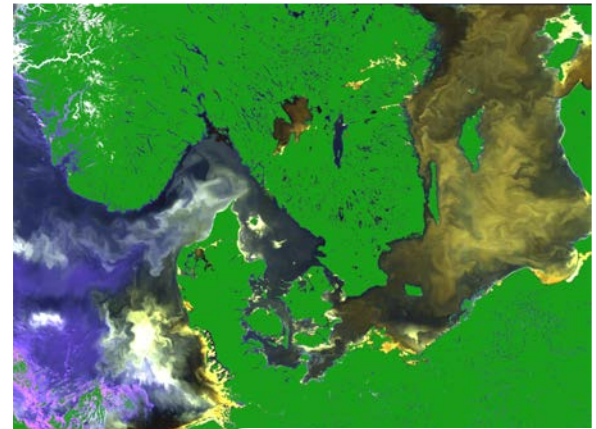
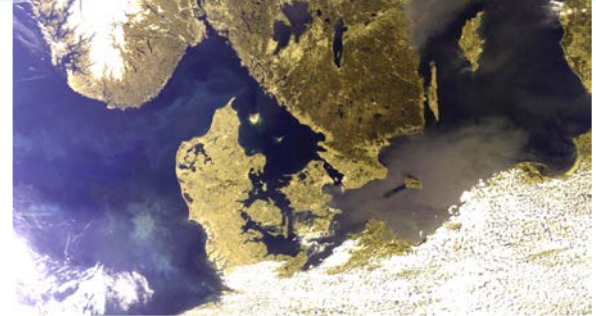
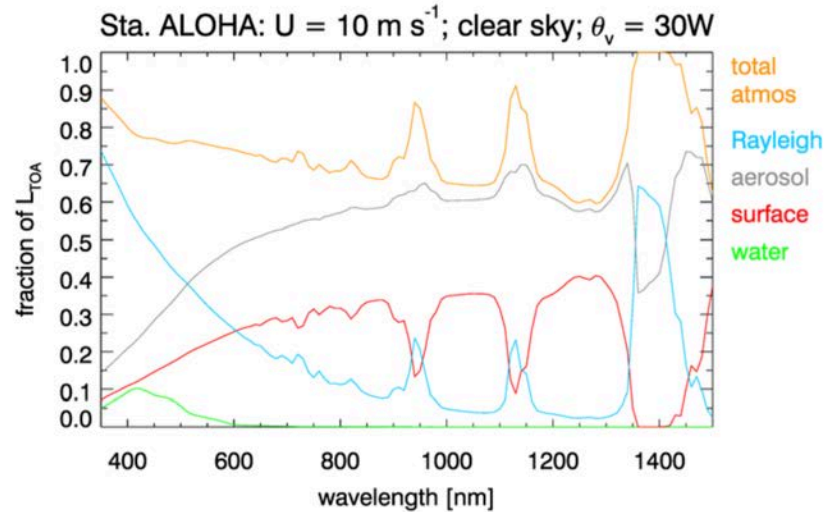


Figure 2.3: The fraction of L_t due to various processes, for the particular simulation of Fig. 2.2. (Need to add a curve for total atmos plus glint.)

Atmospheric path radiance: 70-90% of L_t
Below 500 nm and over 1350 nm Rayleigh scattering is the largest contributor. In between aerosols are the greatest contributors.

Investigating the Ocean Color from Space

Algorithm Specification

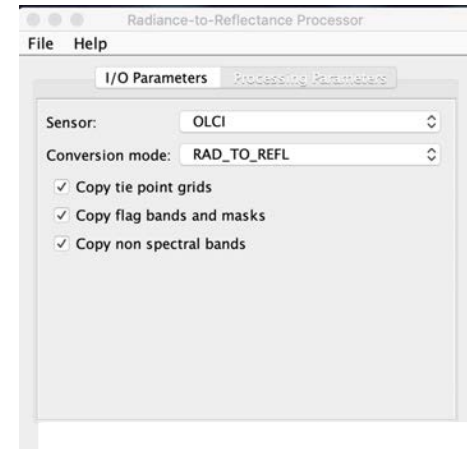
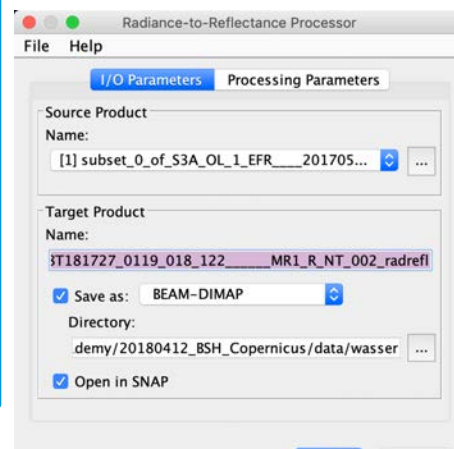
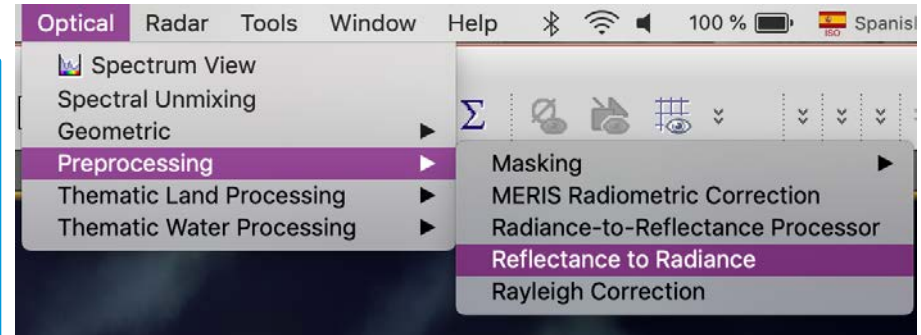
The conversion from TOA radiance (L_{TOA}) to TOA reflectances (R_{TOA}) done by the following equation:

$$R_{TOA}(\lambda) = \frac{\pi L_{TOA}(\lambda)}{E_0(\lambda) \cos(\theta)}$$

where E_0 and θ are the solar spectral irradiance and the sun zenith angle, respectively.

The conversion from reflectances to radiances simply follows the inverse of this equation.

For all sensors supported by the Radiance-to-Reflectance Processor, the sun zenith angle is provided per pixel with the L1b products. The solar spectral irradiance values are provided per pixel in case of OLCI L1b products, taken from the L1 product metadata in case of SLSTR products, and taken from auxiliary data in case of MERIS products.



Investigating the Ocean Color from Space

Optical Radar Tools Window Help

- Spectrum View
- Spectral Unmixing
- Geometric
- Preprocessing**
- Thematic Land Processing
- Thematic Water Processing
- OrfeoToolbox

- Masking
- Sentinel-2 Radiometric Uncertainty Tool
- MERIS Radiometric Correction
- Radiance-to-Reflectance Processor**
- Reflectance to Radiance
- Rayleigh Correction

I/O Parameters Processing Parameters

Source Product
Name: [1] S3A_OL_1_EFR_20180928T103827_... ..

Target Product
Name: 35_0179_036_165_2340_MAR_O_NT_002.SEN3_radrefl ..

Save as: BEAM-DIMAP

Directory: C:\Users\marcela\documents\pen2cor ..

Open in SNAP

Run Close

Radiance-to-Reflectance Processor

File Help

I/O Parameters **Processing Parameters**

Sensor: OLCI

Conversion mode: RAD_TO_REFL

- Copy tie point grids
- Copy flag bands and masks
- Copy non spectral bands

Run Close

Source Product: By default, it is associated to the open image. You can select another image.

Target Product: By default, the name corresponds to the same open image name plus _radrefl suffix.

Apply the 3 Copy options to conserve all the original data in the reflectance product. Finally, Run the process.

If the process is correct:

SNAP - Radiance-to-Reflectance Processor

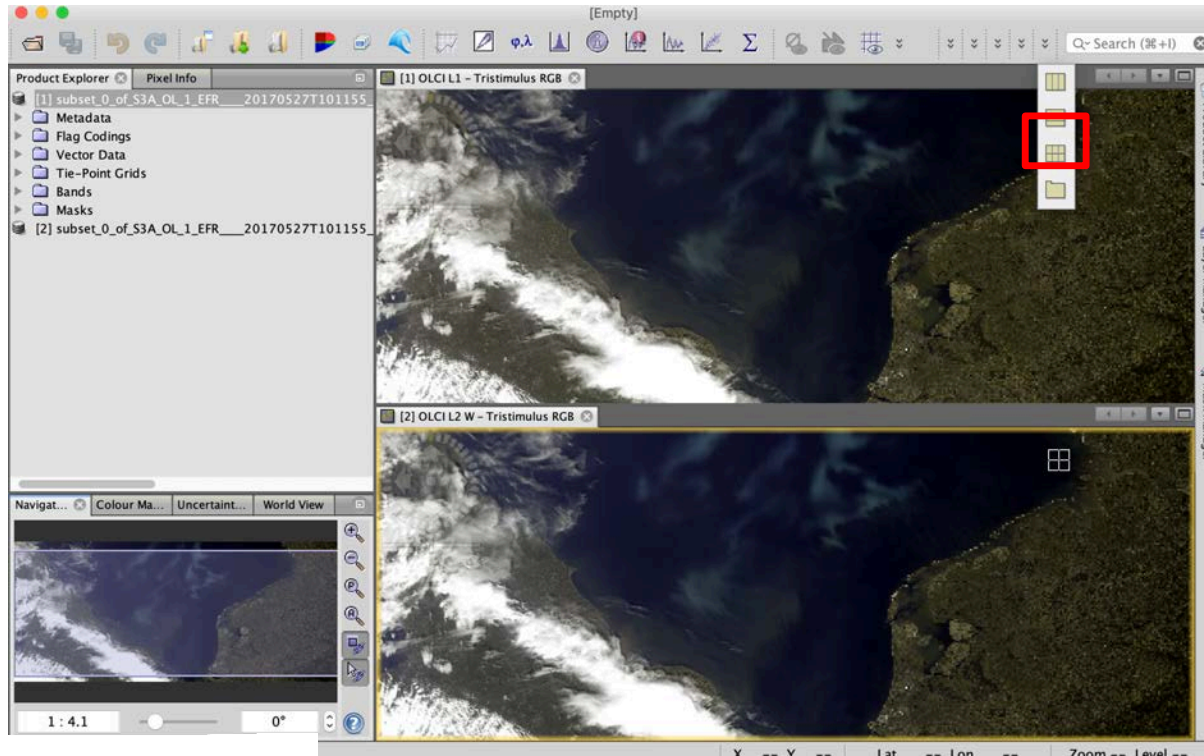
The target product has successfully been created and opened in SNAP.

Actual processing of source to target data will be performed only on demand, for example, if the target product is saved or an image view is opened.

Don't show this message anymore.

OK Cancel

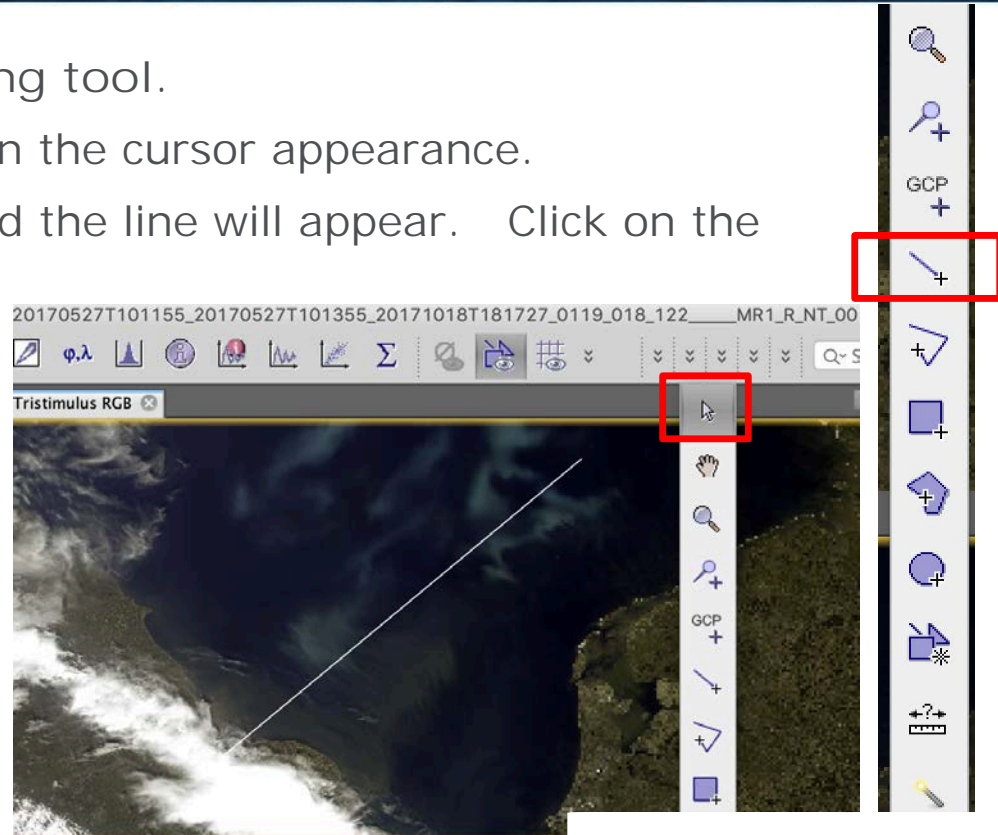
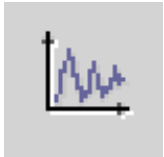
Investigating the Ocean Color from Space



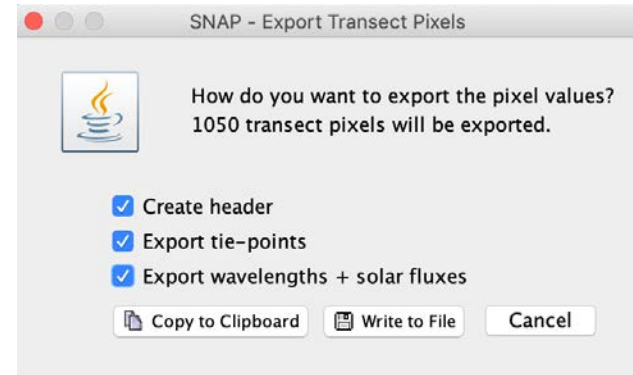
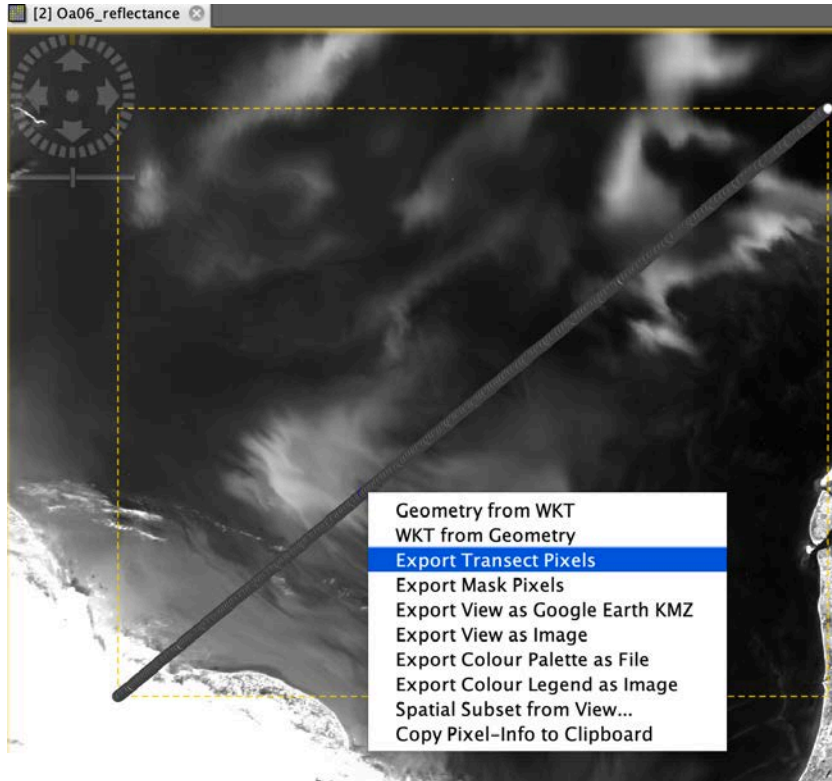
Open the two products (RGB composite) and arrange the view horizontally

Investigating the Ocean Color from Space

- Draw a line with the Line drawing tool.
- After drawing the line select again the cursor appearance.
- Select band Oa06_reflectance and the line will appear. Click on the profile plot icon

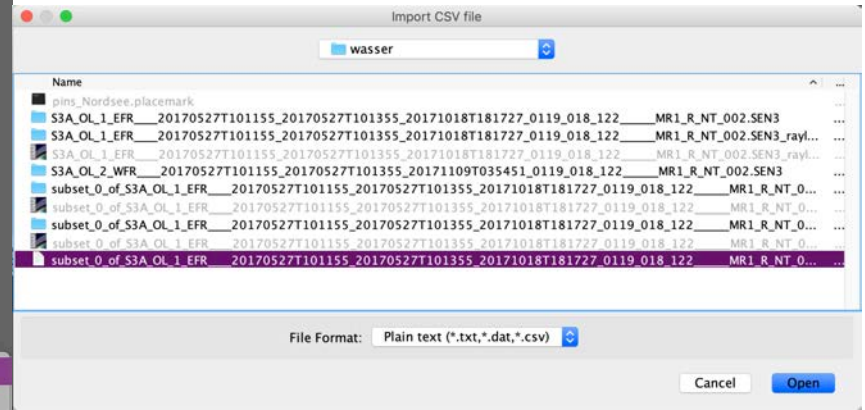
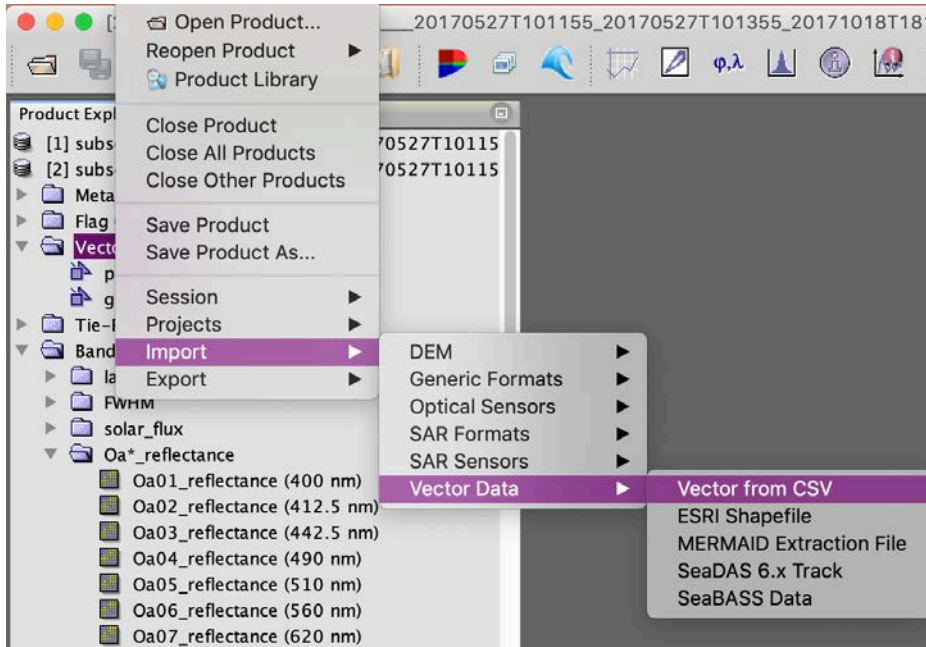


Investigating the Ocean Color from Space



Export the geometry (line) as a transect and save in the same directory.

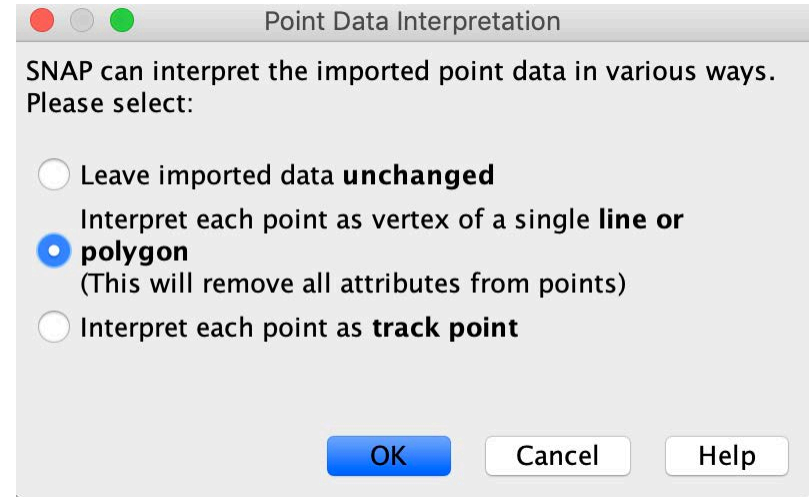
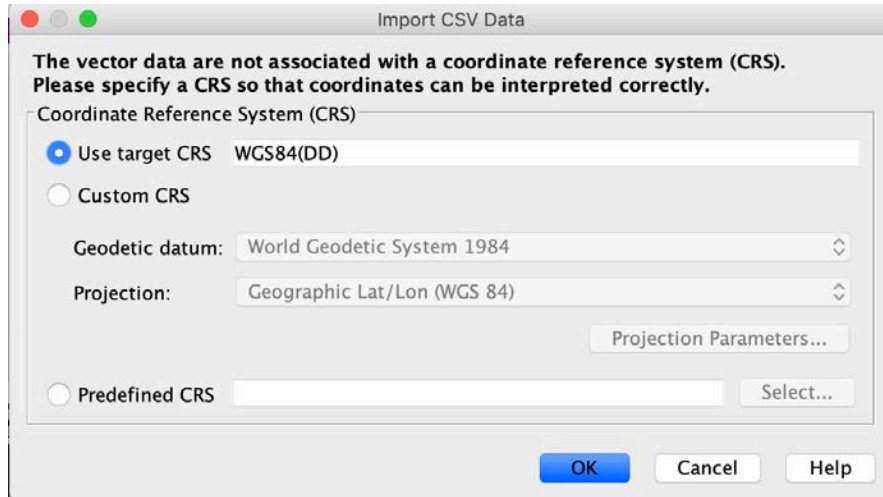
Investigating the Ocean Color from Space



Import the transect in the TOA reflectance image.

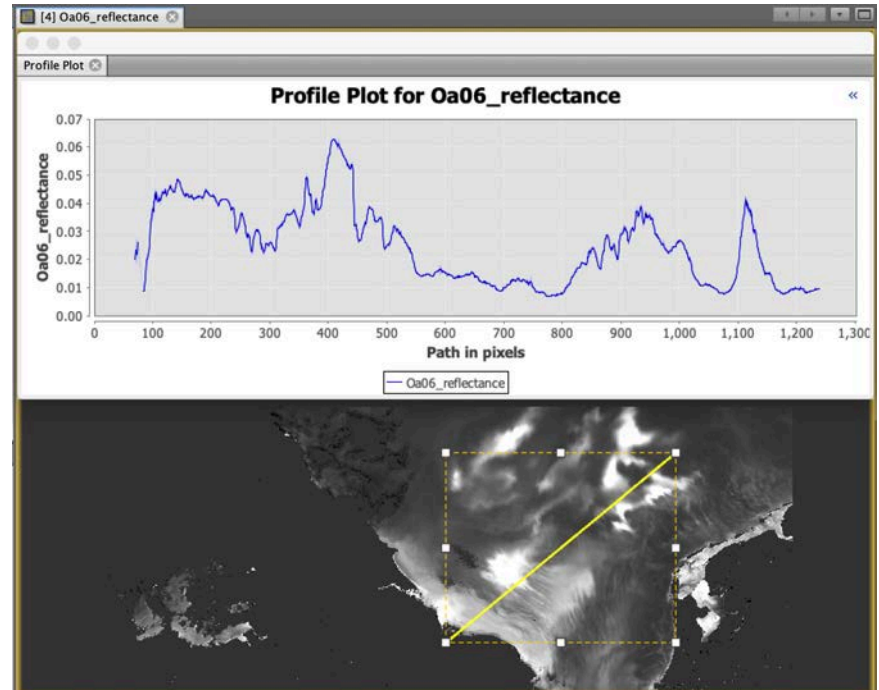
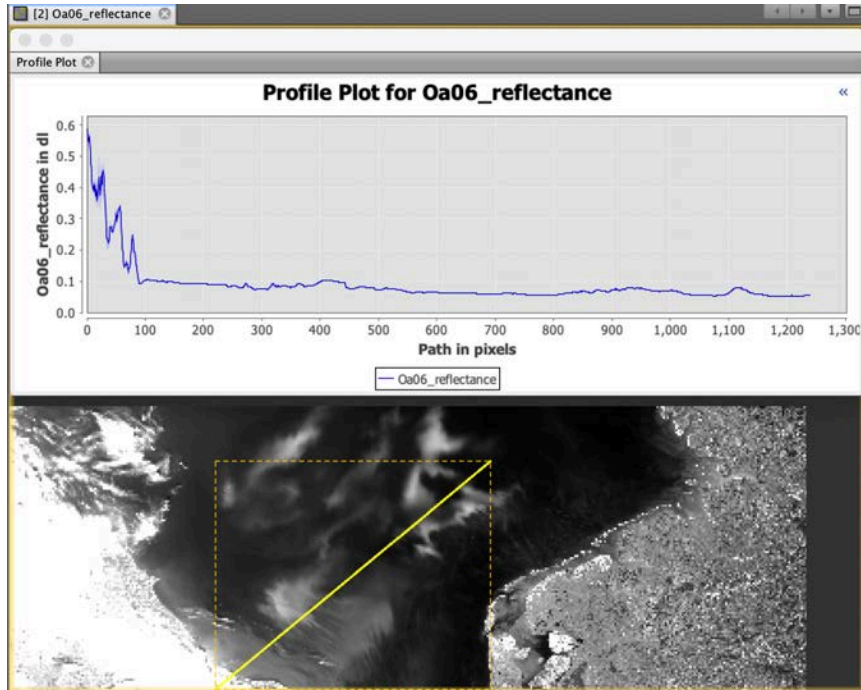
Import the standard L2 product (located in the same directory), open band Oa06_reflectance and import the vector geometry.

Investigating the Ocean Color from Space

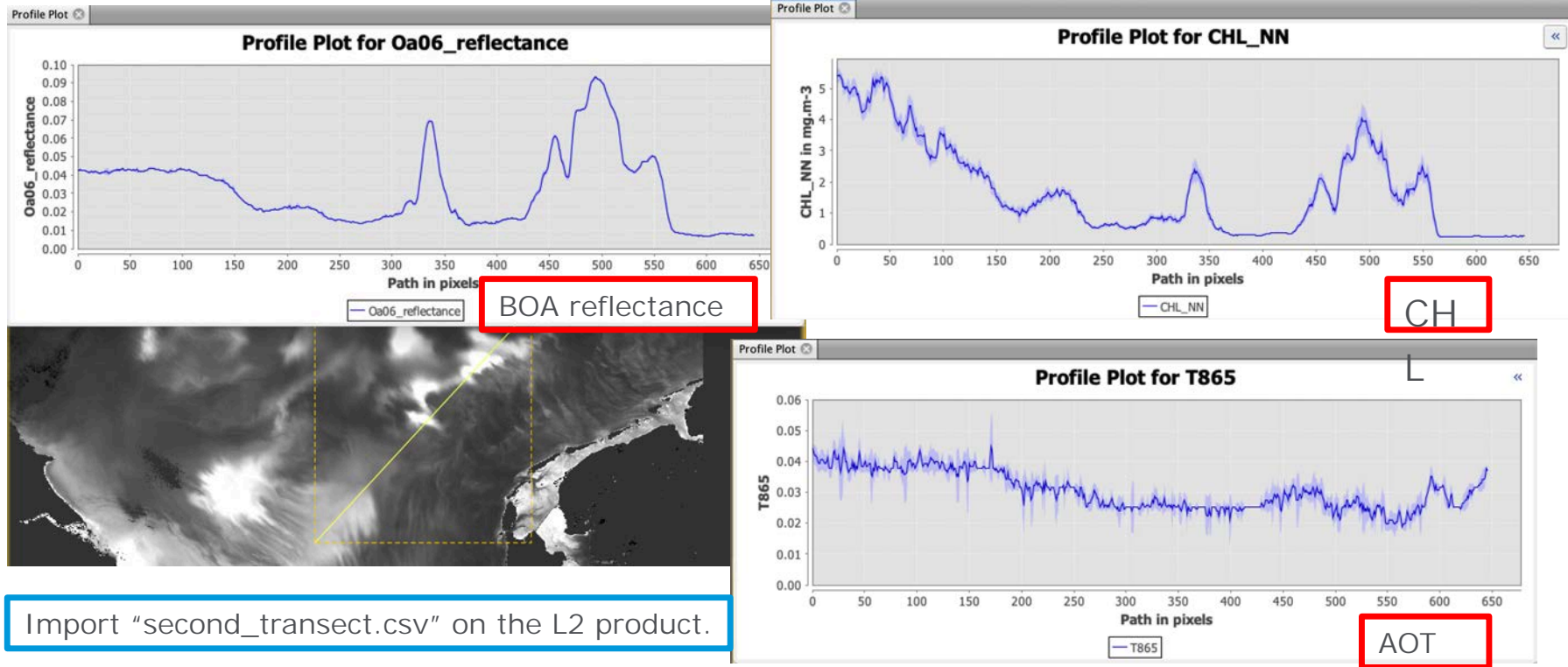


Import the transect: Interpret each point as vertex of a single line or polygon

Investigating the Ocean Color from Space



Investigating the Ocean Color from Space



Investigating the Ocean Color from Space

The atmosphere contributes more than 90% of the top of atmosphere radiance. The atmospheric correction over the ocean is a very critical processing step.

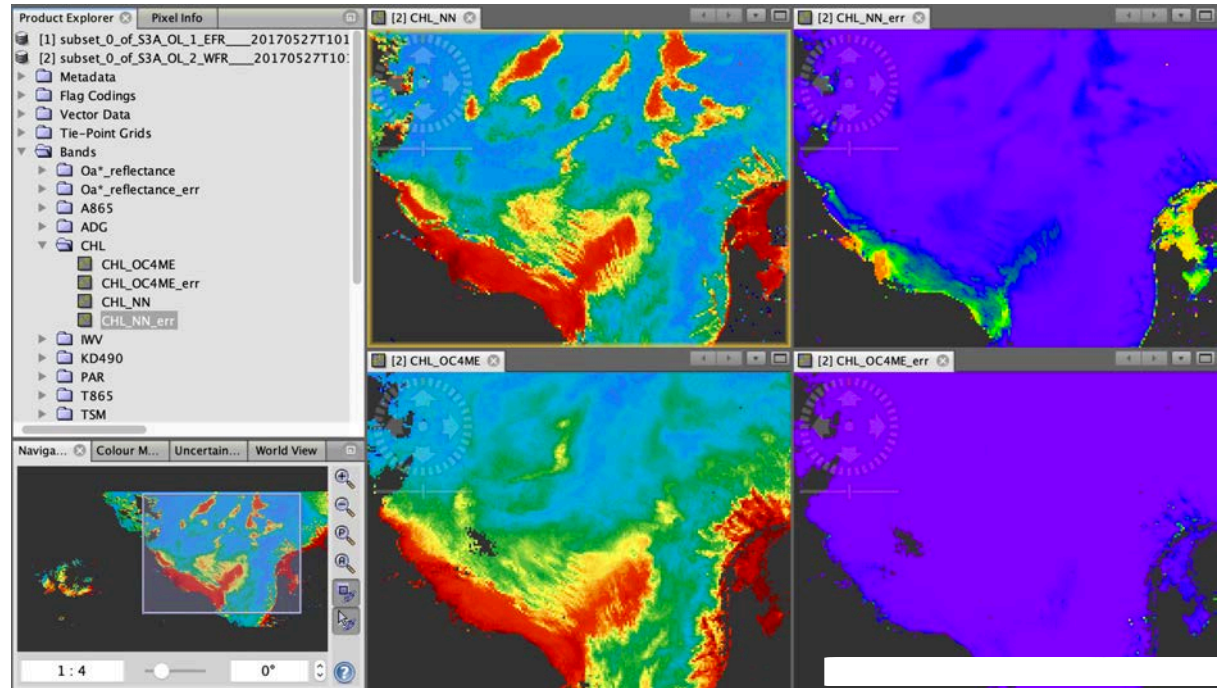
A good indicator of the quality of the atmospheric correction is the decoupling of the atmospheric signal (e.g. Aerosol optical thickness) from the water leaving reflectance.

SNAP provides the spectrum view to quickly investigate spectral quantities.

Investigating the Ocean Color from Space

If we open the L2 standard product, besides the reflectance (atmospherically corrected radiance), we have geo-physical variables like chlorophyll (CHL), CDOM absorption (ADG), total suspended matter (TSM), transparency (KD490), aerosol optical thickness (T865) and so on.

Click on the CHL folder, there are two products: CHL_OC4ME and its equivalent uncertainties (CHL_OC4ME_err); CHL_NN and its uncertainties (CHL_NN_err). These two CHL images are calculated with different algorithms. CHL_OC4ME uses the standard OC4 algorithm developed by NASA and adjusted to OLCI bands; CHL_NN is a product of the Case 2 Regional Coast Colour neural net processor.

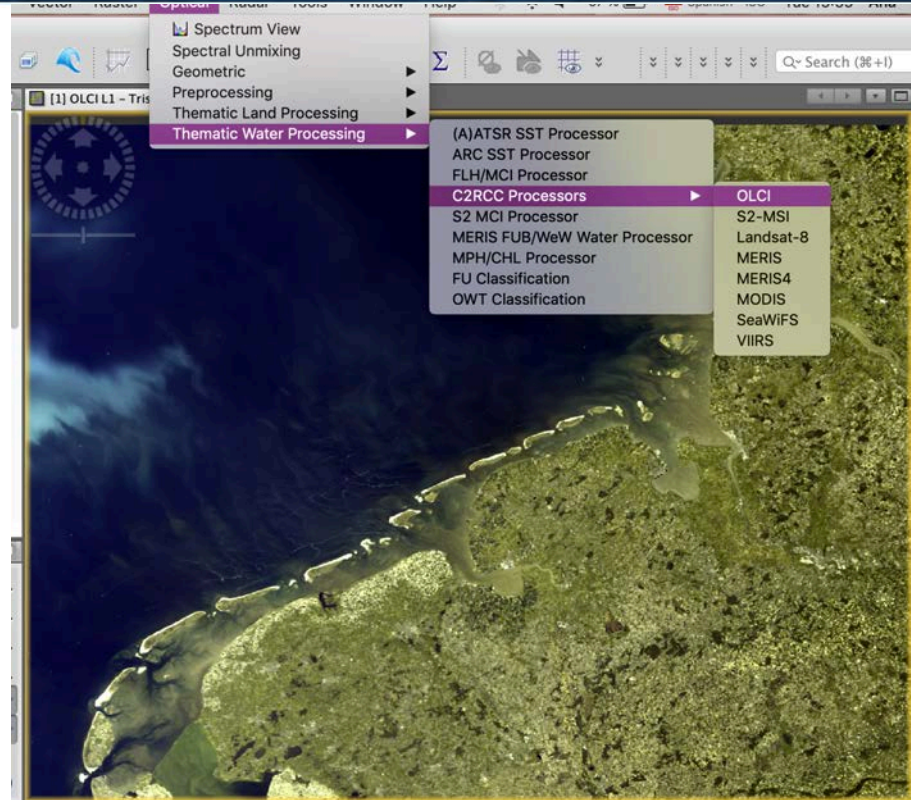


Investigating the Ocean Color from Space

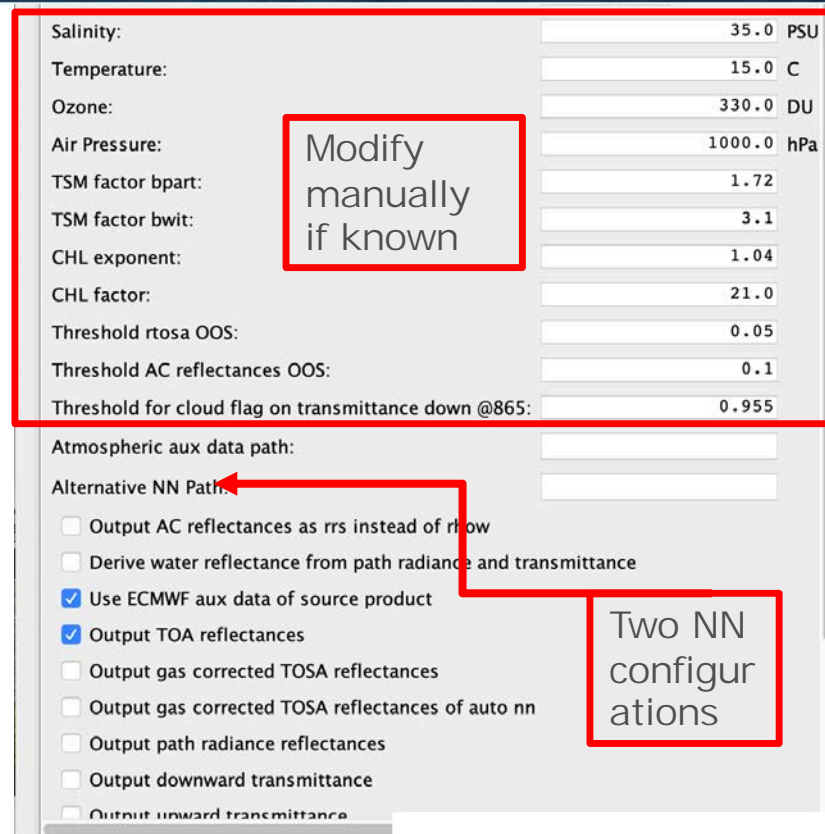
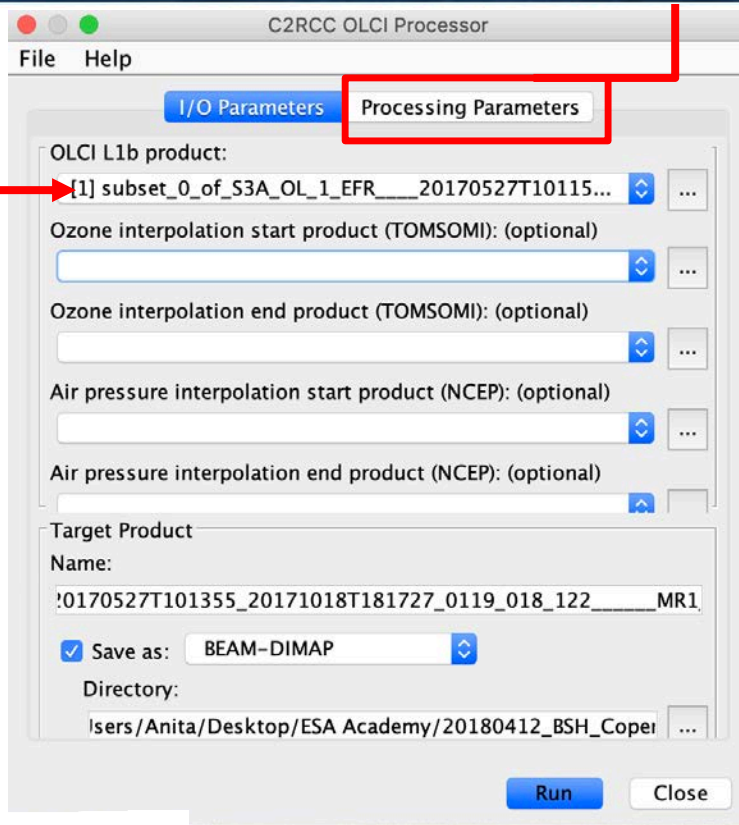
C2RCC NN is one of the processors available in SNAP to atmospherically correct and retrieve bio-geophysical parameters from L1 images.

The C2RCC processor uses a large database of radiative transfer simulations inverted by neural networks as basic technology.
Optical → Thematic Water Processing → C2RCC Processor → OLCI

C. Brockmann et al. Evolution of the C2RCC neural network for Sentinel 2 and 3 for the retrieval of ocean colour products in normal and extreme optically complex waters Living Planet Symposium 2016



Investigating the Ocean Color from Space



Investigating the Ocean Color from Space

- The C2RCC processor breaks down into two major parts: the atmospheric correction part, and the in-water part.
- The main input to the atmospheric part are the top-of-atmosphere radiances/reflectances of the sensor.
- The in-water part gets as input the directional water leaving reflectances from the atmosphere part.

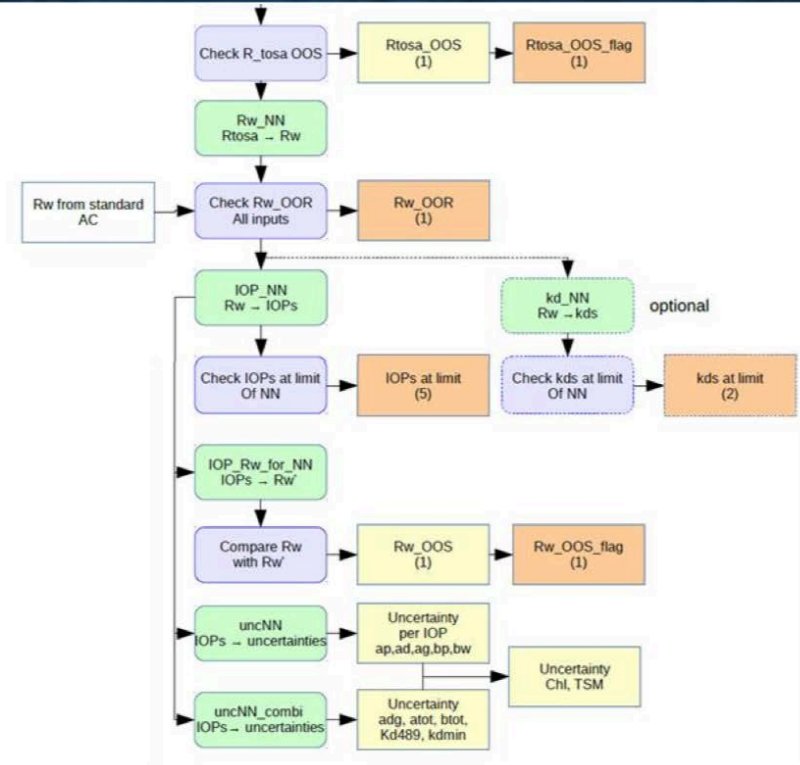


Figure 3: C2RCC processor architecture. Neural nets are shown as green boxes, and outputs as orange boxes.

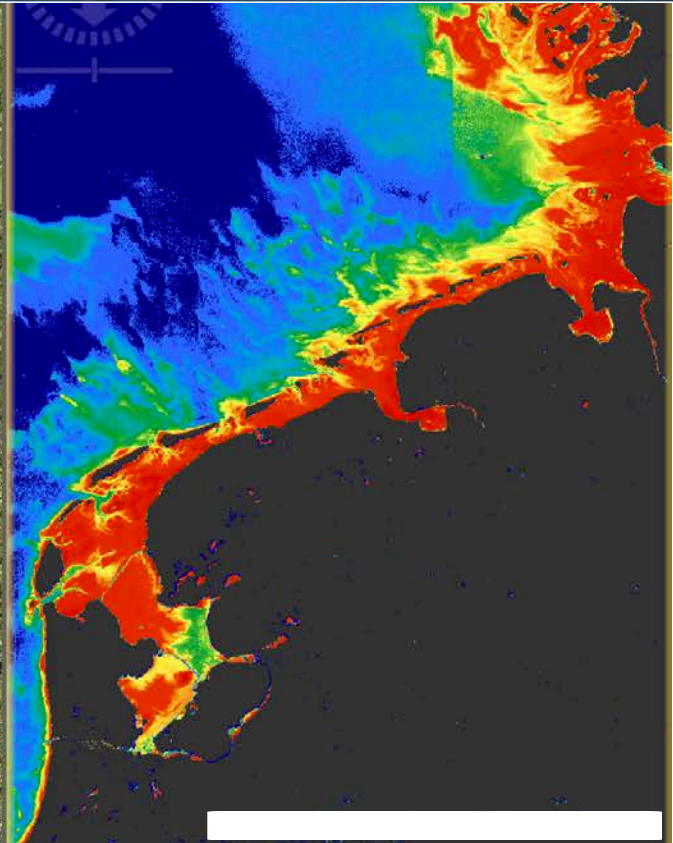
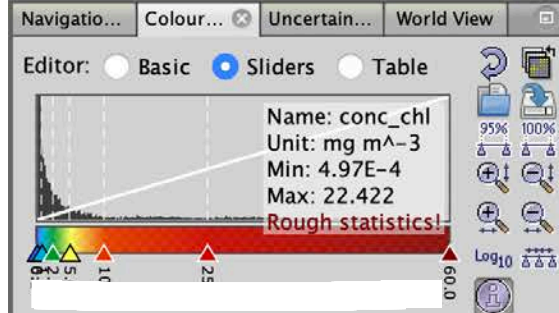
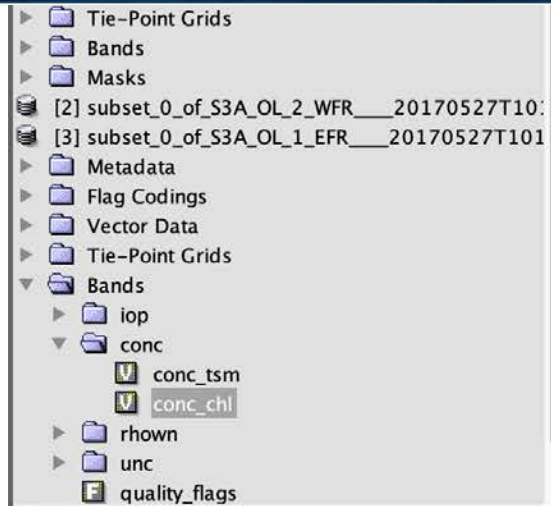
Investigating the Ocean Color from Space

- Output AC reflectances as rrs instead of rhov
- Derive water reflectance from path radiance and transmittance
- Use ECMWF aux data of source product
- Output TOA reflectances
- Output gas corrected TOSA reflectances
- Output gas corrected TOSA reflectances of auto nn
- Output path radiance reflectances
- Output downward transmittance
- Output upward transmittance
- Output atmospherically corrected angular dependent reflectances
- Output normalized water leaving reflectances
- Output of out of scope values
- Output of irradiance attenuation coefficients
- Output uncertainties

We will get only a few of the outputs, this will automatically retrieve the water quality parameters too.

- ▶ Flag Codings
- ▶ Vector Data
- ▶ Tie-Point Grids
- ▼ Bands
 - ▼ iop
 - iop_apig
 - iop_adet
 - iop_agelb
 - iop_bpart
 - iop_bwit
 - iop_adg
 - iop_atot
 - iop_btot
 - ▼ conc
 - conc_tsm
 - conc_chl
 - ▶ rhown
 - ▼ unc
 - unc_apig
 - unc_adet
 - unc_agelb
 - unc_bpart
 - unc_bwit
 - unc_adg
 - unc_atot
 - unc_btot
 - unc_tsm
 - unc_chl

Investigating the Ocean Color from Space



Investigating the Ocean Color from Space

L1 flags

Name	Type	Colour	Tran...	Description
<input type="checkbox"/> quality_flags_land	Maths	Green	0.5	quality_flags.land
<input type="checkbox"/> quality_flags_coastline	Maths	Red	0.5	quality_flags.coastline
<input type="checkbox"/> quality_flags_fresh_inland_water	Maths	Green	0.5	quality_flags.fresh_inland_water
<input type="checkbox"/> quality_flags_tidal_region	Maths	Blue	0.5	quality_flags.tidal_region
<input type="checkbox"/> quality_flags_bright	Maths	Green	0.5	quality_flags.bright
<input type="checkbox"/> quality_flags_straylight_risk	Maths	Cyan	0.5	quality_flags.straylight_risk
<input type="checkbox"/> quality_flags_invalid	Maths	Magenta	0.5	quality_flags.invalid
<input type="checkbox"/> quality_flags_cosmetic	Maths	Yellow	0.5	quality_flags.cosmetic
<input type="checkbox"/> quality_flags_duplicated	Maths	Dark Blue	0.5	quality_flags.duplicated
<input type="checkbox"/> quality_flags_sun_glint_risk	Maths	Green	0.5	quality_flags.sun_glint_risk
<input type="checkbox"/> quality_flags_dubious	Maths	Teal	0.5	quality_flags.dubious
<input type="checkbox"/> quality_flags_saturated_Oa01	Maths	Green	0.5	quality_flags.saturated_Oa01
<input type="checkbox"/> quality_flags_saturated_Oa02	Maths	Brown	0.5	quality_flags.saturated_Oa02
<input type="checkbox"/> quality_flags_saturated_Oa03	Maths	Purple	0.5	quality_flags.saturated_Oa03
<input type="checkbox"/> quality_flags_saturated_Oa04	Maths	Purple	0.5	quality_flags.saturated_Oa04
<input type="checkbox"/> quality_flags_saturated_Oa05	Maths	Olive	0.5	quality_flags.saturated_Oa05
<input type="checkbox"/> quality_flags_saturated_Oa06	Maths	Grey	0.5	quality_flags.saturated_Oa06
<input type="checkbox"/> quality_flags_saturated_Oa07	Maths	Light Blue	0.5	quality_flags.saturated_Oa07
<input type="checkbox"/> quality_flags_saturated_Oa08	Maths	Light Green	0.5	quality_flags.saturated_Oa08
<input type="checkbox"/> quality_flags_saturated_Oa09	Maths	Light Green	0.5	quality_flags.saturated_Oa09
<input type="checkbox"/> quality_flags_saturated_Oa10	Maths	Cyan	0.5	quality_flags.saturated_Oa10
<input type="checkbox"/> quality_flags_saturated_Oa11	Maths	Pink	0.5	quality_flags.saturated_Oa11
<input type="checkbox"/> quality_flags_saturated_Oa12	Maths	Orange	0.5	quality_flags.saturated_Oa12
<input type="checkbox"/> quality_flags_saturated_Oa13	Maths	Light Red	0.5	quality_flags.saturated_Oa13
<input type="checkbox"/> quality_flags_saturated_Oa14	Maths	Pink	0.5	quality_flags.saturated_Oa14
<input type="checkbox"/> quality_flags_saturated_Oa15	Maths	Yellow	0.5	quality_flags.saturated_Oa15
<input type="checkbox"/> quality_flags_saturated_Oa16	Maths	Dark Blue	0.5	quality_flags.saturated_Oa16
<input type="checkbox"/> quality_flags_saturated_Oa17	Maths	Dark Green	0.5	quality_flags.saturated_Oa17
<input type="checkbox"/> quality_flags_saturated_Oa18	Maths	Teal	0.5	quality_flags.saturated_Oa18
<input type="checkbox"/> quality_flags_saturated_Oa19	Maths	Blue	0.5	quality_flags.saturated_Oa19

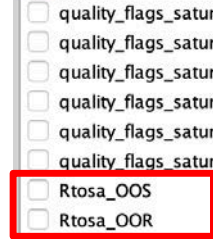


Mask Manager

Product Library

Layer Manager

Name	Type	Colour	Tran...	Description
<input type="checkbox"/> quality_flags_saturated_Oa16	Maths	Dark Blue	0.5	Copied from OLCI
<input type="checkbox"/> quality_flags_saturated_Oa17	Maths	Dark Green	0.5	Copied from OLCI
<input type="checkbox"/> quality_flags_saturated_Oa18	Maths	Dark Teal	0.5	Copied from OLCI
<input type="checkbox"/> quality_flags_saturated_Oa19	Maths	Dark Blue	0.5	Copied from OLCI
<input type="checkbox"/> quality_flags_saturated_Oa20	Maths	Blue	0.5	Copied from OLCI
<input type="checkbox"/> quality_flags_saturated_Oa21	Maths	Light Blue	0.5	Copied from OLCI
<input type="checkbox"/> Rtos_a_OOS	Maths	Red	0.5	The input spectru
<input type="checkbox"/> Rtos_a_OOR	Maths	Yellow	0.5	The input spectru
<input type="checkbox"/> Rhow_OOR	Maths	Yellow	0.5	One of the inputs
<input type="checkbox"/> Cloud_risk	Maths	Grey	0	High downwelling
<input type="checkbox"/> lop_OOR	Maths	Light Green	0.5	One of the IOPs is
<input type="checkbox"/> Apig_at_max	Maths	Light Red	0.5	Apig output of the
<input type="checkbox"/> Adet_at_max	Maths	Magenta	0.5	Adet output of the
<input type="checkbox"/> Agelb_at_max	Maths	Cyan	0.5	Agelb output of th
<input type="checkbox"/> Bpart_at_max	Maths	Grey	0.5	Bpart output of th
<input type="checkbox"/> Bwit_at_max	Maths	Red	0.5	Bwit output of the
<input type="checkbox"/> Apig_at_min	Maths	Yellow	0.5	Apig output of the
<input type="checkbox"/> Adet_at_min	Maths	Yellow	0.5	Adet output of the
<input type="checkbox"/> Agelb_at_min	Maths	Blue	0.5	Agelb output of th
<input type="checkbox"/> Bpart_at_min	Maths	Green	0.5	Bpart output of th
<input type="checkbox"/> Bwit_at_min	Maths	Light Red	0.5	Bwit output of the
<input type="checkbox"/> Rhow_OOS	Maths	Magenta	0.5	The Rhow input s
<input type="checkbox"/> Kd489_OOR	Maths	Cyan	0.5	Kd489 is out of r
<input type="checkbox"/> Kdmin_OOR	Maths	Grey	0.5	Kdmin is out of ra
<input type="checkbox"/> Kd489_at_max	Maths	Red	0.5	Kdmin is at max
<input type="checkbox"/> Kdmin_at_max	Maths	Red	0.5	Kdmin is at max



New flags from C2RCC

Investigating the Ocean Color from Space

Use SNAP's command-line tools:

- From a command-line shell
- From shell scripts
- From Python, IDL, MatLab...using dedicated systems

Many advantages

- ✓ No intermediate files written, no I/O overhead
- ✓ Reusability of processing chains
- ✓ Simple and comprehensive operator configuration
- ✓ Reusability of operator configurations

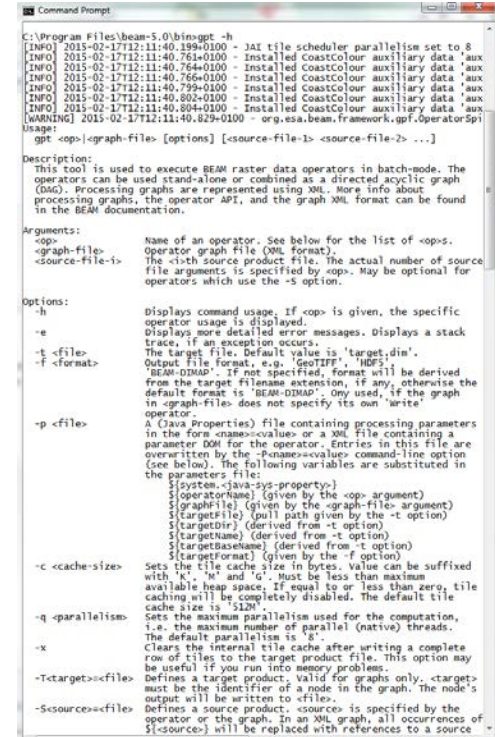
Graph xml: Graph_idepix_c2rcc.xml

Investigating the Ocean Color from Space

- Look into $\{\text{SNAP-HOME}\}/\text{bin}$ directory:
- `gpt` (.exe in Windows) → used to execute various SNAP operators and chain of operators

ESA SNAP/SNAP command line `gpt -h`

- `pconvert` → used to convert product files into other data and image formats (quick-look generation)
- `snappy-conf` → SNAP application configuration launcher for `snap-py`



```
C:\Program Files\beam-5.0\bin>gpt -h
INFO 2015-02-17T12:11:40.199+0100 - 3AT tile scheduler parallelism set to 8
INFO 2015-02-17T12:11:40.764+0100 - Installed CoastColour auxiliary data 'aux
INFO 2015-02-17T12:11:40.766+0100 - Installed CoastColour auxiliary data 'aux
INFO 2015-02-17T12:11:40.799+0100 - Installed CoastColour auxiliary data 'aux
INFO 2015-02-17T12:11:40.802+0100 - Installed CoastColour auxiliary data 'aux
INFO 2015-02-17T12:11:40.804+0100 - Installed CoastColour auxiliary data 'aux
[WARNING] 2015-02-17T12:11:40.829+0100 - org.esa.beam.framework.gpf.OperatorSpi
Usage:
gpt <op> [-graph-file] [options] [-source-file-1 <source-file-2> ...]

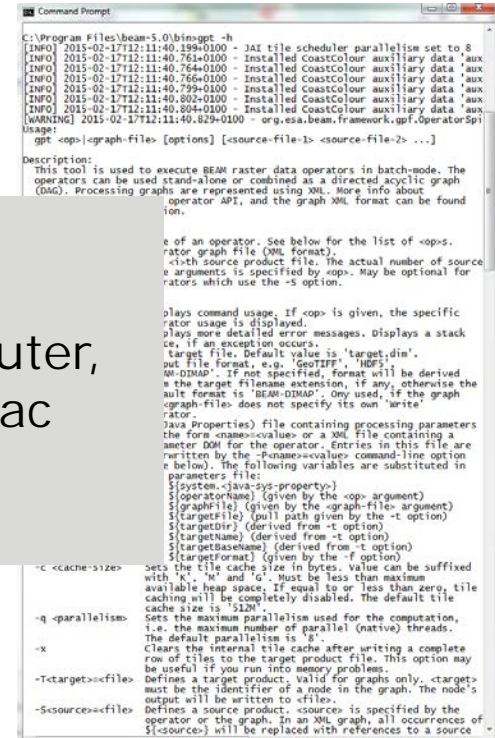
Description:
This tool is used to execute BEAM raster data operators in batch-mode. The
operators can be used stand-alone or combined as a directed acyclic graph
(DAG). Processing graphs are represented using XML. More info about
processing graphs, the operator API, and the graph XML format can be found
in the BEAM documentation.

Arguments:
  <op>          Name of an operator. See below for the list of <op>.
  <graph-file>  Operator graph file (XML format).
  <source-file-i> The <i>n</i>-th source product file. The actual number of source
                 file arguments is specified by <op>. May be optional for
                 operators which use the <-s option>.

Options:
  -h            Displays command usage. If <op> is given, the specific
                 operator usage is displayed.
  -e            Displays more detailed error messages. Displays a stack
                 trace, if an exception occurs.
  -t <file>    The target file. Default value is 'target.din'.
  -f <format>  Output file format, e.g. 'GeoTIFF', 'HDF3',
                 'BEAM-DIMAP'. If not specified, format will be derived
                 from the target filename extension, if any, otherwise the
                 default format is 'BEAM-DIMAP'. Only used, if the graph
                 in <graph-file> does not specify its own 'write'
                 operator.
  -p <file>    A (Java Properties) file containing processing parameters
                 in the form <name>=<value> or a XML file containing a
                 parameter DAG for the operator. Entries in this file are
                 overwritten by the <-pname=>value</> command-line option
                 (see below). The following variables are substituted in
                 the parameters file:
                 ${system.<java-sys-property>}
                 ${operatorName} (given by the <op> argument)
                 ${graphFile} (given by the <graph-file> argument)
                 ${targetFile} (full path given by the <-t option>)
                 ${targetDir} (derived from <-t option>)
                 ${targetName} (derived from <-t option>)
                 ${targetBaseName} (derived from <-t option>)
                 ${targetFormat} (given by the <-f option>)
  -c <cache-size> Sets the tile cache size in bytes. Value can be suffixed
                 with 'k', 'M' and 'G'. Must be less than maximum
                 available heap space. If equal to or less than zero, tile
                 caching will be completely disabled. The default tile
                 cache size is '512M'.
  -q <parallelism> Sets the maximum parallelism used for the computation,
                 i.e. the maximum number of parallel (native) threads.
                 The default parallelism is '8'.
  -x            Clears the internal tile cache after writing a complete
                 row of tiles to the target product file. This option may
                 be useful if you run into memory problems.
  -T <target>=<file> Defines a target product. Valid for graphs only. <target>
                 must be the identifier of a node in the graph. The node's
                 output will be written to <file>.
  -S <source>=<file> Defines a source product. <source> is specified by the
                 operator or the graph. In an XML graph, all occurrences of
                 ${<source>} will be replaced with references to a source
```

Investigating the Ocean Color from Space

- Look into $\{\text{SNAP-HOME}\}/\text{bin}$ directory:
- `gpt` (.exe in Windows) → used to execute various SNAP operators and chain of operators



```
C:\Program Files\beam-5.0\bin>gpt -h
[INFO] 2015-02-17T12:11:40.199+0100 - JAI tile scheduler parallelism set to 8
[INFO] 2015-02-17T12:11:40.764+0100 - Installed CoastColour auxiliary data 'aux
[INFO] 2015-02-17T12:11:40.766+0100 - Installed CoastColour auxiliary data 'aux
[INFO] 2015-02-17T12:11:40.799+0100 - Installed CoastColour auxiliary data 'aux
[INFO] 2015-02-17T12:11:40.802+0100 - Installed CoastColour auxiliary data 'aux
[INFO] 2015-02-17T12:11:40.804+0100 - Installed CoastColour auxiliary data 'aux
[WARNING] 2015-02-17T12:11:40.829+0100 - org.esa.beam.framework.gpf.OperatorSpi
Usage:
  gpt <op> [-graph-file] [options] [-source-file-1s <source-file-2s ...>]

Description:
  This tool is used to execute BEAM raster data operators in batch-mode. The
  operator can be used stand-alone or combined as a directed acyclic graph
  (DAG). Processing graphs are represented using XML. More info about
  operator API, and the graph XML format can be found
  on:
  http://www.esa.beam.org/developers/external-libs/beam-raster/beam-raster-api/doc/html/
  e of an operator. See below for the list of <op>:
  rator graph file (XML format),
  <with source product file, the actual number of source
  e arguments is specified by <op>. May be optional for
  rators which use the -s option.

  plays command usage, if <op> is given, the specific
  rator usage is displayed.
  rator more detailed error messages. Displays a stack
  ce, if an exception occurs.
  Target file. Default value is 'target.din'.
  put file format, e.g. 'GeoTIFF', 'HDF5',
  'BAM-DIMAP'. If not specified, format will be derived
  e the target filename extension, if any, otherwise the
  ulti format is 'BEAM-DIMAP'. Only used, if the graph
  <graph-file> does not specify its own 'write'
  rator.
  Java Properties file containing processing parameters
  the form <name>=<value> or a XML file containing a
  ameter DOM for the operator. Entries in this file are
  rewritten by the -P<name>=<value> command-line option
  e below). The following variables are substituted in
  parameters file:
  ${system.<java-sys-property>}
  ${operatorName} (given by the <op> argument)
  ${graphFile} (given by the -graph-file argument)
  ${targetFile} (full path given by the -t option)
  ${targetDir} (derived from -t option)
  ${targetName} (derived from -t option)
  ${targetBaseName} (derived from -t option)
  ${targetFormat} (given by the -f option)

  -c <cache-size> Sets the tile cache size in bytes. Value can be suffixed
  with 'k', 'm' and 'g'. Must be less than maximum
  available heap space. If equal to or less than zero, tile
  caching will be completely disabled. The default tile
  cache size is '152M'.

  -q <parallelism> Sets the maximum parallelism used for the computation,
  i.e. the maximum number of parallel (native) threads.
  The default parallelism is '8'.

  -x Clears the internal tile cache after writing a complete
  row of tiles to the target product file. This option may
  be useful if you run into memory problems.

  -T<target>=<file> Defines a target product. Valid for graphs only. <target>
  must be the identifier of a node in the graph. The node's
  output will be written to <file>.

  -S<source>=<file> Defines a source product. <source> is specified by the
  operator or the graph. In an XML graph, all occurrences of
  ${<source>} will be replaced with references to a source
```

ESA SNAP Go to your SNAP folder and look
Call `gpt`

- `pconvert` → (if only one SNAP instance on your computer, other data generation) just type `gpt` on the command line; on Mac you need to type the full path in your terminal)
- `snappy-co` launcher for `snap-py`

Investigating the Ocean Color from Space

- Most important SNAP batch-mode tool
- Usage:
`gpt <op> | <graph-file> [options] [<source-file-1> <source-file-2> ...]`
- Which operator are available?
`gpt -h`
- List of operators may vary depending on installed SNAP plug-ins

Investigating the Ocean Color from Space

```
PS C:\> C:\progra-1\snap6.0-PREVIEW6\bin\gpt.exe Idepix.Sentinel3.Olci -h
INFO: org.esa.snap.core.gpf.operators.tooladapter.ToolAdapterIO: Initializing external tool adapters
Usage:
  gpt Idepix.Sentinel3.Olci [options]

Description:
  Pixel identification and classification for OLCI.

Source Options:
  -SourceProduct=<file>      The OLCI Lib source product.
                             This is a mandatory source.

Parameter Options:
  -PcloudBufferWidth=<int>    The width of a cloud 'safety buffer' around a pixel which was classified as cloudy.
                             Valid interval is [0,100].
                             Default value is '2'.
  -PcomputeCloudBuffer=<boolean> Sets parameter 'computeCloudBuffer' to <boolean>.
                             Default value is 'true'.
  -PcomputeCloudShadow=<boolean> If applied, a cloud shadow is computed. This requires the cloud top pressure operator (Python plugin based on CAWA) to be installed. Still experimental.
                             Default value is 'false'.
  -PcomputeCtp=<boolean>      Compute cloud top pressure (time consuming, requires Python plugin based on CAWA).
                             Default value is 'false'.
                             If applied, write NN value to the target product
  -PoutputSchillerNNValue=<boolean> If applied, write NN value to the target product
                             Default value is 'false'.
  -PradianceBandsToCopy=<string,string,string,...> The list of radiance bands to write to target product.
                             Value must be one of '0a01_radiance', '0a02_radiance', '0a03_radiance', '0a04_radiance', '0a05_radiance', '0a06_radiance', '0a07_radiance', '0a08_radiance', '0a09_radiance', '0a10_radiance', '0a11_radiance', '0a12_radiance', '0a13_radiance', '0a14_radiance', '0a15_radiance', '0a16_radiance', '0a17_radiance', '0a18_radiance', '0a19_radiance', '0a20_radiance', '0a21_radiance'.
  -PreflectanceBandsToCopy=<string,string,string,...> The list of reflectance bands to write to target product.
                             Value must be one of '0a01_reflectance', '0a02_reflectance', '0a03_reflectance', '0a04_reflectance', '0a05_reflectance', '0a06_reflectance', '0a07_reflectance', '0a08_reflectance', '0a09_reflectance', '0a10_reflectance', '0a11_reflectance', '0a12_reflectance', '0a13_reflectance', '0a14_reflectance', '0a15_reflectance', '0a16_reflectance', '0a17_reflectance', '0a18_reflectance', '0a19_reflectance', '0a20_reflectance', '0a21_reflectance'.

Graph XML Format:
<graph id="someGraphId">
  <version>1.0</version>
  <node id="someNodeId">
    <operator>Idepix.Sentinel3.Olci</operator>
    <sources>
      <sourceProduct>${sourceProduct}</sourceProduct>
    </sources>
    <parameters>
      <radianceBandsToCopy>string,string,string,...</radianceBandsToCopy>
      <reflectanceBandsToCopy>string,string,string,...</reflectanceBandsToCopy>
      <outputSchillerNNValue>boolean</outputSchillerNNValue>
      <computeCloudBuffer>boolean</computeCloudBuffer>
      <cloudBufferWidth>int</cloudBufferWidth>
      <computeCtp>boolean</computeCtp>
      <computeCloudShadow>boolean</computeCloudShadow>
    </parameters>
  </node>
</graph>
```

Investigating the Ocean Color from Space

```
PS C:\> C:\progra-1\snap6.0-PREVIEW6\bin\gpt.exe Idepix.Sentinel3.Olci -h
INFO: org.esa.snap.core.gpf.operators.tooladapter.ToolAdapterIO: Initializing external tool adapters
Usage:
  gpt Idepix.Sentinel3.Olci [options]

Description:
  Pixel identification and classification for OLCI.
```

```
<graph id="Olci_HSC">
  <version>1.0</version>
  <node id="idepix">
    <operator>Idepix.Sentinel3.Olci</operator>
    <sources>
      <sourceProduct>${sourceProduct}</sourceProduct>
    </sources>
    <parameters>
      <computeCloudBuffer>true</computeCloudBuffer>
      <cloudBufferWidth>2</cloudBufferWidth>
    </parameters>
  </node>
</graph>
```

```
<computeCloudBuffer>boolean</computeCloudBuffer>
<cloudBufferWidth>int</cloudBufferWidth>
<computeCtp>boolean</computeCtp>
<computeCloudShadow>boolean</computeCloudShadow>
</parameters>
</node>
</graph>
```

Investigating the Ocean Color from Space

The screenshot displays a software interface for remote sensing data processing. On the left, a globe shows the world with labels for continents (EUROPE, ASIA, AFRICA, SOUTH AMERICA) and oceans (North Atlantic Ocean, South Atlantic Ocean, Southern Ocean). Below the globe is a scale bar for 2000 km. The central panel shows a list of parameters with their units and values:

Parameter	Value	Unit
Salinity:	35.0	PS
Temperature:	15.0	C
Ozone:	330.0	DA
Air Pressure:	1000.0	HP
TSM factor bpart:	1.72	
TSM factor bwit:	3.1	
CHL exponent:	1.04	
CHL factor:	21.0	
Threshold rtosa OOS:	0.005	
Threshold AC reflectances OOS:	0.1	
Threshold for cloud flag on transmittance down @865:	0.955	
Atmospheric aux data path:		
Alternative NN Path:		

Below the parameter list are several checkboxes for output options:

- Output AC reflectances as rrs instead of rhov
- Derive water reflectance from path radiance and transmittance
- Use ECMWF aux data of source product
- Output TOA reflectances
- Output gas corrected TOSA reflectances
- Output gas corrected TOSA reflectances of auto nn
- Output path radiance reflectances
- Output downward transmittance
- Output upward transmittance

The right panel shows a search bar and a list of products and layers. The bottom status bar indicates the current location (DEU) and time (13:47, 08.11.2017).

Investigating the Ocean Color from Space

The screenshot displays a software interface with a globe on the left and a parameters window on the right. The globe shows the Atlantic Ocean with labels for Europe, Asia, Africa, South America, North Atlantic Ocean, South Atlantic Ocean, and Southern Ocean. A scale bar indicates 2000 km. The parameters window, titled 'cZrcc.ola Parameters', contains a list of parameters and their values, along with a 'Display Parameters...' button. The parameters are:

- Salinity: <validPixelExpression>quality_flags.invalid && (!quality_flags.land || quality_flags.fresh_inland_water)</validPixelExpression>
- Temperature: <salinity> 35.0 </salinity>
- Ozone: <temperature> 15.0 </temperature>
- Air Pressure: <ozone> 330.0 </ozone>
- TSM factor bpart: <press> 1000.0 </press>
- TSM factor bwit: <TSMfakBpart> 1.72 </TSMfakBpart>
- CHL exponent: <TSMfakBwit> 3.1 </TSMfakBwit>
- CHL factor: <CHLexp> 1.04 </CHLexp>
- Threshold rtosa OOS: <CHL fak> 21.0 </CHL fak>
- Threshold AC reflectances OOS: <thresholdRtosaOOS> 0.005 </thresholdRtosaOOS>
- Threshold for cloud flag on transmi: <thresholdAcReflecOos> 0.1 </thresholdAcReflecOos>
- Atmospheric aux data path: <thresholdCloudTDown865> 0.955 </thresholdCloudTDown865>
- Alternative NN Path: <outputAsRrs> false </outputAsRrs>

The parameters window also includes a 'Display Parameters...' button and an 'OK' button. The software interface includes a menu bar (File, Edit, View, Analysis, Layer, Vector, Raster, Optical, Radar, Tools, Win) and a toolbar with various icons. The bottom of the screen shows a Windows taskbar with various application icons and a system tray with the date and time (14:31, 08.11.2017).

Investigating the Ocean Color from Space

Save your parameter setting from SNAP and copy them into your graph for ease of use.

The screenshot displays the SNAP (Sentinel Application Platform) interface. A dialog box titled 'cZrcc.ola Parameters' is open, showing a list of parameters for a specific process. The parameters include:

- <validPixelExpression> <quality_flags.invalid && (!quality_flags.land || quality_flags.fresh_inland_water)</validPixelExpression>
- <salinity> 35.0 </salinity>
- <temperature> 15.0 </temperature>
- <ozone> 330.0 </ozone>
- <press> 1000.0 </press>
- <TSMfakBpart> 1.72 </TSMfakBpart>
- <TSMfakBwrit> 3.1 </TSMfakBwrit>
- <CHLexp> 1.04 </CHLexp>
- <CHL fak> 31.0 </CHL fak>
- DOS > 0.005 </thresholdRtosaOOS>
- lecOos > 0.1 </thresholdAcReflecOos>
- TDown865 > 0.955 </thresholdCloudTDown865>
- also </outputAsRrs>
- athAndTransmittance > false </deriveRwFromPathAndTransmittance>
- ota > true </useEcmwfAuxData>
- ie </outputRtoa>
- > false </outputRtosaGc>
- Aann > false </outputRtosaGcAann>
- also </outputRpath>
- false </outputTdown>
- ie </outputTup>
- tance > true </outputAcReflectance>
- true </outputRdown>
- ie </outputOos>
- </outputKd>
- </outputUncertainties> true </outputUncertainties>
- </parameters>

The dialog also shows a list of checkboxes for output options:

- Output AC reflectances as rrs
- Derive water reflectance from
- Use ECMWF aux data of source product
- Output TOA reflectances
- Output gas corrected TOSA reflectances
- Output gas corrected TOSA reflectances of auto nn
- Output path radiance reflectances
- Output downward transmittance
- Output upward transmittance

The background shows a globe with labels for continents (EUROPE, ASIA, AFRICA, SOUTH AMERICA) and oceans (North Atlantic Ocean, South Atlantic Ocean, Southern Ocean). The text 'Off Globe' is visible at the bottom of the globe. The Windows taskbar is visible at the bottom of the screen, showing the time as 14:31 on 08.11.2017.

Investigating the Ocean Color from Space

```
<node id="c2rcc">
  <operator>c2rcc.olci</operator>
  <sources>
    <sourceProduct>${sourceProduct}</sourceProduct>
  </sources>
  <parameters>
    <outputAsRrs>true</outputAsRrs>
    <thresholdRtosaOOS>0.05</thresholdRtosaOOS>
    <validPixelExpression>!quality_flags.invalid AND (!quality_flags.land || quality_flags.fresh_inland_water)</validPixelExpression>
    <!--

    <salinity>double</salinity>
    <temperature>double</temperature>
    <ozone>double</ozone>
    <press>double</press>
    <TSMfakBpart>double</TSMfakBpart>
    <TSMfakBwit>double</TSMfakBwit>
    <CHLexp>double</CHLexp>
    <CHLfak>double</CHLfak>
    <thresholdAcReflecOos>double</thresholdAcReflecOos>
    <thresholdCloudTDown865>double</thresholdCloudTDown865>
    <alternativeNNPath>${nnPath}</alternativeNNPath>
    <atmosphericAuxDataPath>string</atmosphericAuxDataPath>
    <deriveRwFromPathAndTransmittance>boolean</deriveRwFromPathAndTransmittance>
    <useEcmwfAuxData>boolean</useEcmwfAuxData>
    <outputRtoa>boolean</outputRtoa>
    <outputRtosaGc>boolean</outputRtosaGc>
    <outputRtosaGcAann>boolean</outputRtosaGcAann>
    <outputRpath>boolean</outputRpath>
    <outputTdown>boolean</outputTdown>
    <outputTup>boolean</outputTup>
    <outputAcReflectance>boolean</outputAcReflectance>
  </parameters>
</node>
```

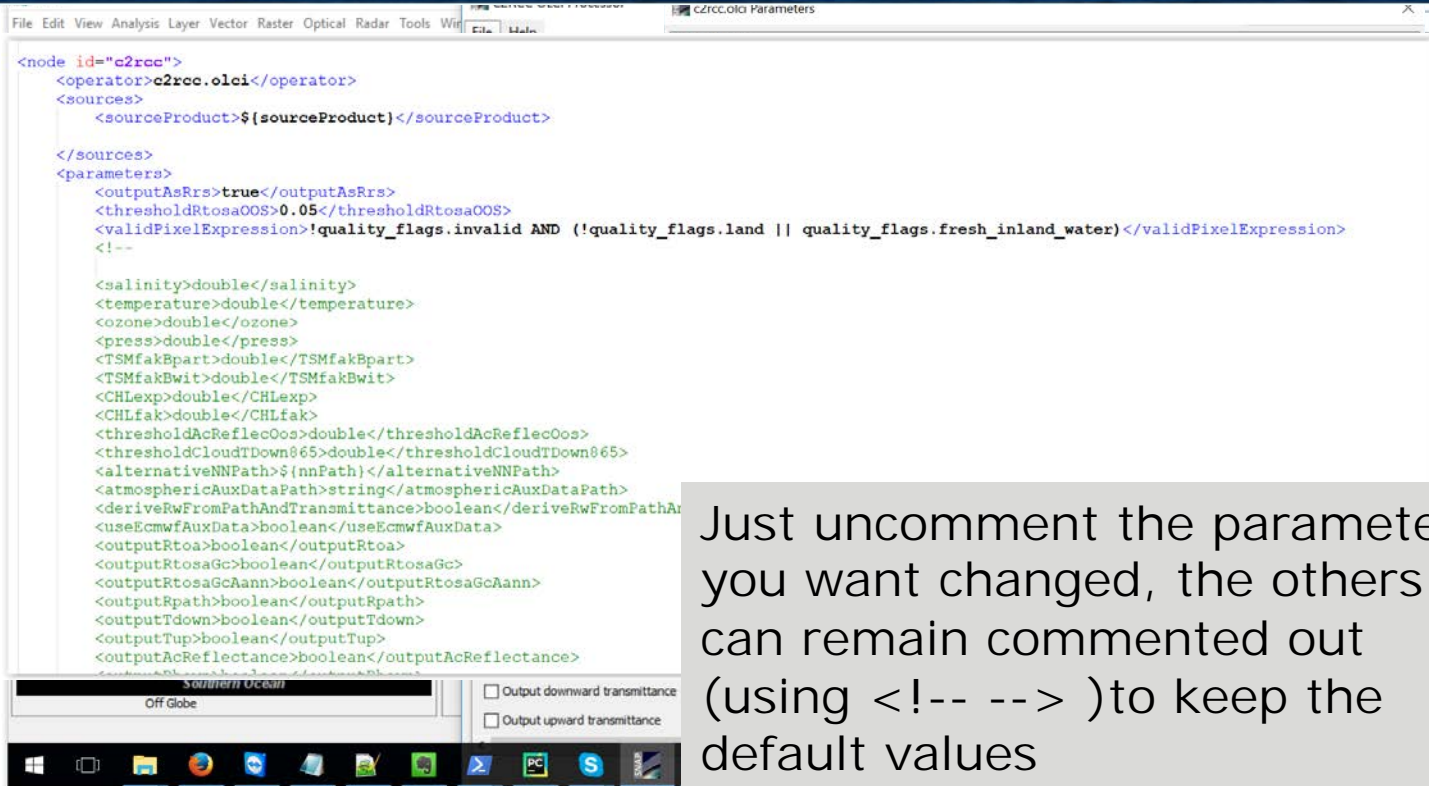
Southern Ocean
Off Globe

Output downward transmittance
 Output upward transmittance

Lat -- Lon -- Zoom -- Level --

14:31 DEU 08.11.2017

Investigating the Ocean Color from Space



```
<node id="c2rcc">
  <operator>c2rcc.olci</operator>
  <sources>
    <sourceProduct>${sourceProduct}</sourceProduct>
  </sources>
  <parameters>
    <outputAsRrs>true</outputAsRrs>
    <thresholdRtosaOos>0.05</thresholdRtosaOos>
    <validPixelExpression>!quality_flags.invalid AND (!quality_flags.land || quality_flags.fresh_inland_water)</validPixelExpression>
    <!--

    <salinity>double</salinity>
    <temperature>double</temperature>
    <ozone>double</ozone>
    <press>double</press>
    <TSMfakBpart>double</TSMfakBpart>
    <TSMfakBwit>double</TSMfakBwit>
    <CHLexp>double</CHLexp>
    <CHL fak>double</CHL fak>
    <thresholdAcReflecOos>double</thresholdAcReflecOos>
    <thresholdCloudTDown865>double</thresholdCloudTDown865>
    <alternativeNNPath>${nnPath}</alternativeNNPath>
    <atmosphericAuxDataPath>string</atmosphericAuxDataPath>
    <deriveRwFromPathAndTransmittance>boolean</deriveRwFromPathAndTransmittance>
    <useEcmwfAuxData>boolean</useEcmwfAuxData>
    <outputRtoa>boolean</outputRtoa>
    <outputRtosaGc>boolean</outputRtosaGc>
    <outputRtosaGcAann>boolean</outputRtosaGcAann>
    <outputRpath>boolean</outputRpath>
    <outputTdown>boolean</outputTdown>
    <outputTup>boolean</outputTup>
    <outputAcReflectance>boolean</outputAcReflectance>

  </parameters>
</node>
```

Just uncomment the parameters you want changed, the others can remain commented out (using `<!-- -->`) to keep the default values

Investigating the Ocean Color from Space

```
<node id="final_merge">
  <operator>Merge</operator>
  <sources>
    <masterProduct>c2rcc</masterProduct>
    <sourceProducts>idepix</sourceProducts>
  </sources>
</node>
'graph>
```

This operator is ONLY available from the command line

Investigating the Ocean Color from Space

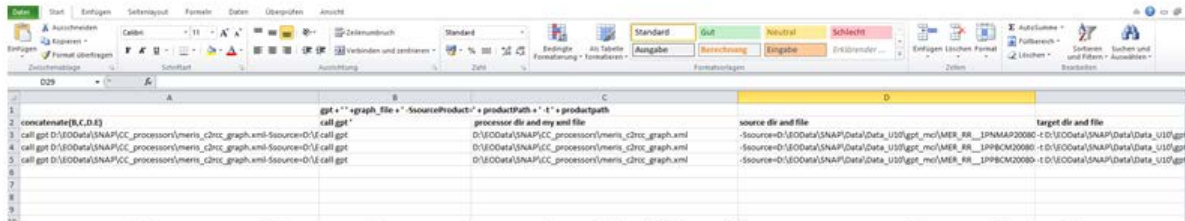
```
<!--  
<graph id="Olci_HSC">  
  <version>1.0</version>  
  <node id="idepix">  
    <operator>Idepix.Sentinel3.Olci</operator>  
    <sources>  
      <sourceProduct>${sourceProduct}</sourceProduct>  
    </sources>  
  </node>  
</graph>
```

C:\progra~1\snap6.0-PREVIEW6\bin\gpt.exe
C:\Users\bc\Desktop\HIGHROC\Training\olci_c2rcc.xml -t
"C:\Users\bc\Desktop\HIGHROC\Training\c2rcc_graph_test.dim" "path/to/your/.SEN3"

```
<validPixelExpression>!quality_flags.invalid AND (!quality_flags.land || quality_flags.fresh_inland_water)</validPixelExpression>  
<!--  
|  
<salinity>double</salinity>  
<temperature>double</temperature>  
<ozone>double</ozone>  
<press>double</press>  
<TSMfakBpart>double</TSMfakBpart>  
<TSMfakBwit>double</TSMfakBwit>  
<CHLexp>double</CHLexp>  
<CHLfak>double</CHLfak>  
<thresholdAcReflecOos>double</thresholdAcReflecOos>  
<thresholdCloudTDown865>double</thresholdCloudTDown865>  
<alternativeNNPath>${nnPath}</alternativeNNPath>  
<atmosphericAuxDataPath>string</atmosphericAuxDataPath>  
<deriveRwFromPathAndTransmittance>boolean</deriveRwFromPathAndTransmittance>  
<useEcmwfAuxData>boolean</useEcmwfAuxData>  
<outputRtoa>boolean</outputRtoa>  
<outputRtosaGc>boolean</outputRtosaGc>  
<outputRtosaGcAann>boolean</outputRtosaGcAann>  
<outputRpath>boolean</outputRpath>  
<outputTdown>boolean</outputTdown>  
<outputTup>boolean</outputTup>  
  <reflectance>boolean</outputAcReflectance>  
  <rhown>boolean</outputRhown>
```

Investigating the Ocean Color from Space

- **Running on several images (batch mode):**
 - Use Excel or other spreadsheet /editor for making a list with all products to be processed (*merisc2rcc_gpt_batch.xlsx*):



	A	B	C	D	E
1		<code>gpt + "*" + graph_file + "*" + SourceProduct + "*" + productPath + "*" + "*" + productPath</code>			
2	<code>concatenate(B,C,D,E)</code>	<code>call gpt *</code>	<code>processor dir and my excel file</code>	<code>source dir and file</code>	<code>target dir and file</code>
3	<code>call gpt D:\EODData\SNAP\CC_processor\mers_c2rcc_graph.xml-Source=D:\call gpt</code>	<code>D:\EODData\SNAP\CC_processor\mers_c2rcc_graph.xml</code>	<code>-Source=D:\EODData\SNAP\Data\Data_US0\gpt_mer_FR_1980M20000-I D:\EODData\SNAP\Data\Data_US0\gpt</code>		
4	<code>call gpt D:\EODData\SNAP\CC_processor\mers_c2rcc_graph.xml-Source=D:\call gpt</code>	<code>D:\EODData\SNAP\CC_processor\mers_c2rcc_graph.xml</code>	<code>-Source=D:\EODData\SNAP\Data\Data_US0\gpt_mer_FR_1980M20000-I D:\EODData\SNAP\Data\Data_US0\gpt</code>		
5	<code>call gpt D:\EODData\SNAP\CC_processor\mers_c2rcc_graph.xml-Source=D:\call gpt</code>	<code>D:\EODData\SNAP\CC_processor\mers_c2rcc_graph.xml</code>	<code>-Source=D:\EODData\SNAP\Data\Data_US0\gpt_mer_FR_1980M20000-I D:\EODData\SNAP\Data\Data_US0\gpt</code>		
6					
7					
8					


- Compile a bat or shell file for running in the command line (*merisc2rcc-gpt-bat.bat*) → go to dir where the bat file is and call it from the terminal:

`>merisc2rcc-gpt-bat.bat`

Investigating the Ocean Color from Space

SNAP / ... / Processing

Bulk Processing with GPT

 **Marco Peters**
Zuletzt geändert 2017-07-27

Bulk Processing with GPT

This little tutorial gives an introduction on bulk processing with the command shell on Windows and Unix systems. The provided scripts try to stay very generic in order to serve multiple processing requirements. However, not every edge case can be covered. The intention is to cover at least the main use cases. The scripts can probably be improved at multiple points but they can give you a starting point to write your own scripts. If you know improvements to the scripts or have questions regarding the usage of the script you are kindly invited to the [SNAP Forum](#).

A general introduction to GPT and graphs can be found at [Creating a GPF Graph](#).

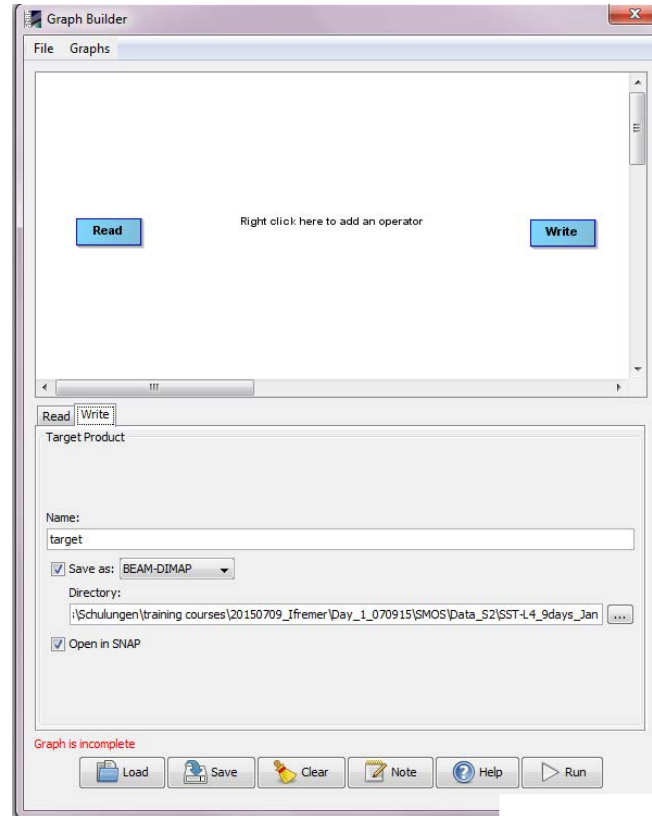
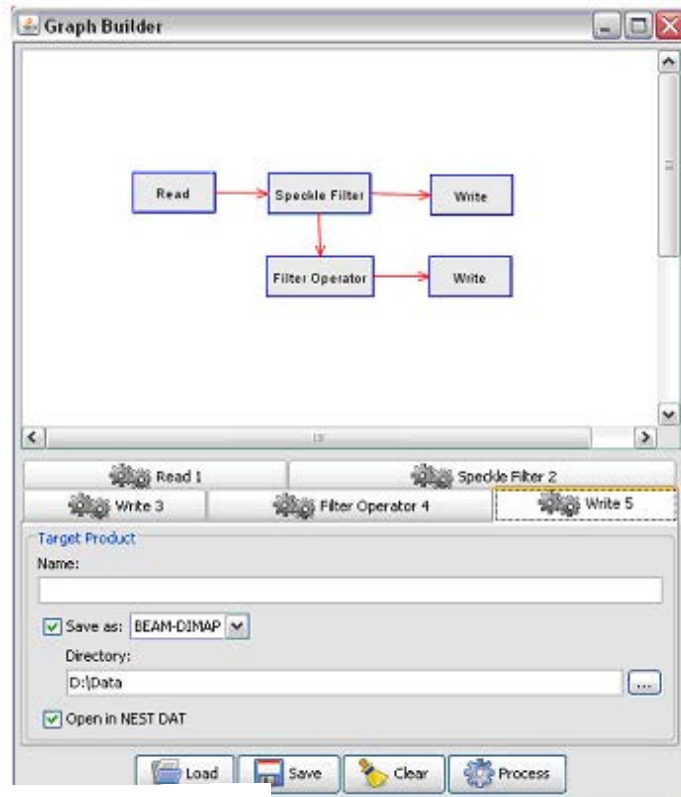
The four files mentioned below are attached for download.

- [processDataset.bat](#) (Windows)
- [processDataset.bash](#) (Unix)
- [reasample_s2.xml](#)
- [resample_20m.properties](#)

Table of Contents

- [The Windows Script](#)

Investigating the Ocean Color from Space



Investigating the Ocean Color from Space

Batch Processing

I/O Parameters

File Name	Type	Acquisition	Track	Orbit	Add
-----------	------	-------------	-------	-------	-----

Target Folder

Save as: BEAM-DIMAP

Directory: C:\Users\Ana

Load Graph

Batch Processing

I/O Parameters Calibration SRGR Multilook

File Name	Type	Acquisition	Track	Orbit	Add	Remove	Clear
ASA_GM1_1PNPDE200907...	ASA_GM1_1P	14.Jul.2009	403	38533			
ASA_GM1_1PNPDE200907...	ASA_GM1_1P	15.Jul.2009	417	38547			
ASA_GM1_1PNPDE200907...	ASA_GM1_1P	16.Jul.2009	432	38562			
ASA_GM1_1PNPDE200907...	ASA_GM1_1P	16.Jul.2009	445	38575			
ASA_GM1_1PNPDE200907...	ASA_GM1_1P	16.Jul.2009	445	38575			
ASA_GM1_1PNPDE200907...	ASA_GM1_1P	17.Jul.2009	446	38576			

Target Folder

Directory: c:\data\output

Investigating the Ocean Color from Space

- There are several ways of obtaining chlorophyll_a and other water quality parameters using empirical or semi-analytical algorithms.
- Input bands can be atmospherically corrected or not, depending on the method selected. This selection will depend on the final objective, for instance, to detect cyanobacteria in lakes, MCI could be a good solution.
- The selection of the algorithm would also depend on the availability of in situ data to calibrate them.
- The optical water type pre-knowledge is always recommended. The OWT classifier could be used in case we do not know the area.

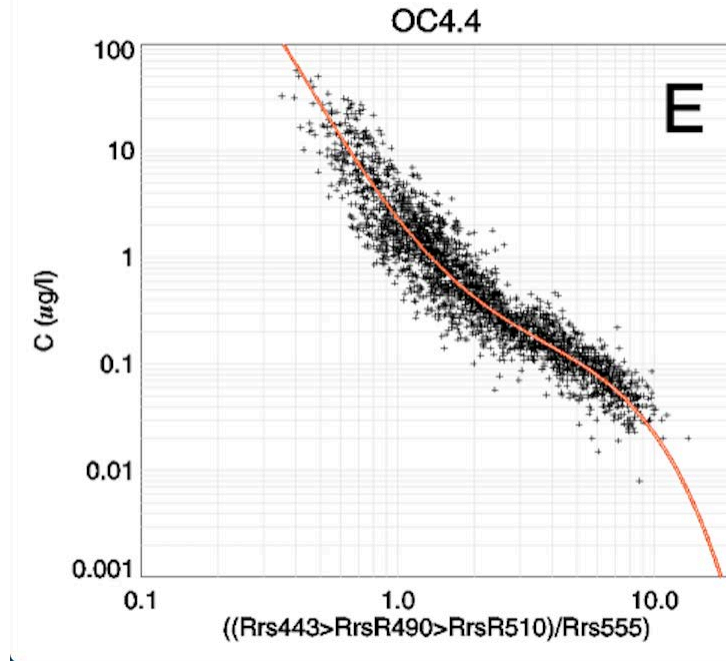
Investigating the Ocean Color from Space

- Apply in-water algorithms for the detection and quantification of chlorophyll-a and related algae blooms.
- Empirical algorithms: apply a simple band ratio algorithm to retrieve a proxy to chlorophyll
- Understand the MCI algorithm.
- Write algorithm in the band math with and without the valid pixel expression.
- Compare results with standard product.

Investigating the Ocean Color from Space

- Open OLCI L1C image and analyse the contents
- Convert TOA radiance to TOA reflectance
- Create a new band containing a chlorophyll index with band math operator
- Design a good colour palette for the index
- Copy the band into the L2 product
- Comparing chlorophyll index with chlorophyll bands from OLCI L2 product

Investigating the Ocean Color from Space



OC4 version 4

$$C = 10.0^{(a(0) + a(1)*R + a(2)*R^2 + a(3)*R^3 + a(4)*R^4)}$$

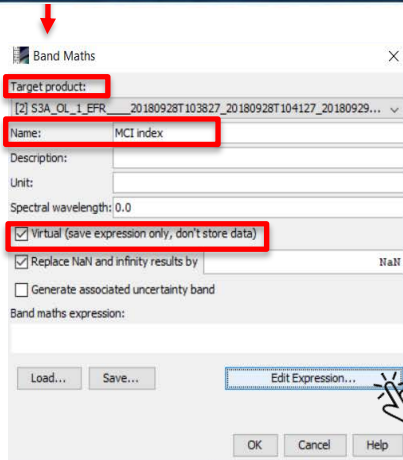
$$R = \text{ALOG10}((Rrs443 > Rrs490 > Rrs510) / Rrs555)$$

$$a = [0.366, -3.067, 1.930, 0.649, -1.532]$$

Generate three band ratios with Band Maths and select the highest values of the three per pixel.

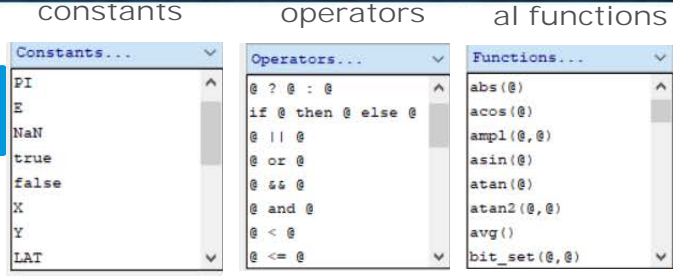
Reflec_443/Reflec_560
Reflec_490/Reflec_560
Reflec_510/Reflec_560

Investigating the Ocean Color from Space

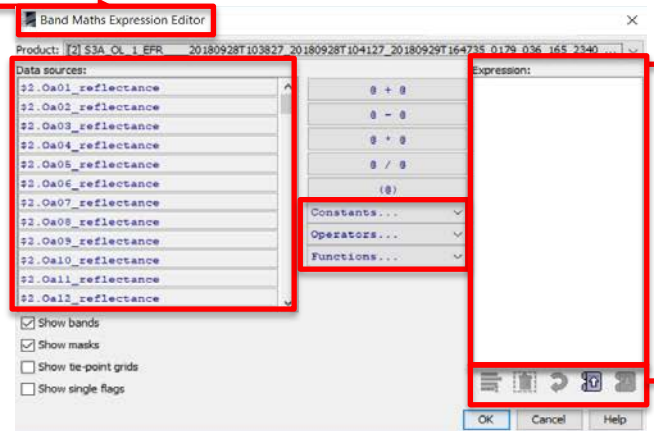


Target Product: By default, it corresponds to the open image. You can select any S3 product.

Name: it is the band name that will be create. Here, MCI index.



Data sources: S3 original data (bands, tie-point grids and flag values). You should select specific data to generate an expression.



Expression: area to set up the math expressions. Here you can apply: mathematical constants, unary operators and mathematical functions.

- Tools to edit expressions:
- Select all
 - Clear
 - Undo
 - Scroll history up
 - Scroll history down

Investigating the Ocean Color from Space

Assign a new name to the band

Target product:
[1] subset_0_of_S3A_OL_1_EFR____20170527T101155_20170527T101355_20171018T181727_0119_018_122_____MR1_R_NT_002.SEN3_radrefl

Name: OC4

Description:

Unit:

Spectral wavelength:

Virtual (save exp
 Replace NaN and
 Generate associa

Band maths expression:

Load... Sa

Band Maths Expression Editor

Data sources:

- solar_flux_band_17
- solar_flux_band_18
- solar_flux_band_19
- solar_flux_band_20
- solar_flux_band_21
- reflec_443
- reflec_490
- reflec_510
- reflec_560

Show bands
 Show masks
 Show tie-point grids
 Show single flags

Operators:

- + e + e
- e - e
- * e * e
- / e / e
- (e)

Constants...
Operators...
Functions...

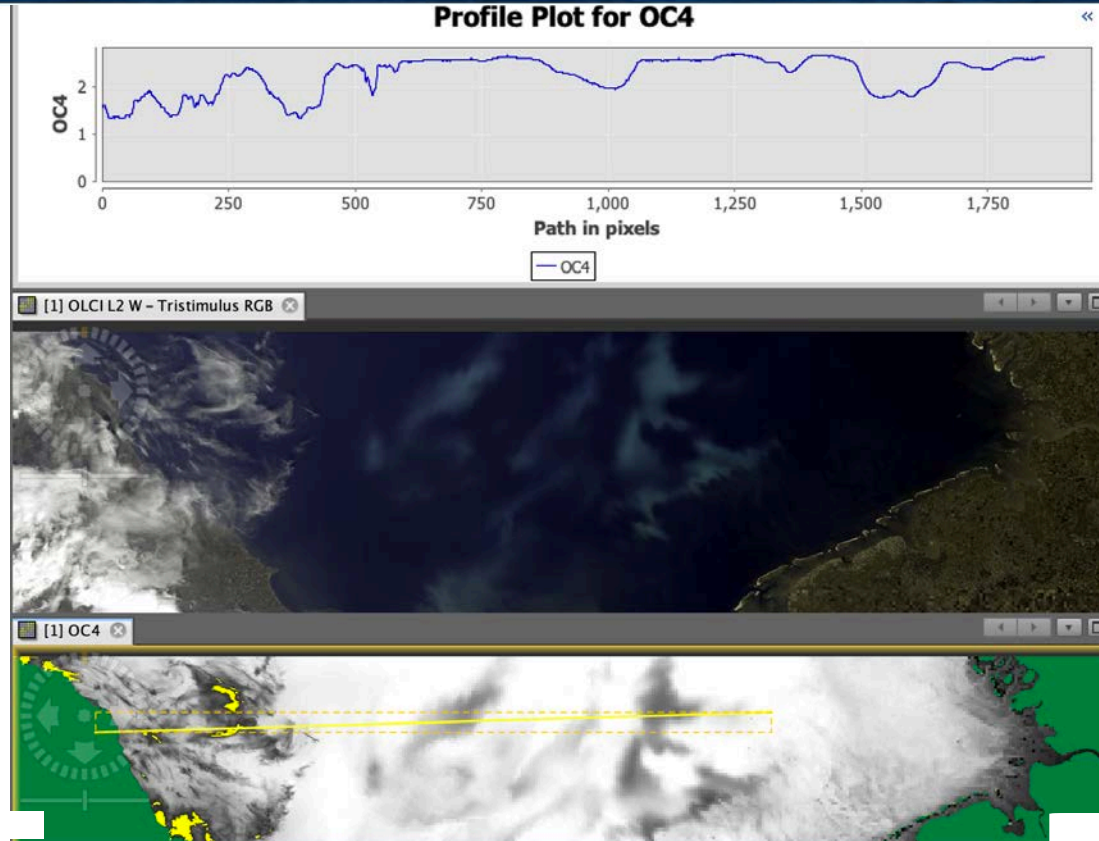
Expression:
max(max(reflec_443/reflec_560,reflec_490/reflec_560),reflec_490/reflec_560)

Edit expression

Ok, no errors.

OK Cancel Help

Investigating the Ocean Color from Space

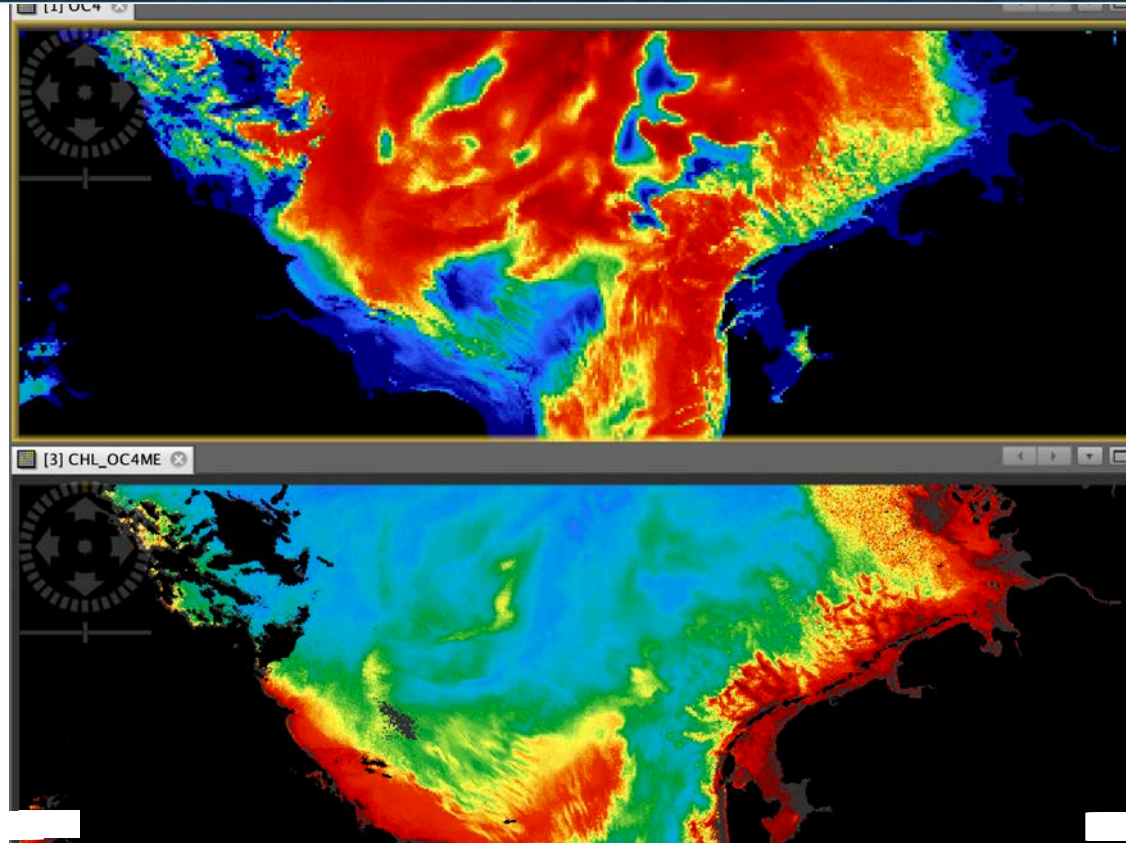


Investigating the Ocean Color from Space

Using the band math, copy the OC4 band into the L2 product. This would allow a direct comparison of their values in the Pixel Information Window.

The image shows two overlapping windows from a software application. The top window, titled "Band Maths", has a "Target product:" dropdown menu containing the text "[3] subset_0_of_S3A_OL_2_WFR____20170527T101155_20170527T101355_20171109T035451_0119_018_122_____MR1_R_NT_002.SEN3". Below this, the "Name:" field is set to "OC4_ratio". The bottom window, titled "Band Maths Expression Editor", has a "Product:" dropdown menu containing the text "[1] subset_0_of_S3A_OL_1_BFR____20170527T101155_20170527T101355_20171018T181727_0119_018_122_____MR1_R_NT_002.SEN3_radrefl". In the "Data sources:" list on the left, the band "\$1.OC4" is selected. In the "Expression:" field on the right, the text "\$1.OC4" is entered. The interface includes various operators like "+", "-", "*", "/", and parentheses, as well as checkboxes for "Show bands", "Show masks", and "Show tie-point grids".

Investigating the Ocean Color from Space

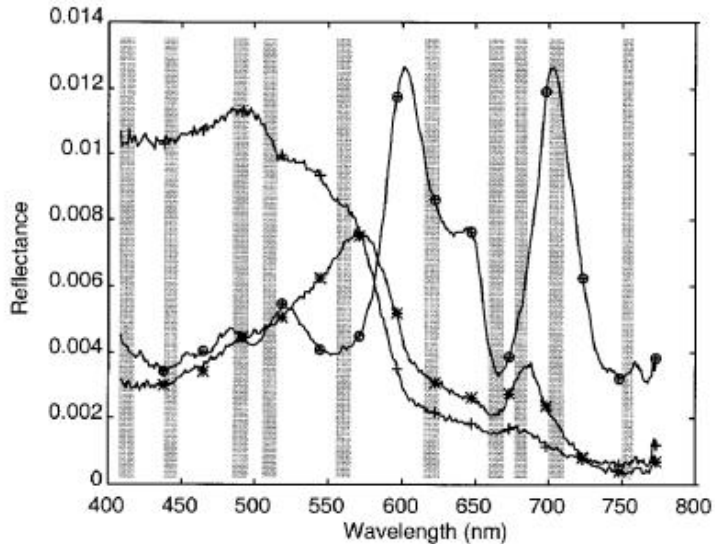


Investigating the Ocean Color from Space

- Open OLCI L1C image and analyse the contents
- Apply MCI to L1 data using the graphic interface
- Manual calculation of MCI with Band Math
- Comparison of both products

```
S3B_OL_1_EFR____20190618T093412_20190618T093712_20190619T143145_0179  
_026_307_1980_MAR_O_NT_002.SEN3
```

Investigating the Ocean Color from Space



$$\text{LineHeight} = L_2 - L_1 - (L_3 - L_1) \frac{(\lambda_2 - \lambda)}{(\lambda_3 - \lambda)}$$

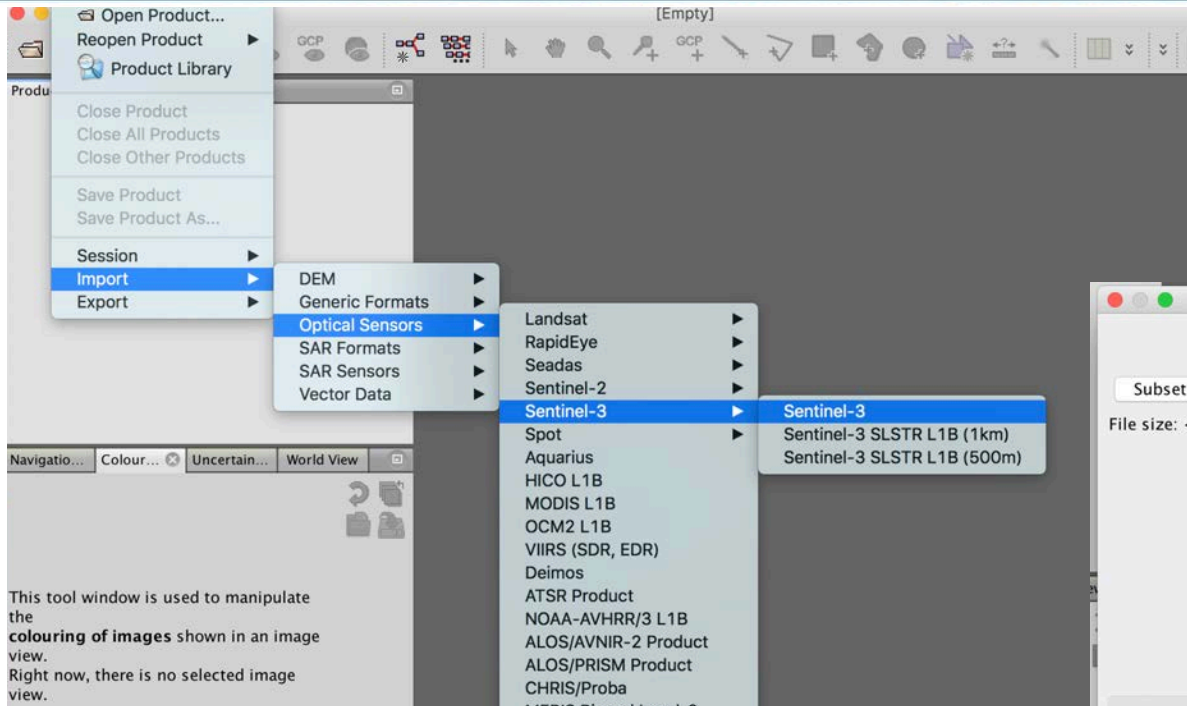
FLH/MCI

The fluorescence line height and maximum chlorophyll index algorithms exploit the height of the measurement in a certain spectral band above a baseline, which passes through two other spectral bands.

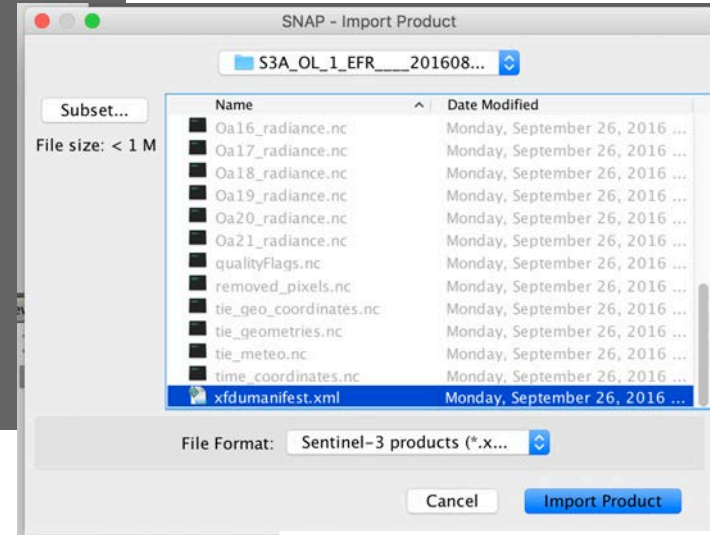
The maximum chlorophyll index (bands 680.5, 708 and 753nm), which can be applied, for example, to L1b measurements can help to indicate red tides.

Relevant wavelengths: 680nm, 708nm, 753nm

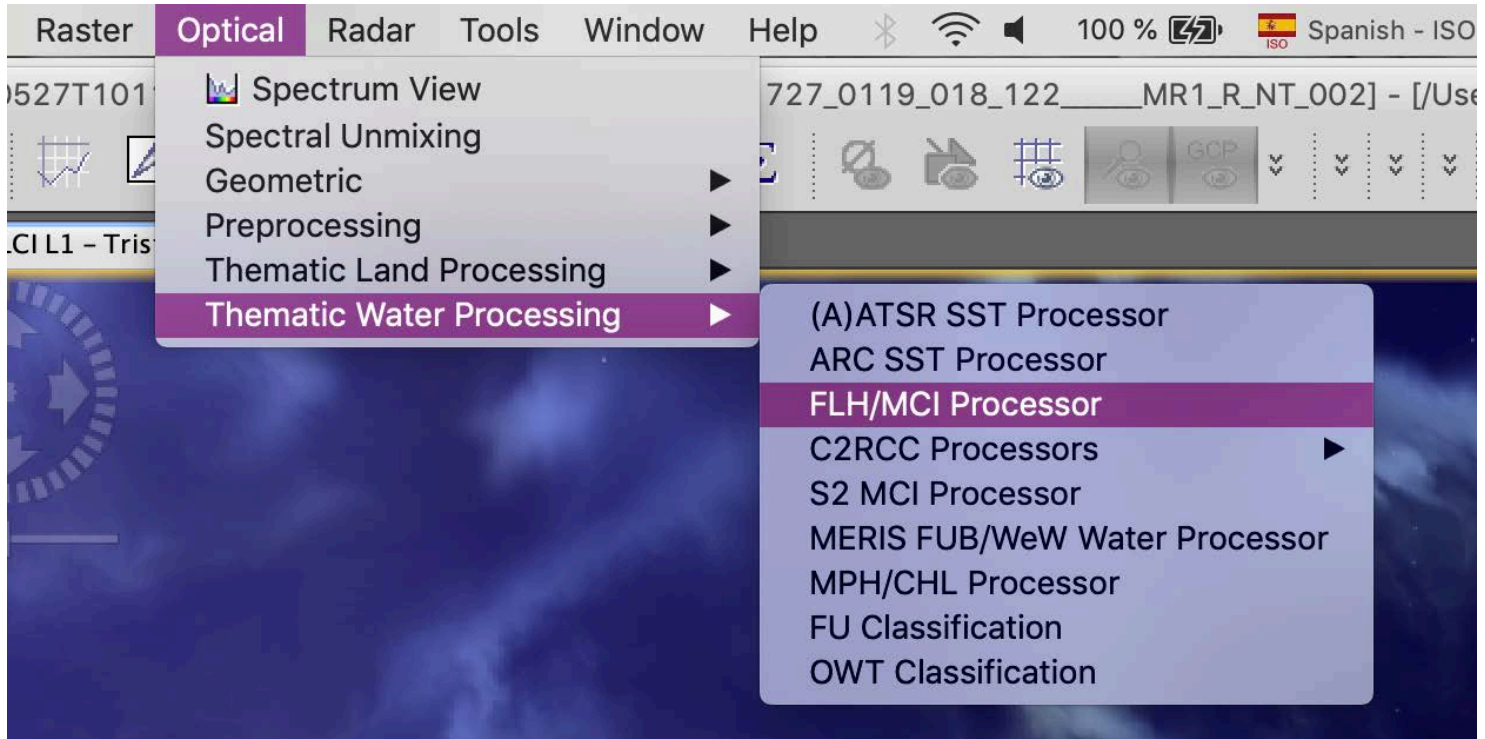
Investigating the Ocean Color from Space



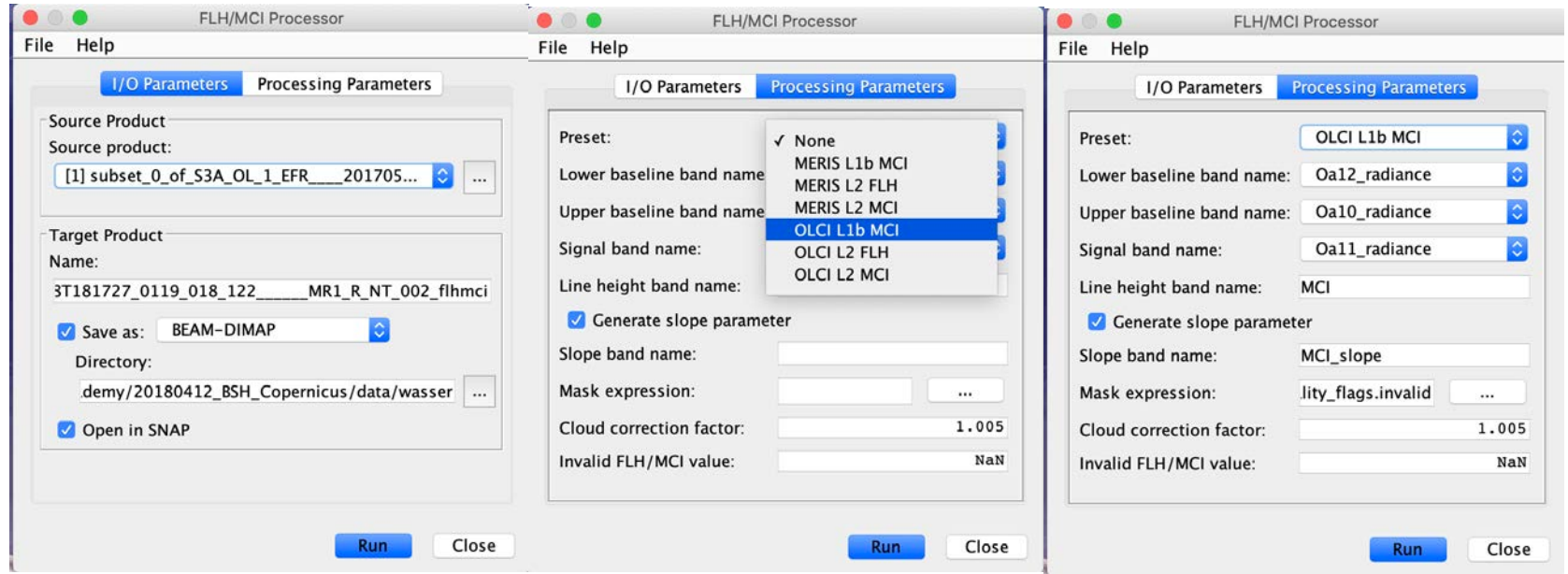
This tool window is used to manipulate the **colouring of images** shown in an image view. Right now, there is no selected image view.



Investigating the Ocean Color from Space



Investigating the Ocean Color from Space



Cloud correction factor: 'If we use $K=1$, then FLH increases as radiance rises in thin cloud. We correct this using $K=1.005$. This is what I mean by "reducing the effect of thin cloud." We then find a mask at band 7 level 1 at about 50 radiance units gives a good picture. Using the same formula on level 2 reflectance data requires a mask at about .017 reflectance in band 7.' , J.F.R. Gower.

Investigating the Ocean Color from Space

Basic operations: models by default.
You must replace "@" by specific data.

Expression: Use the basic operations to add the MCI index. You must replace each @ by selecting required radiance bands.

Without any constraints:

The screenshot shows the 'Band Maths Expression Editor' window. On the left, a list of 'Data sources' includes Oa00_radiance through Oa15_radiance. A red box highlights the Oa10_radiance, Oa11_radiance, Oa12_radiance, and Oa13_radiance bands, with a hand icon pointing to them. In the center, a red box highlights the basic arithmetic operators: '+', '-', '*', and '/'. The 'Expression' field contains the following text:
`Oa11_radiance - Oa10_radiance - (Oa12_radiance - Oa10_radiance) * (708.7-681.25) / (753.75-681.25)`
At the bottom, the 'Ok, no errors.' button is highlighted with a red box and a hand icon pointing to it.

Excluding land and bright pixels
(indicator for clouds):

The screenshot shows the 'Band Maths Expression Editor' window with an error. The 'Expression' field contains the following text:
`quality_flags_land or quality_flags_bright ?
NaN : Oa11_radiance - Oa10_radiance -
(Oa12_radiance -
Oa10_radiance) * (708.7-681.25) / (753.75-681.25`
The 'Missing)' button at the bottom right is highlighted with a red box and an arrow pointing to it, indicating the error.

Once you have added the expression, it is automatically evaluated. If it is successful the result is "Ok, no errors" and you can apply it. OK to run the process.

If the expression is not correct, the error will be pointed. Here, we need a final parenthesis.

Investigating the Ocean Color from Space

1. Without any constraints:

$$\text{Oa11_radiance} - \text{Oa10_radiance} - (\text{Oa12_radiance} - \text{Oa10_radiance}) * (708.7 - 681.25) / (753.75 - 681.25)$$

2. Excluding land and bright pixels (indicator for clouds):

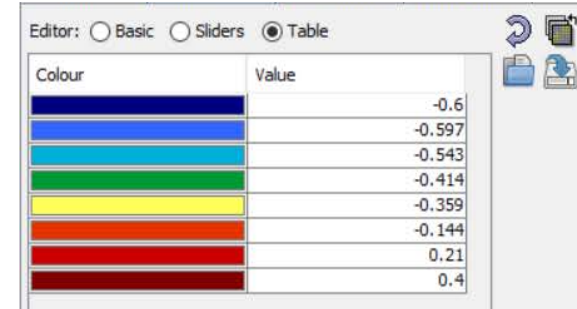
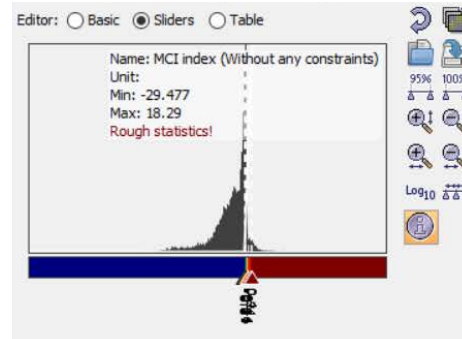
quality_flags_land or quality_flags_bright ? NaN :

$$\text{Oa11_radiance} - \text{Oa10_radiance} - (\text{Oa12_radiance} - \text{Oa10_radiance}) * (708.7 - 681.25) / (753.75 - 681.25)$$

Investigating the Ocean Color from Space

Colour manipulation: is used to add a color palette or modify it. The colour manipulation label is found besides the Navigation label. There are three modes to change the palette: basic, sliders and table.

Basic: Drag and drop it to select a specific palette. Several colour palettes are stored by default.



Display range: establish a minimum and maximum value.

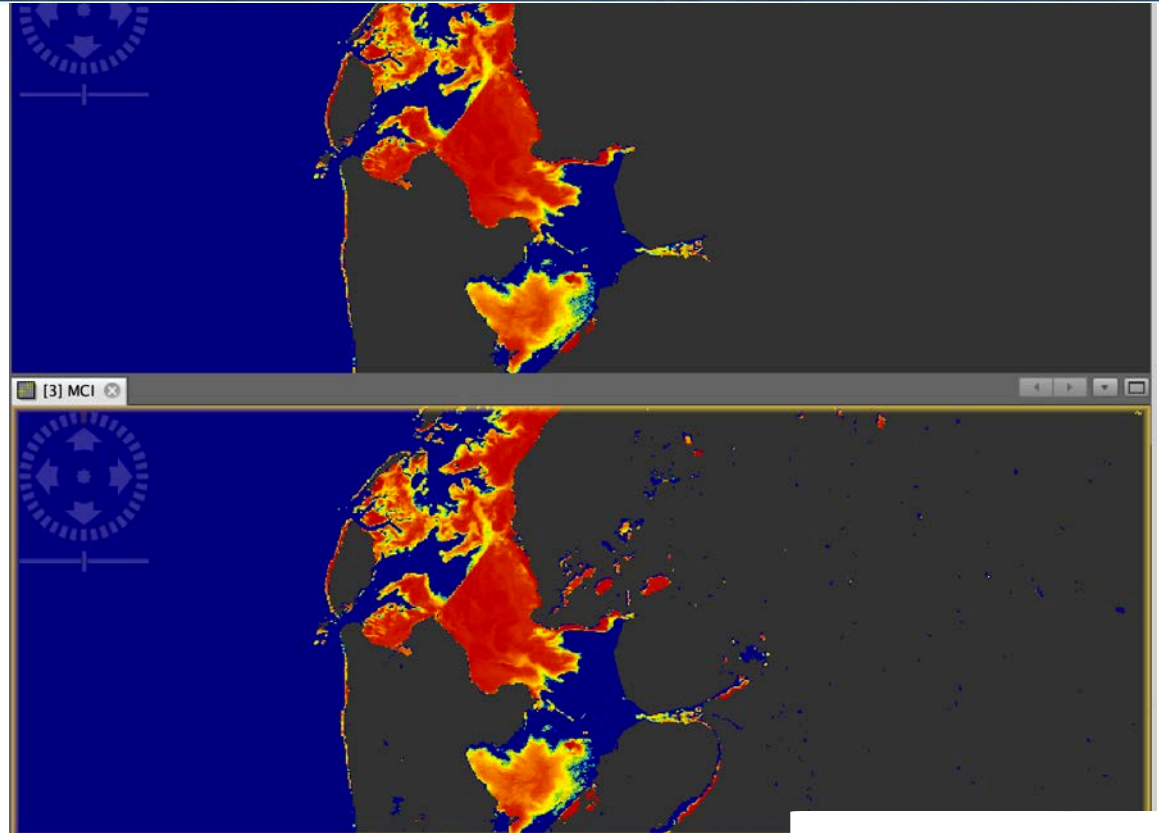
Explore the image values.

Sliders: As the white diagonal line above the histogram indicates, the colour palette will be linearly applied to the samples of the current band. By moving a slider with the mouse you can change its sample value.

Table: the value range can be edited manually and adjusted it according to your necessities.

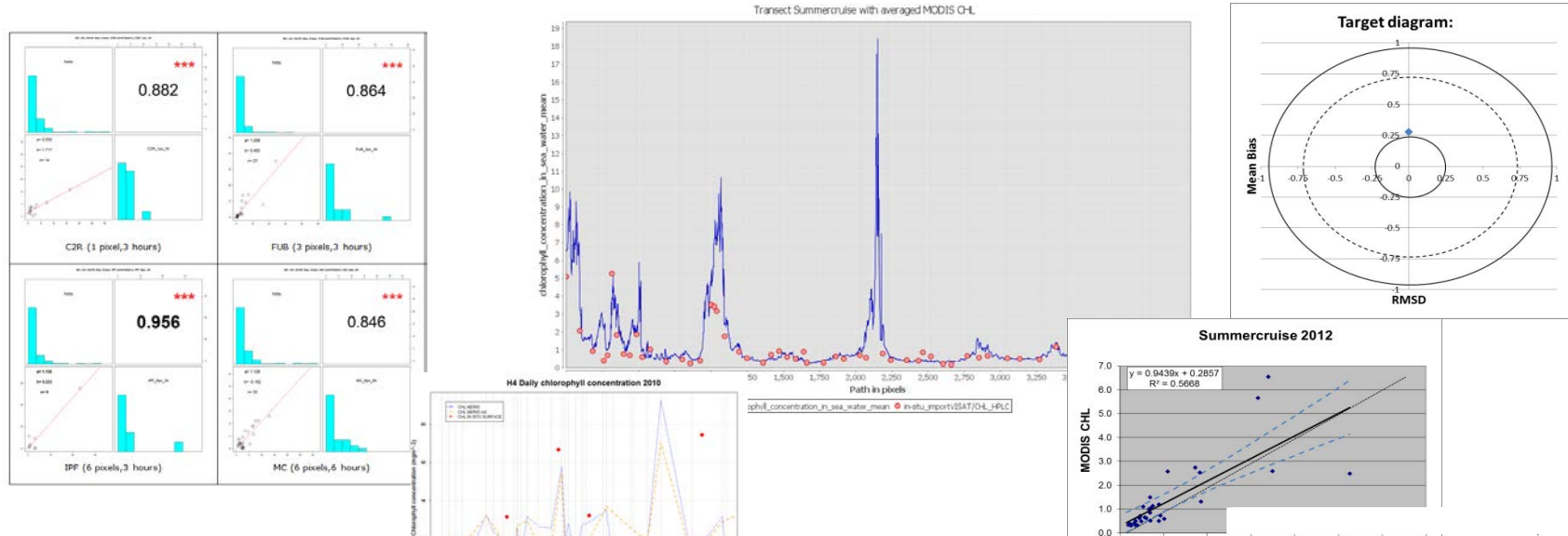


Investigating the Ocean Color from Space



Investigating the Ocean Color from Space

- Parameters to be validated (most common): water leaving radiance or reflectance (Lw, pw), transmittance (t), inherent optical properties (absorption $-a-$ and (back)scattering $-b-$ of several substances), chlorophyll-a, suspended matter, yellow substance, turbidity, transparency.
- Methods used: linear regression statistics and its representation in scatter plots, histograms, time series plots, target diagrams, transects, etc.



Investigating the Ocean Color from Space

- Tabstop separated
- A CSV file must have a header line specifying the column names
 - Latitude: 'lat' or 'latitude'
 - Longitude: 'lon', 'long' or 'longitude'
 - Column(s) with in-situ values
- Points, Lines, Polygons

```
Name Lon Lat Label CHL TSM
Station_1 8.433142 54.063217 Station_1 20 40
Station_2 8.248533 54.270275 Station_2 10 20
Station_3 8.100735 54.493687 Station_3 8 25
Station_4 7.9993324 54.66786 Station_4 12 20
Station_5 8.017196 54.945965 Station_5 13 18
Station_6 8.073449 55.284126 Station_6 14 1
Station_7 7.724219 55.33581 Station_7 16 4
Station_8 7.6007733 55.081173 Station_8 14 2
Station_9 7.526144 54.820965 Station_9 20 3
Station_10 7.4434566 54.583225 Station_10 1 5
Station_11 7.329495 54.252396 Station_11 1 6
Station_12 7.2102094 53.997543 Station_12 4 2
Station_13 7.622393 53.926735 Station_13 6 5
Station_14 8.13969 53.970703 Station_14 3 15
```

.CSV,
.txt

Vector file

```
# MULTIPOLYGONS
#
# Product: subset_1_MER_RR_1PQBCM20030809_101416_000002002018_00466_07534_0168
# Created on: Thu Apr 12 14:48:36 CEST 2012

# Wavelength: 884.94403
org.esa.beam.Multipolygon Name:String Geometry:MultiPolygon radiance_14:Double
0 multipolygon_1 MULTIPOLYGON (((10 47, 0 43, 6 40, 10 47))), ((2 39, 3 39, 2.5 38, 2 39))) 59.383057
1 multipolygon_2 MULTIPOLYGON (((8 38, 2 45, 8 42, 8 38))), ((3 35, 5 36, 3.5 39, 3 35))) 59.383057
```

Investigating the Ocean Color from Space

- Shapefile
 - ESRI shapefile
 - Points, lines, polygons
 - Import of elements as a whole or separately
- MERMAID Extraction file

- Points

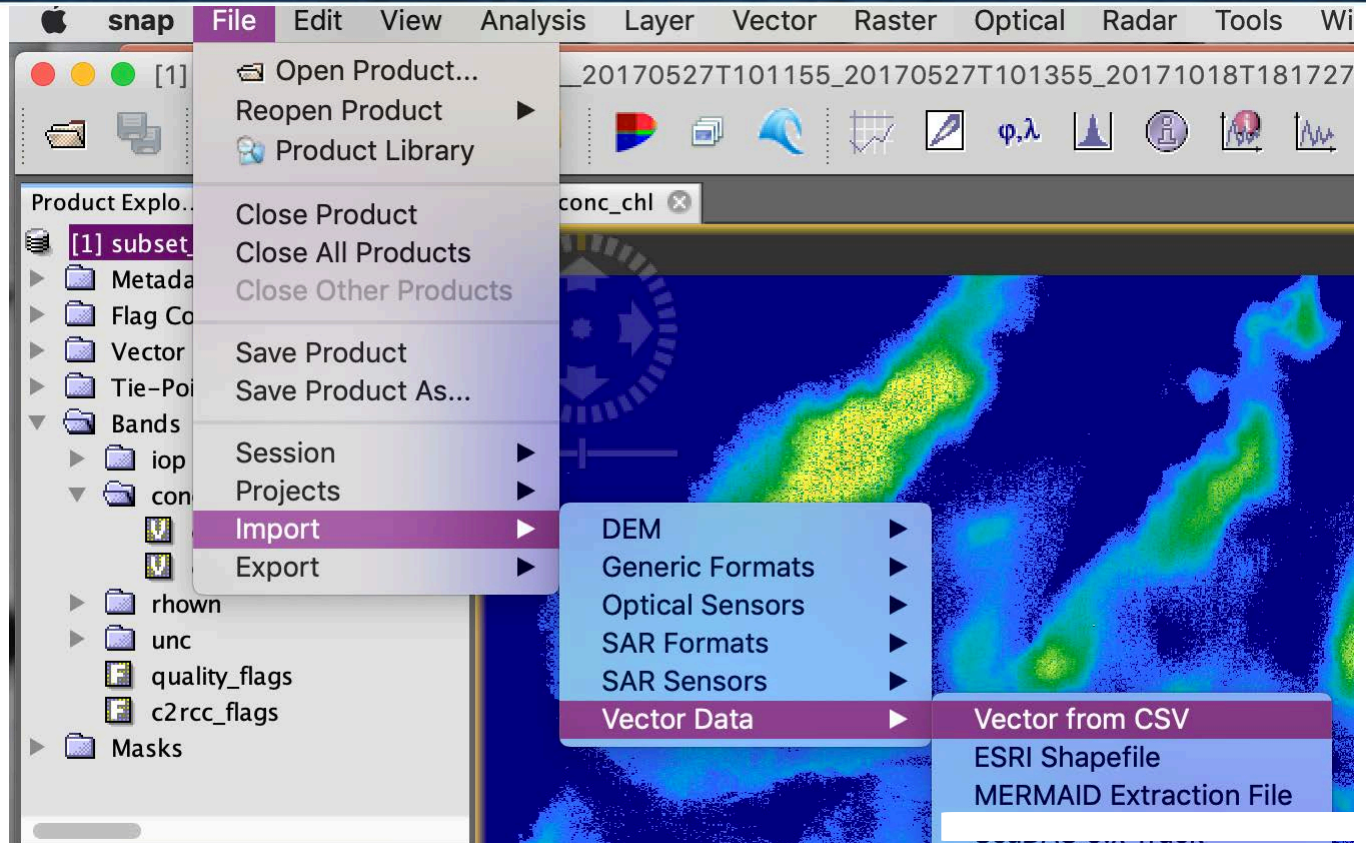
```
PROCESSING_VERSION;site;PI;lat_IS;lon_IS;TIME_IS;thetas_IS;PQC;MQC;chl_IS;  
MEGS_8.0;BOUSSOLE;DavidAntoine;43.367;7.9;20030907T130033Z;42.237999;P00000100;M110110101101111010;1.12E-01;  
MEGS_8.0;BOUSSOLE;DavidAntoine;43.367;7.9;20030908T100033Z;41.848999;P00000100;M110110101101111010;1.10E-01;  
MEGS_8.0;BOUSSOLE;DavidAntoine;43.367;7.9;20030910T101533Z;41.109001;P00000100;M110110101101111010;1.05E-01;  
MEGS_8.0;BOUSSOLE;DavidAntoine;43.367;7.9;20030911T110034Z;38.824001;P00000100;M110110101101111010;1.03E-01;  
MEGS_8.0;BOUSSOLE;DavidAntoine;43.367;7.9;20030914T100033Z;43.737999;P00000100;M110110101101111010;9.60E-02;  
MEGS_8.0;BOUSSOLE;DavidAntoine;43.367;7.9;20030916T101535Z;43.101002;P00000100;M110110101101111010;9.10E-02;
```

- SeaDAS 6.x Track
 - Points

Investigating the Ocean Color from Space

With the cursor on the name of the image, go to File → Import → Vector Data → Vector from CSV

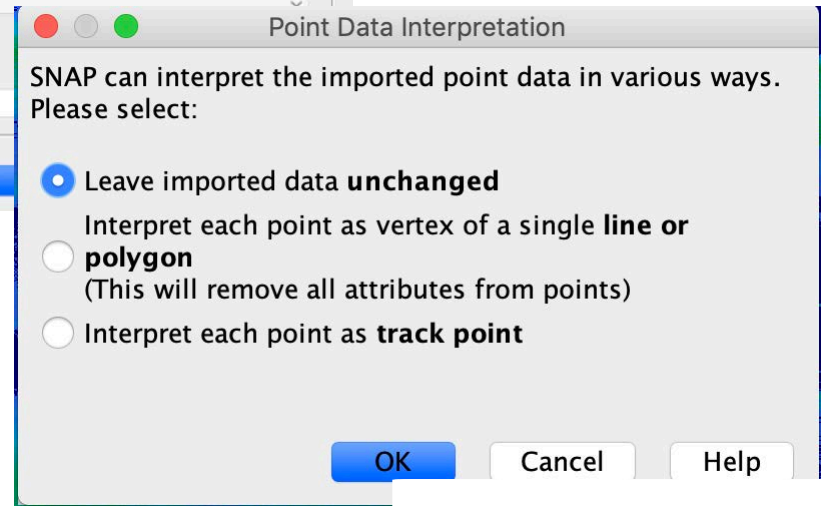
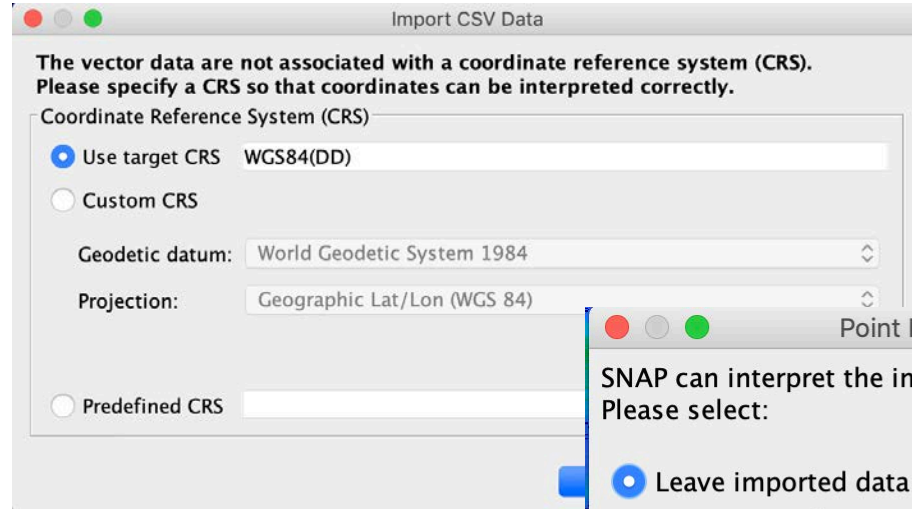
Import file:
fake_NorthSea_2012_import_in-situ.txt



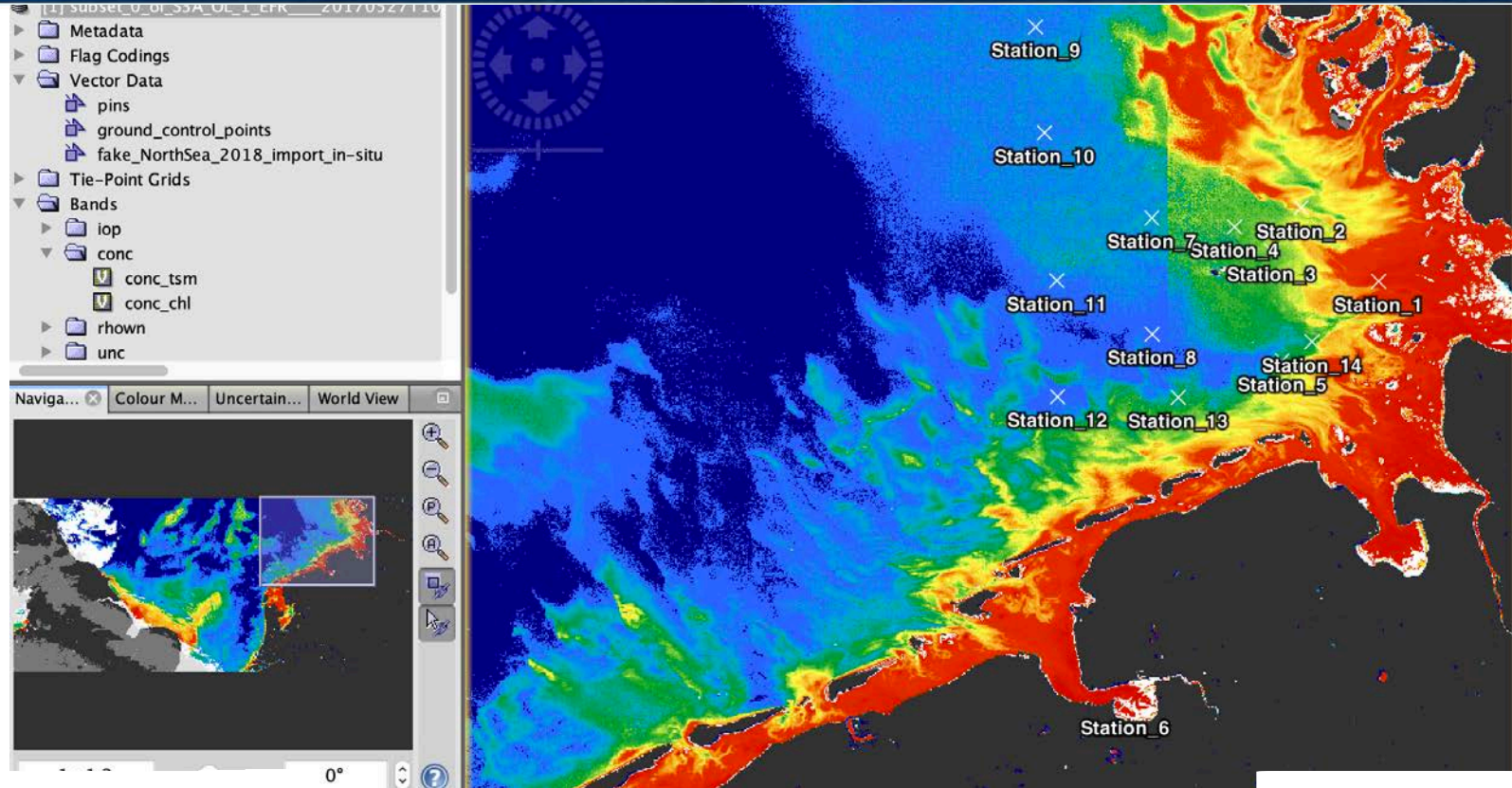
Investigating the Ocean Color from Space

With the cursor on the name of the image, go to File → Import → Vector Data → Vector from CSV

Import file:
faked_insitu_20190618.txt



Investigating the Ocean Color from Space



Investigating the Ocean Color from Space

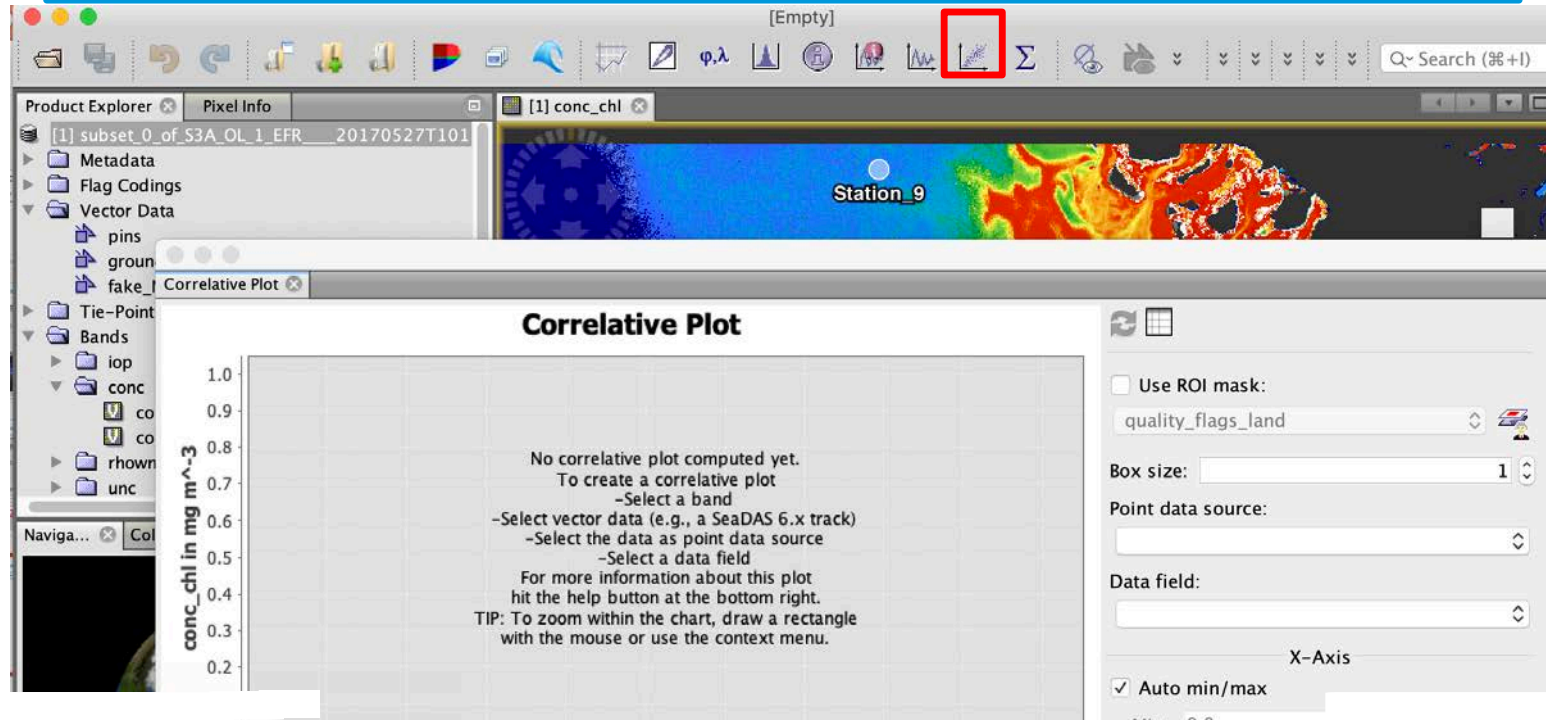
View → Tool Windows → Layer Manager

The screenshot displays the QGIS software interface. The central map shows a satellite-derived ocean color map of the North Sea region, with a color scale ranging from blue (low concentration) to red (high concentration). Several sampling stations are marked with colored circles and labeled: Station 1 (red), Station 2 (green), Station 3 (green), Station 4 (green), Station 5 (green), Station 7 (green), Station 8 (green), Station 9 (blue), Station 10 (blue), Station 11 (blue), Station 12 (blue), and Station 13 (blue). Station 14 is also marked but not labeled. The interface includes several tool windows:

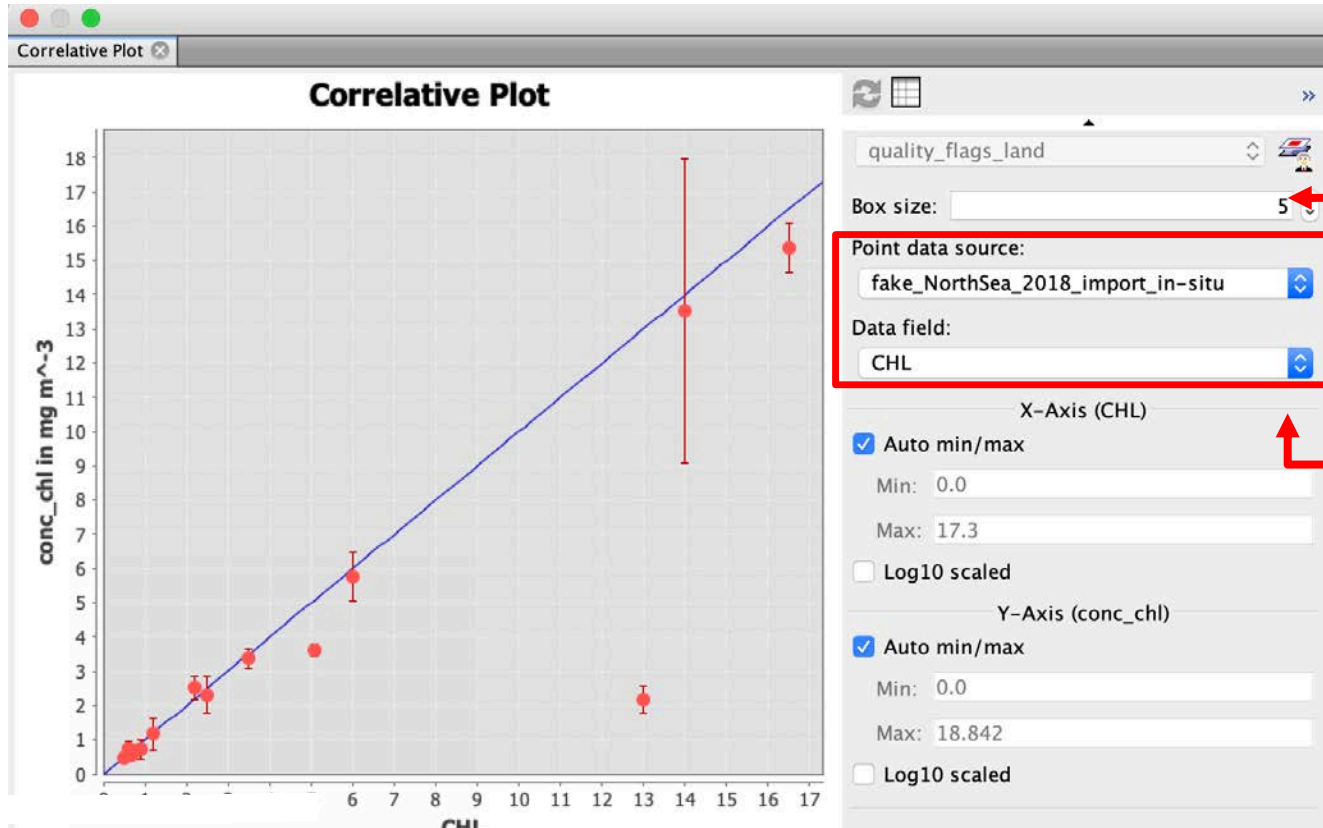
- Product Explorer:** Shows a hierarchical tree of data layers. The 'conc' folder is expanded, showing 'conc_tsm' and 'conc_chl'.
- Layer Manager:** Lists the loaded layers. Under 'Vector data', 'fake_NorthSea_2018_import_in-situ' is selected. Under 'Masks', 'quality_flags_bright' is checked.
- Symbol Properties:** Located at the bottom left, it shows the 'Fill' property is set to 'circle'.

Investigating the Ocean Color from Space

Investigate how the satellite data and in situ data match by using the correlative plot: Analysis → Correlative Plot



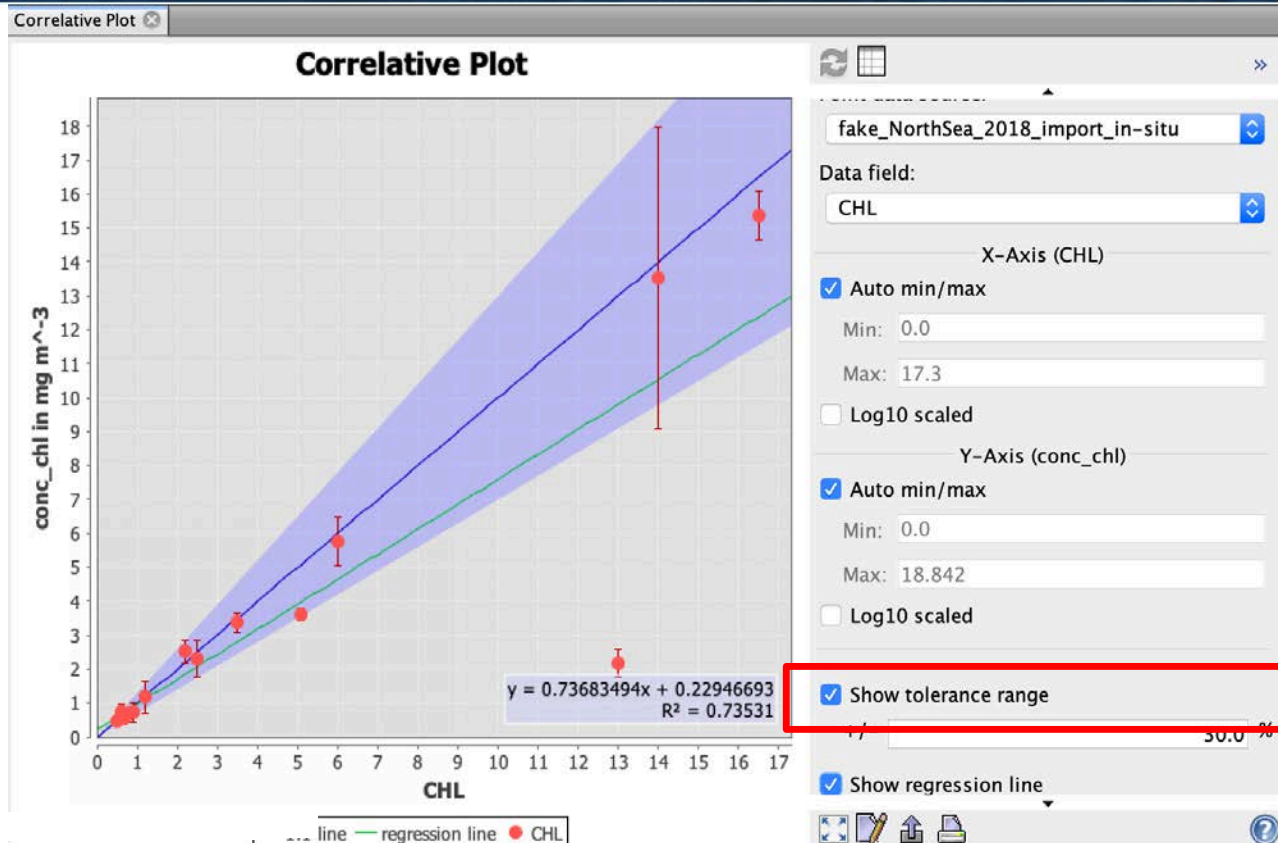
Investigating the Ocean Color from Space



The box size indicates the number of pixels around the central location to calculate statistics: mean, standard deviation (plotted as vertical lines from the point).

Indicate the source of the point data to plot together with the satellite data.

Investigating the Ocean Color from Space

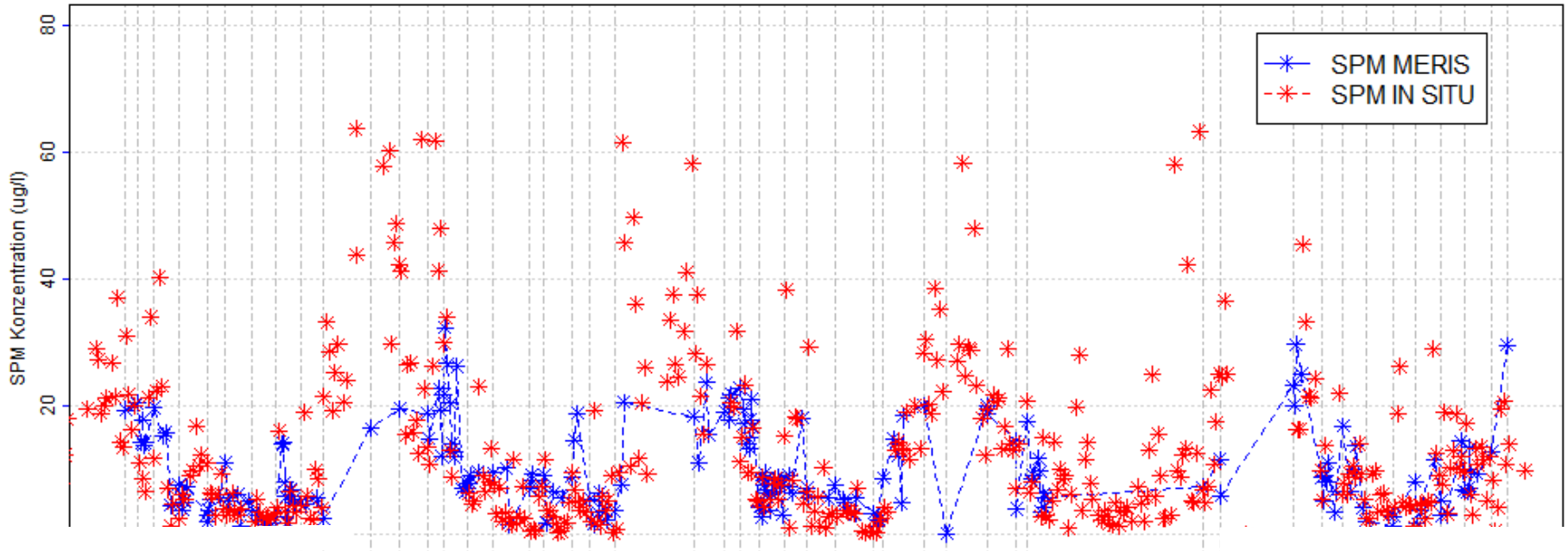


The uncertainty allowed boundaries can also be plotted and percentage change to match conventions. The regression line can also be shown.

Investigating the Ocean Color from Space

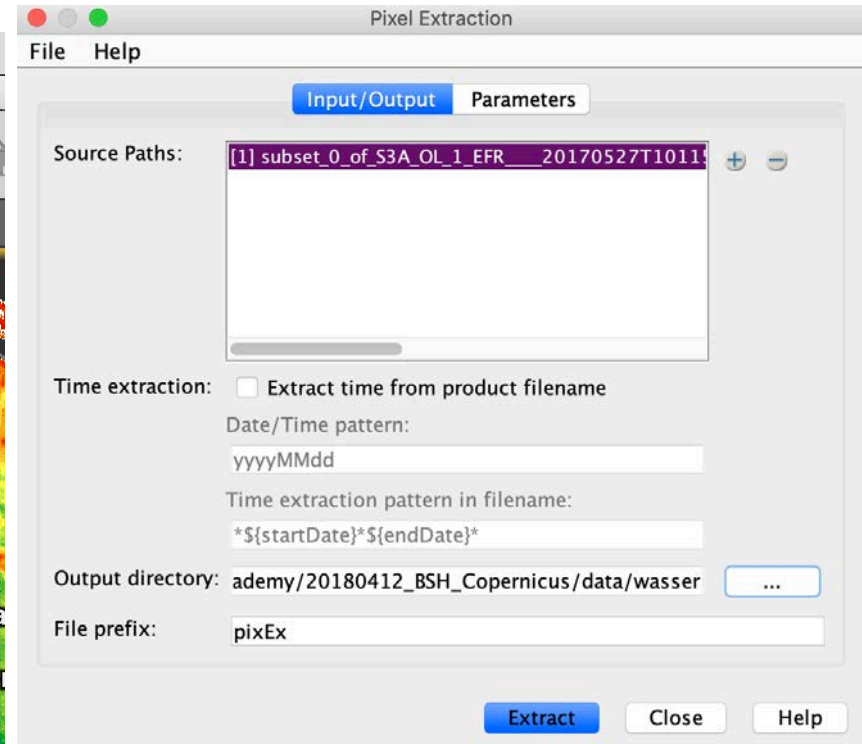
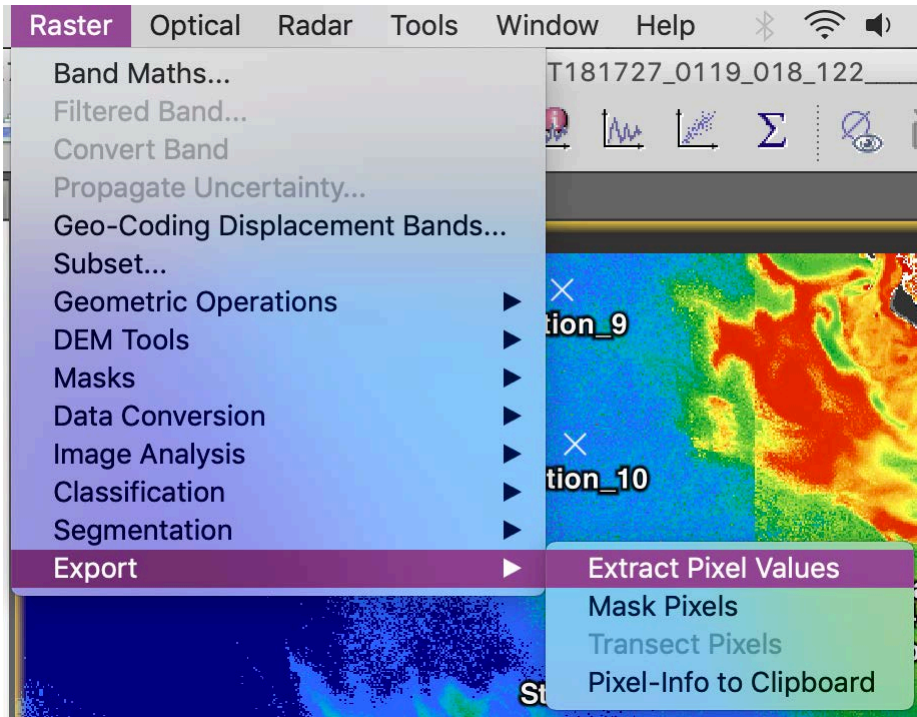
- Extraction of data with Pixel Extraction Tool: using pin locations, we will extract information from the image and export in a .csv or .txt file
- For extraction of match-ups and time series generation using external tools.

Station1 Tageswerte



Investigating the Ocean Color from Space

Raster → Export → Extract Pixel Values



Investigating the Ocean Color from Space

Raster → Export → Extract Pixel Values

Pixel Extraction

File Help

Input/Output Parameters

Coordinates:

Name	Latitude	Longitu...	DateTime (UTC)
Station_1	54.0632	8.4331	
Station_2	54.2703	8.2485	
Station_3	54.1937	8.1007	
Station_4	54.2679	7.9993	

Allowed time differ... Use time difference constraint

Export: Bands Tie-point grids Masks

Window size: 3 x 3

Pixel value aggrega... no aggregation

Expression: Use expression Edit Expression...

Note: The expression might not be applicable to...

Use expression as filter

Sub-scenes: Enable export Border size: 0

Google Earth export: Export output coordinates to Google Earth (...)

Match with original... Include original input

Extract Close Help

Pixel Extraction

File Help

Input/Output Parameters

Allowed time differ... Use time difference constraint

Export: Bands Tie-point grids Masks

Window size: 3 x 3

Pixel value aggrega... no aggregation

- mean
- min
- max
- median

Use expression as filter

Sub-scenes: Enable export Border size: 0

Google Earth export: Export output coordinates to Google Earth (...)

Match with original... Include original input

Investigating the Ocean Color from Space

Expression Editor

Data sources:

- quality_flags.land
- quality_flags.coastline
- quality_flags.fresh_inland_water
- quality_flags.tidal_region
- quality_flags.bright
- quality_flags.straight_risk
- quality_flags.invalid
- quality_flags.cosmetic

Expression: `quality_flags.land or quality_flags.bright`

Show bands

Show masks

Show tie-point grids

Show single flags

Use expression

Note: The expression might not be applicable to...

Use expression as filter

Sub-scenes: Enable export Border size: 0

Google Earth export: Export output coordinates to Google Earth (...)

Match with original... Include original input

- Table of extracted pixels, all bands
- List of input products (product ID)

Name	Lon	Lat	Label	OI	TSM	geometry	Expression n	ProdID	CoordID	Name	Latitude	Longitude	PixelX	PixelY	Date/yyyy-MM	Time/HH:mi	quality	Flag	rows
Station_1	8.433142	54.063217	Station_1	16.5	40 POINT (8.431	TRUE	0	1 Station_1	54.054541	8.430622	2808.5	240.5	27/05/2017	15:12:05	272629760	0.011277			1
Station_1	8.433142	54.063217	Station_1	16.5	40 POINT (8.431	TRUE	0	1 Station_1	54.064759	8.434554	2809.5	240.5	27/05/2017	10:12:05	272629760	0.0114532			2
Station_1	8.433142	54.063217	Station_1	16.5	40 POINT (8.431	TRUE	0	1 Station_1	54.064066	8.438506	2810.5	240.5	27/05/2017	10:12:05	272629760	0.0119490			3
Station_1	8.433142	54.063217	Station_1	16.5	40 POINT (8.431	TRUE	0	1 Station_1	54.062918	8.429323	2808.5	241.5	27/05/2017	10:12:05	272629760	0.0114993			4
Station_1	8.433142	54.063217	Station_1	16.5	40 POINT (8.431	TRUE	0	1 Station_1	54.062226	8.433275	2809.5	241.5	27/05/2017	10:12:05	272629760	0.012042			5
Station_1	8.433142	54.063217	Station_1	16.5	40 POINT (8.431	TRUE	0	1 Station_1	54.061534	8.437226	2810.5	241.5	27/05/2017	10:12:05	272629760	0.012404			6
Station_1	8.433142	54.063217	Station_1	16.5	40 POINT (8.431	TRUE	0	1 Station_1	54.060385	8.428044	2808.5	242.5	27/05/2017	10:12:05	272629760	0.0121006			7
Station_1	8.433142	54.063217	Station_1	16.5	40 POINT (8.431	TRUE	0	1 Station_1	54.059693	8.431995	2809.5	242.5	27/05/2017	10:12:05	272629760	0.012006			8
Station_1	8.433142	54.063217	Station_1	16.5	40 POINT (8.431	TRUE	0	1 Station_1	54.059001	8.435947	2810.5	242.5	27/05/2017	10:12:05	272629760	0.0123625			9
Station_2	8.248533	54.270275	Station_2	6	20 POINT (8.241	TRUE	0	2 Station_2	54.273741	8.246669	2741.5	176.5	27/05/2017	10:12:03	272629760	0.0102069			10
Station_2	8.248533	54.270275	Station_2	6	20 POINT (8.241	TRUE	0	2 Station_2	54.272955	8.250443	2742.5	176.5	27/05/2017	10:12:03	272629760	0.0115944			11
Station_2	8.248533	54.270275	Station_2	6	20 POINT (8.241	TRUE	0	2 Station_2	54.272369	8.245618	2743.5	176.5	27/05/2017	10:12:03	272629760	0.0114355			12
Station_2	8.248533	54.270275	Station_2	6	20 POINT (8.241	TRUE	0	2 Station_2	54.271205	8.245396	2741.5	177.5	27/05/2017	10:12:03	272629760	0.0084598			13
Station_2	8.248533	54.270275	Station_2	6	20 POINT (8.241	TRUE	0	2 Station_2	54.270519	8.24937	2742.5	177.5	27/05/2017	10:12:03	272629760	0.009529			14
Station_2	8.248533	54.270275	Station_2	6	20 POINT (8.241	TRUE	0	2 Station_2	54.269834	8.253345	2743.5	177.5	27/05/2017	10:12:03	272629760	0.0098818			15
Station_2	8.248533	54.270275	Station_2	6	20 POINT (8.241	TRUE	0	2 Station_2	54.268669	8.244123	2741.5	178.5	27/05/2017	10:12:03	272629760	0.0082025			16
Station_2	8.248533	54.270275	Station_2	6	20 POINT (8.241	TRUE	0	2 Station_2	54.267983	8.248097	2742.5	178.5	27/05/2017	10:12:03	272629760	0.0086223			17
Station_2	8.248533	54.270275	Station_2	6	20 POINT (8.241	TRUE	0	2 Station_2	54.267297	8.252072	2743.5	178.5	27/05/2017	10:12:03	272629760	0.0101738			18
Station_3	8.100735	54.193687	Station_3	5.1	25 POINT (8.101	TRUE	0	3 Station_3	54.19771	8.206496	2715.5	213.5	27/05/2017	10:12:04	4194304	0.0074666			19
Station_3	8.100735	54.193687	Station_3	5.1	25 POINT (8.101	TRUE	0	3 Station_3	54.197033	8.20047	2716.5	213.5	27/05/2017	10:12:04	4194304	0.0091413			20
Station_3	8.100735	54.193687	Station_3	5.1	25 POINT (8.101	TRUE	0	3 Station_3	54.196357	8.104445	2717.5	213.5	27/05/2017	10:12:04	4194304	0.007805			21
Station_3	8.100735	54.193687	Station_3	5.1	25 POINT (8.101	TRUE	0	3 Station_3	54.195173	8.095234	2715.5	214.5	27/05/2017	10:12:04	4194304	0.0069454			22
Station_3	8.100735	54.193687	Station_3	5.1	25 POINT (8.101	TRUE	0	3 Station_3	54.194496	8.099208	2716.5	214.5	27/05/2017	10:12:04	4194304	0.00623			23

3 x 3 micropixel size with all bands for the list images available

Investigating the Ocean Color from Space

- Without independent validation, satellite data products lack credibility.
- The main problem for a good validation is the scarcity of matched data sets consisting of reliable in situ measurements, and the estimate of the same variable retrieved from satellites.
- Another problem is the mismatch between a single point sample and the area average acquired from the remote sensor
- The definition of match-ups: is the value of an ocean variable determined from EO with an in situ measurement coincident in space and time.
- The algorithm should be tested using data spanning the whole range of variable values, and this is often difficult to achieve (several in situ campaigns).
- Some limits should be establish when interpreting data. Usually a $\pm 35\%$ of permissible limit is established.
- Validation activities should continue over the whole like of a mission.
- Consistency in the treatment of the complete time series of data from a mission should be ensured (several re-processing and validation tests, even when the mission has ended).

2. Ocean synergy

Investigating the Ocean Color from Space

Spatial and temporal aggregation for analysis of time series and trends
Study correlation between parameters
Working with different sensors: collocation

Investigating the Ocean Color from Space

1. Spatial and temporal aggregation
 - Open three OLCI WRR L2 images
 - Calculate the average product (L3)
 - Parameters of interest: chlorophyll concentration, suspended matter concentration
 - Investigate the L3 product and find the sources of artefacts
2. Combination of products:
 - Collocation of OLCI and SLSTR products
 - Analysis of the combined product:
 - overlay the chlorophyll concentration with the SST band
 - analyse both parameters by swiping and blending
 - show the correlation of both parameters in a scatterplot

Investigating the Ocean Color from Space

Spatial and temporal aggregation

S3A_OL_2_WFR____20190622T101006_20190622T101306_20190623T203014_0179_046_122_1980
_MAR_O_NT_002.SEN3

S3B_OL_2_WFR____20190618T093412_20190618T093712_20190619T163055_0179_026_307_1980
_MAR_O_NT_002.SEN3

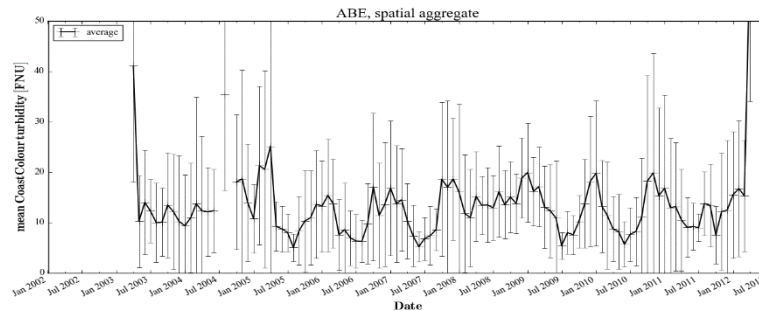
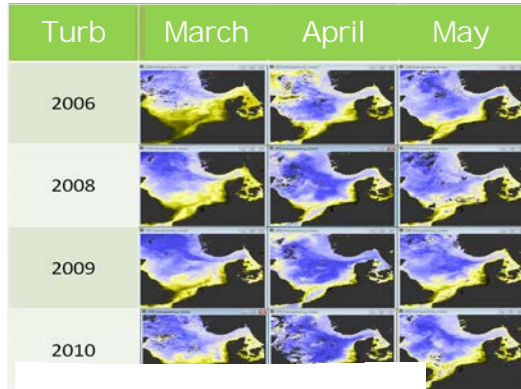
Combination of products:

S3A_OL_2_WFR____20170508T151414_20170508T151614_20171108T175554_0119_017_239____
_MR1_R_NT_002.SEN3

subset_0_of_S3A_SL_2_WST____20170508T022010_20170508T040109_20180929T011826_6059_0
17_231____MR1_R_NT_003

Investigating the Ocean Color from Space

Temporal and spatial aggregation is needed for several applications. It reduces the scatter in time and space and is therefore good for analysing large data sets, e.g. full satellite archives. The temporal interval and the spatial resolution is driven by the question to be answered. Often those products used for further analyses such as heatmaps or time series plots and can be correlated to other data sets.



NLC2	1	2	3	4	5	6	7	8	9	10	11	12
2006					9.5	4.5	10.5	3.5	4.1	4.0	3.7	3.9
2007	3.0	2.3	4.0	16.1	9.9	7.6	4.6	5.4	2.9	3.6	3.6	
2008	1.1	2.7	5.6	12.8	12.9	8.2	7.4	5.2	4.9	3.8	2.9	3.6
2009	2.9	3.2	6.1	8.8	11.0	5.1	4.0	4.4	2.8	1.7		2.9
2010	3.0	2.0	6.2	11.3	4.6	11.0	8.5	5.8	5.0	4.4	3.7	5.6
2011	3.8	2.1	2.8	13.0	13.7	6.3	6.6	4.6	3.5	3.5		

Investigating the Ocean Color from Space

The image shows a software interface with a menu on the left and a dialog box in the foreground. The menu path is: **Geometric Operations** > **Level-3 Binning**. The dialog box, titled "Add product", contains a list of three products, each with a checked checkbox:

- [1] S3A_OL_2_WRR___20170811T104539_20170811T104739_20171221T224636_0119_021_051___MR1_R_NT_002.SEN3
- [2] S3A_OL_2_WRR___20170819T103812_20170819T104012_20171221T232557_0119_021_165___MR1_R_NT_002.SEN3
- [3] S3A_OL_2_WRR___20170831T102659_20170831T102859_20171222T002326_0119_021_336___MR1_R_NT_002.SEN3

At the bottom of the dialog box, there are radio buttons for "Select all" (checked) and "Select none". A red arrow points from a blue-bordered box containing the text "Click here to add the WRR products" to a plus sign icon in the background interface.

Investigating the Ocean Color from Space

The screenshot shows a software window titled "Binning" with a menu bar containing "File" and "Help". Below the menu bar are three tabs: "I/O Parameters", "Filter" (which is selected), and "Configuration".

The "Filter" tab is divided into two sections:

- Spatial Filter / Region:** This section contains three radio button options:
 - Compute the geographical region according to extents of input products
 - Use the whole globe as region
 - Enter WKT: [text input field]
- Specify region:** This section contains four text input fields for bounding box coordinates:
 - North: 75.0 °
 - West: -15.0 °
 - East: 30.0 °
 - South: 35.0 °

The **Temporal Filter** section contains the following controls:

- Time filter method: A dropdown menu currently set to "NONE".
- Start date: A text input field followed by the format "yyyy-MM-dd(HH:mm:ss)".
- Period duration: A text input field followed by the unit "days".
- Min data hour: A text input field.

At the bottom of the window, there are three buttons: "Run" (highlighted in blue), "Close", and "Help".

Investigating the Ocean Color from Space

Selection of bands to be averaged

Specification of the aggregator

Definition of intermediate variables (e.g. band combinations)

Valid pixel expression (important!!)

Spatial resolution: in our case we will use a 10km/pixel

I/O Parameters Filter Configuration

Aggregator	Source Bands	Parameters	Target Bands
AVG	CHL_NN	targetName = weightCoeff = 0.0 outputCounts = false outputSums = false	CHL_NN_mean CHL_NN_sigma
AVG	TSM_NN	targetName = weightCoeff = 0.0 outputCounts = false outputSums = false	TSM_NN_mean TSM_NN_sigma

Intermediate Source Bands (optional)

Name	Expression
------	------------

Valid pixel expression: !GIN and not WQSF_lsb.OCNN_FAIL

#Rows (90N - 90S): 40076

Spatial resolution (km/px): 0,5

Super-sampling: 1

Run Close Help

Edit Aggregator

Source band name: CHL_NN

Target band name prefix (optional):

Weight coefficient: 0.0

Output counts

Output sums

OK Cancel

Expression Editor

Data sources:

- WQSF_lsb.INVALID
- WQSF_lsb.WATER
- WQSF_lsb.LAND
- WQSF_lsb.CLOUD
- WQSF_lsb.CLOUD_AMBIGUOUS
- WQSF_lsb.CLOUD_MARGIN
- WQSF_lsb.SNOW_ICE
- WQSF_lsb.INLAND_WATER

Expression:

```
not WQSF_lsb.CLOUD and not  
WQSF_lsb.CLOUD_AMBIGUOUS and not  
WQSF_lsb.CLOUD_MARGIN and not  
WQSF_lsb.OCNN_FAIL and not  
WQSF_msb.ANNOT_TAU0
```

Show bands

Show masks

Show tie-point grids

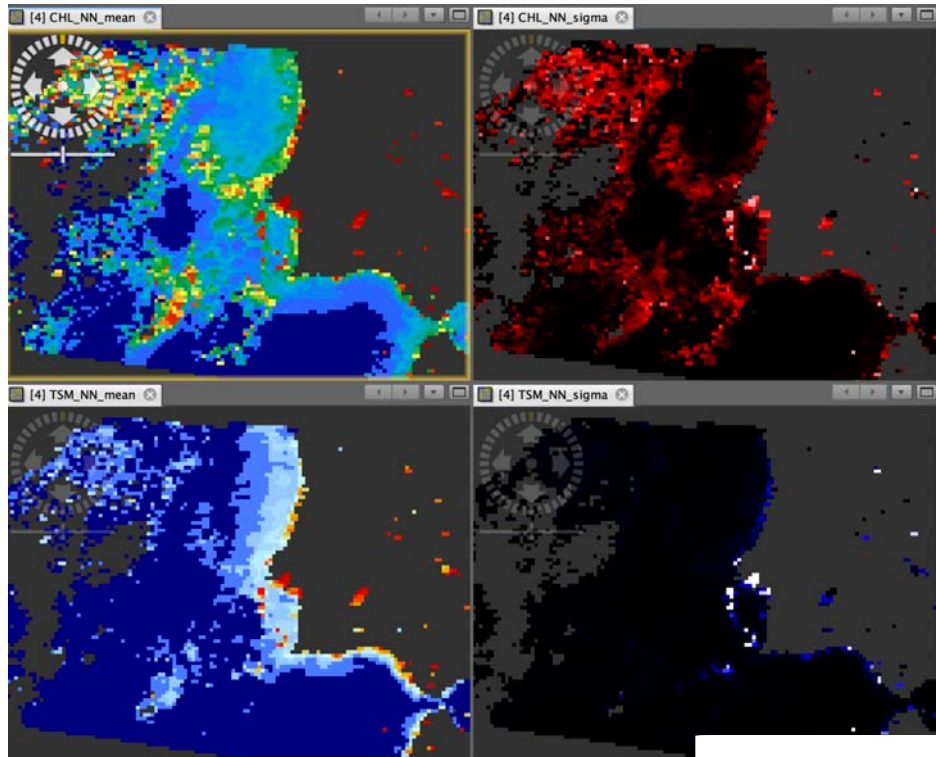
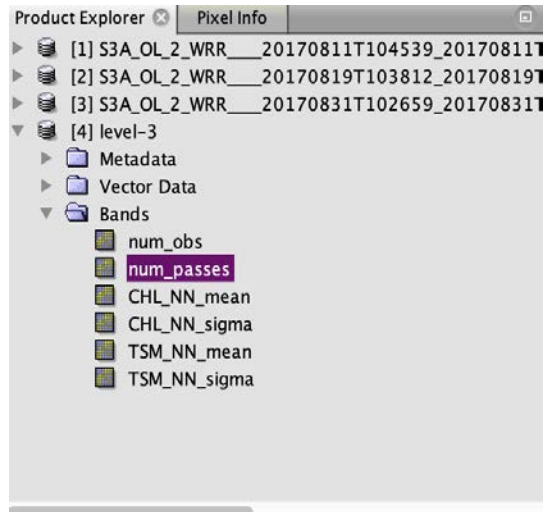
Show single flags

Ok, no errors.

OK Cancel Help

Investigating the Ocean Color from Space

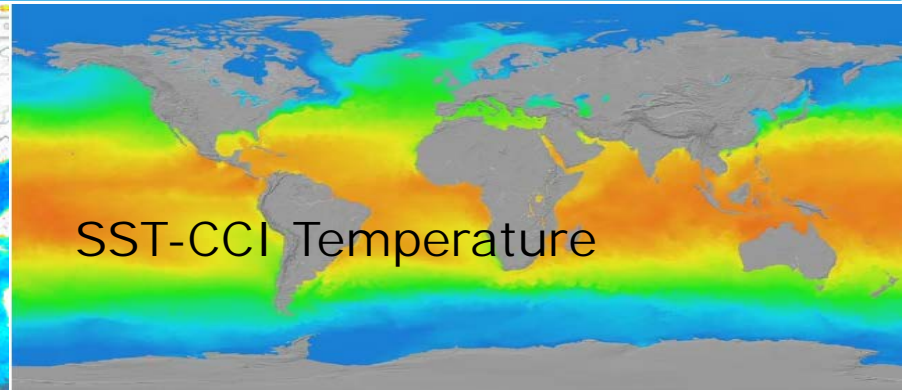
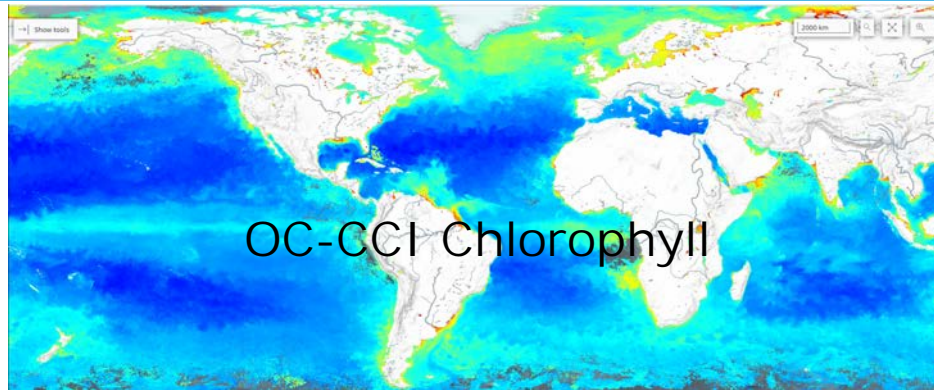
CHL_NN and TSM_NN,
with 10 km/pixel
spatial resolution



Investigating the Ocean Color from Space

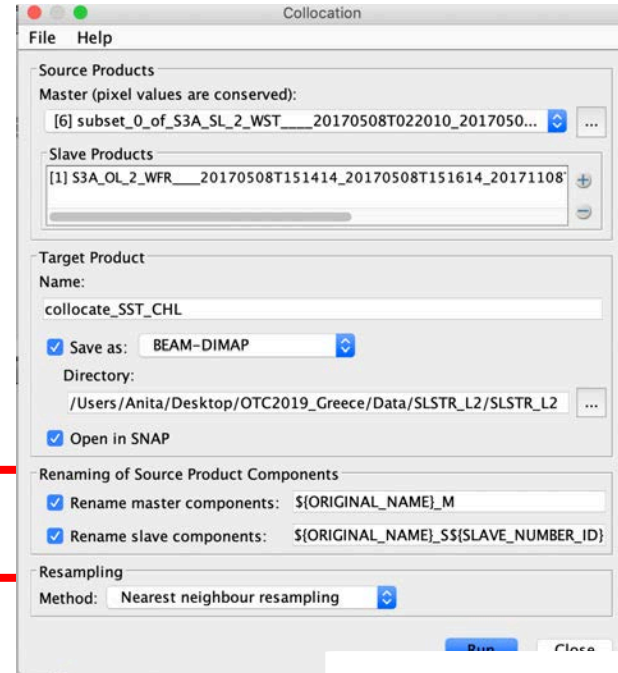
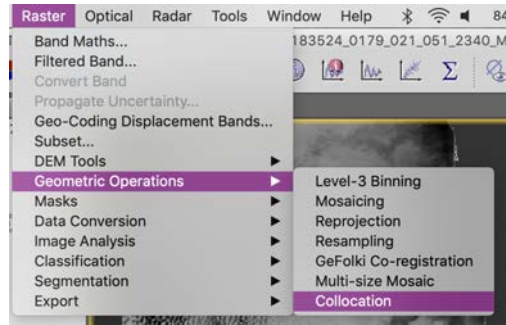
Combining information from different sources is key for a good analysis of the environment. The influence of the temperature and upwelling on the chlorophyll production is one example. Where phytoplankton grow depends on available sunlight, temperature, and nutrient levels. When cold and nutrient rich deep water reaches the surface, phytoplankton starts to grow in the combination with sun light.

Coastal upwelling systems represent less than 1% of the total area of the oceans, but are responsible for about 11% of the world oceanic primary production (Chavez and Toggweiler, 1995).



Investigating the Ocean Color from Space

The collocation tool enables to combine two different data sets to the same raster. The raster is defined by the master product.



The bands of the input products can be pre or post fixed

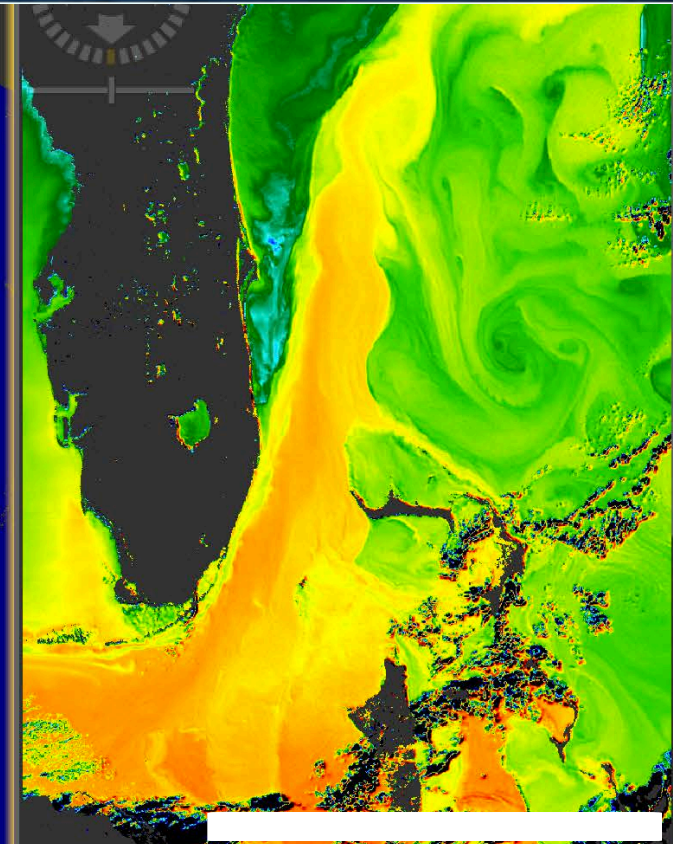
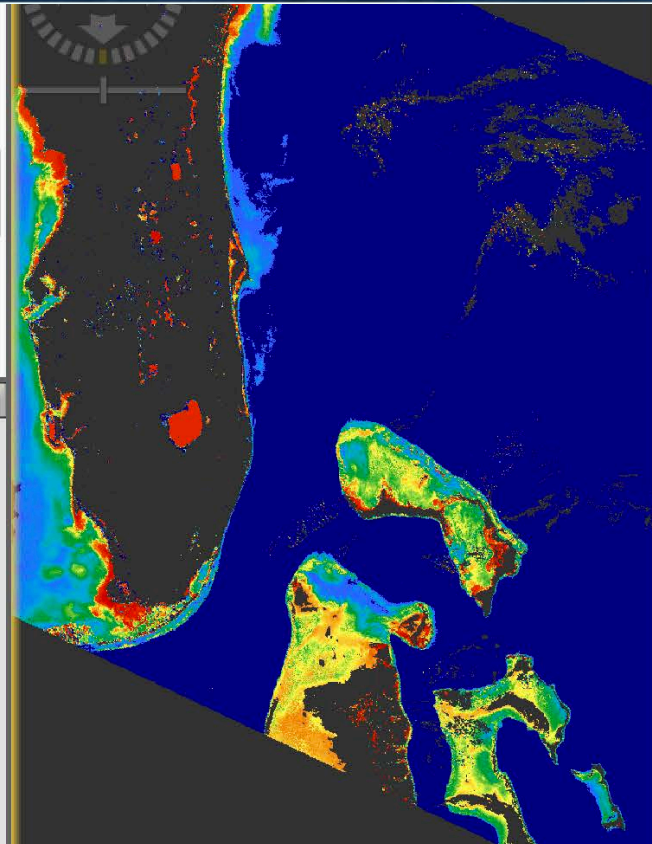
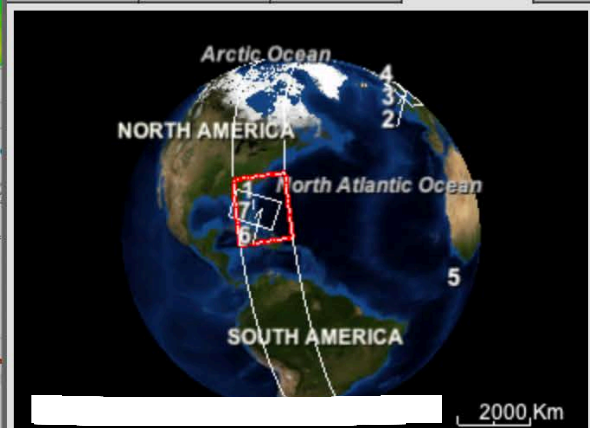
Specification of interpolation method



Investigating the Ocean Color from Space

- satellite Zenith_angle_M
- sea_ice_fraction_M
- sea_ice_fraction_dtime_from_sst_M
- sea_surface_temperature_M
- sses_bias_M
- sses_standard_deviation_M
- sst_algorithm_type_M
- sst_dtime_M
- sst_theoretical_uncertainty_M
- wind_speed_M
- wind_speed_dtime_from_sst_M
- WQSF_Isb_S
- WQSF_mch_S

Navigation... Colour Ma... Uncertain... World ...



Investigating the Ocean Color from Space

Mask Manager

Name	Type	Colour	Trans...	Description
<input type="checkbox"/> WQSF_Isb_WATER_S	Maths	Blue	0.5	WQSF_Isb.WATER
<input type="checkbox"/> WQSF_Isb_LAND_S	Maths	Green	0.5	WQSF_Isb.LAND
<input checked="" type="checkbox"/> WQSF_Isb_CLOUD_S	Maths	White	0	WQSF_Isb.CLOUD
<input checked="" type="checkbox"/> WQSF_Isb_CLOUD_AMBIGUOUS_S	Maths	White	0	WQSF_Isb.CLOUD_AMBIGUOUS
<input checked="" type="checkbox"/> WQSF_Isb_CLOUD_MARGIN_S	Maths	White	0	WQSF_Isb.CLOUD_MARGIN
<input type="checkbox"/> WQSF_Isb_SNOW_ICE_S	Maths	White	0.5	WQSF_Isb.SNOW_ICE
<input type="checkbox"/> WQSF_Isb_INLAND_WATER_S	Maths	Green	0.5	WQSF_Isb.INLAND_WATER
<input type="checkbox"/> WQSF_Isb_TIDAL_S	Maths	Bright Green	0.5	WQSF_Isb.TIDAL
<input type="checkbox"/> WQSF_Isb_COSMETIC_S	Maths	Cyan	0.5	WQSF_Isb.COSMETIC
<input type="checkbox"/> WQSF_Isb_SUSPECT_S	Maths	Magenta	0.5	WQSF_Isb.SUSPECT
<input type="checkbox"/> WQSF_Isb_HISOLZEN_S	Maths	Yellow	0.5	WQSF_Isb.HISOLZEN

[7] CHL_NN_S [7] sea_surface_temperature_M

Product Explorer Pixel Info

- [7] collocate_SST_CHL
 - Metadata
 - Index Codings
 - Flag Codings
 - Vector Data
 - Bands
 - *brightness_temperature*_M
 - *nedt*_M
 - *Oa*_reflectance*_S*
 - *Oa*_reflectance_err*_S*
 - *A865*_S*
 - *ADG*_S*
 - *CHL*_S*
 - *IWV*_S*
 - *KD490*_S*
 - *PAR*_S*
 - *T865*_S*
 - *TSM*_S*
 - *atmospheric_temperature_profile*_S*
 - *lambda0*_S*
 - *FWHM*_S*
 - *solar_flux*_S*
 - adi_dtime_from_sst_M
 - aerosol_dynamic_indicator_M
 - dt_analysis_M
 - dual_nadi...
 - l2p_flags...

Output bands

Investigating the Ocean Color from Space

What to do:

- overlay the chlorophyll concentration with the SST band
- analyse both parameters by swiping and blending
- show the correlation of both parameters in a scatterplot

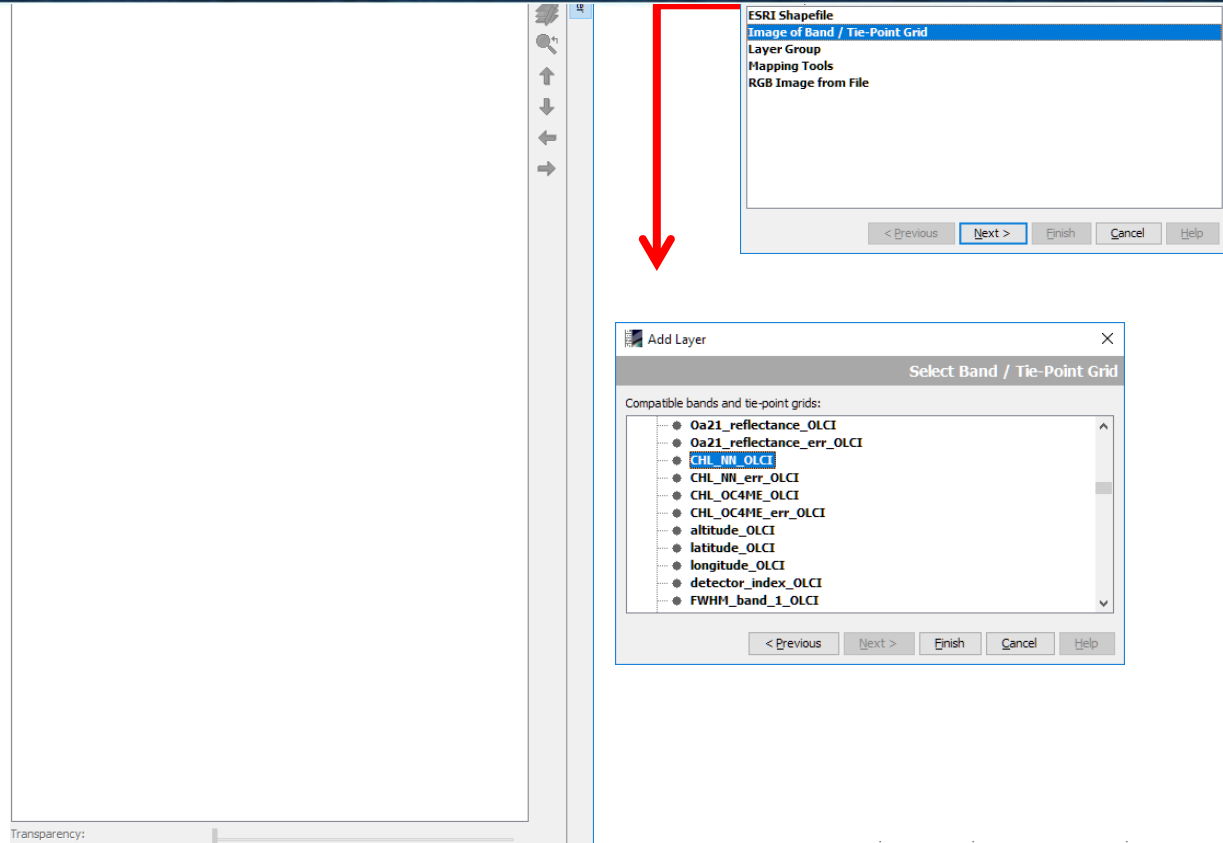
Products:

- Computed collocation product: `collocate_SLSTR_OLCI.dim`

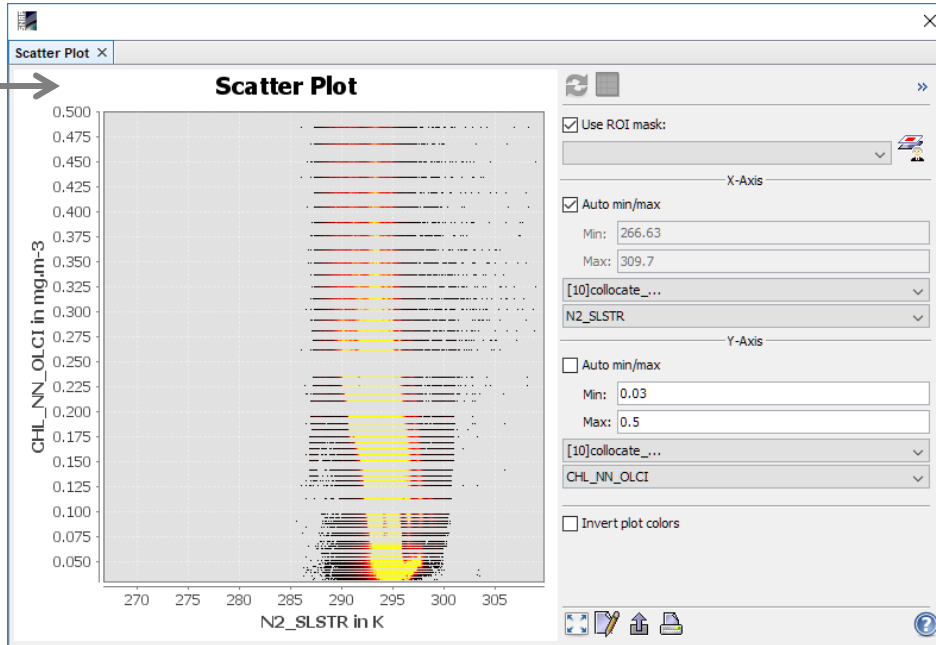
Investigating the Ocean Color from Space

layer management

The purpose is to overlay the chlorophyll NN product over the SST using the layer management.



Investigating the Ocean Color from Space



Visualize possible correlation between the two variables.

Select product and band for x-axes

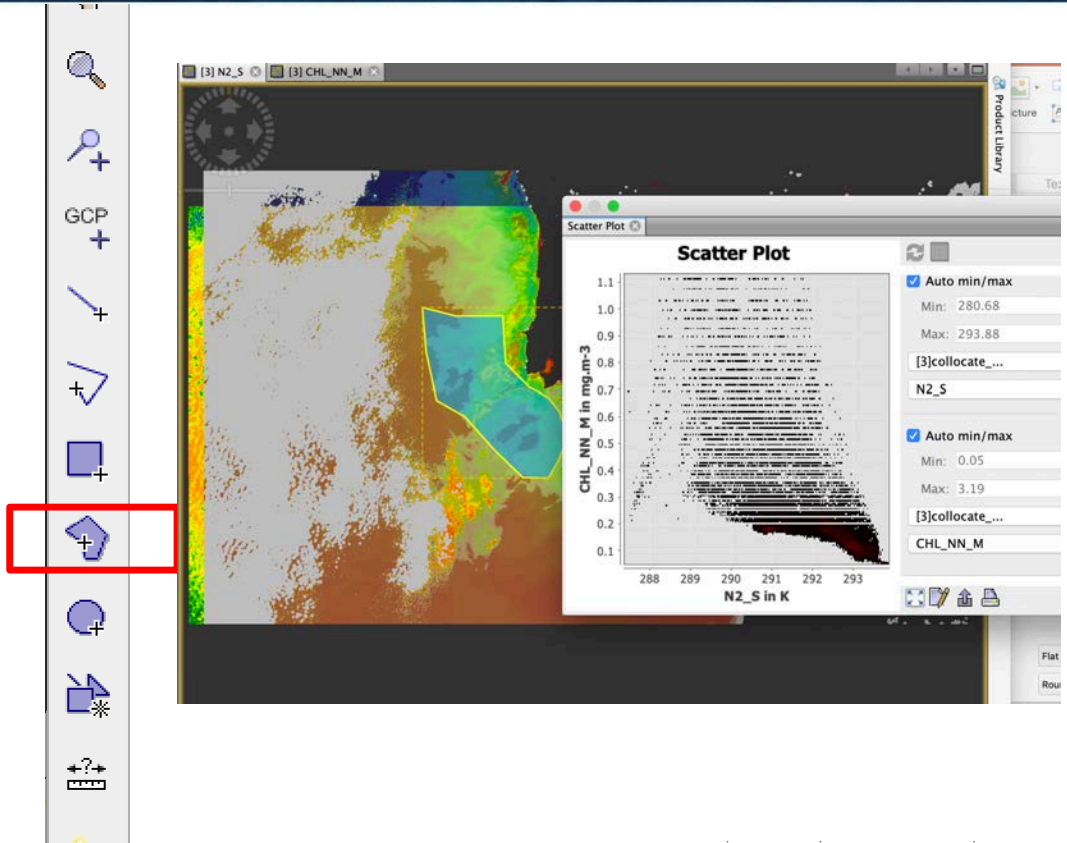
Select product and band for y-axes

Investigating the Ocean Color from Space

Scatter plots can be generated for a region of interest defined by a mask or a region.

Input bands need to be quality controlled for a generating a valid scatter plot.

Select are of interest using a geometry. This will be automatically converted into a mask.



Investigating the Ocean Color from Space

- The L3 binner is one of many processors that are available in SNAP. They follow all the same structure (input/output, parameters) and they generate new products. All processors can also be called by command line by using the gpt framework of SNAP.
- Aggregated products are a first step for further analyses of large data archives. The quality of the input products is very important and a good valid pixel expression is mandatory.
- Overlays can be a good tool to combine visually different parameters. Products need to be in the same raster, this can be reached by the collocation operator.
- All analyses of data need a careful data handling and quality control by eliminating invalid pixels. The scatter plot tool is one option to analyse two data sets.
- SST and CHL have an inverse correlation in the upwelling zone at the Portuguese coast.

Investigating the Ocean Color from Space

With appreciation and thanks to

ESA

A. Ruescas, K. Stelzer, C. Brockmann

I hope you learnt a lot!