Exploring MERIS Products

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Contents

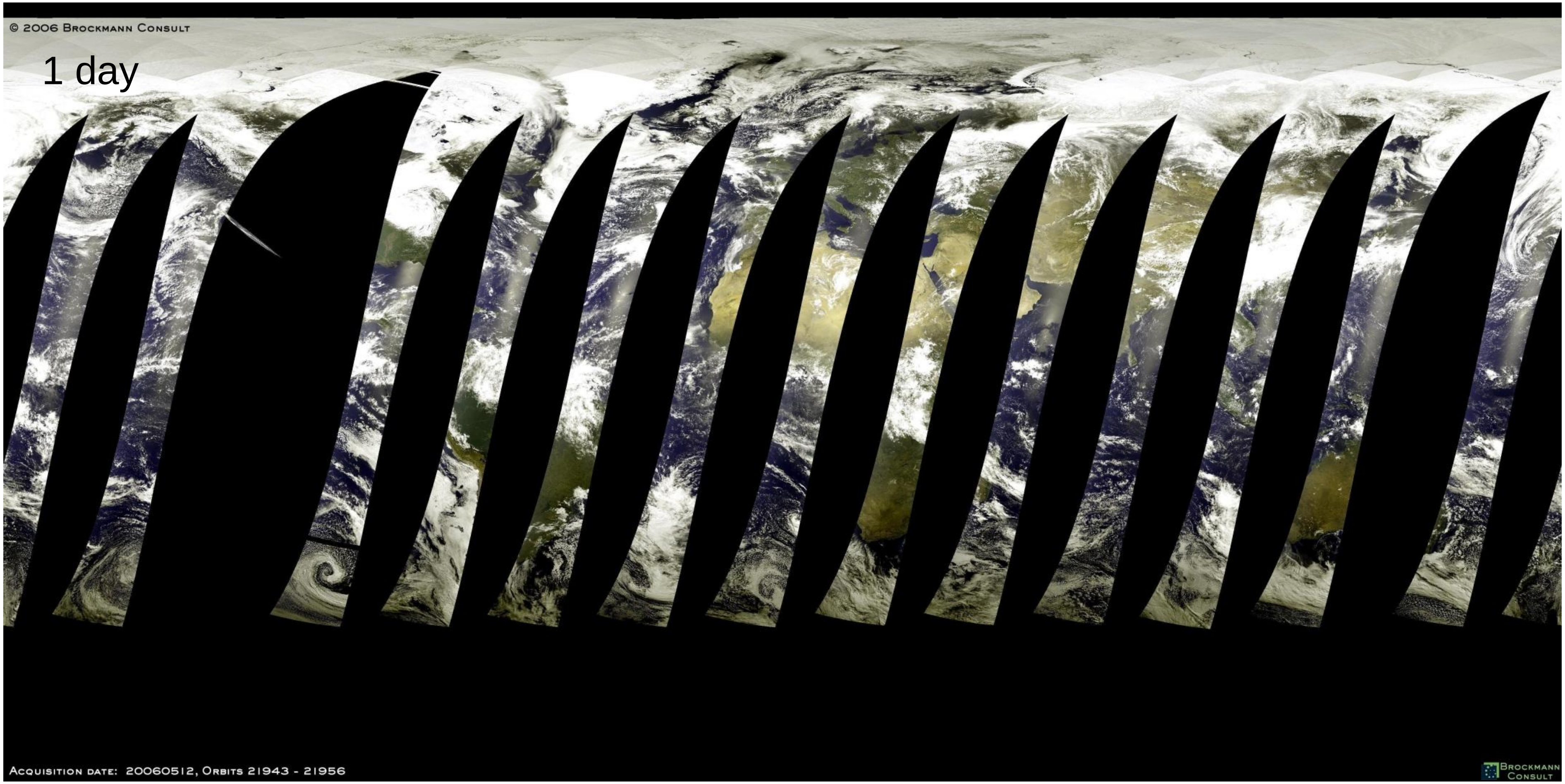
ENVISAT satellite

Photo: ESA

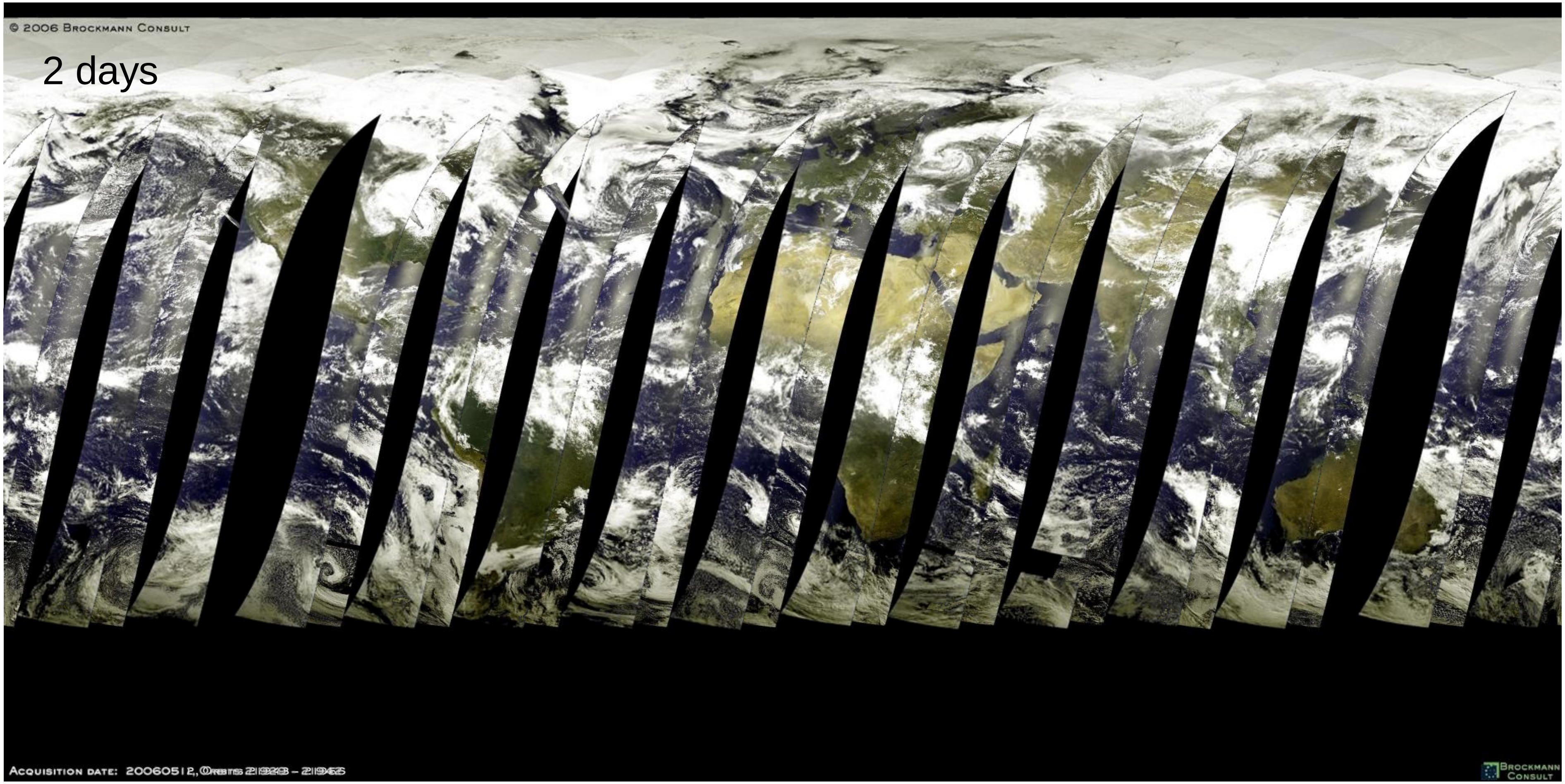
MERIS spectral bands

	Band	Band centre (nm)	Bandwidth (nm)	Primary Use
VISIBLE	1	412.5	10	Yellow substance and pigments detritus
	2	442.5	10	Chlorophyll absorption maximum
	3	490	10	Chlorophyll and other pigments
	4	510	10	Suspended sediment, red tides
	5	560	10	Chlorophyll absorption minimum
	6	620	10	Suspended sediment
	7	665	10	Chlorophyll absorption and fluo. reference
	8	681.25	7.5	Chlorophyll fluorescence peak
	9	708.75	10	Fluo. Reference, atmospheric corrections
INFRARED	10	753.75	7.5	Vegetation, cloud
	11	760.625	3.75	Oxygen absorption R-branch
	12	778.75	15	Atmosphere corrections
	13	865	20	Atmosphere corrections
	14	885	10	Vegetation, water vapour reference
	15	900	10	Water vapour, land

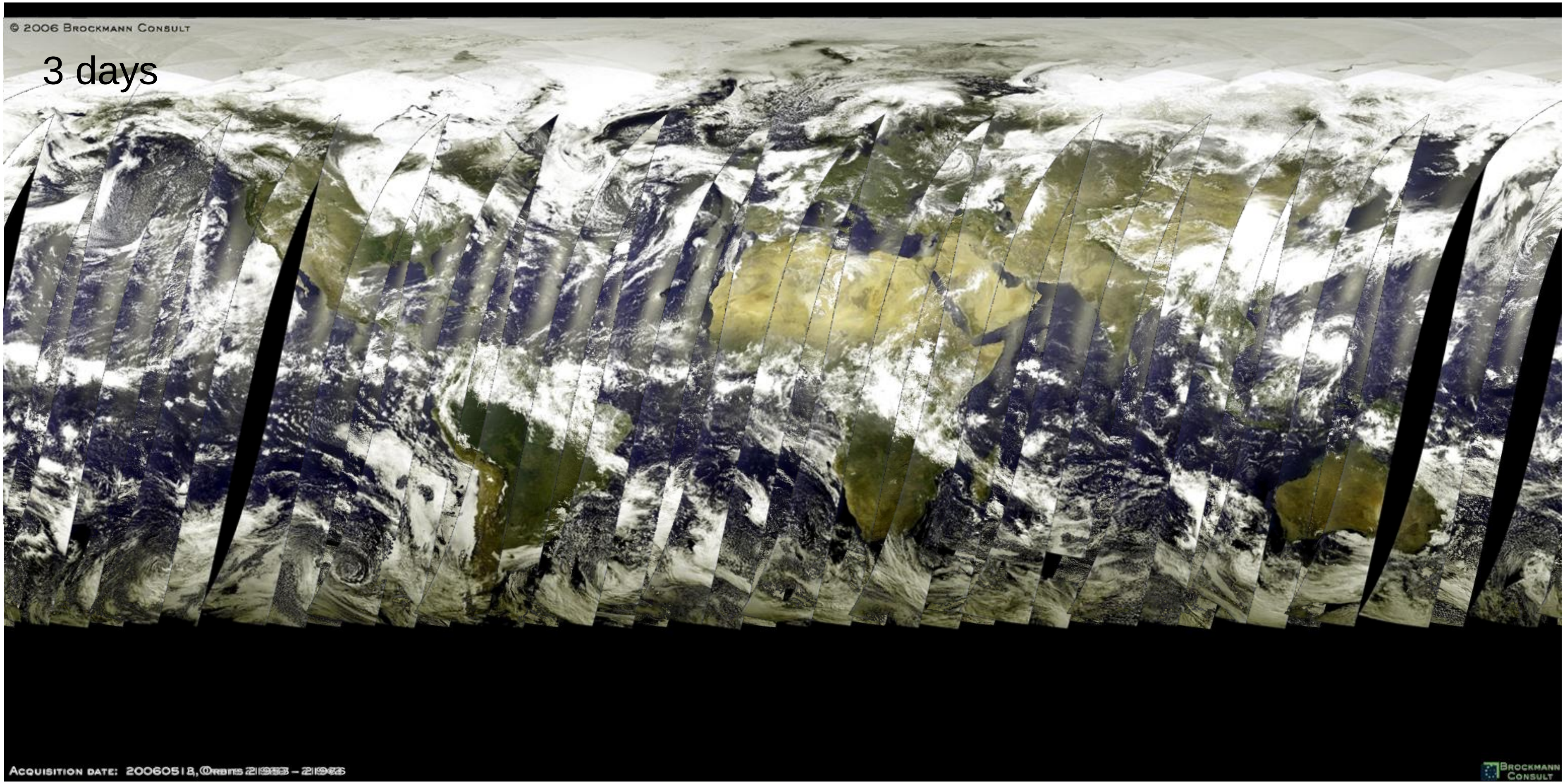
MERIS daily acquisition



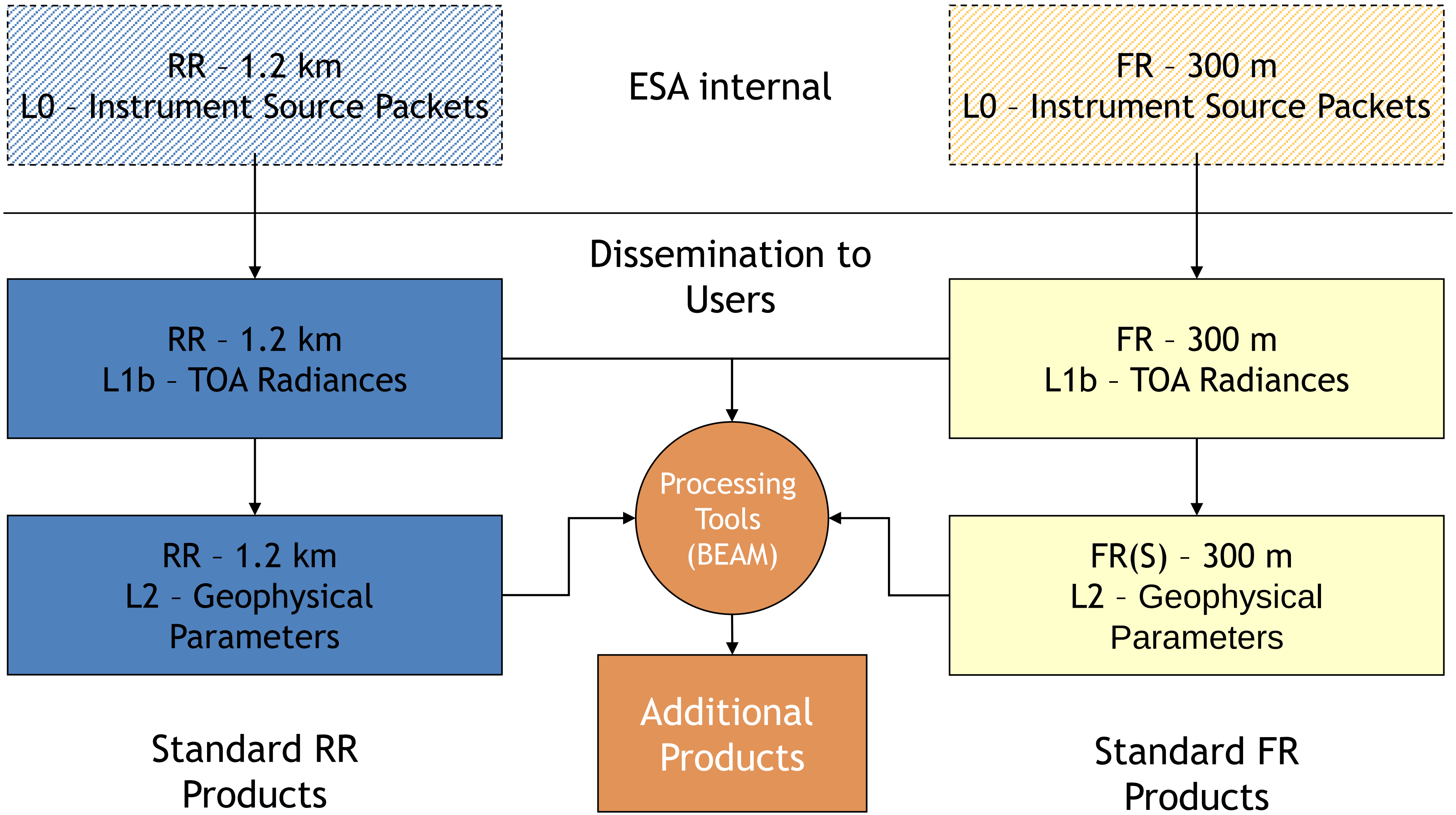
MERIS daily acquisition



MERIS daily acquisition



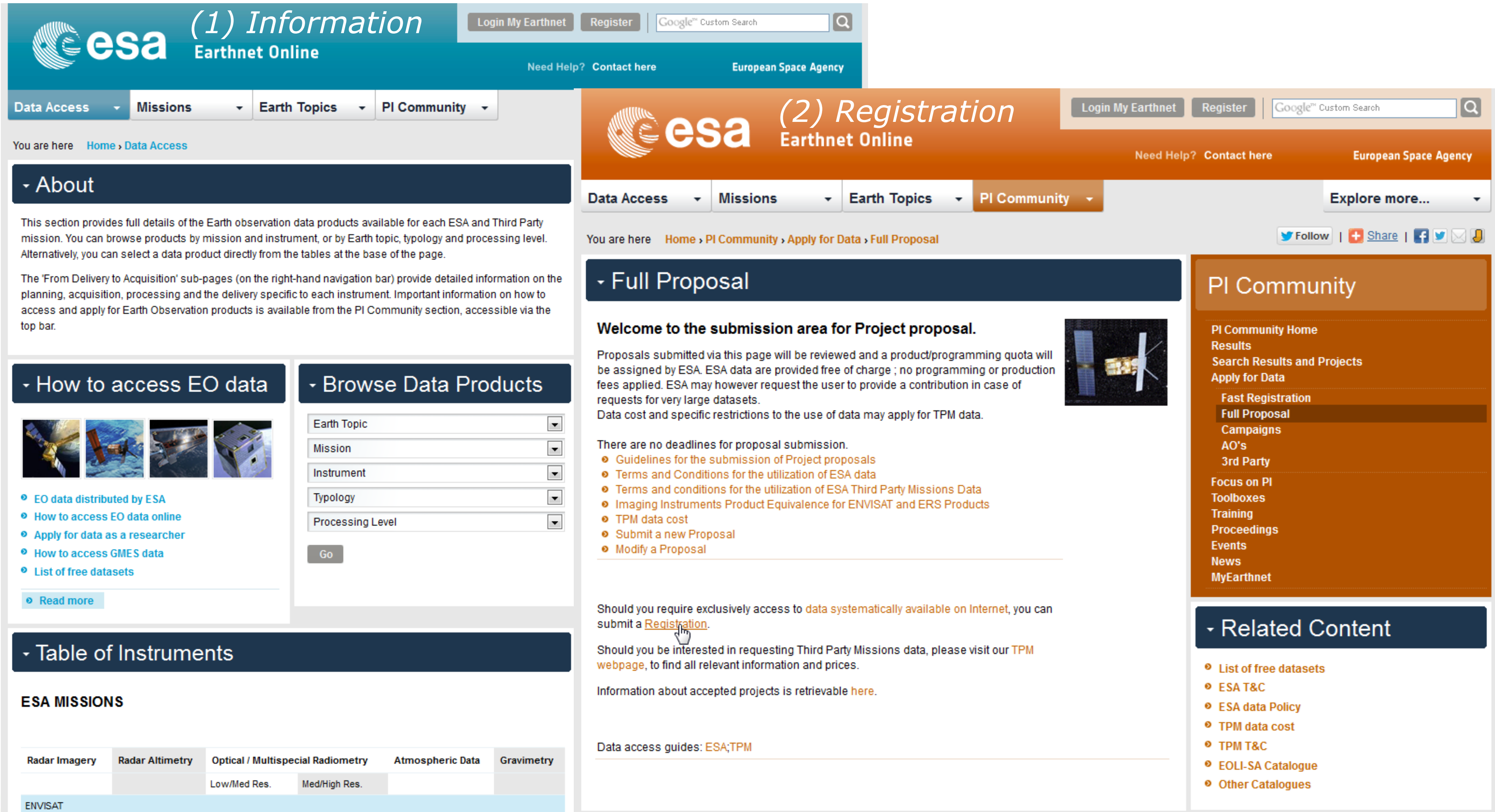
MERIS products



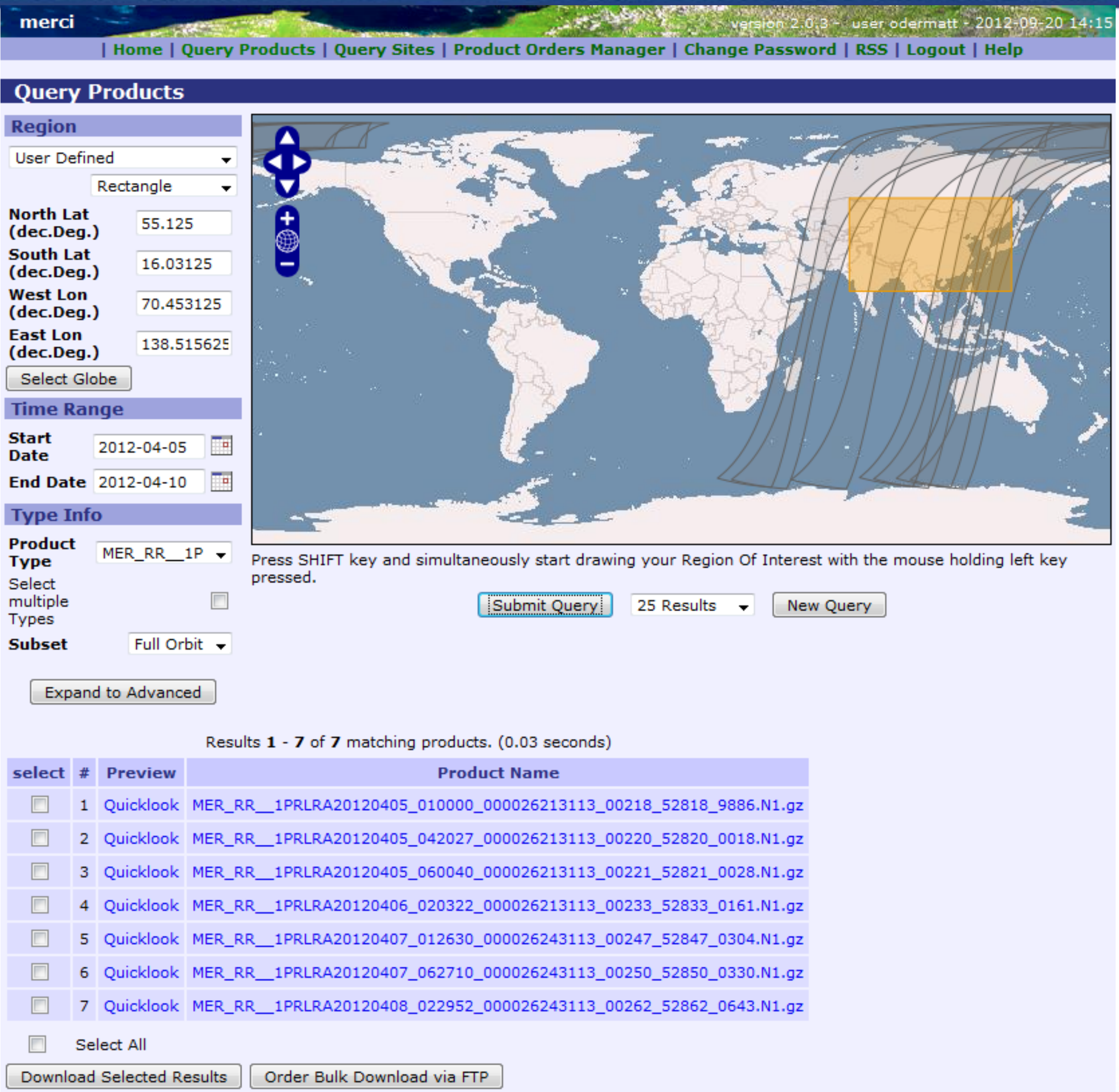
Data availablilty and access

- RR
  - ESA-MERCI (Archiv)
  - ftp access
- FR(S)
  - EOLI-SA (Archiv)
- Access:
  - ESA-Merci & ftp: Cat-1 Fast Registration
  - EOLI-SA: Cat-1 proposal
- Costs:
  - FTP: 0 €
  - DVD: 10 € (cost of reproduction)

Data access www.earth.esa.int



MERIS RR archive



http://merci-srv.eo.esa.int/merci

- Enables quick download of the full 2002-2012 MERIS RR archive
- Download of single full orbits
- Mass download via ftp
- Subsetting by area

Documentation

http://earth.eo.esa.int/pcs/envisat/meris/documentation/

MERIS Technical Documents - Documentation applicable to the processors MEGS 8 used for the 3rd reprocessing and to the equivalent operational processor IPF 6

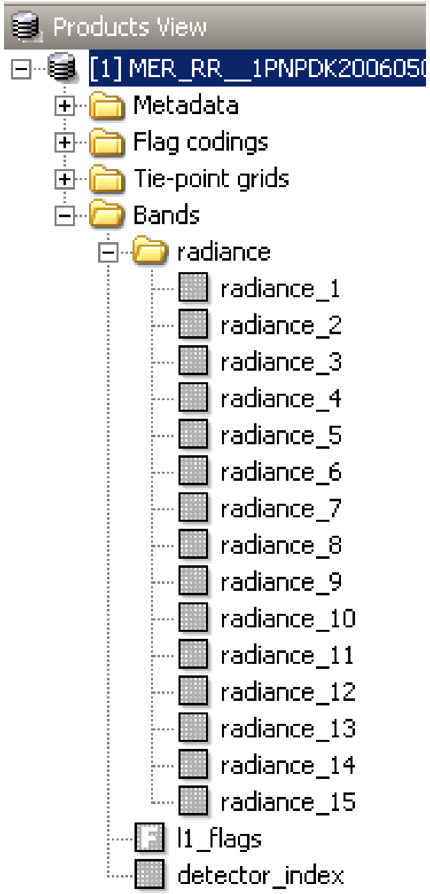
- MERIS 3rd data reprocessing documentation
  - MERIS 3rd data reprocessing - Reprocessing Changes
  - MERIS 3rd data reprocessing - Reprocessing Changes Synthesis
  - MERIS 3rd data reprocessing - Validation Report
  - MERIS 3rd data reprocessing - Validation Report Synthesis
- MERIS product Specifications
- Algorithm Theoretical Basis Documents – ATBD
  - Table with ATBD
- Detailed Processing Model
  - DPM L1
  - DPM L2
- Reference Model and Radiative Transfer Model description for MERIS Level 2 processing
  - Ocean RMD Reference Model for MERIS Level 2 Processing
  - Specification of the scientific contents of the MERIS L1b & L2 Auxiliary Data Products
  - Specification of the scientific contents of the MERIS Radiative Transfer Tools used to generate the L2 Auxiliary Data Products
- MERIS instrument calibration, Ludovic Bourg and Steven Delwart, 2012

MERIS Product Quality Reporting

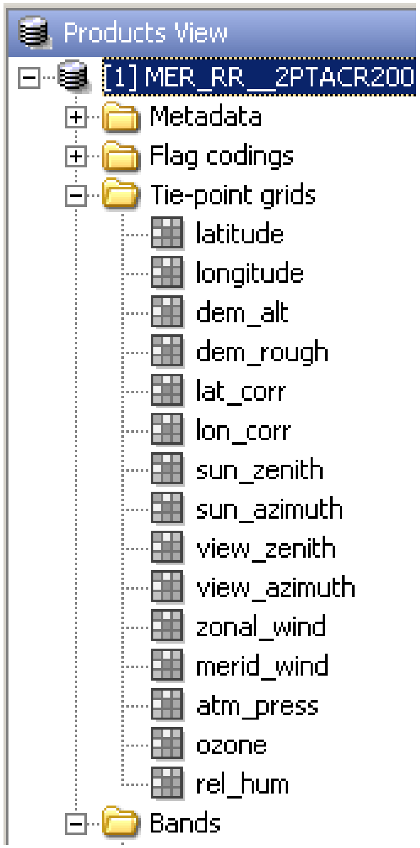
MERIS Product layers in BEAM

- Bands
  - contains all measured spectral/geophysical and quality raster datasets of a product (mandatory)
- Tie-point grids
  - contains all tie-point grid raster datasets (16x16 RR Pixels)
- Flag coding
  - contains flag coding metadata for quality flags datasets
- Metadata
  - contains additional metadata

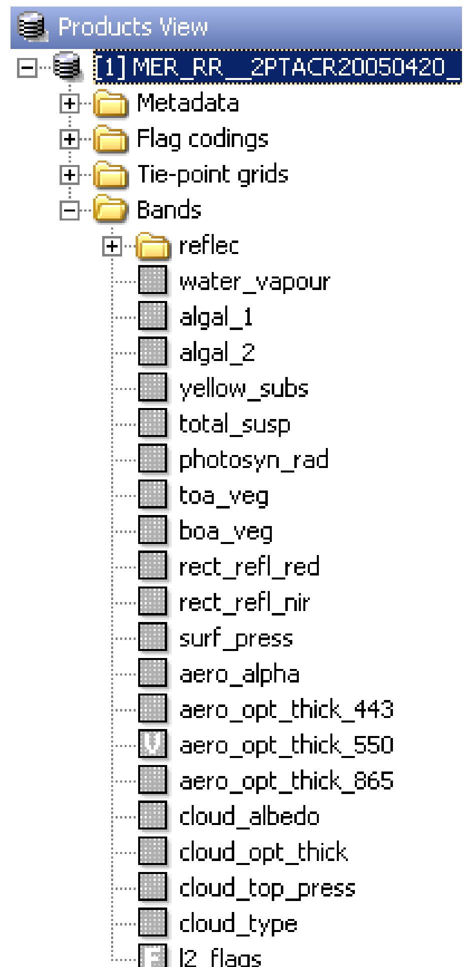
MERIS products



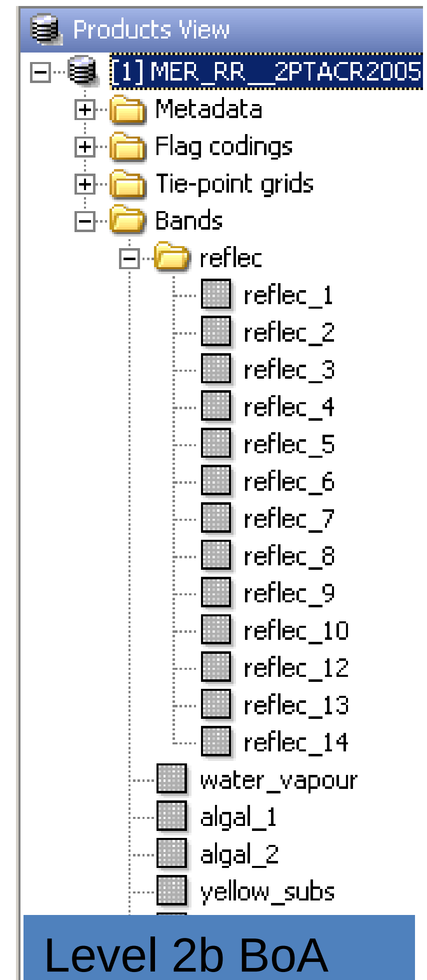
Level 1b bands



Aux. data



Level 2b



Level 2b BoA reflectances

MERIS L1B product

- [2] MER_RR__1PP01R20030514_105031_000001072016_00223_06289_0001
  - Metadata
  - Flag Codings
  - Tie Point Grids
  - Bands
    - radiance_1
    - radiance_2
    - radiance_3
    - radiance_4
    - radiance_5
    - radiance_6
    - radiance_7
    - radiance_8
    - radiance_9
    - radiance_10
    - radiance_11
    - radiance_12
    - radiance_13
    - radiance_14
    - radiance_15
    - l1_flags
    - detector_index

Top of atmosphere radiances

MERIS L2 product

- [2] MER_RR__2PP01R20030920_081741_000001072020_00064_08134_0001.N1
  - Metadata
  - Flag Codings
  - Tie Point Grids
  - Bands
    - reflec_1
    - reflec_2
    - reflec_3
    - reflec_4
    - reflec_5
    - reflec_6
    - reflec_7
    - reflec_8
    - reflec_9
    - reflec_10
    - reflec_12
    - reflec_13
    - reflec_14
    - water_vapour
    - algal_1
    - algal_2
    - yellow_subs
    - total_susp
    - photosyn_rad
    - toa_veg
    - boa_veg
    - rect_refl_red
    - rect_refl_nir
    - surf_press
    - aero_alpha
    - aero_opt_thick
    - cloud_albedo
    - cloud_opt_thick
    - cloud_top_press
    - cloud_type
    - l2_flags

Water: water leaving radiance reflectances
Land: Rayleigh corrected reflectances
Clouds: TOA reflectance

Water vapour

Water products

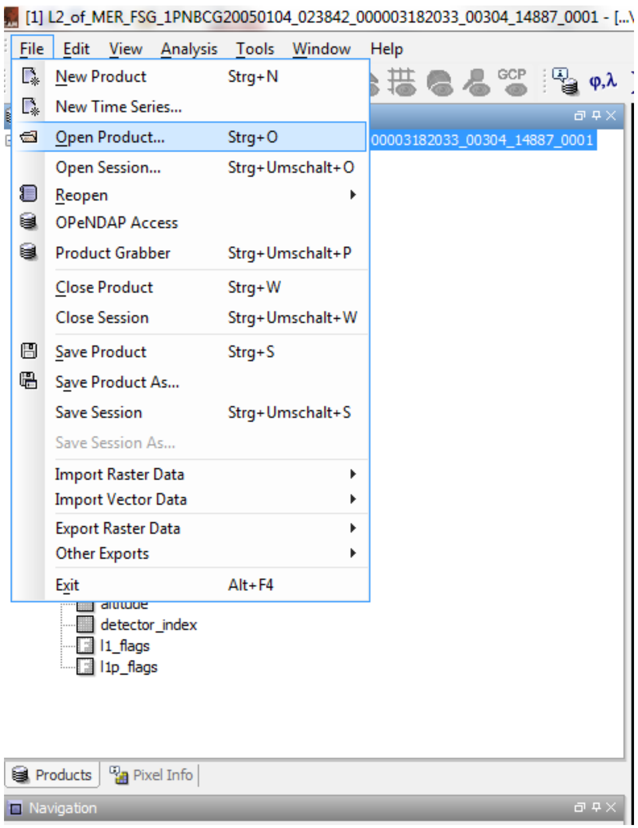
Land products

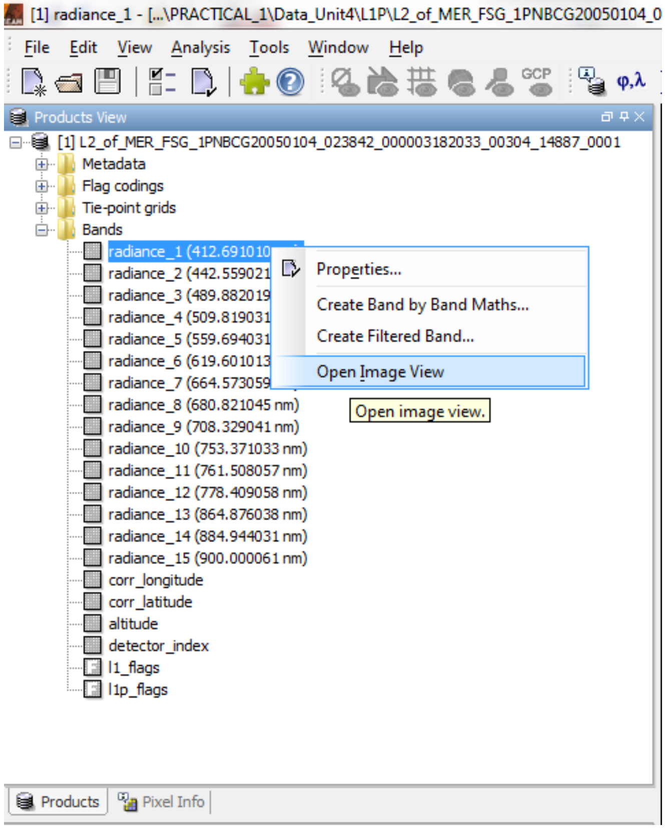
Aerosol products

Cloud products

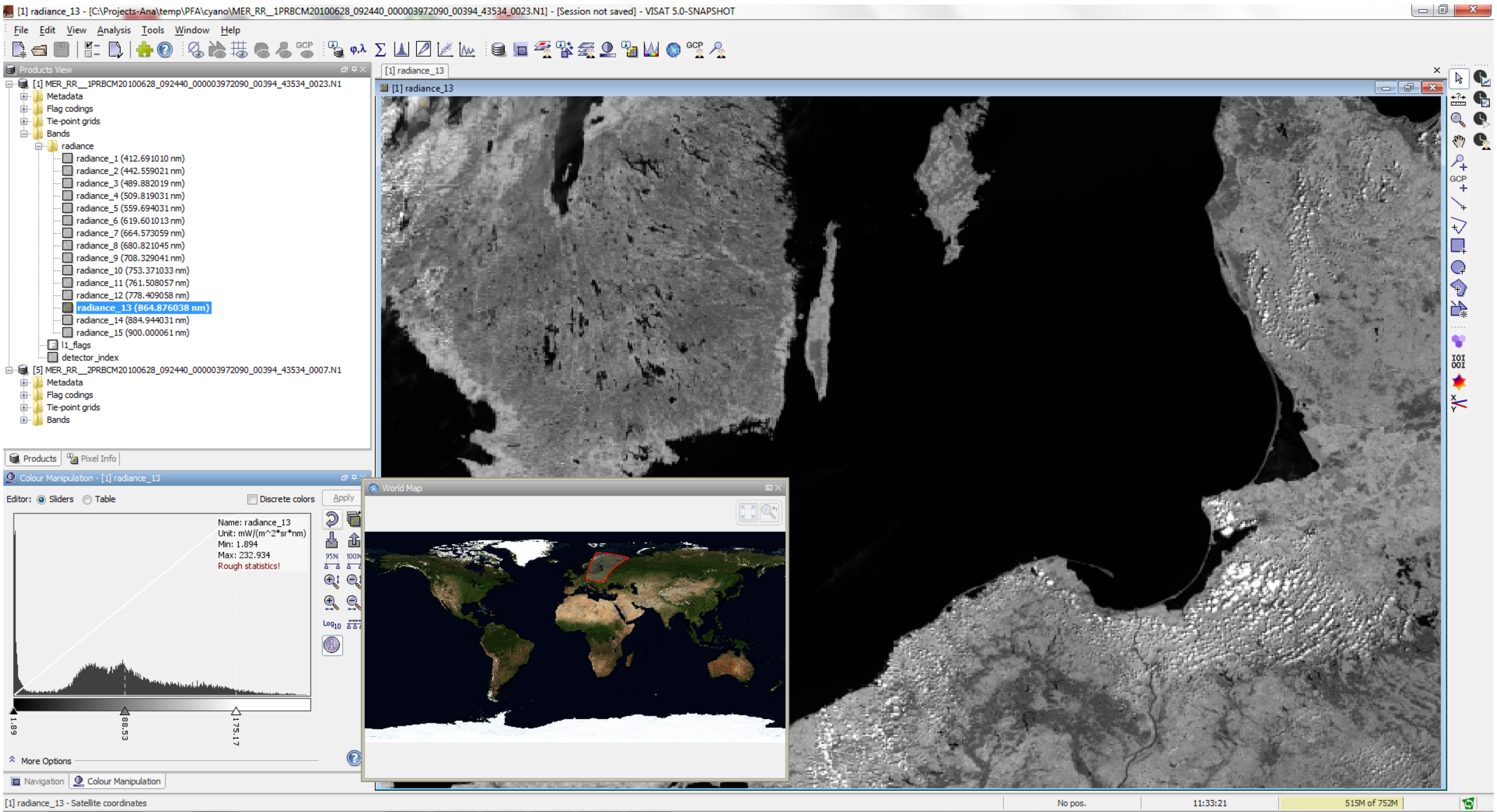
Exercise 1: Analyse MERIS images content

- Open *.N1 or *.dim products in BEAM-VISAT



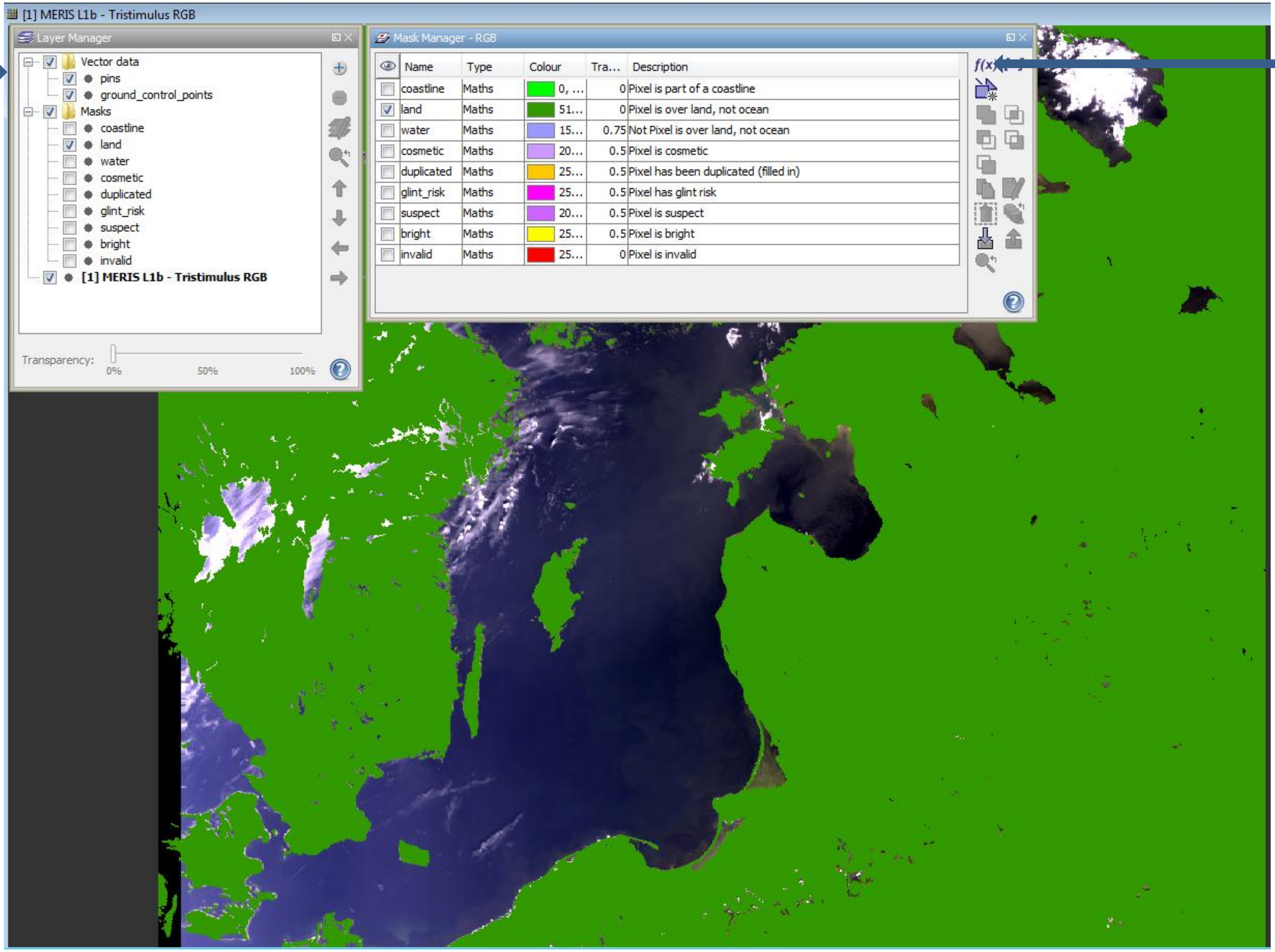


Exercise 1a: Display MERIS scenes L1b



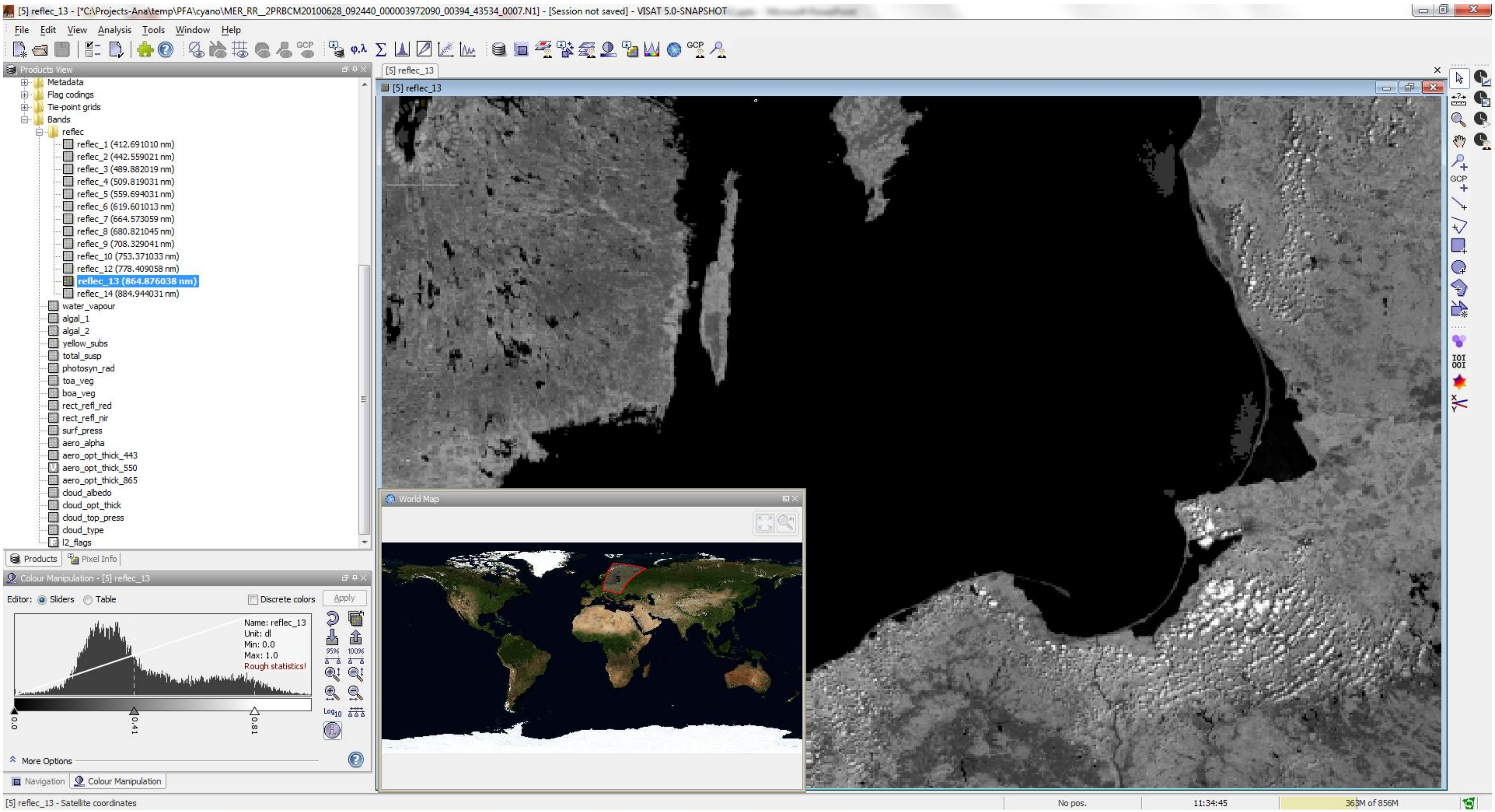
Masks in MERIS scenes (L1b)

Layer Manager

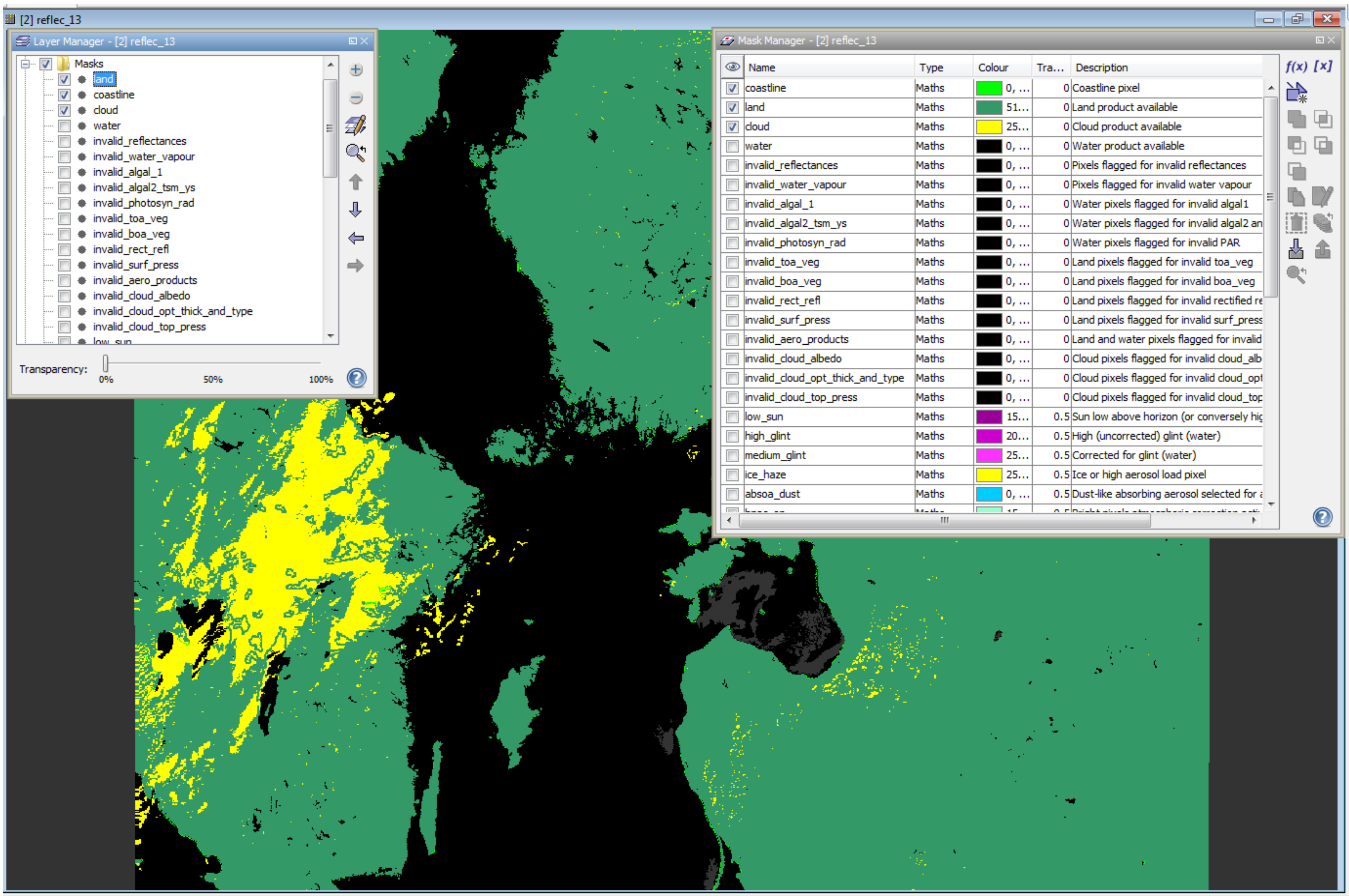


Mask Manager

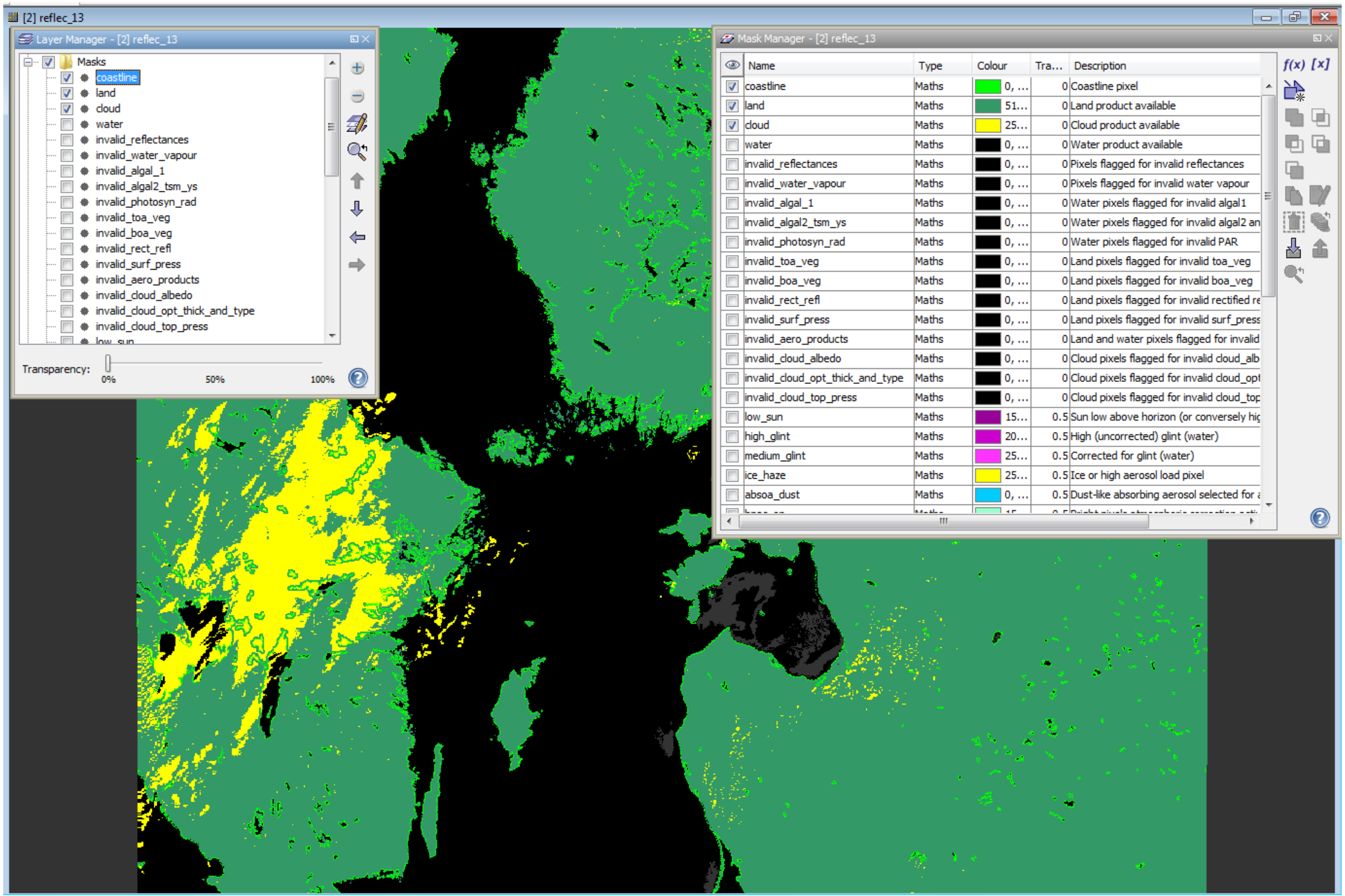
Exercise 1b: Display MERIS scenes L2



Masks in MERIS scenes (L2)



Masks in MERIS scenes (L2)



Take-home messages

- MERIS products are available as top-of-atmosphere radiances (Level 1b) and geophysical products (Level 2)
- The products product contains bands (e.g. chlorophyll concentration) and flags (e.g. turbid Case 2 water)
- VISAT allows visualisation of radiance/reflectances (grey scale, RGB) and colour coded geophysical quantities. Flags can be overlayed as masks with transparency
- It is good practise to always inspect the TOA RGB together with the Level 2 geophysical quantities. VISAT support analysis by image linking.
- Inspect the flags!

End of Unit

Marine Reflectances (atmospheric correction)

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Contents

- Analysis of marine reflectances as a result of the atmospheric correction

- VISAT Tools:
  - Exercise 1: Comparing TOA and marine reflectances with image linking, pins and the spectrum view
  - Exercise 2: Reflectance analysis using transects
  - Exercise 3: Layer management, visualization and creation

Atmospheric correction

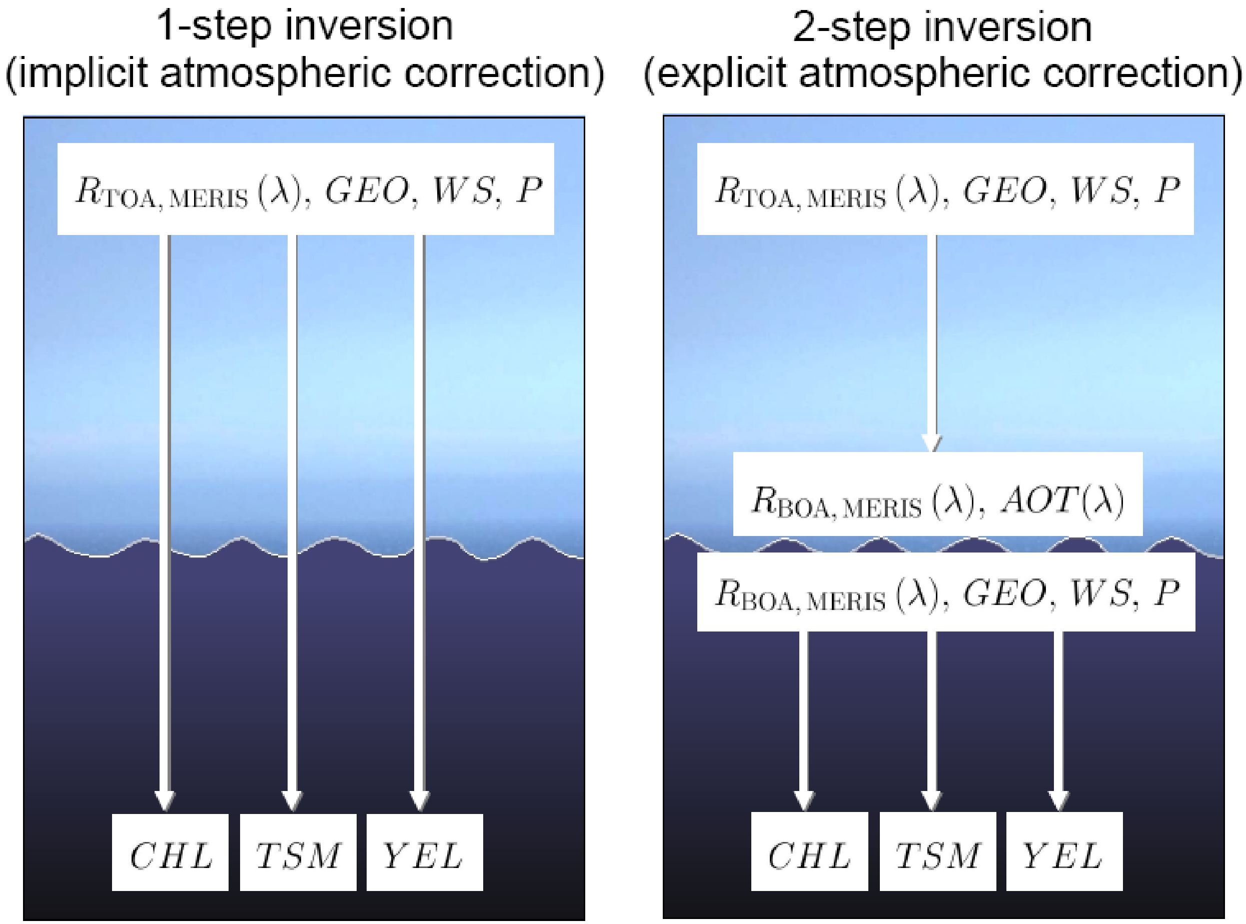
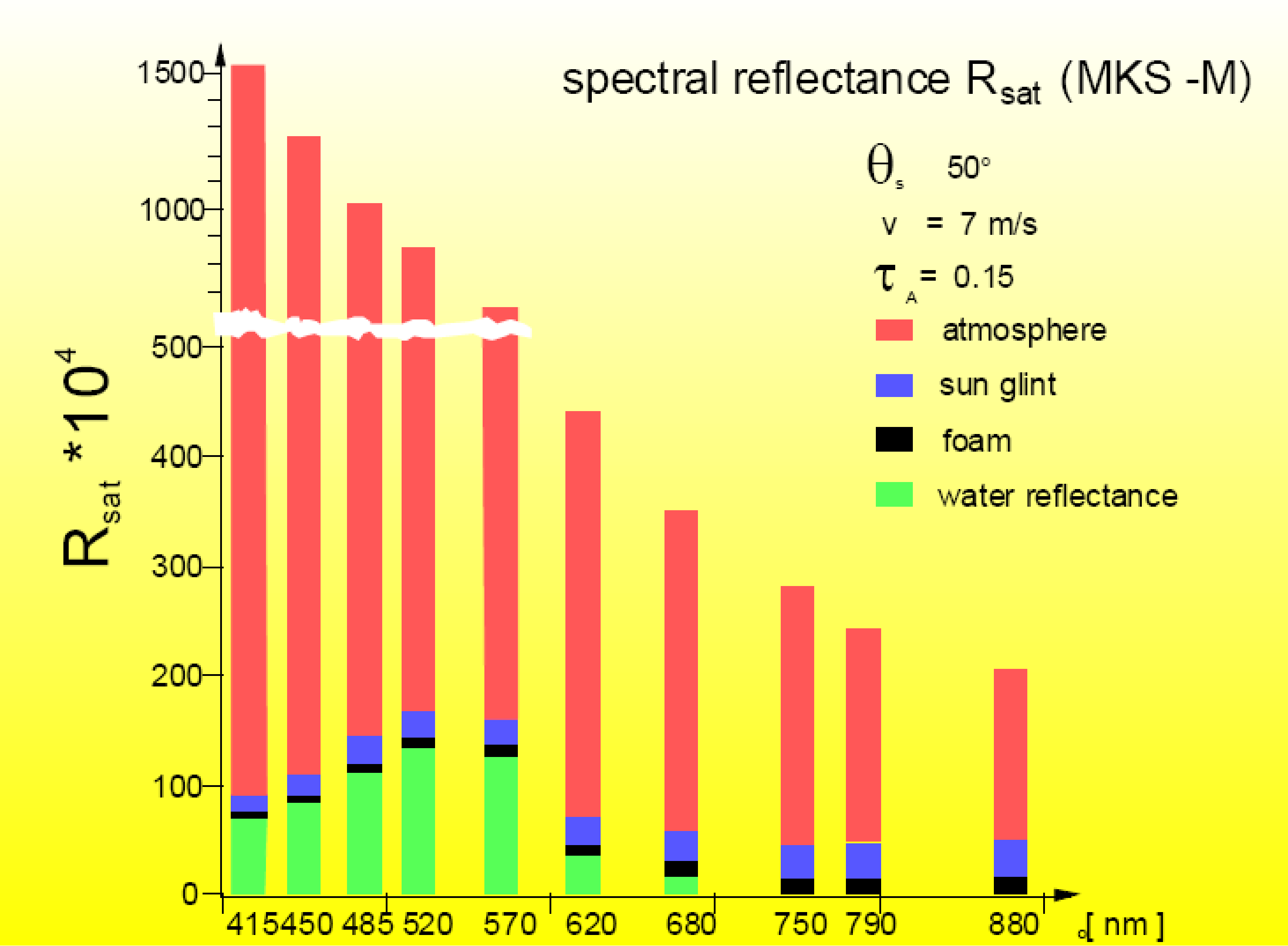


Figure courtesy of T. Schroeder

Atmospheric correction



Atmospheric correction

- Relative proportions of the spectrum at the top of the atmosphere

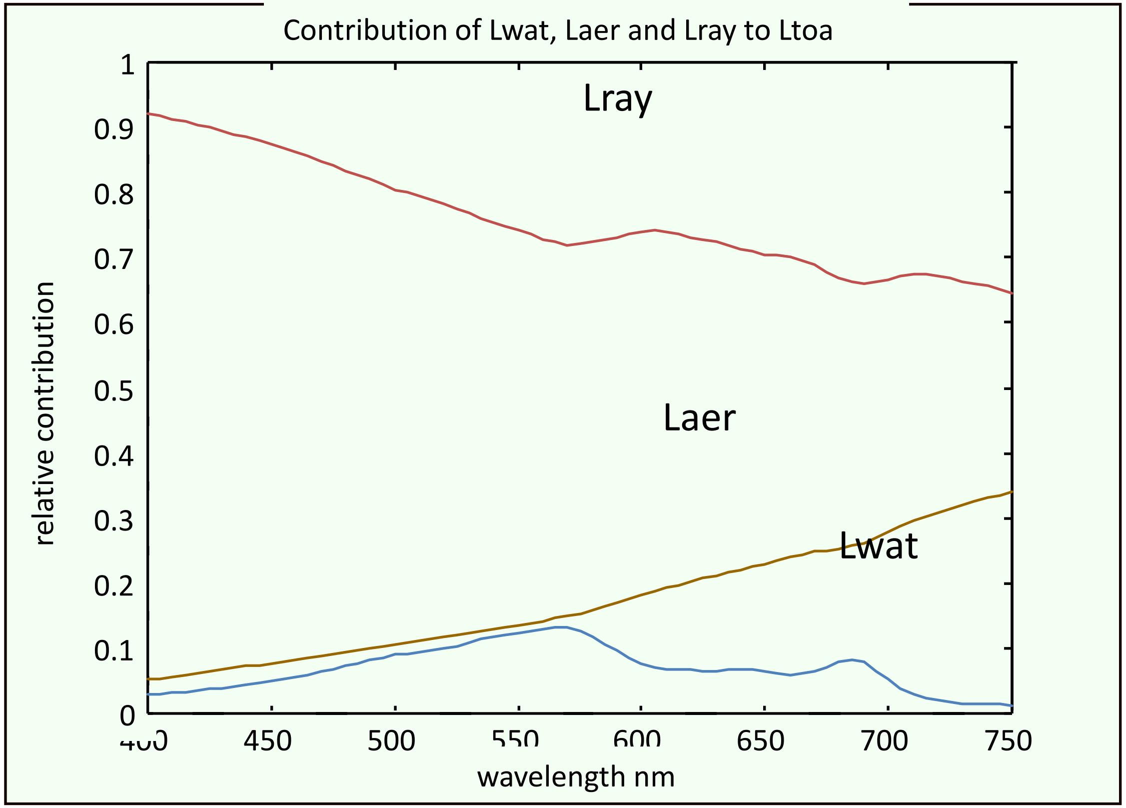


Figure courtesy of R. Doerffer

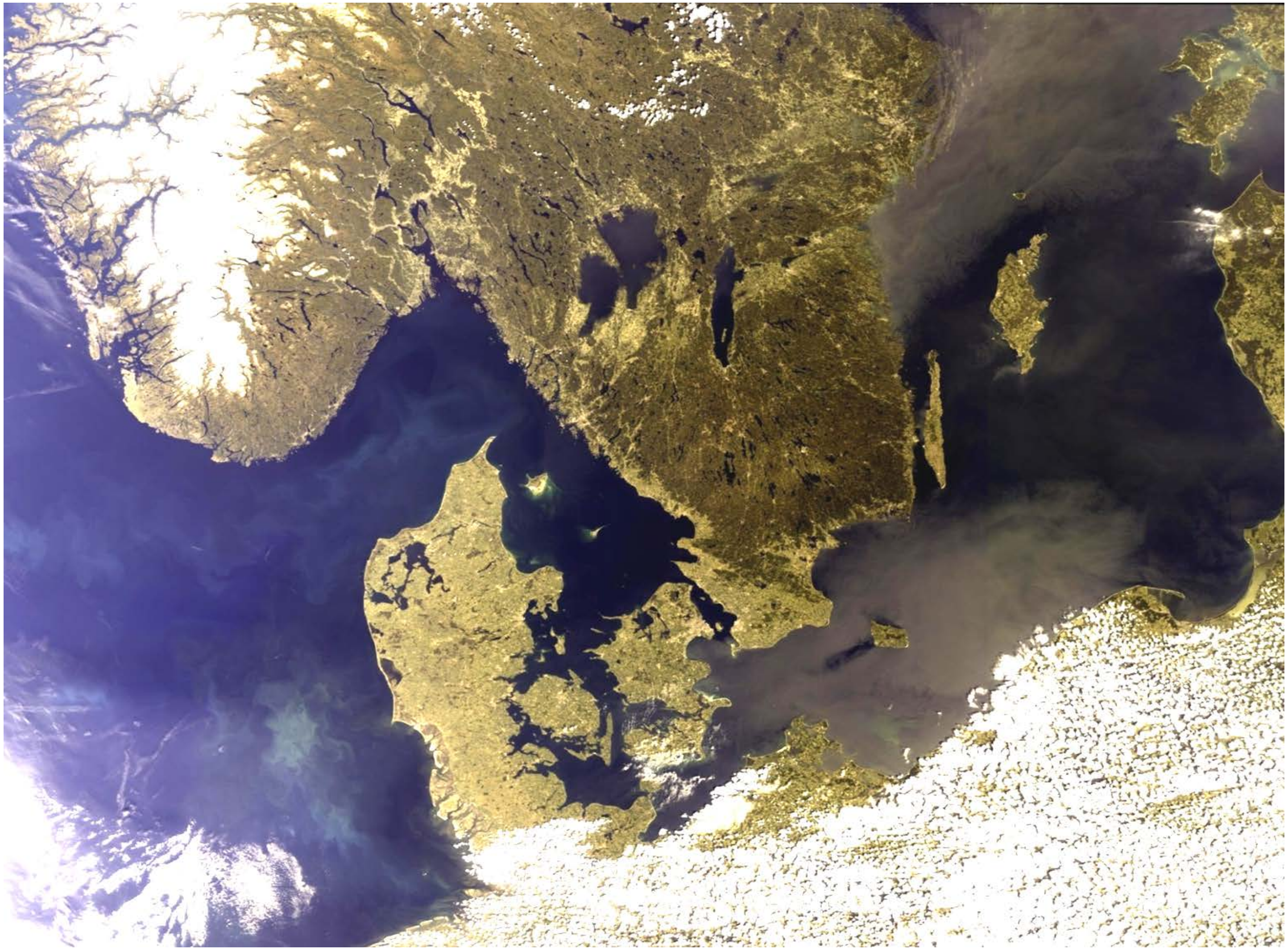
Relative contribution to TOA radiance

water leaving radiance: Lw

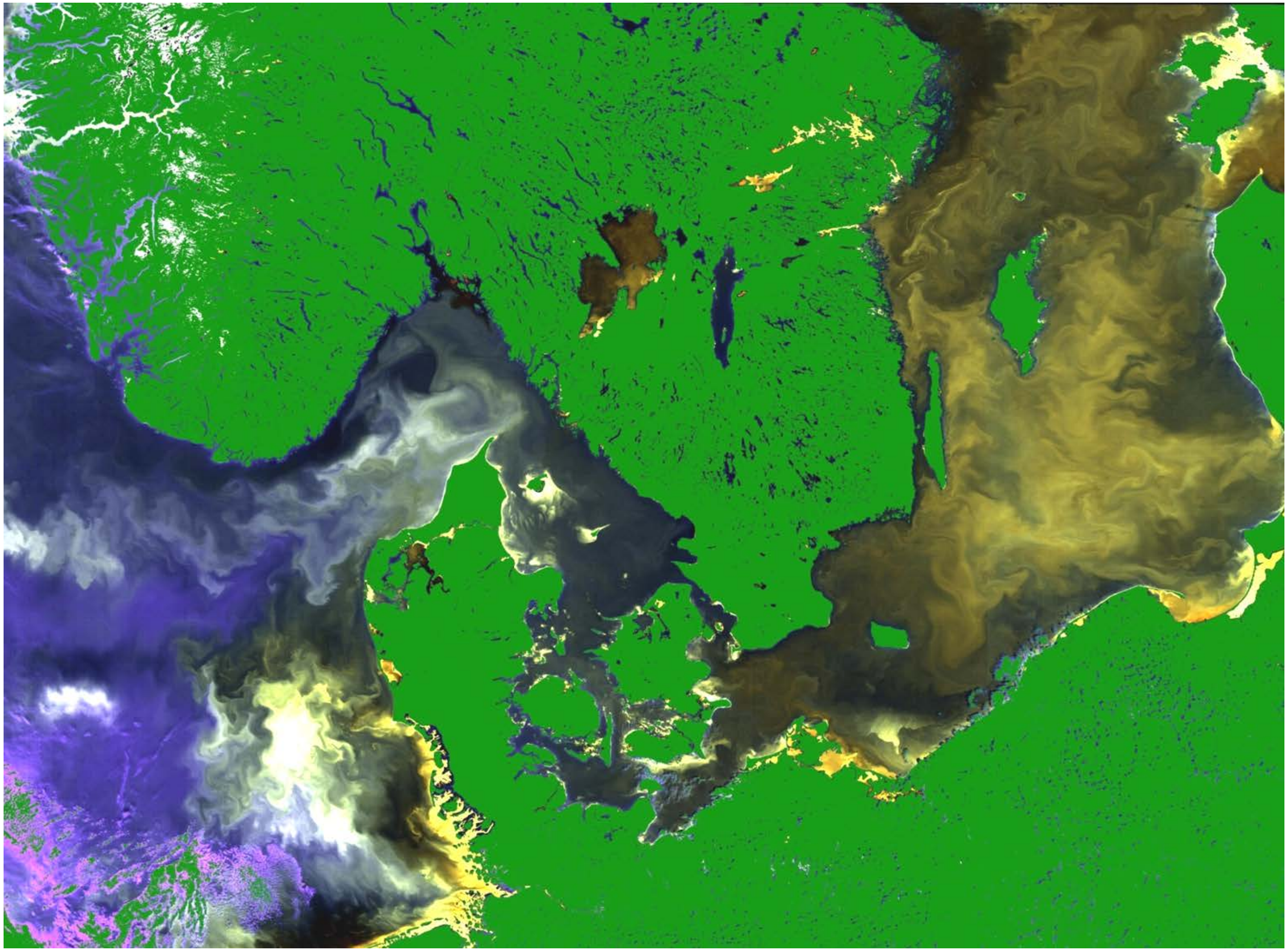
aerosol path radiance: Laer

Rayleigh path radiance: Lray

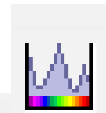
Top of Atmosphere

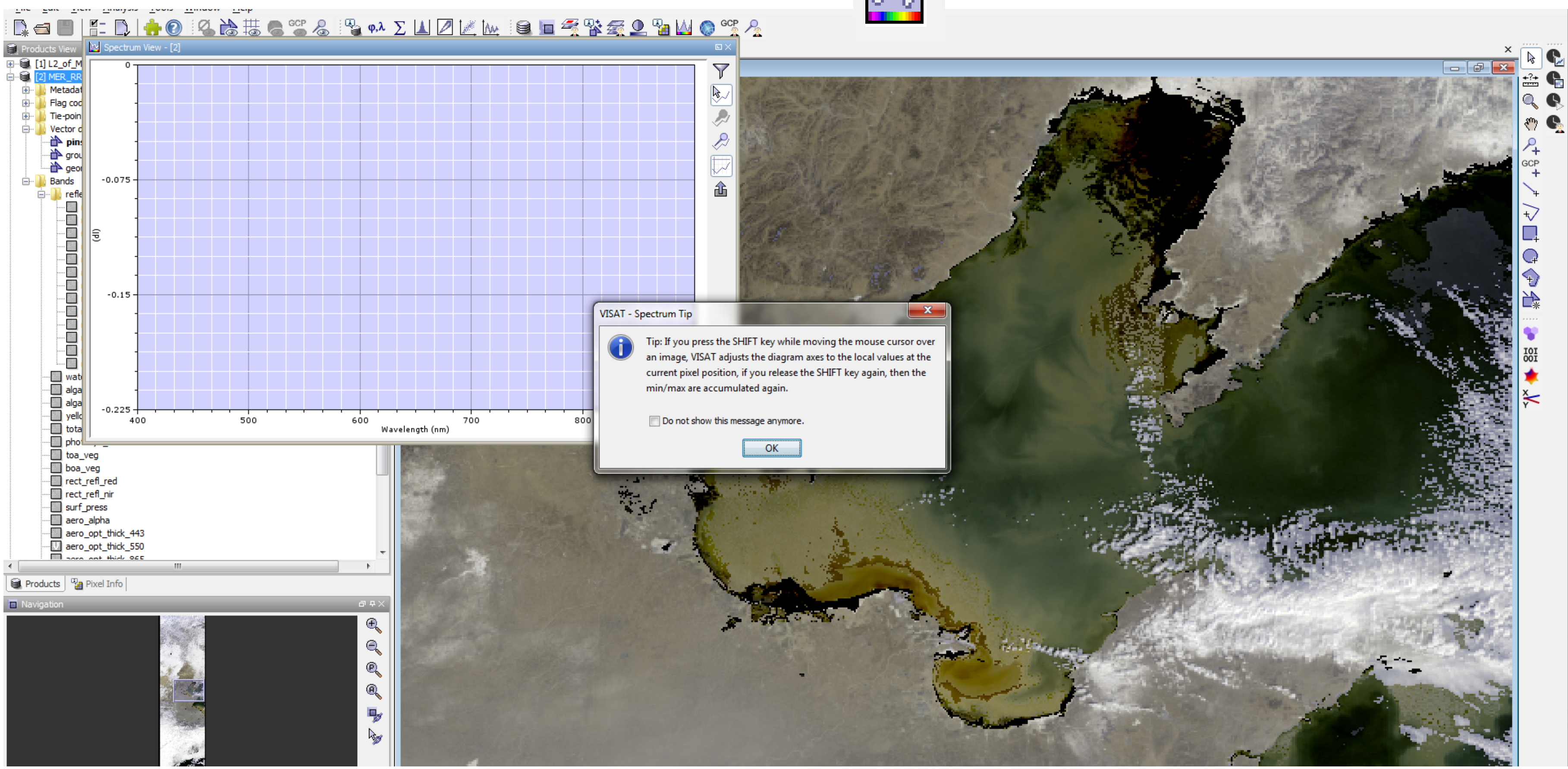


Water leaving reflectance

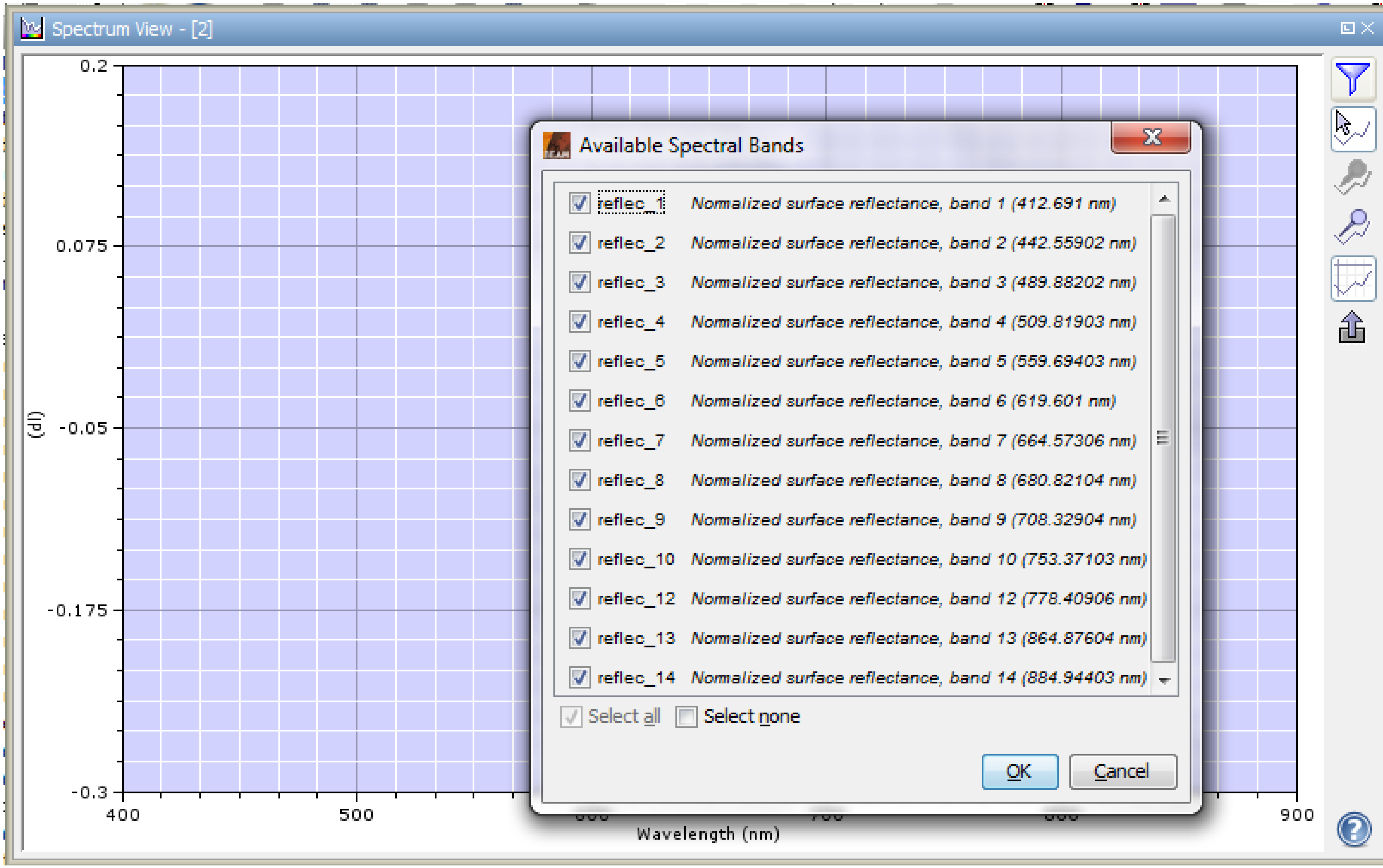


Exercise 1a:
Investigate reflectances with the spectrum view

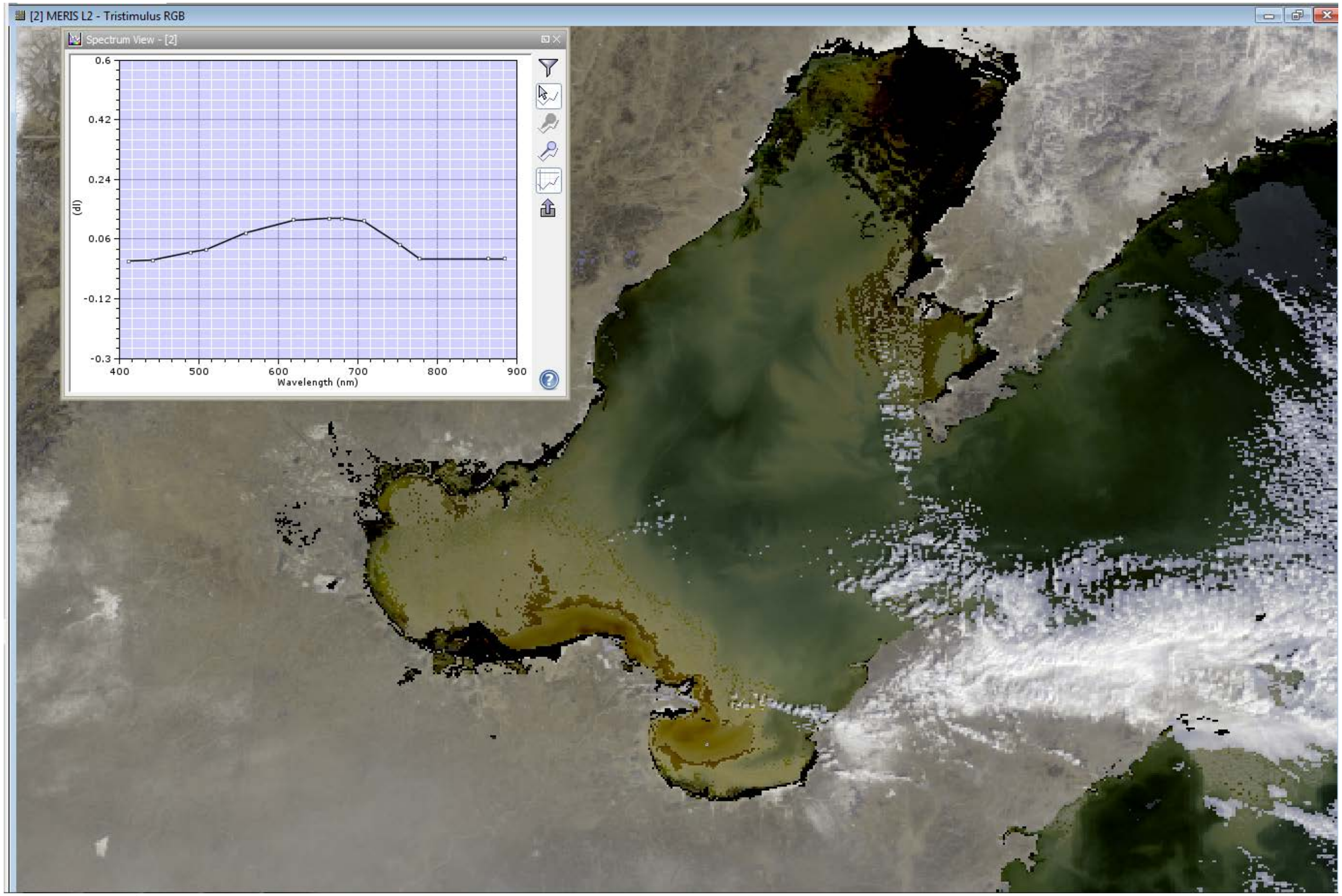




Filter band for spectrum view

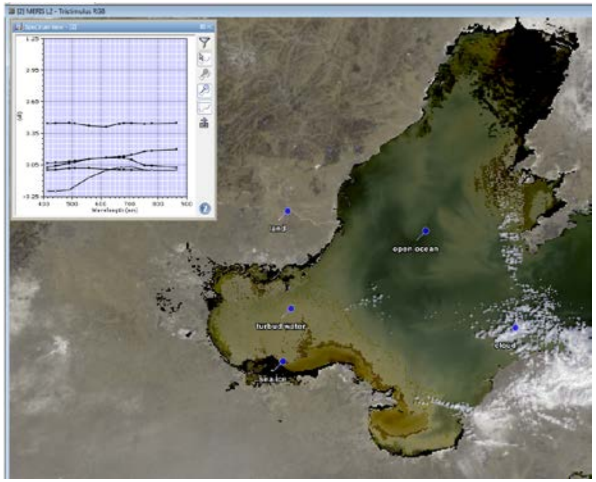


Investigate spectral behaviour of different surfaces



Exercise 1a: Solution

- Open Spectrum view
- Filter band for spectral visualisation
- Press shift key and move the cursor around the image
- Look at the spectral plot to see the different spectral response of several surfaces:
  turbid water, sea ice,
  land, clouds, etc.



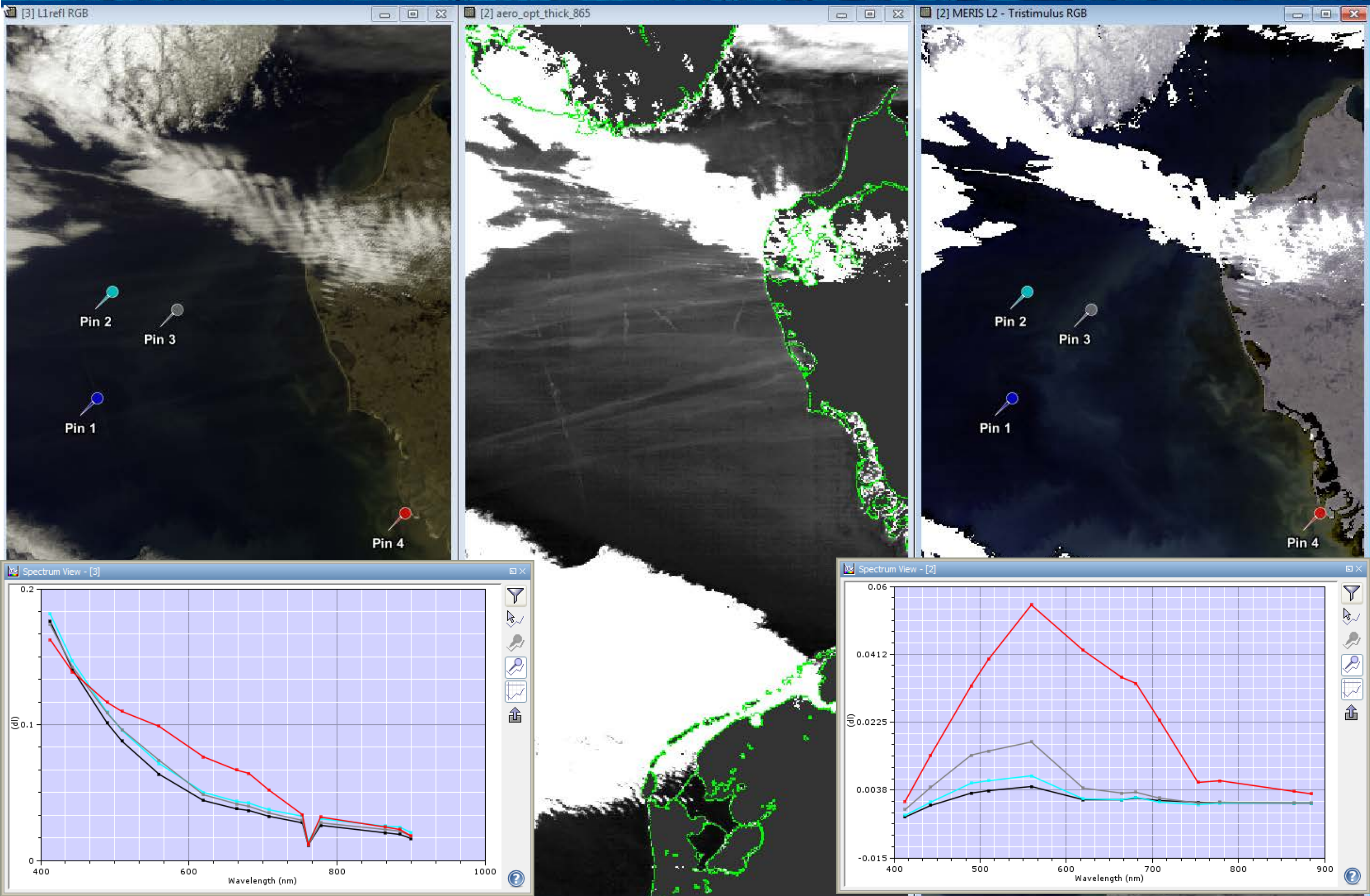
Exercise 1b: Comparing TOA and marine reflectances

- Investigate the spectra of the top of atmosphere reflectances and of the marine reflectances of different water types and atmospheric conditions

Exercise 1b: Comparing TOA and marine reflectances

- What to do:
  - Display images: L1 refl RGB, L2 aero_opt_thick_865 and L2 RGB
  - Open spectrum view and look at both spectra – L1 TOA refletances and L2 marine reflectances
  - Open the pin manager and load pin file and understand the spectra
  - Switch between displays for comparing TOA and marine reflectances

- Data:
  - MER_RR_1REFL_20110324.dim
  - MER_RR__2PRBCM20110324_102358_000005943100_00396_47393_0002.N1


[3] L1refl RGB
Pin 2
Pin 3
Pin 1
Pin 4
[2] aero_opt_thick_865
[2] MERIS L2 - Tristimulus RGB
Pin 2
Pin 3
Pin 1
Pin 4
Spectrum View - [3]
0.2
0.1
0
(dl)
400
600
800
1000
Wavelength (nm)
Spectrum View - [2]
0.06
0.0412
0.0225
0.0038
-0.015
(dl)
400
500
600
700
800
900
Wavelength (nm)

Exercise 1b - solution

- Open products and bands
  - L1 reflec_2
  - L2 aero_opt_thick_865
  - L2 reflec_2
- Open Spectrum view
- Filter band for spectral visualisation
- Press shift key and move the cursor around the image
- Look at the spectral plot to see the different spectral response of several surfaces:
  turbid water, sea ice,
  land, clouds, etc.

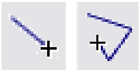
Exercise 2: Reflectance analysis using transects

- What to do:
  - Draw transects and compare the reflectance values along the transect L1 reflec_2, L2 aero_opt_thick_865 and L2 reflec_2
  - Explain what you see
  - Export to Excel

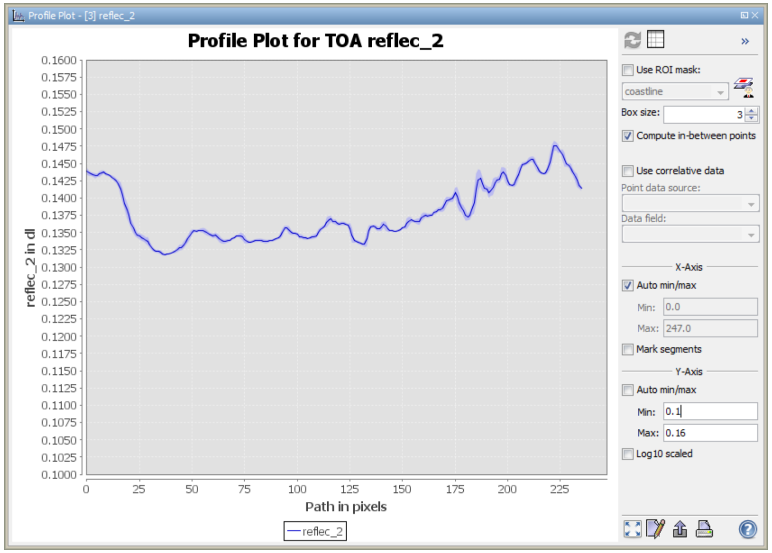
- Data:
  - MER_RR_1REFL_20110324.dim
  - MER_RR__2PRBCM20110324_102358_000005943100_00396_47393_0002.N1
  - Transect coordinate file: TRANSECT.txt

Transects

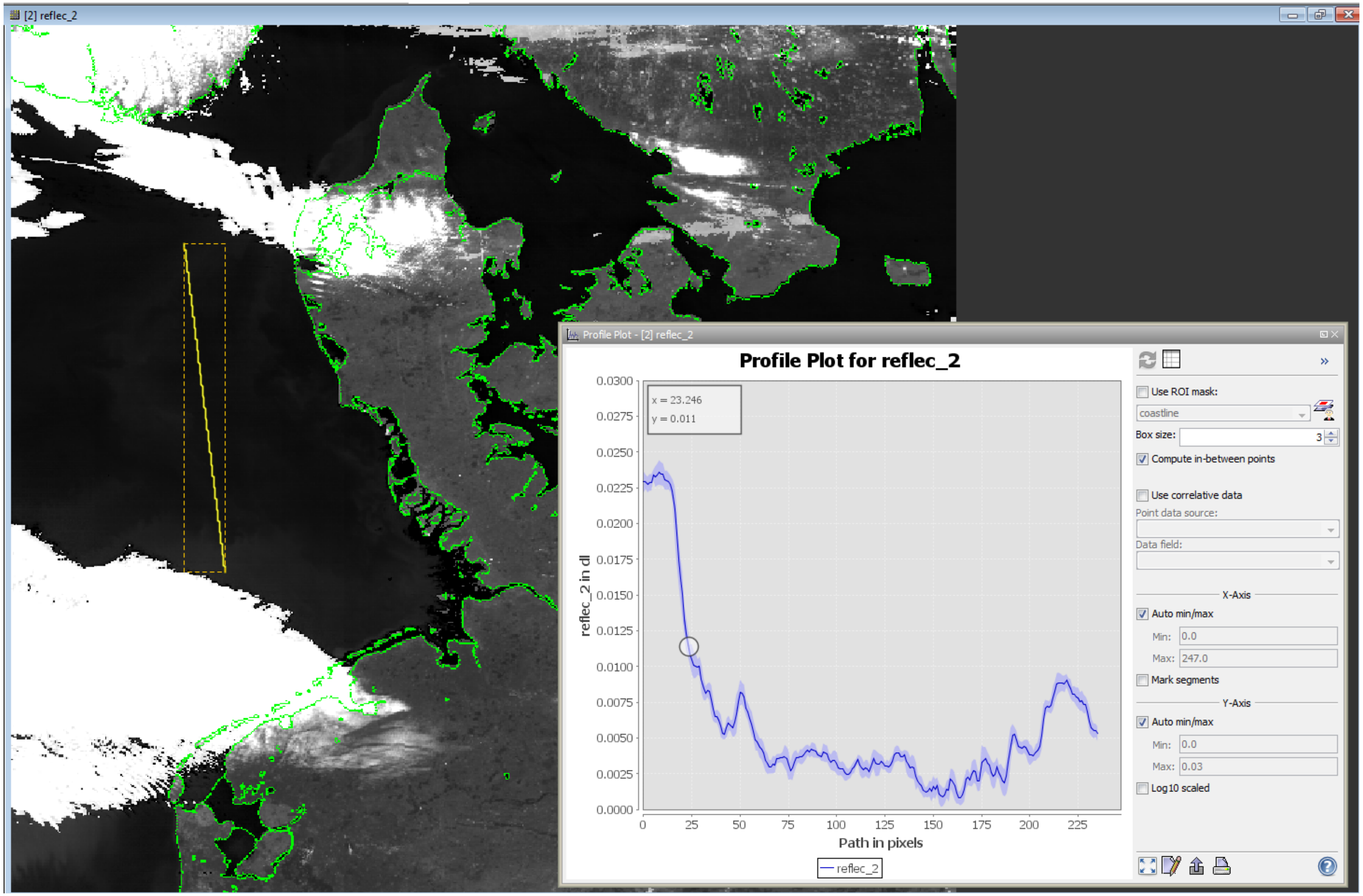
- Lines or polylines
- Transects belong always to the respective band
- Adding a transect



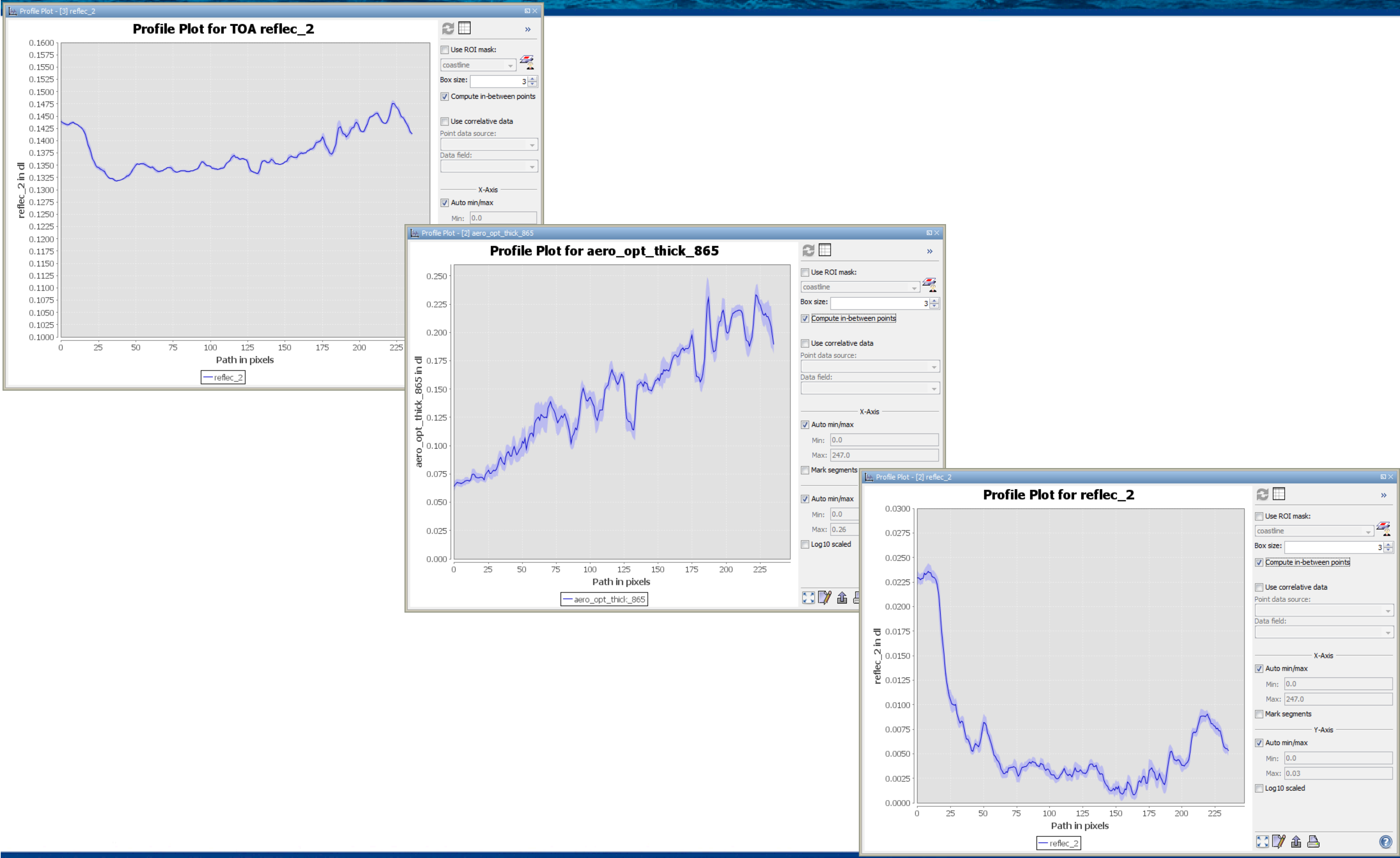
  - Draw a line with `Draw Line` or `Draw Polyline` tool
  - Importing a coordinates list (containing 2 columns: latitude, longitude)
- Display of pixel values along a transect:
  - `Analysis → Profile Plot…`
- Exporting of pixel values along a transect:
  - `File → Export`
    `→ Export Transect Pixels…`
  - Right mouse click on image
    `→ Export Transect Pixels…`



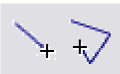
Transect Tool



Comparison of transects



Exercise 2: Solution



- Draw line using the `Draw Line` or `Draw Polyline` tool
  or import existing transect coordinate file: `File`→`Import Vector Data` →`CSV…`

  For `Files of type` choose: `plain text (*.txt, *.dat, *.csv)`
- Open profile plot window: `Analysis`→`Profile Plot…`
- Toggle between views: L1 reflec_2, L2 aero_opt_thick_865 and L2 reflec_2
- The pixels can also be copied to a text file or to the clipboard: click with right mouse button into one of the displayed bands and choose `Export Transect pixels…`
- Right mouse click on transect for copying to clipboard and insert into an Excel sheet

ROI, Mask, Layer: Concept definitions

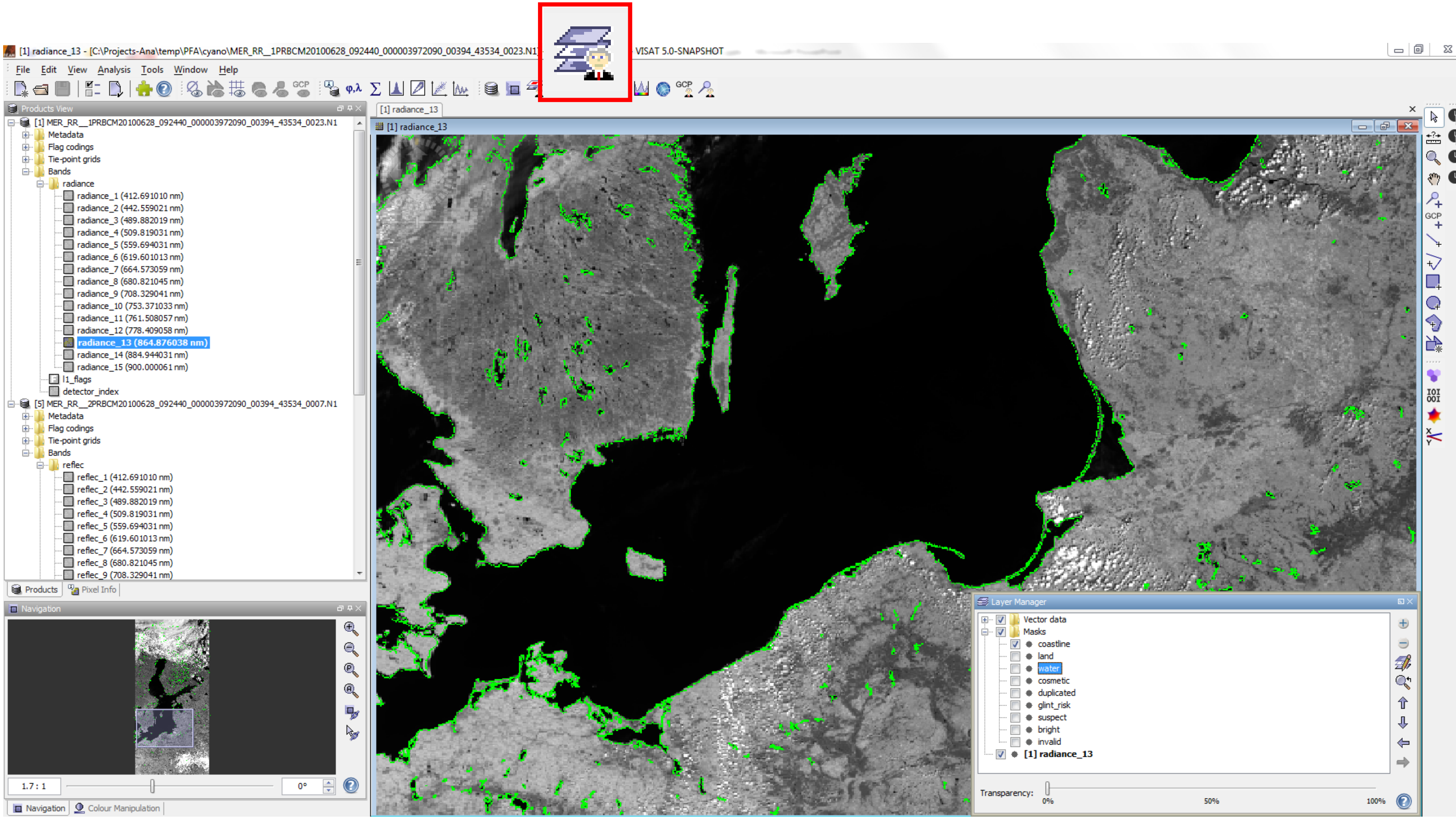
- Layer
  - Views in BEAM are composed of multiple, configurable layers
  - A layer is used to visualise a certain data source
  - Vector data, raster data and masks and represented by special layer types
- Mask
  - Masks a regions of raster dataset.
  - Masks can be derived from an expression, a value range, a geometry or from combinations of different masks.
- Geometry
  - A geometric shape (point, line, polyline or polygon).
  - Geometries can be drawn on a product view or imported from external files.
- ROI
  - Statistical computation and Analysis Tools can be performed on ROIs.
  - Masks are always and automatically applicable ROIs (→ ROIs are a role of Masks).

Exercise 3a:
Layer management and visualization

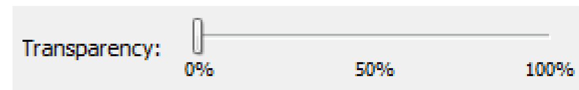
- What to do:
  - Display image, L1b
  - Open the layer manager and study the masks
  - Play around with order and transparency
  - Add new layer

- Data:
  - MER_RR__1PNMAP20120407_095350_000003443113_00252_52852_0001.N1

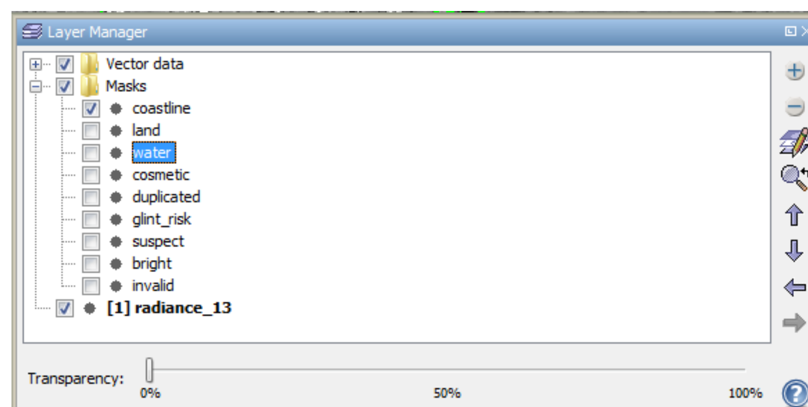
Layer management



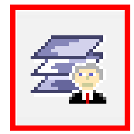
Options for Layers

- Handling visualisation
  - Order of layers 
  - Transparency of overlays 

- Add and remove layers 
  - Overlay two bands
  - Overlay polygon files (visualisation only)



Exercise 3a: Solution

- Display image (L1 and L2 to see differences in the layers)
- Click on layer manager 
- Play around with the layers:
  - Change order 
  - Transparency overlay 

- Add layer clicking at in the layer manager box 

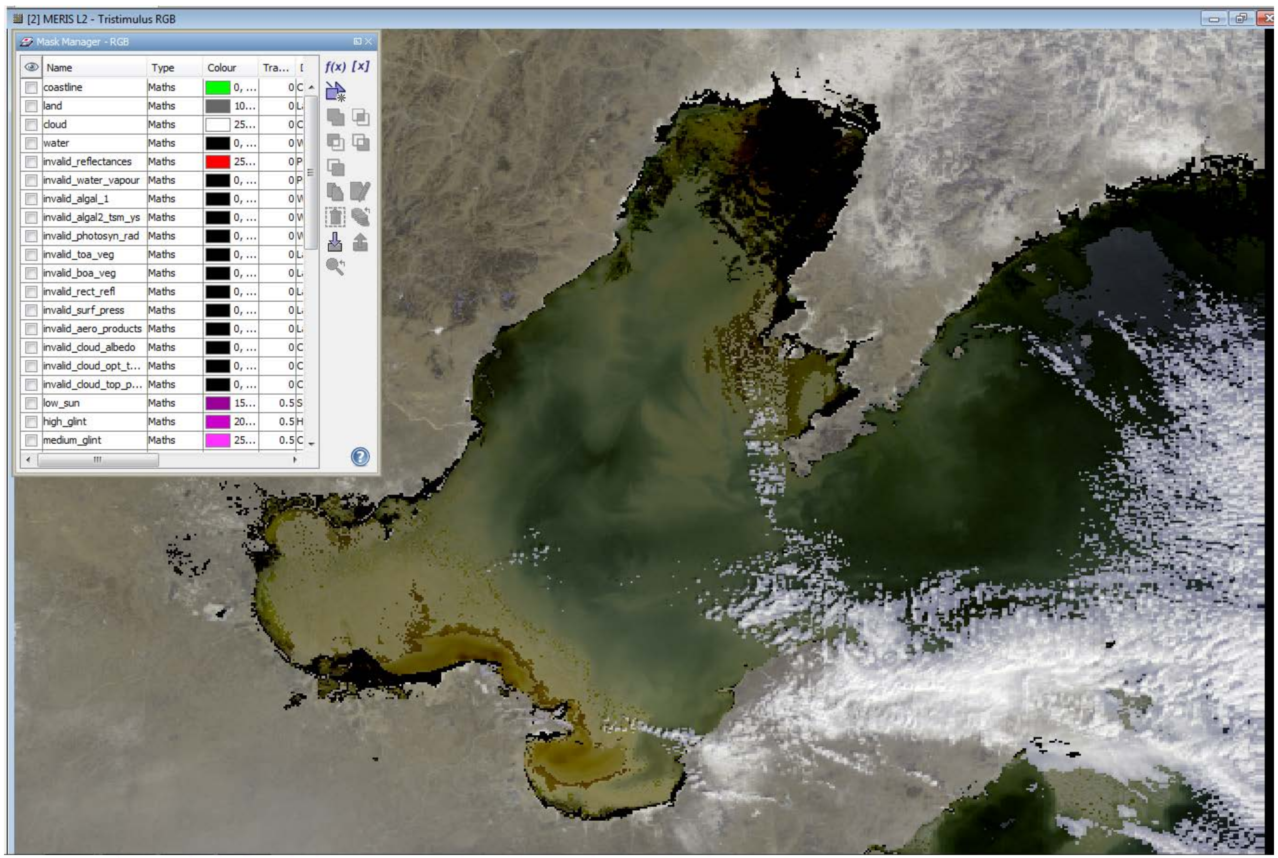
Exercise 3b: Create new Masks

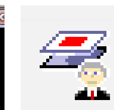
- What to do:
  - Create new mask:
    - By band math expression
    - By value range
    - By using region of interest (geometry)
  - Combine mask

- Data:
  - *MER_RR__2PRBCM20050120_023210_000007352034_00032_15116_0001.N1*

Create new Masks

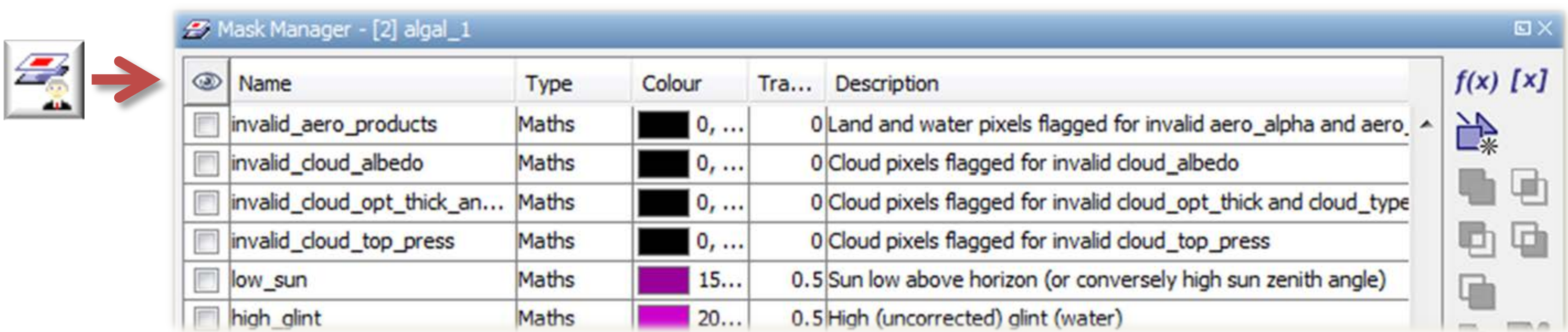
- Create a new mask on the level 2 image that covers the invalid pixels and the ice-haze covered pixels in the Baltic Sea





Masks in BEAM VISAT

- Flags of ENVISAT standard products are automatically included as masks
- All geometries, pins and imported vector data are included as masks
- Own masks can be generated
  - from flags, geometries, band math expression
  - By combination of flags

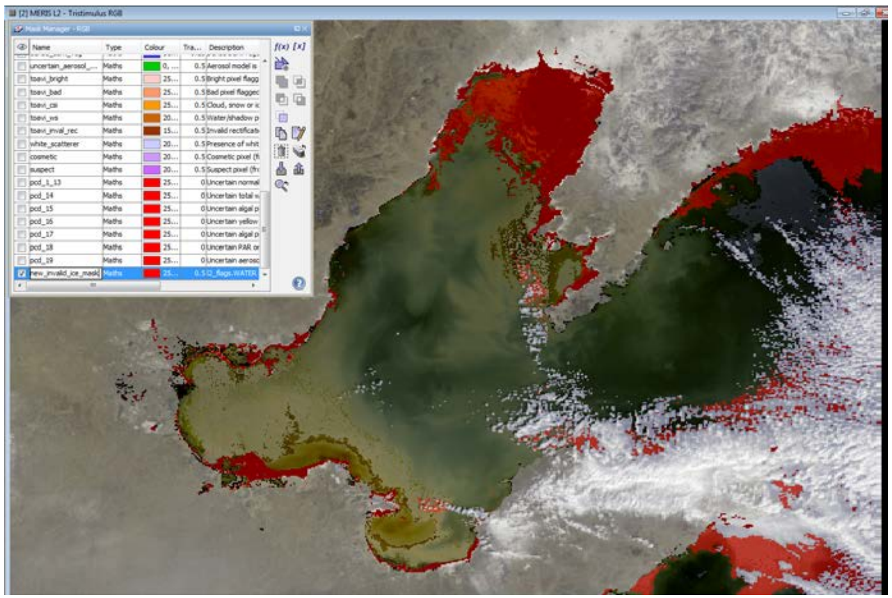


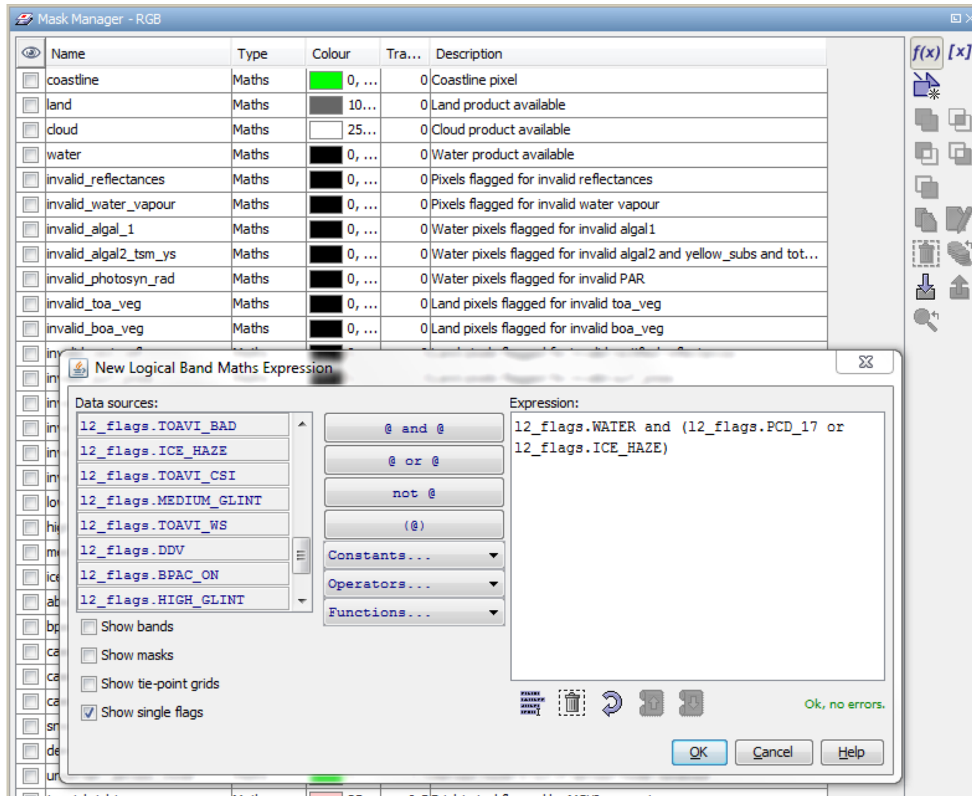
Generation of new masks

- Generation of Masks
  - Masks defined by a band maths expression

f(x)

l2_flags.WATER and (l2_flags.PCD_17 or l2_flags.ICE_HAZE)

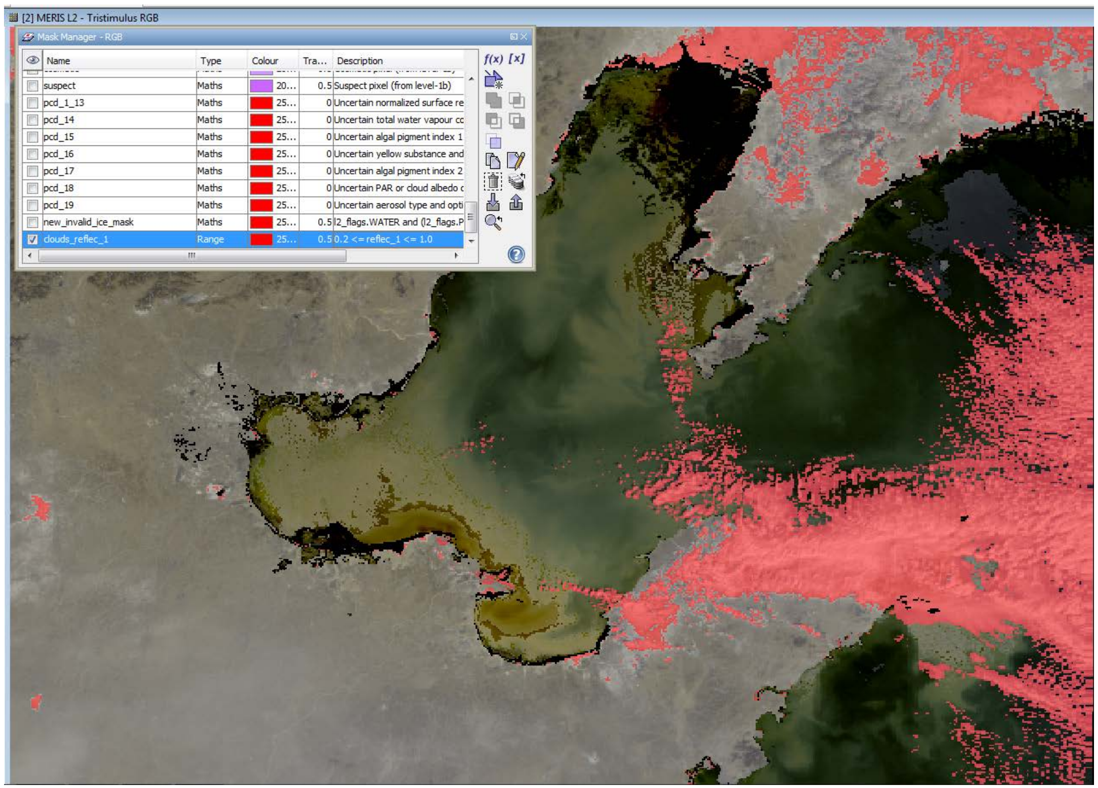


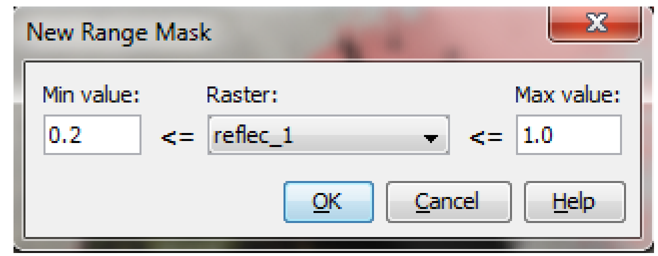


Generation of new masks

– Masks defined by a value range

[x]

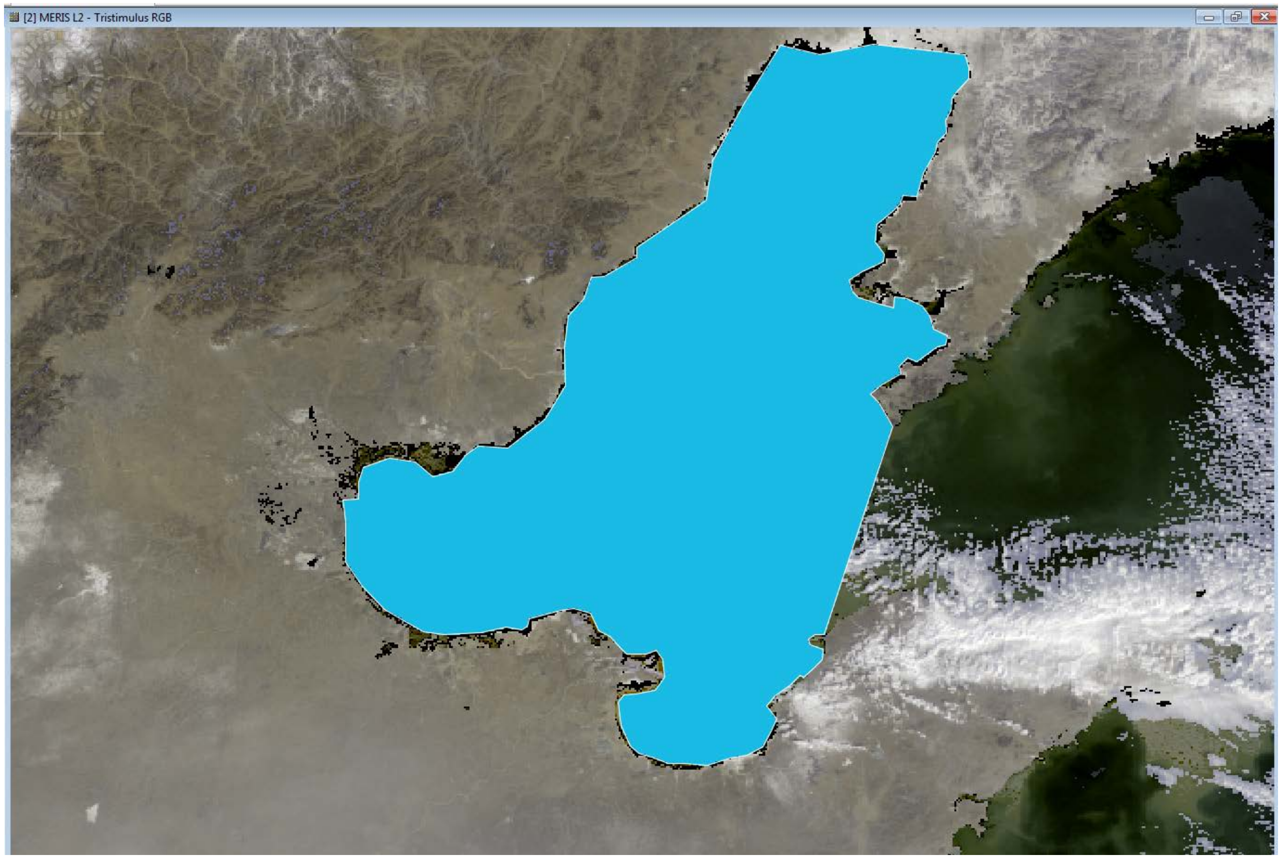




This a cloud mask

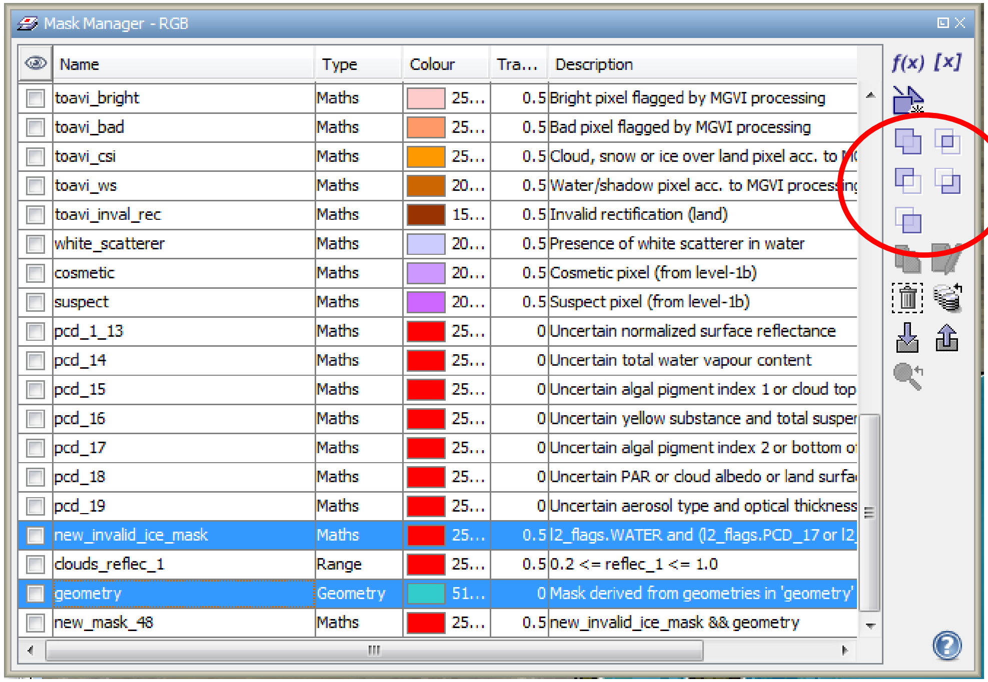
Generation of new masks

– Masks defined by a geometry such as lines and polygons



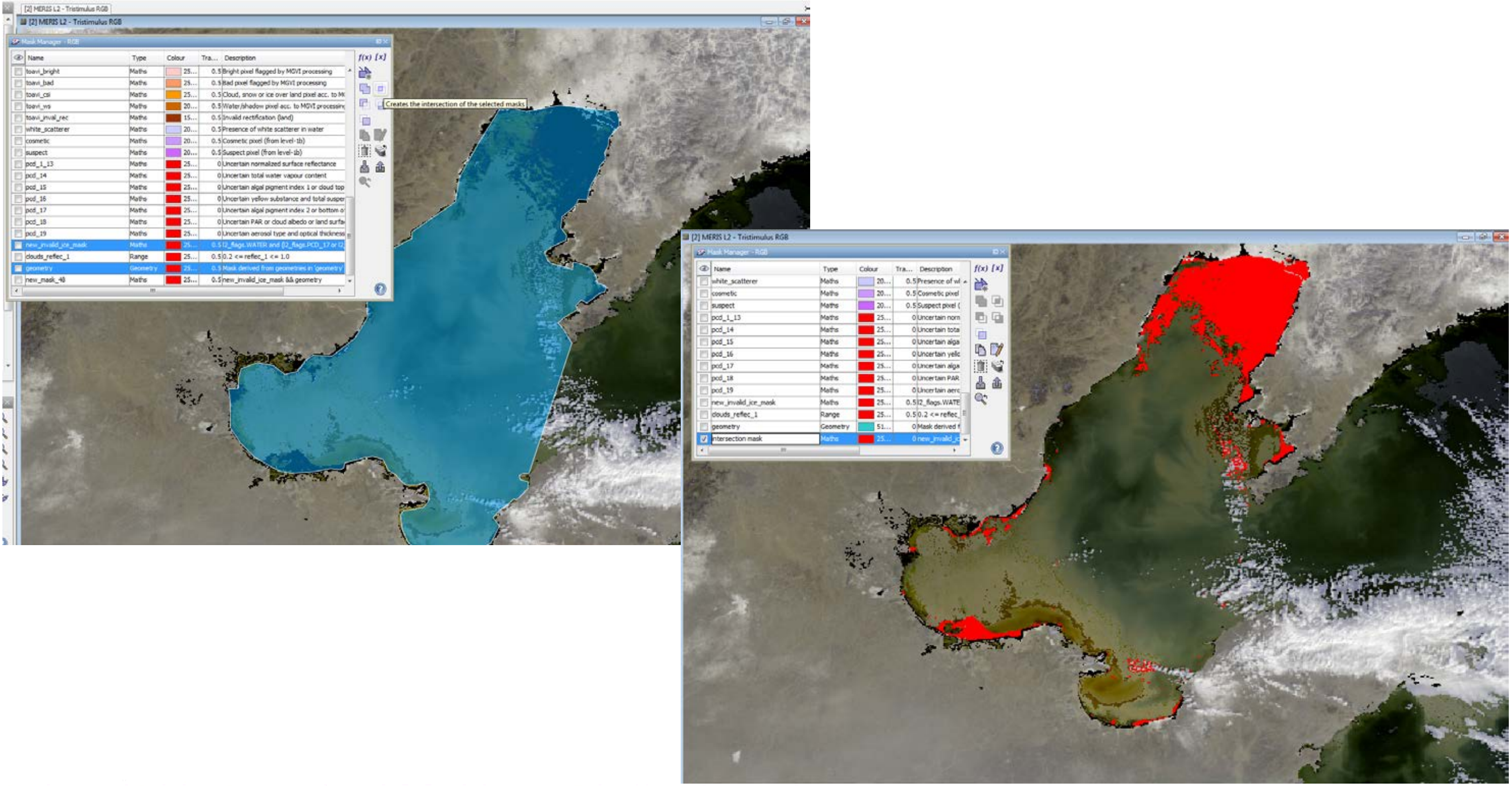
Generation of new masks

- Combination of Masks
  - Union
  - Intersection
  - Differences
  - Complement of a mask



Name	Type	Colour	Tra...	Description
toavi_bright	Maths	25...	0.5	Bright pixel flagged by MGVI processing
toavi_bad	Maths	25...	0.5	Bad pixel flagged by MGVI processing
toavi_csi	Maths	25...	0.5	Cloud, snow or ice over land pixel acc. to M
toavi_ws	Maths	20...	0.5	Water/shadow pixel acc. to MGVI processing
toavi_inval_rec	Maths	15...	0.5	Invalid rectification (land)
white_scatterer	Maths	20...	0.5	Presence of white scatterer in water
cosmetic	Maths	20...	0.5	Cosmetic pixel (from level-1b)
suspect	Maths	20...	0.5	Suspect pixel (from level-1b)
pcd_1_13	Maths	25...	0	Uncertain normalized surface reflectance
pcd_14	Maths	25...	0	Uncertain total water vapour content
pcd_15	Maths	25...	0	Uncertain algal pigment index 1 or cloud top
pcd_16	Maths	25...	0	Uncertain yellow substance and total susper
pcd_17	Maths	25...	0	Uncertain algal pigment index 2 or bottom o
pcd_18	Maths	25...	0	Uncertain PAR or cloud albedo or land surfa
pcd_19	Maths	25...	0	Uncertain aerosol type and optical thickness
new_invalid_ice_mask	Maths	25...	0.5	l2_flags.WATER and (l2_flags.PCD_17 or l2
clouds_reflec_1	Range	25...	0.5	0.2 <= reflec_1 <= 1.0
geometry	Geometry	51...	0	Mask derived from geometries in 'geometry'
new_mask_48	Maths	25...	0.5	new_invalid_ice_mask && geometry

i.e. Intersection of two masks



Exercise 3b: Solution

– Zoom to the Baltic Sea and test the flagging of the algal_2 product
  - Ice_haze areas are not covered fully by the PCD flag

– Create a new mask that includes the water mask as well as the ice_haze and the PCD_17 flag
  - A) Using math expression *f(x)*
    – *l2_flags.WATER and (l2_flags.PCD_17 or l2_flags.ICE_HAZE)*
  - B) Using ROIs- geometry
  - C)Using the tools for combinations
    – select both flags: *l2_flags.WATER and (l2_flags.PCD_17 or l2_flags.ICE_HAZE) and the one created from the ROI*
    – Choose the tool: *intersection*

Take-home messages

- 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.
- BEAM provides the spectrum view to quickly investigate spectral quantities.
- Masks and layers support the visual analysis of image data.
- Transect are a powerful tool to investigate spatial pattern.

End of Unit

Blue-Green Ratio Algorithm

Carsten Brockmann

Ana Ruescas

Kerstin Stelzer

Brockmann Consult GmbH

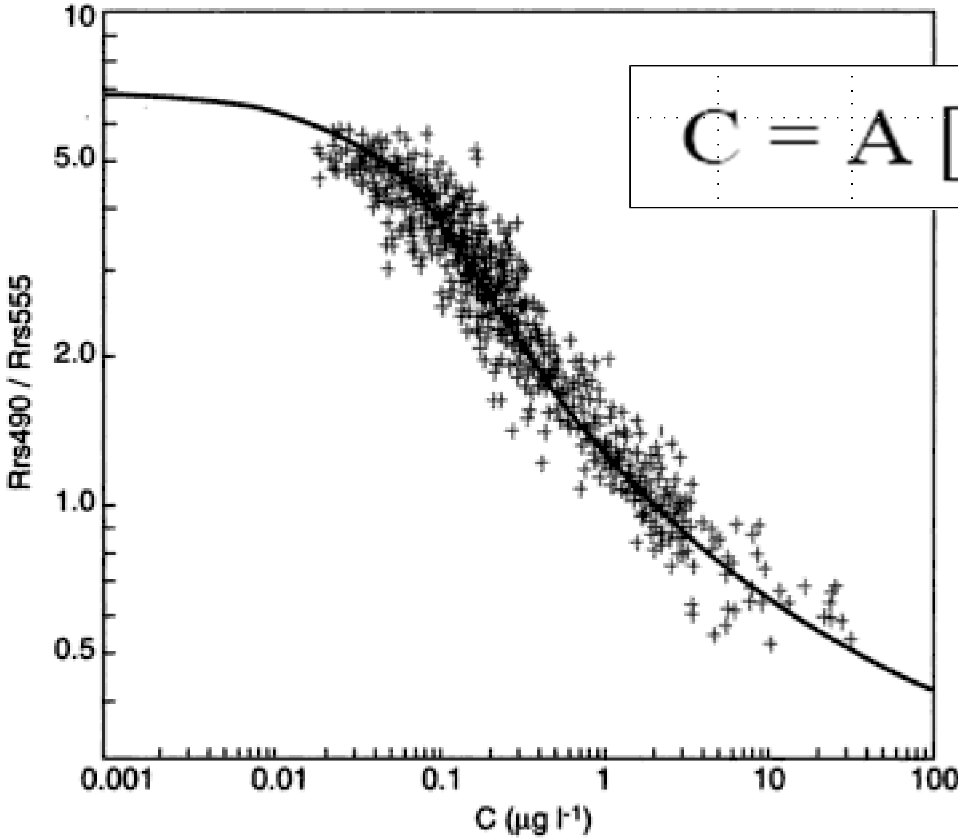
Content

- From reflectance to water quality parameters:
  - Blue/green ratio algorithm

- BEAM exercises
  - Exercise 1: Band arithmetic
  - Exercise 2: Compare water products
- Data:
  - subset_0_of_MER_RR__2PRBCM20080606_095728_000007182069_00151_32770_0001.dim

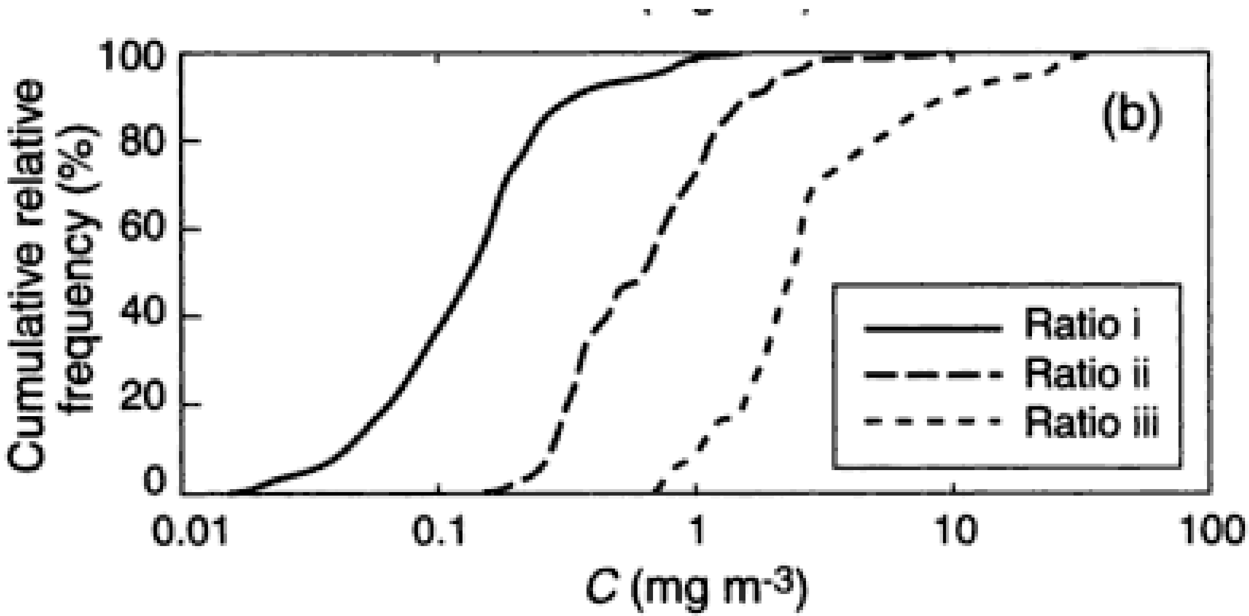
Blue Green Ratio

- Relation of chlorophyll and Rrs(490)/Rrs(555) ration for SeaBAM dataset (OC2)



$$C = A\,[R(445)\,/\,R(550)]^{B}$$

OC4 – 3 different ratios



The OC4 includes another two ratios in the blue-green and selects the one that has the largest value for each station: Rrs(443)/Rrs(555); Rrs(490)/Rrs(555); Rrs(510)/Rrs(555). Each ratio works best best for a different part of the CHL range. This is the actual standard NASA CHL algo for SeaWiFS and MODIS.

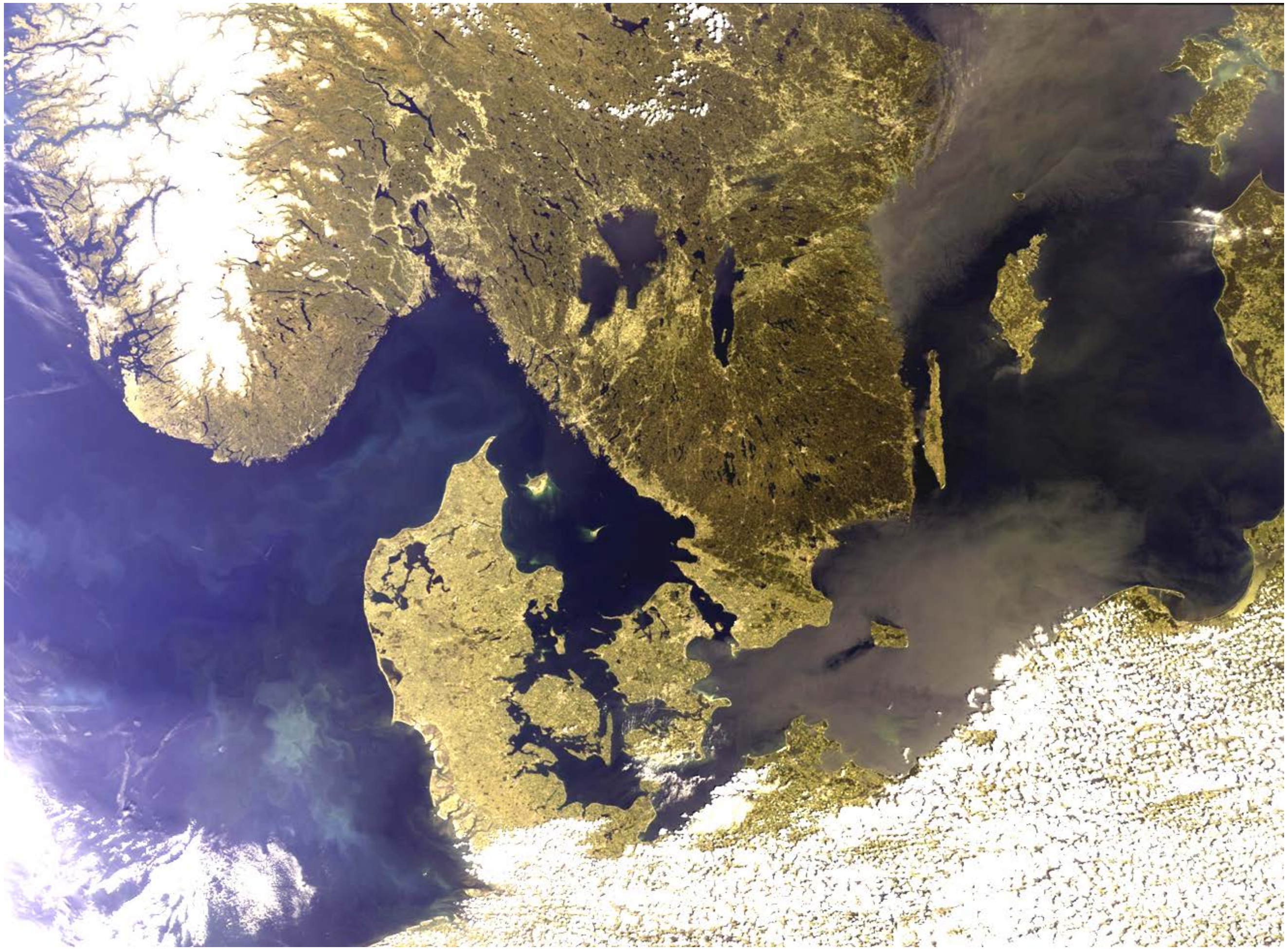
Exercise 1: Band ratios using band math

- Open data: L2 atmospherically corrected radiance:

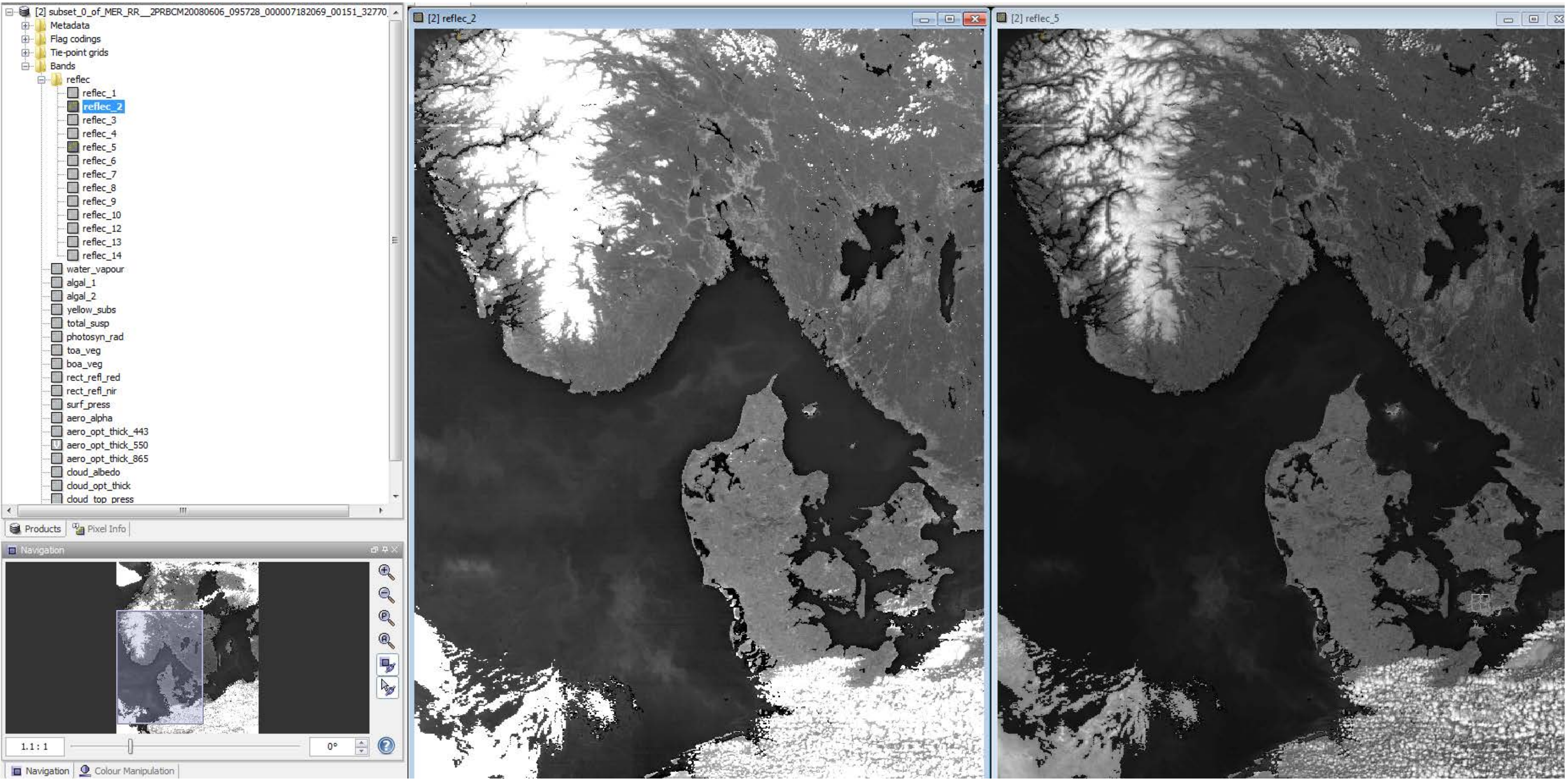
  subset_0_of_MER_RR__2PRBCM20080606_095728_000007182069_00151_32770_0001.dim

- Compute a simple band ratio for Chl estimation:
  - Open reflectance_2 and reflectance_5 bands
  - Use pin and spectrum view to investigate the spectra
  - Calculate band ratios
  - Compare with algal_1 in Level 2 product

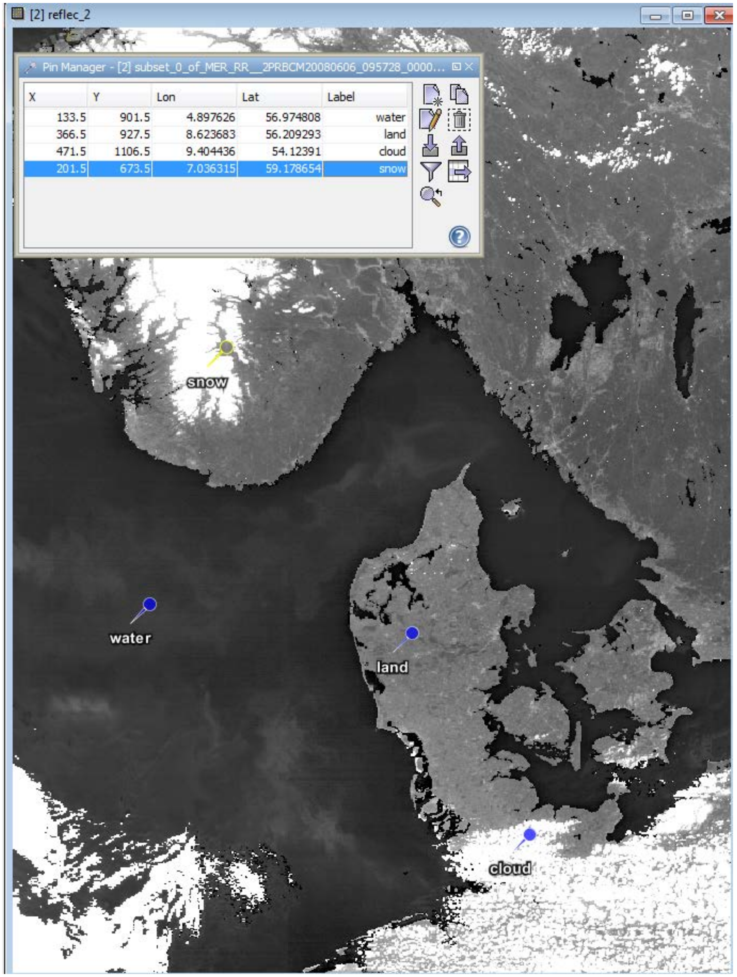
Exercise 1:
Band ratios using band math



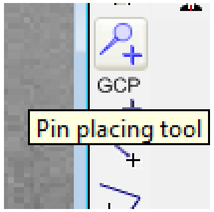
Open reflec_2 and reflec_5

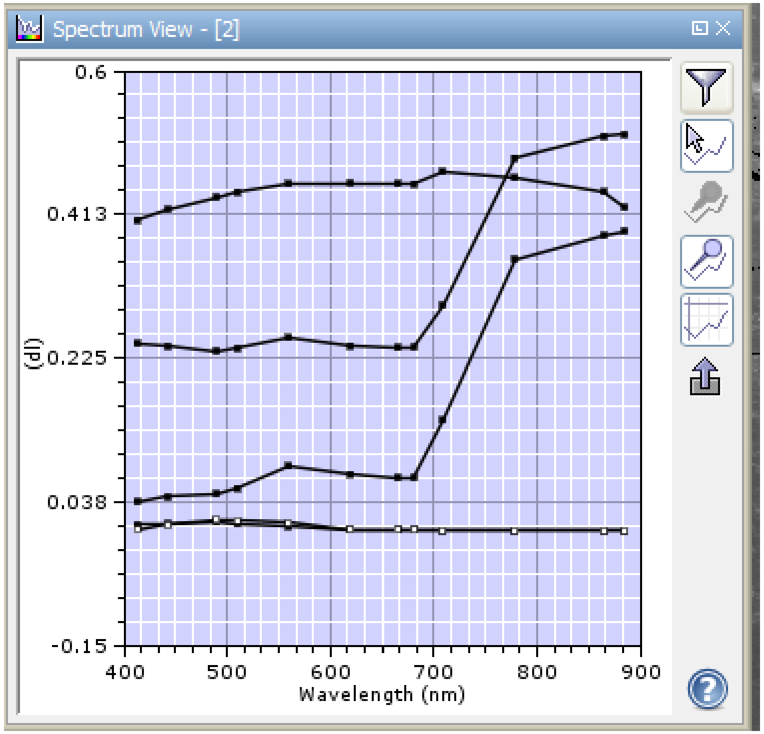


Create pins and open spectrum view



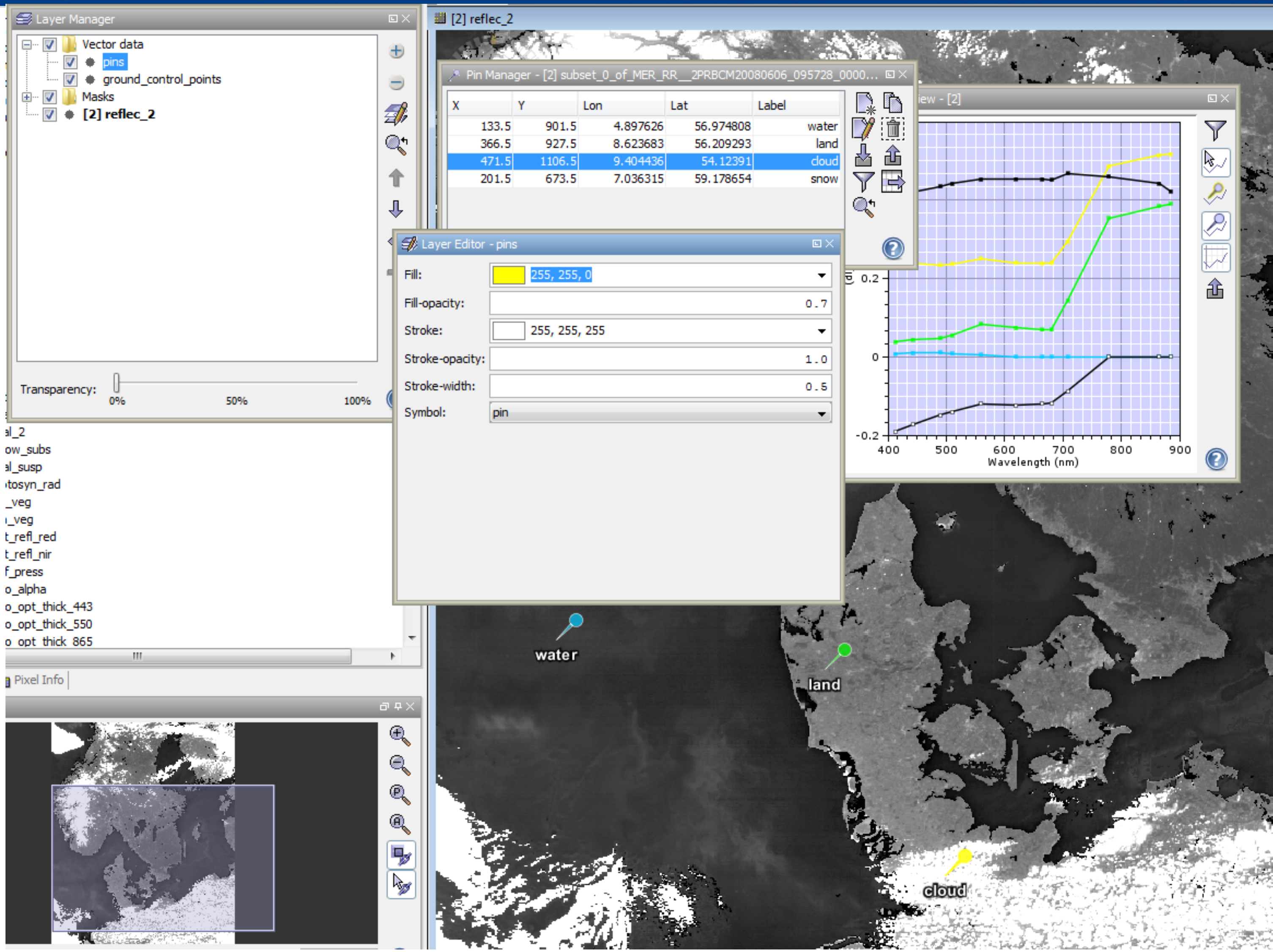
X	Y	Lon	Lat	Label
133.5	901.5	4.897626	56.974808	water
366.5	927.5	8.623683	56.209293	land
471.5	1106.5	9.404436	54.12391	cloud
201.5	673.5	7.036315	59.178654	snow



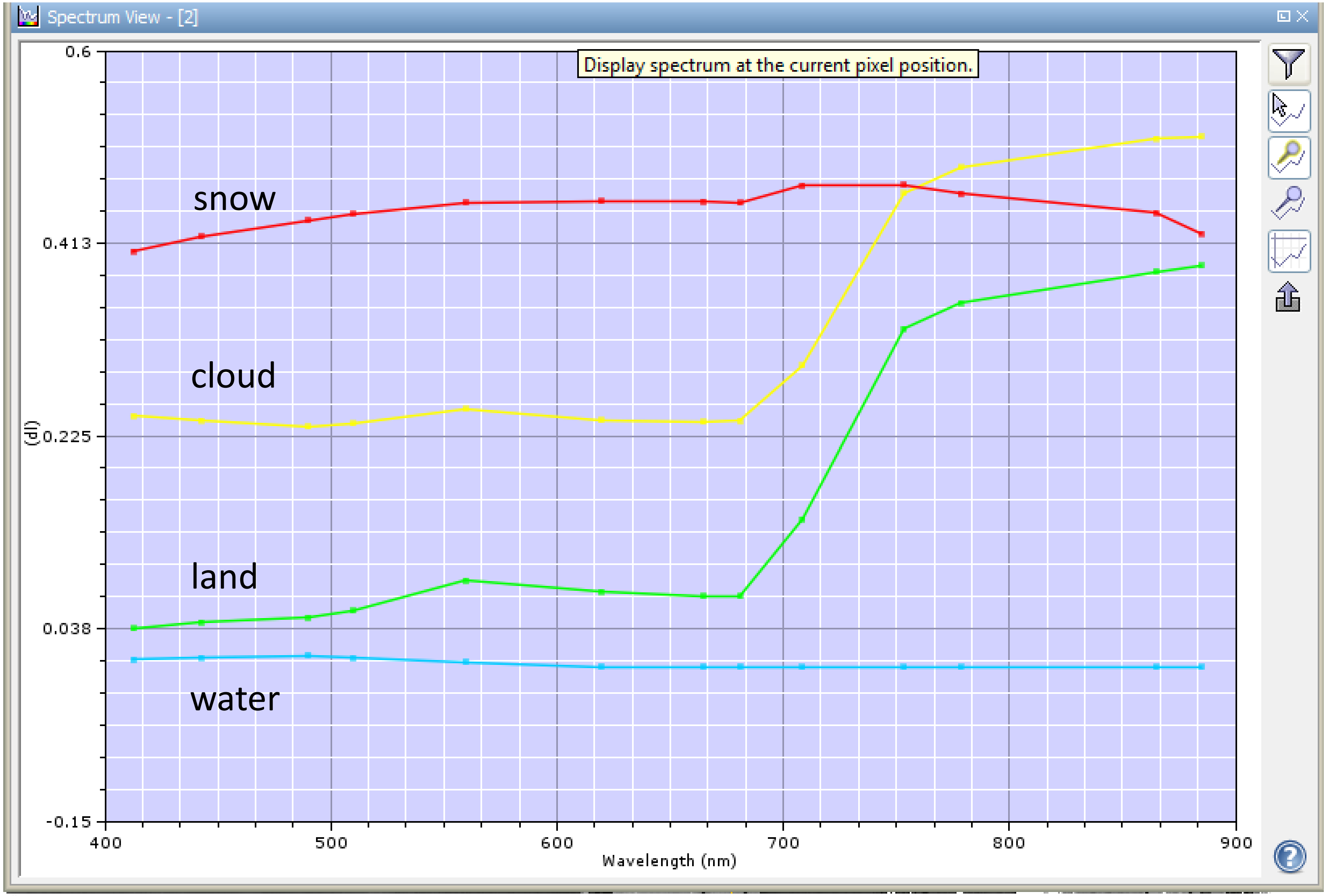


How to modify pins

- To be able to differentiate between pins, and use this information in the spectrum view, use: layer manager
- With the pin manager open, select each pixel and modify color using the layer manager-layer editor tool
- Save pins in file “Data_pins_MER_RR_20080606.txt”

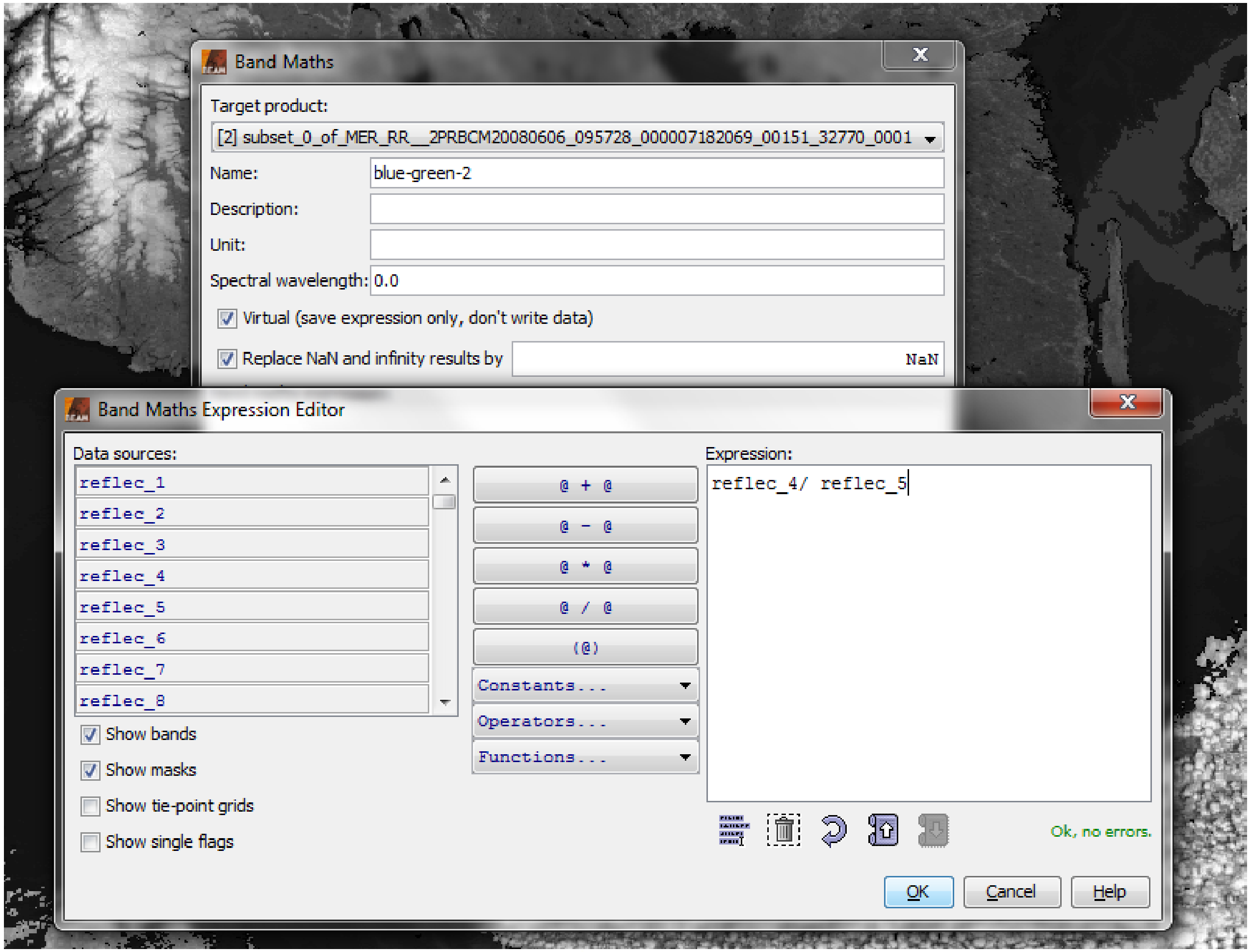

Layer Manager
Vector data
pins
ground_control_points
Masks
[2] reflec_2
Transparency:
0%
50%
100%
[2] reflec_2
Pin Manager - [2] subset_0_of_MER_RR__2PRBCM20080606_095728_0000...
X Y Lon Lat Label
133.5 901.5 4.897626 56.974808 water
366.5 927.5 8.623683 56.209293 land
471.5 1106.5 9.404436 54.12391 cloud
201.5 673.5 7.036315 59.178654 snow
Layer Editor - pins
Fill: 255, 255, 0
Fill-opacity: 0.7
Stroke: 255, 255, 255
Stroke-opacity: 1.0
Stroke-width: 0.5
Symbol: pin
Wavelength (nm)
water
land
cloud
Pixel Info

Spectrum View



Band Math Expressions

- Open Tools/Create Band by Band Maths



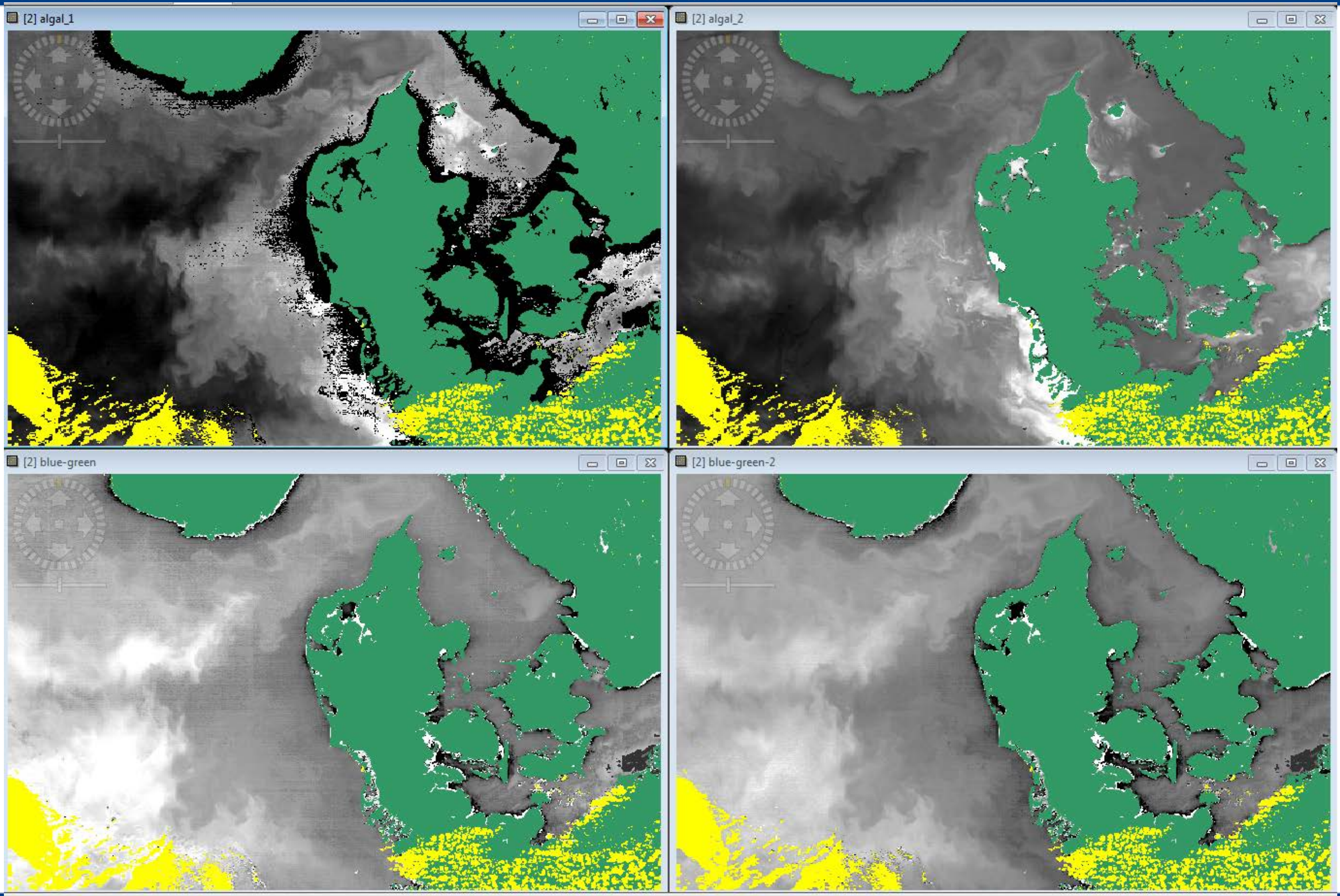
Exercise 1: Solution

- Display L2R reflectance bands: double click on reflec_2 and reflec_5
- Put new pins on different parts of the North Sea or open the file “Data_pins_MER_RR_20080606.txt”
- Generate a spectrum view plot and discuss the results for the different surfaces
- Open the band math a calculate ratio of bands reflec_2/reflec_5. Name it “blue-green” ratio→Tools/Create band by band maths
- Calculate a second blue-green ratio with reflec_4/reflec_5. Named it “blue-green-2”
- Display the new band ratios

Exercise 1b: Compare with standard water quality products

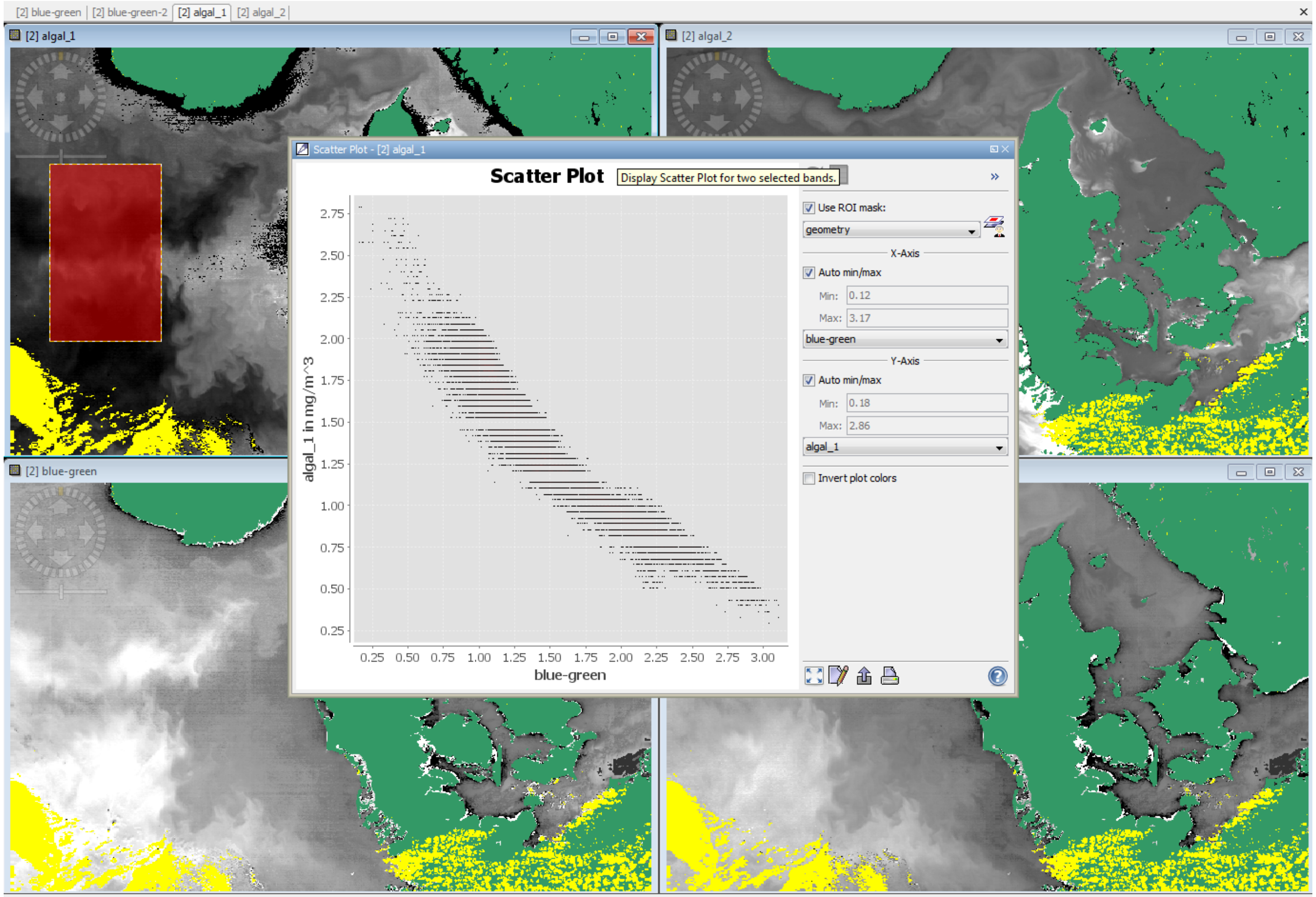
- Open data:
  - L2 atmospherically corrected radiance and water quality products:
  - subset_0_of_MER_RR__2PRBCM20080606_095728_000007182069_00151_32770_0001.dim
- Display blue-green ratios saved before in L2
- Display algal_1 and algal_2 from the L2 standard product
- Display scatter plot comparing algal_1 and blue-green ratios

Compare Water Quality Products



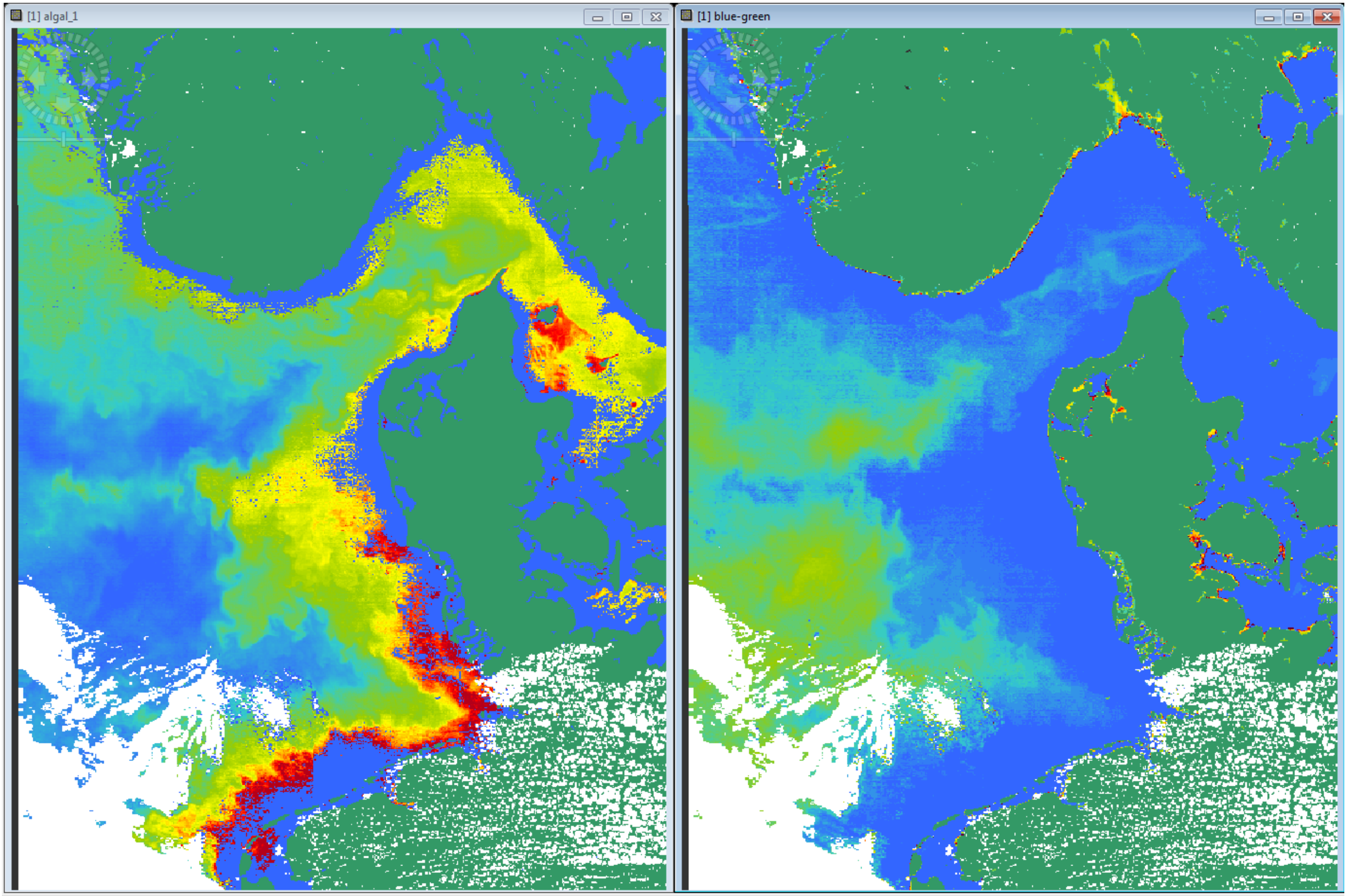
Compare Water Quality Products

- Use geometry over water and display scatter plot



Compare Water Quality Products

- Compare using same colour palette

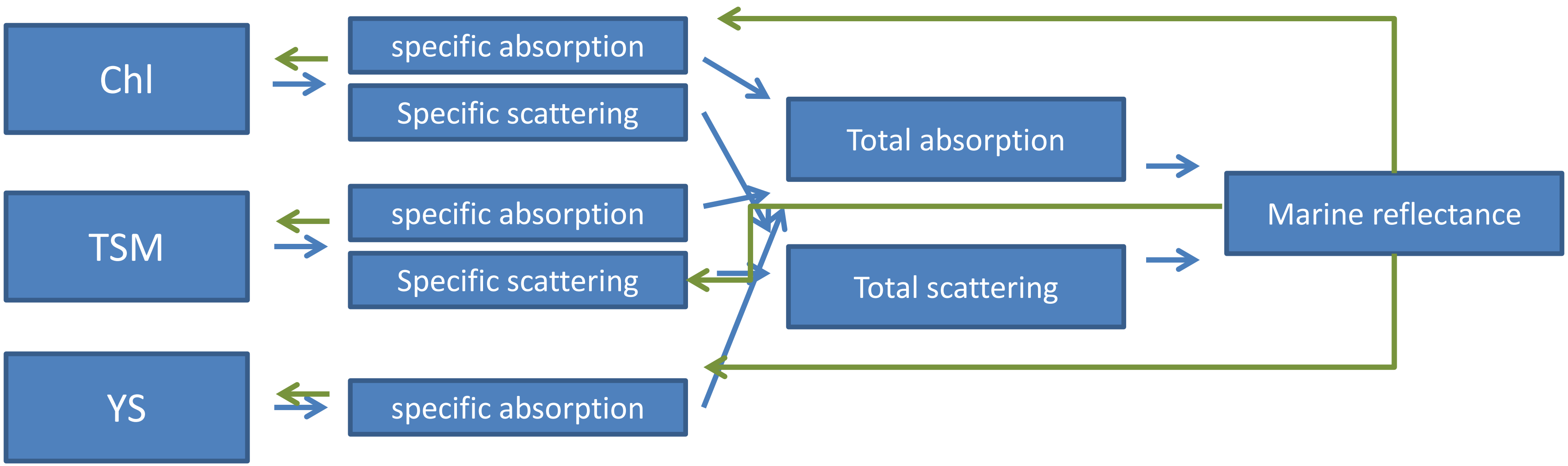


Exercise 2: Solution

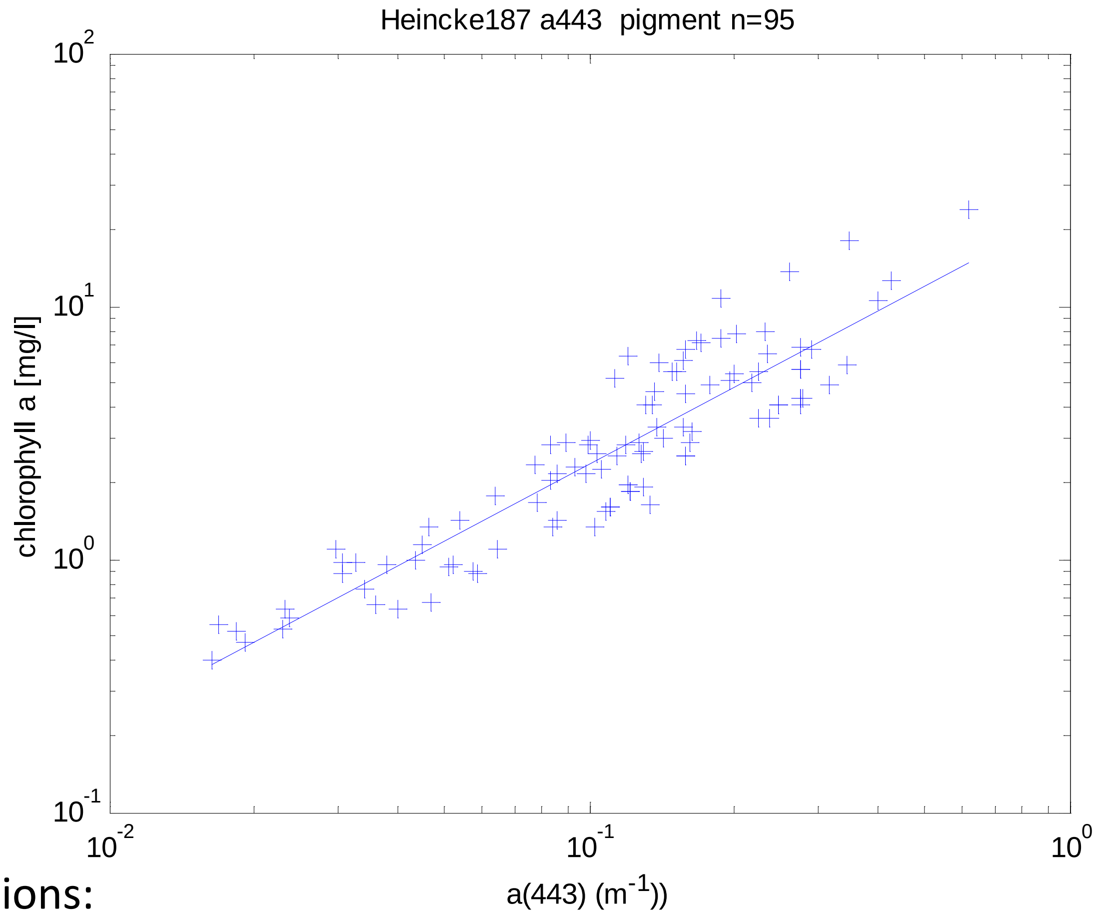
- Display new ratios calculated using the L2R scenes
- Display bands algal_1 and algal_2 from the standard level 2 products
- Use the geometry to use it as a ROI in the scatter plot to compare results of algal_1 with the blue-green ratio.
- Compare results using the same colour palette: palettes\CHL_colours.cpd

Bio-optical models

- Blue – green ratios work well where only Phytoplankton pigment absorption determines the water colour (so called Case 1 waters)
- If other optically active substances are in the water, the relationship between blue-green and Chl-a breaks. A model is required that relates the inherent optical properties of the water (IOP) to concentrations (Chl, TSM, yellow substance) as well as to the marine reflectance spectrum (Case 2 waters)



Pigment absorption



Conversions:

Chl. a [mg m-3] = 21 * a_pig_442 ^1.04

Take-home messages

- In Case 1 waters the blue-green ratio is closely related to the chlorophyll-a concentration
- In Case 2 waters a complex bio-optical model is required
- Pins allow to study and compare pixel values, also across different products.
- BEAM math tools enables creation of new bands using mathematical expressions.
- BEAM scatter plot allow comparison of different bands. Masks can be applied.

End of Unit

Statistical analysis of in-water products

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Contents

- Analysing water quality parameters:
  - Average chlorophyll concentration close to sea ice
  - Comparing water quality parameters with in-situ measurements
- VISAT Basics 1
  - Masks creation & manipulation
  - Region of interest and tools for statistics
  - Exercise 3: Region of interest, plots and statistics tool

Exercise 3: ROIs and statistics tool

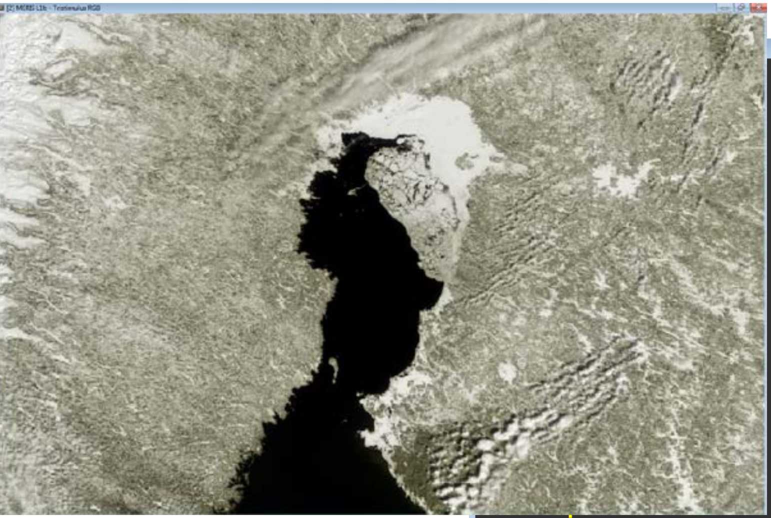
- What to do:
  - Use masks as ROIs
  - ROIs in profile plots
  - ROI in statistics tool

- Data:
  - MER_RR__2PNMAP20120407_095350_000003443113_00252_52852_0001.N1
  - in-situ/ferrybox_cosyna_20120402.txt

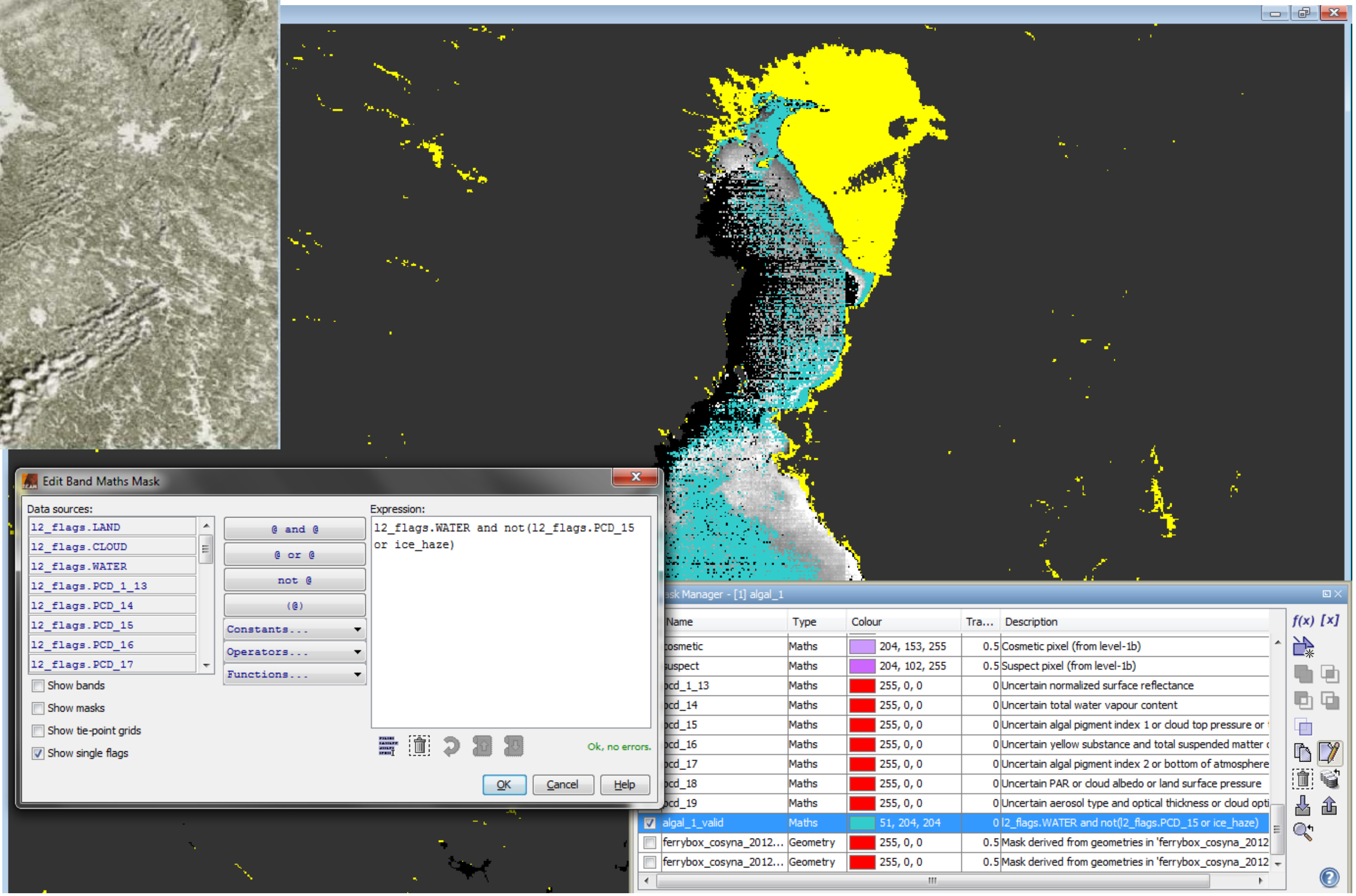
Create a new mask

- Create a new mask that covers the invalid pixels and the ice covered pixels in the Bothnian Bay
- Steps:
  - Zoom to the Bothnian Bay and test the flagging of the algal_1 product
    - Ice areas are not covered fully by the PCD flag
  - Create a new mask that includes the PCD as well as the ice_haze flag
    - f(x) → Using math expression
      - l2_flags.WATER and not(l2_flags.PCD_15 or ice_haze)

Mask: algal_1_valid

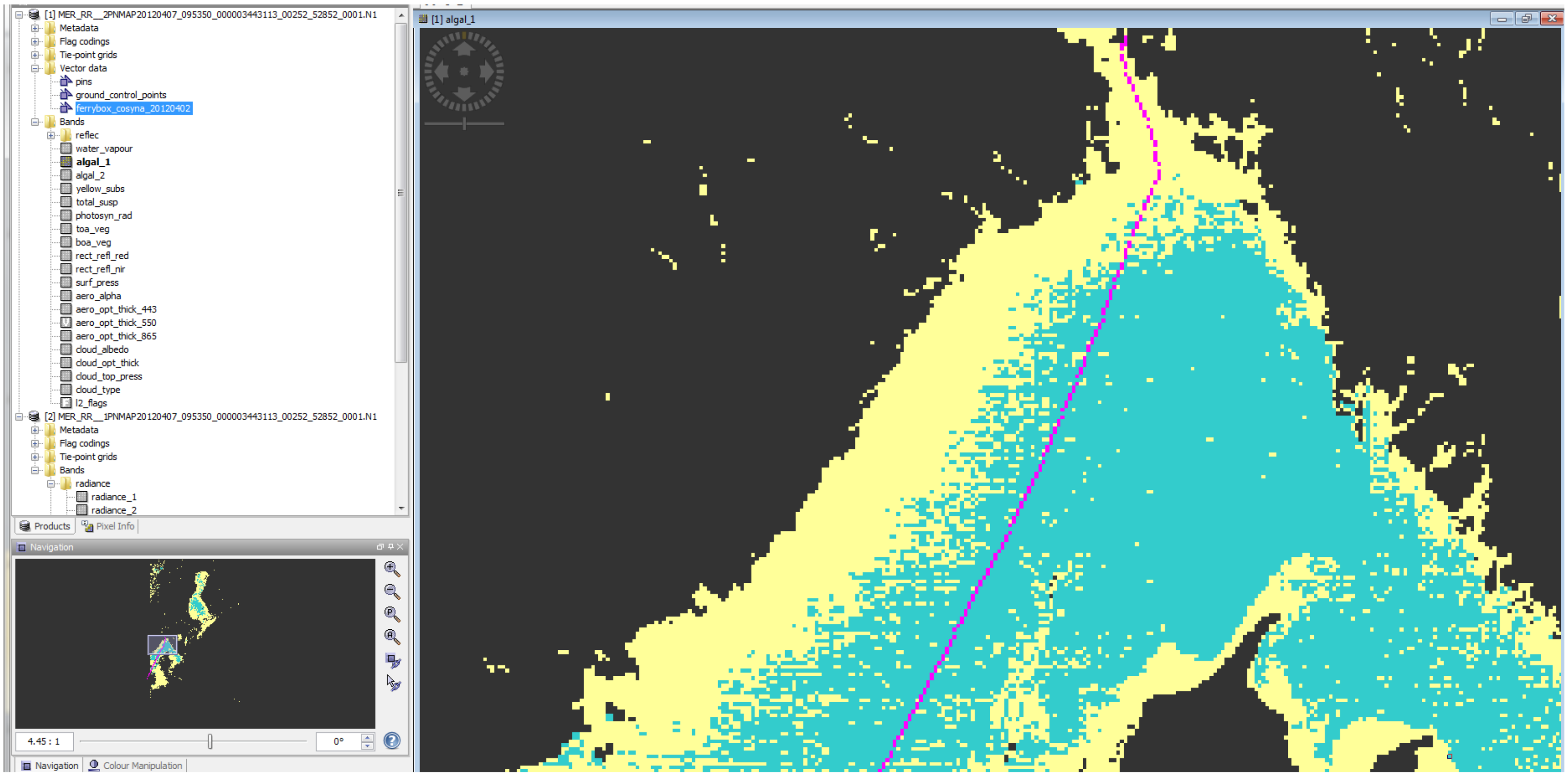


RGB with sea ice visible



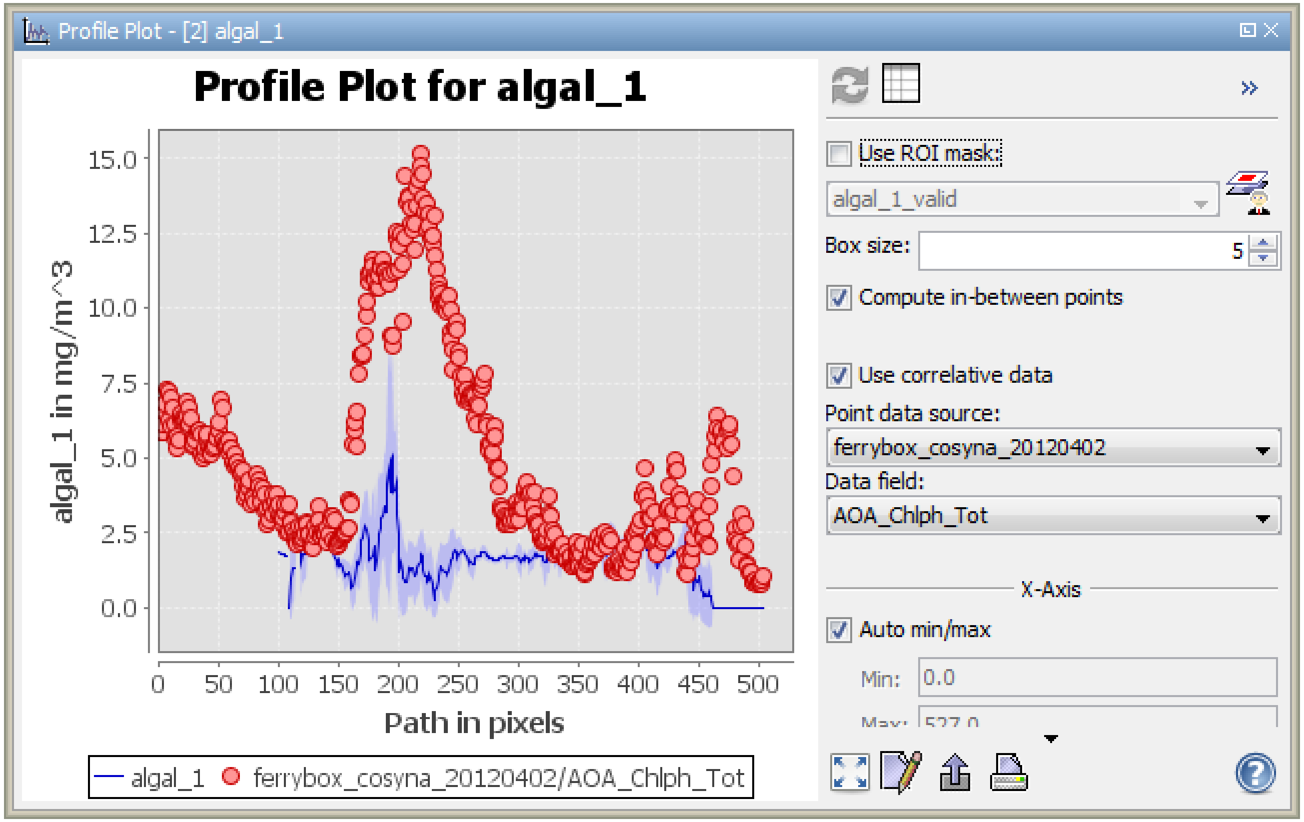
Import track data

- Import vector data/CSV/ferrybox_cosyna_20120402.txt

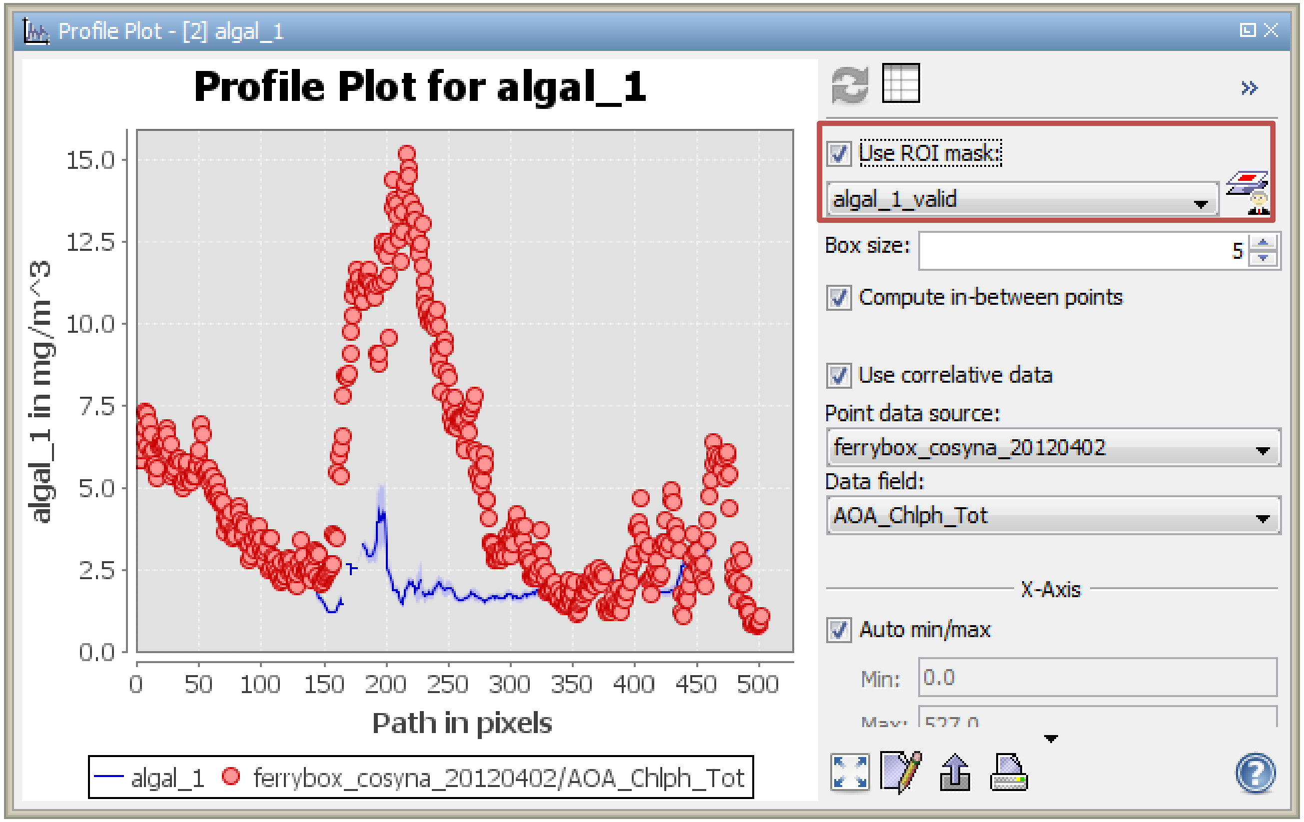


The data were provided by the COSYNA system operated by Helmholtz-Zentrum Geesthacht Zentrum für Material- und Küstenforschung GmbH

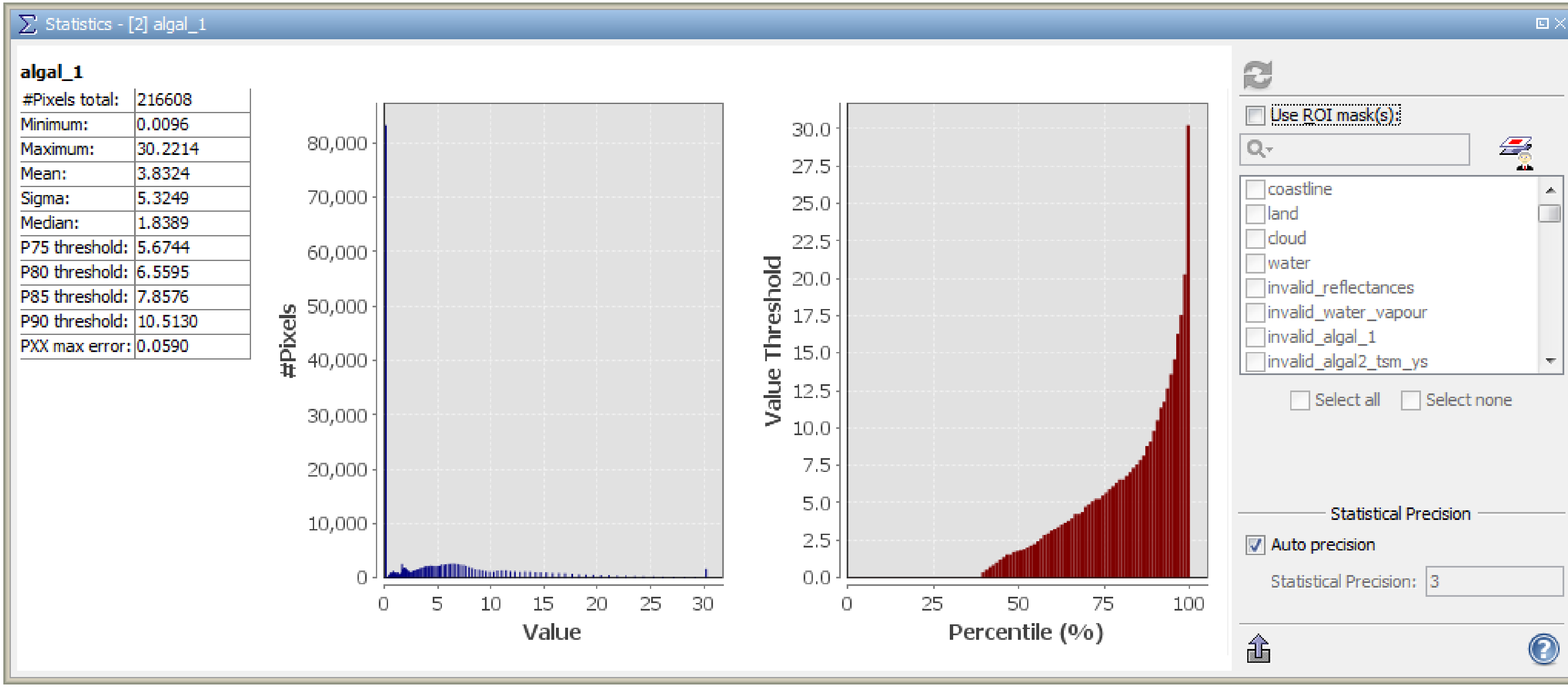
Profile plots



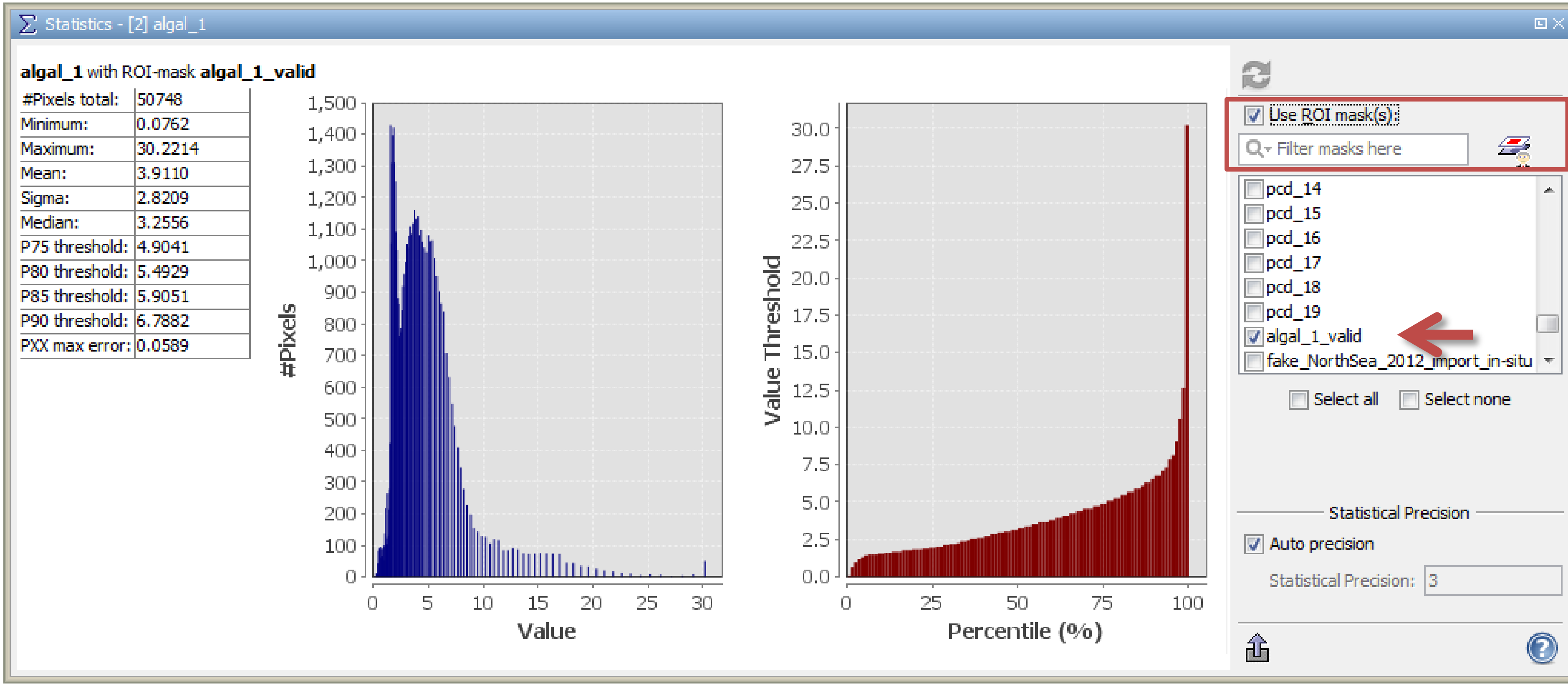
ROIs in profile plots



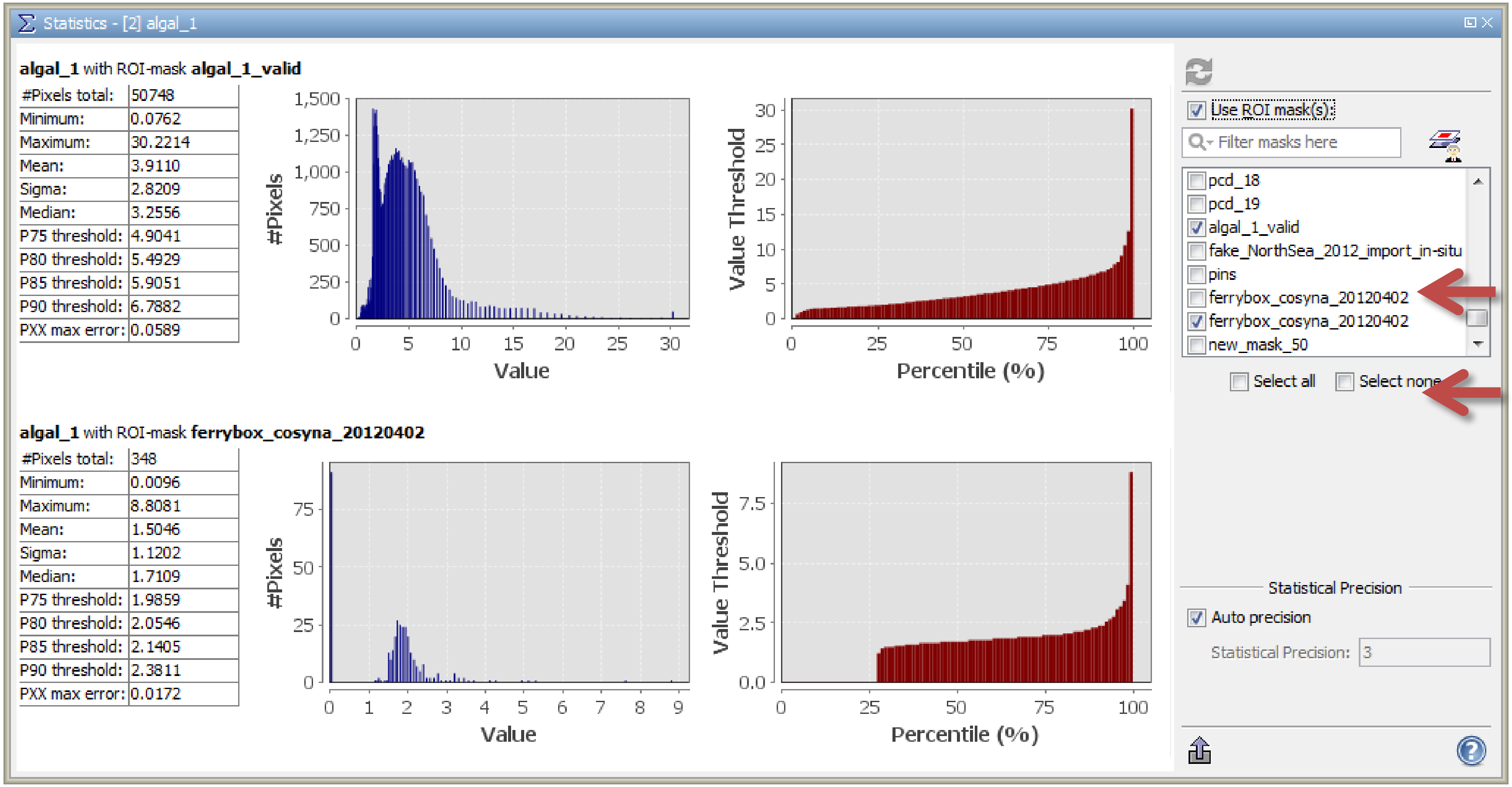
Statistic Tool



ROIs in statistic tool



ROIs in statistic tool



Exercise 3: Solution

- Create a new mask with valid pixels of algal_2: use math expression in mask manager
  - l2_flags.WATER and not(l2_flags.PCD_15 or ice_haze)
- Import ferry-box in situ data:
- Import vector data/CSV/ferrybox_cosyna_20120402.txt
- Use mask as ROIs in correlative plots :
- Click on the ROI and select algal_1_valid mask
- ROIs in profile plots:
- Click on the ROI and select algal_1_valid mask
- ROI in statistics tool:
- Click on the ROI and select algal_1_valid mask

Take-home messages

- Selecting valid pixels is important. The PCDs in MERIS products should identify them, but a critical look is necessary and a refinement sometime necessary.

- The mask manager in BEAM provides many ways to construct Regions of interest. These can be visualised as masks and they can be used to select pixels for statistical analysis, histograms, scatter plots and transect analysis.

End of Unit

Temporal analysis of water quality parameters

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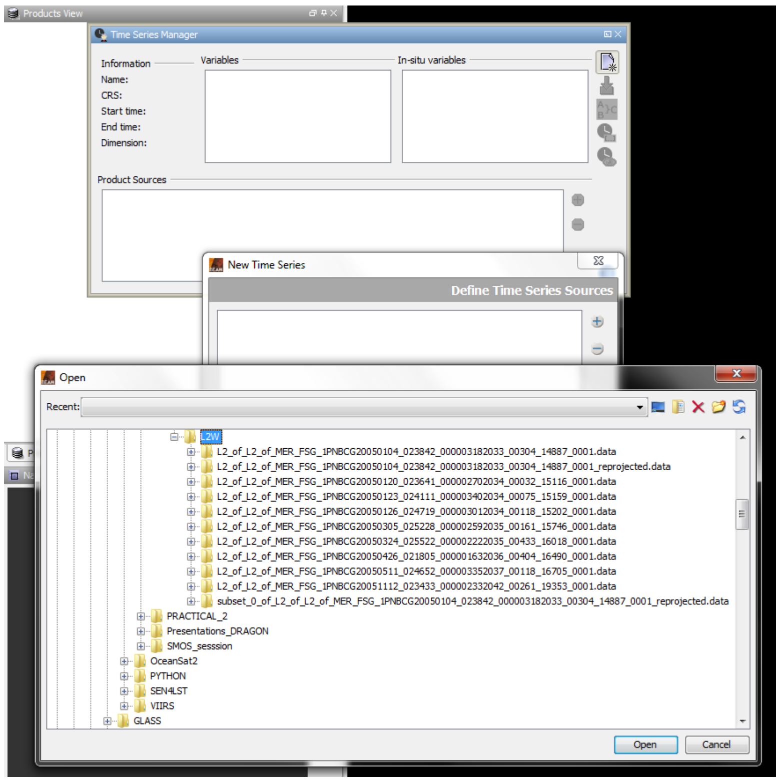
Brockmann Consult GmbH

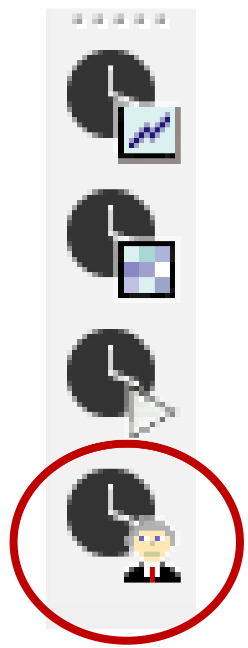
Contents

- Analysis of water quality dynamics
  - Study a timeline of products
  - Compare with in-situ data
- BEAM exercises
  - Spatial and temporal analysis tools
  - (re-)projection
  - Exercise 4: Time series of water quality parameters
  - Exercise 5: L3 binning tool

Exercise 4: Time series of WQ parameters

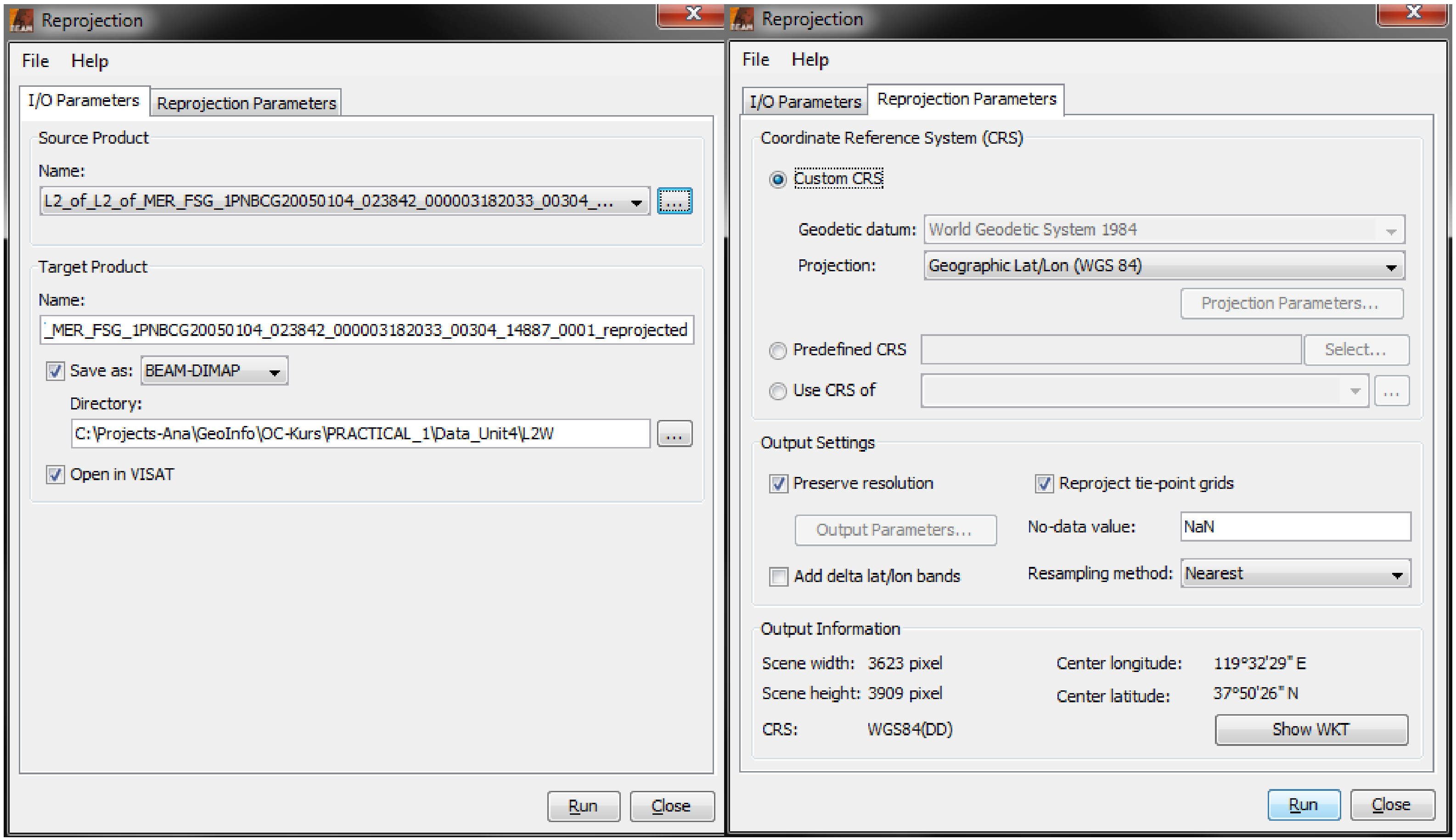
- Bohai_Sea, temporal and spatial variation of TSM values:
  - Directory: L2W





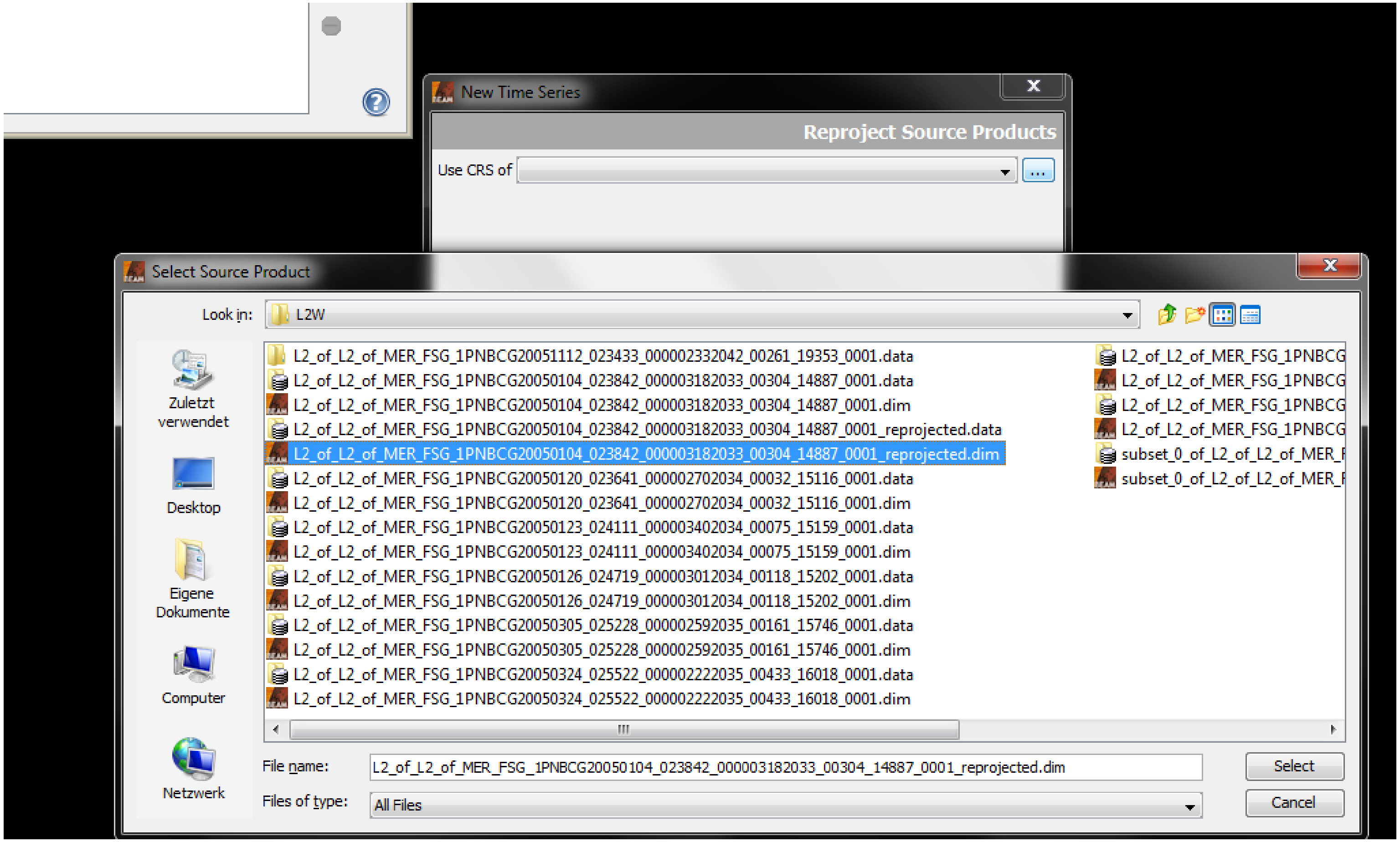
Time Series Tool – Prepare Data

- How to re-project a product: Tools/Reprojection



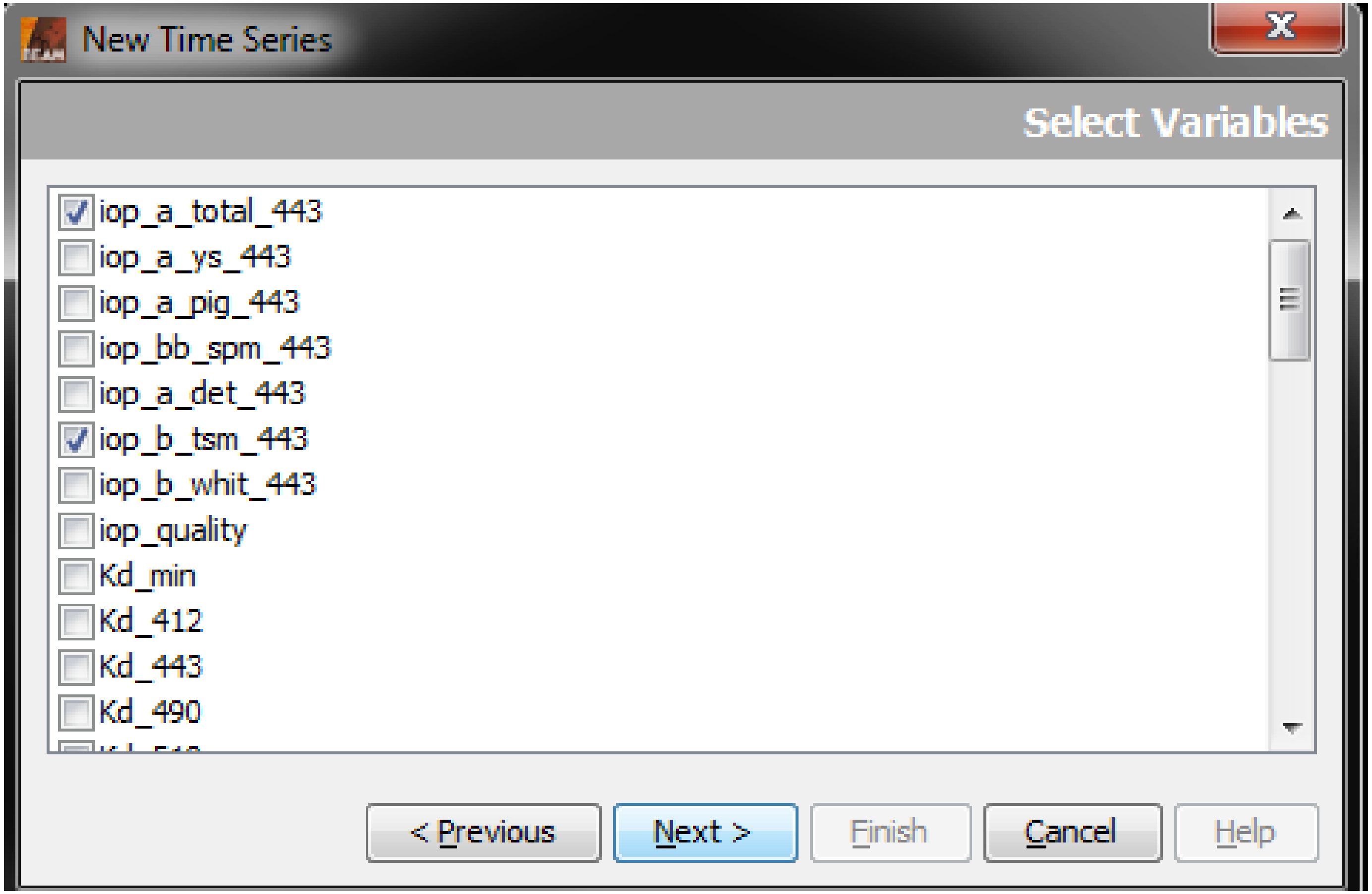
Time Series Tool – Prepare Data

- Link to a re-projected product



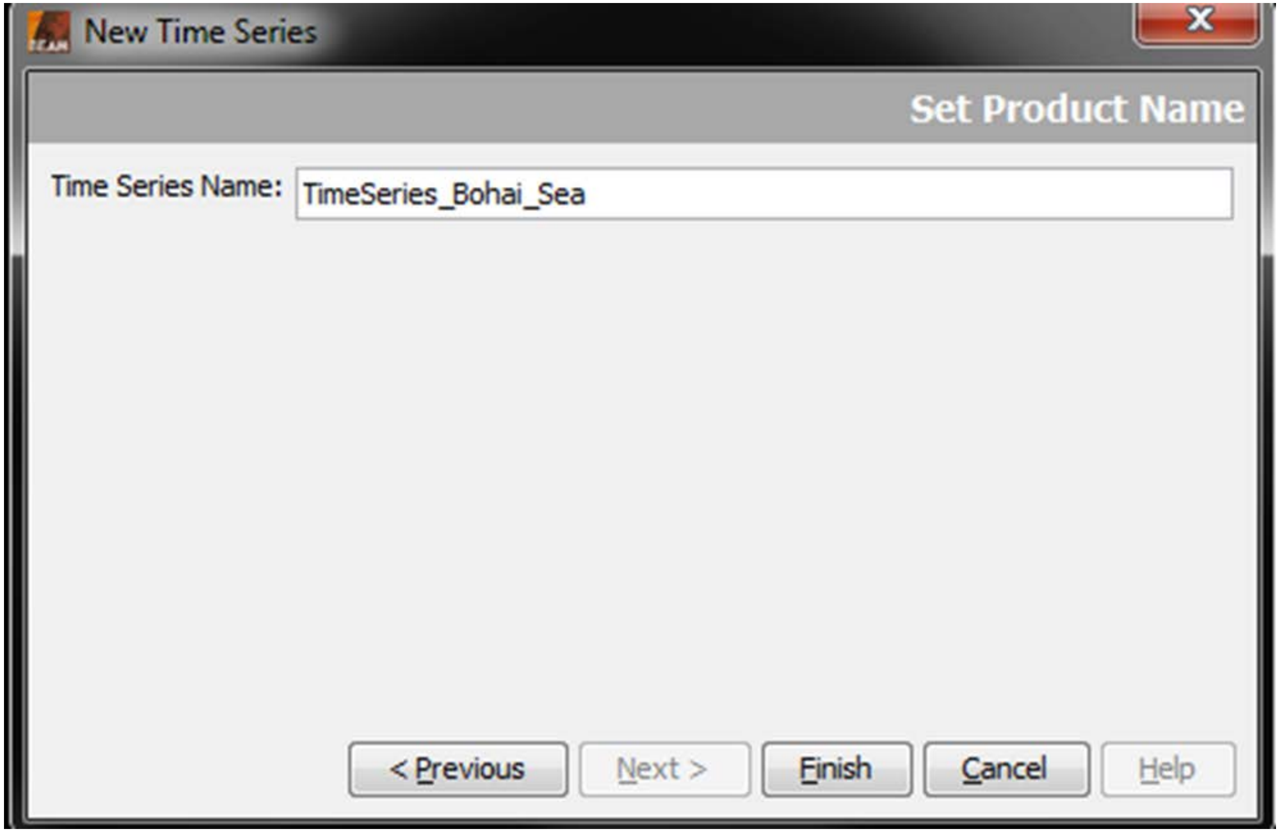
Time Series Tool – Prepare Data

- Select parameters for time series



Time Series Tool – Prepare Data

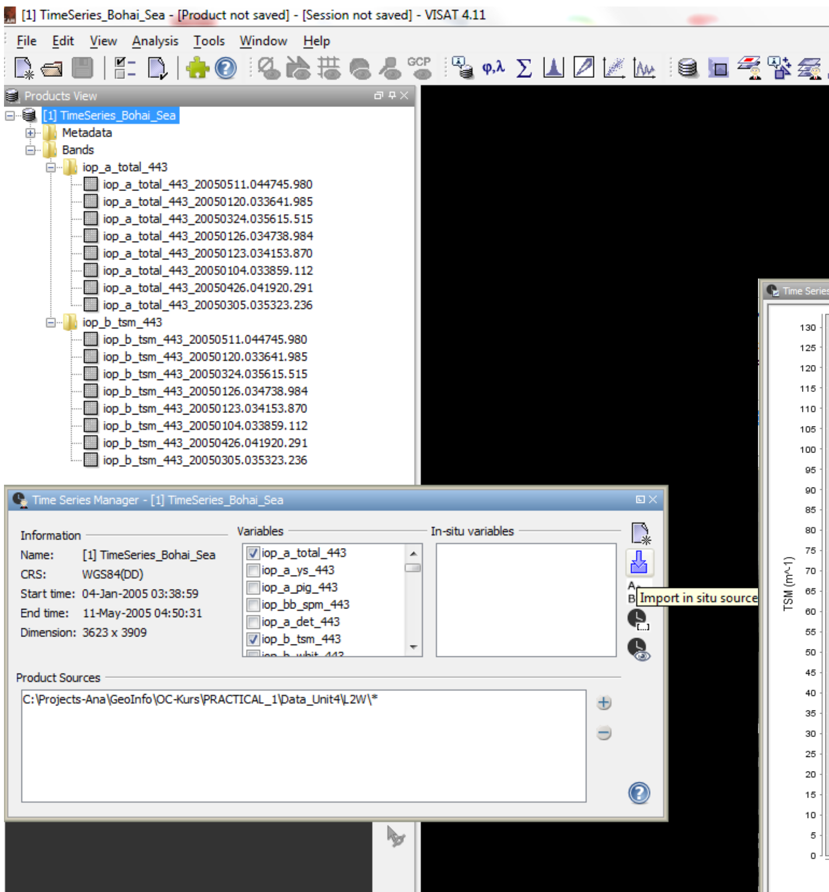
- Give a name to the time series

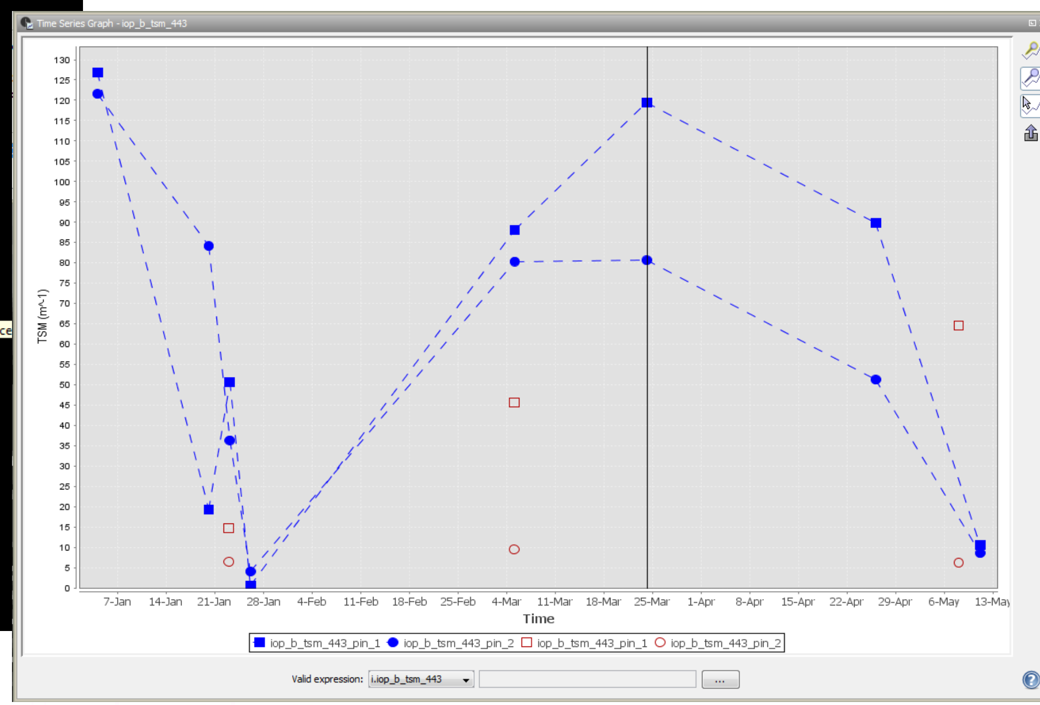


Time Series Tool – In Situ Data

- It is possible to import in situ data

If in situ data from the study area is available, it is possible to import it and to visualize it in the time series plot together with the actual data stored in pins or form the query.



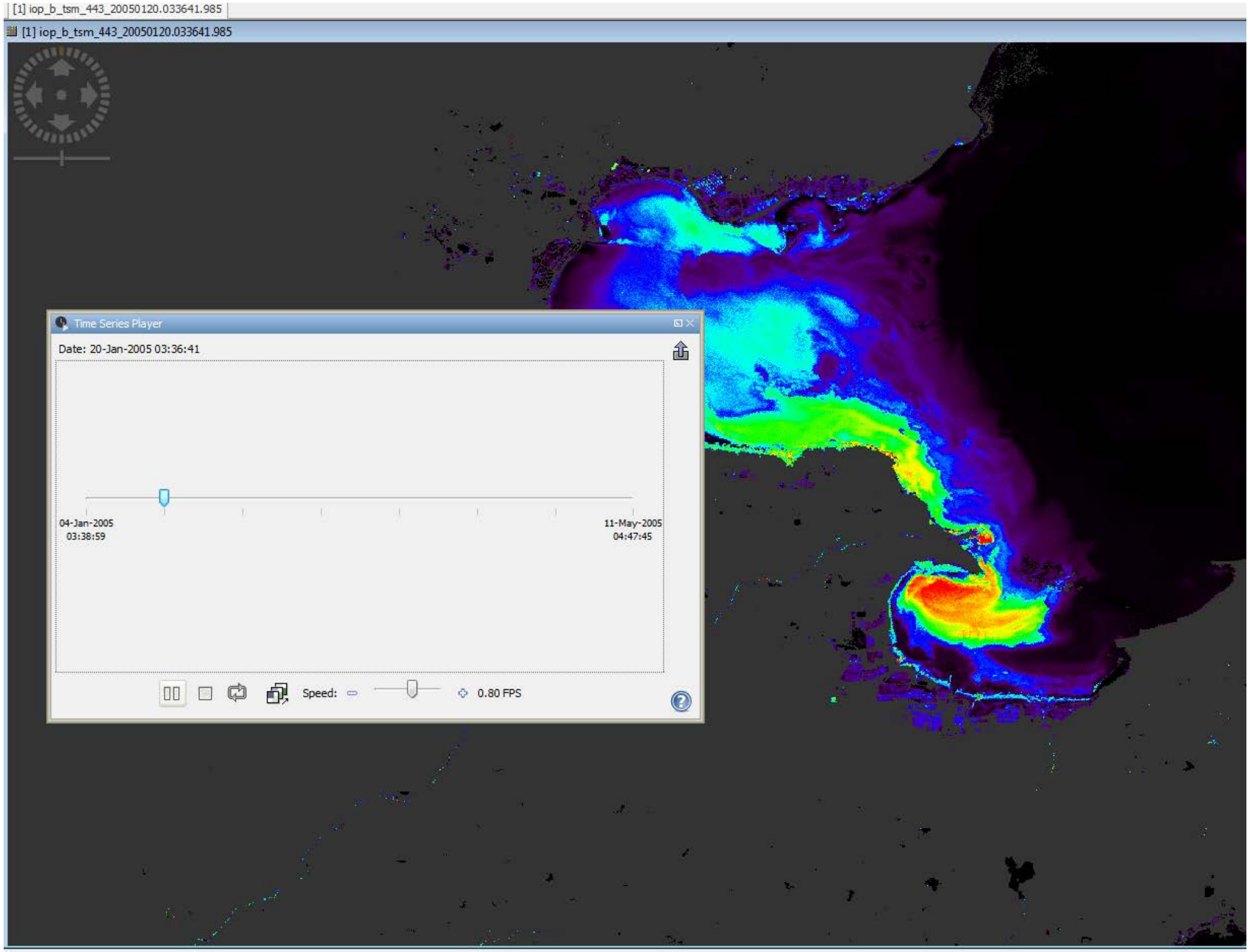


Time Series Tool – In Situ Data

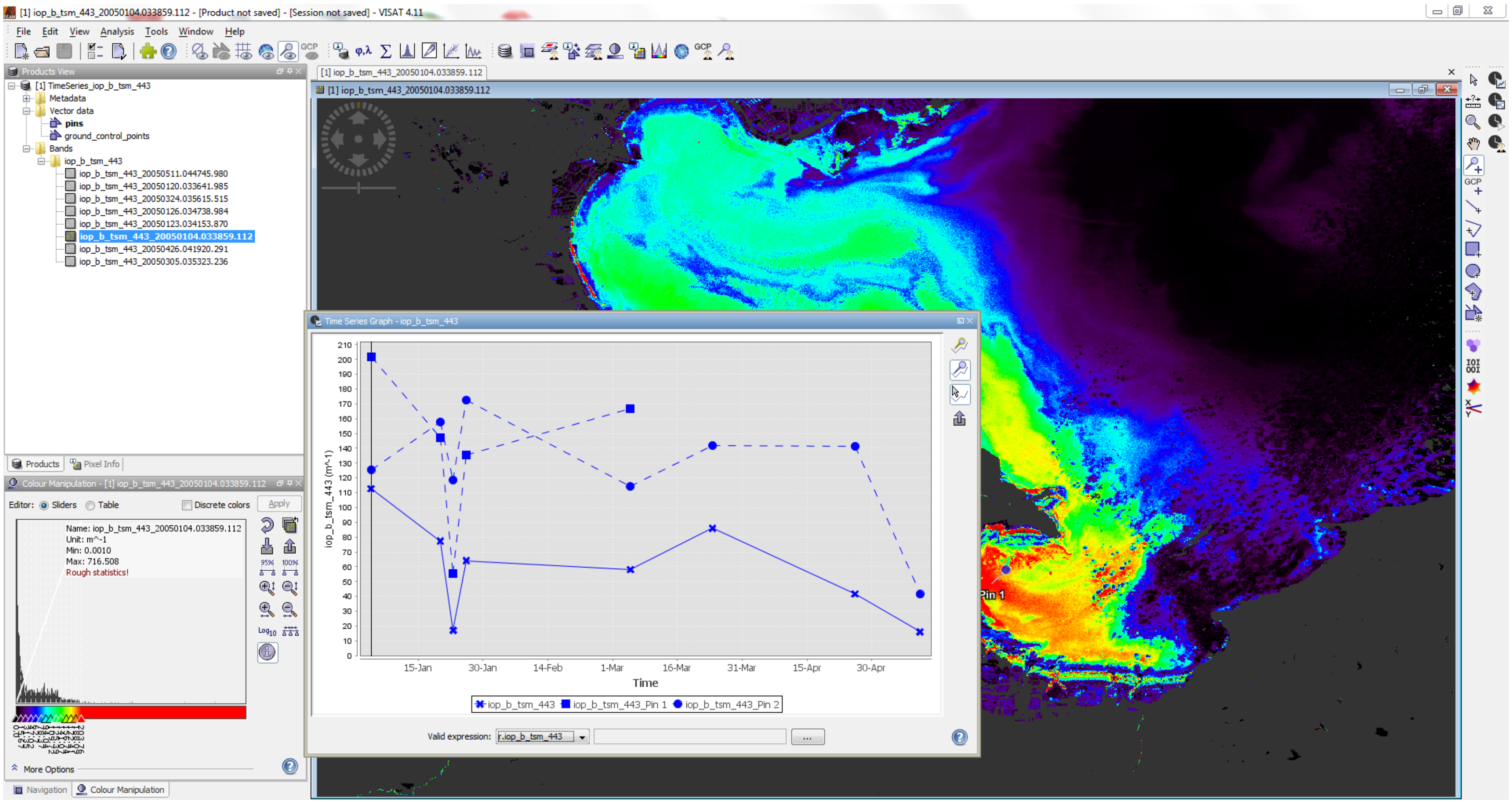
- In situ file format

Name	Lon	Lat	iop_a_total_443	iop_b_tsm_443	Kd_490	turbidity	Time
pin_1	118.09384	38.447865	10.13997	64.65231	7.4306326	82.568665	08.05.2005
pin_2	118.209465	38.522823	1.530985	6.183371	1.2814502	25.765766	08.05.2005
pin_1	118.09384	38.447865	18.33707	14.762576	14.821138	4.677825	23.01.2005
pin_2	118.209465	38.522823	4.5607004	6.3481402	3.3385184	20.446308	23.01.2005
pin_1	118.09384	38.447865	10.13997	45.690357	7.4306326	89.6349	05.03.2005
pin_2	118.209465	38.522823	1.530985	9.526975	1.2814502	22.61	05.03.2005

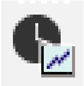
Time series player



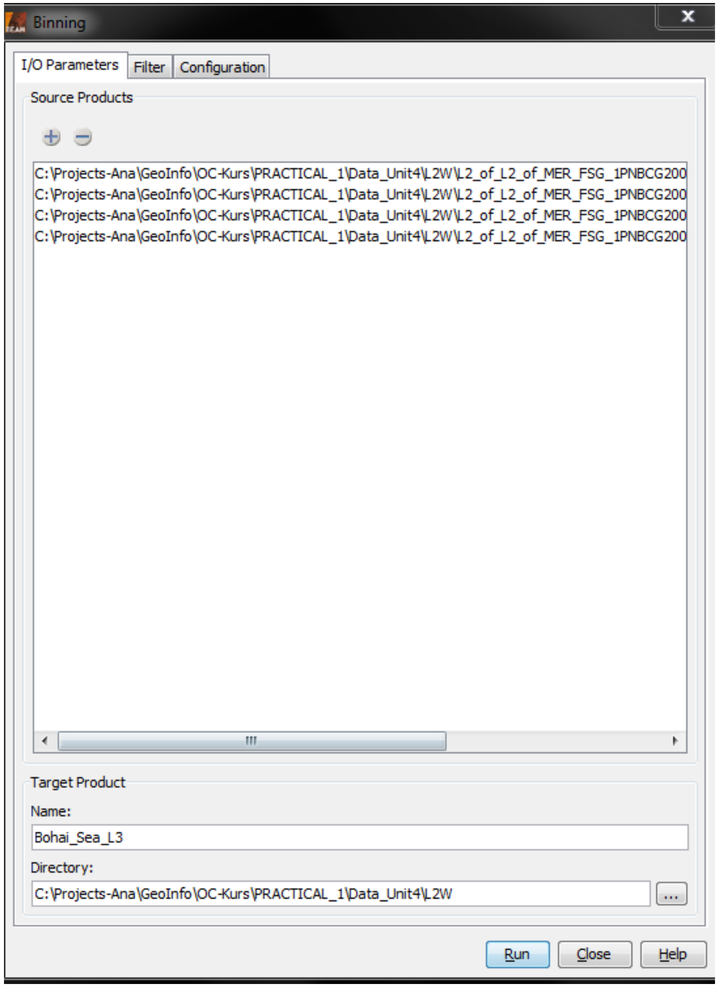
Time series graph



Exercise 4: Solution

- Re-project one L2W product to use as master
- Open Time Series tool and link the rest of the L2W images to the re-projected one 
- Select parameters for time series
- Import in situ data: ”faked_insitu_china.txt”
- Time series player 
- Time series graph 

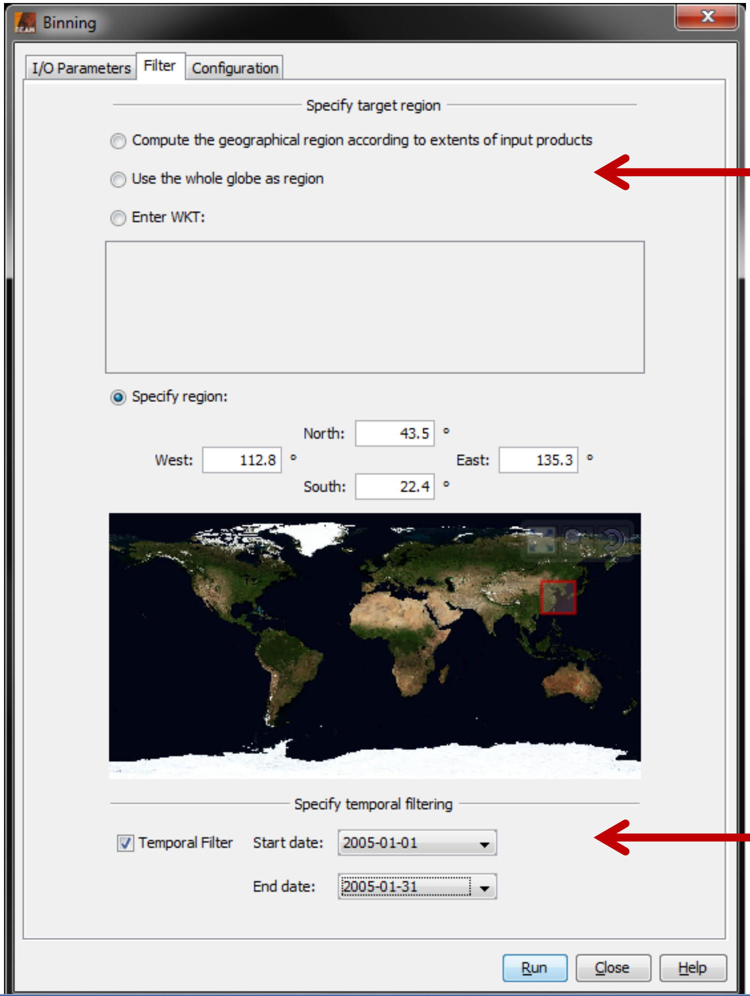
Exercise 5:
Level 3 binning (Tools/L3 binning)



The term binning refers to the process of distributing the contributions of Level 2 pixels in satellite coordinates to a fixed Level 3 grid using a geographic reference system. The Level 2 pixels may come from several input products and are collected in the binning cells, respectively. Statistics are calculated for each bin cell.

L3 Binning Tool - Filters

- Filters: specific target region and temporal filter

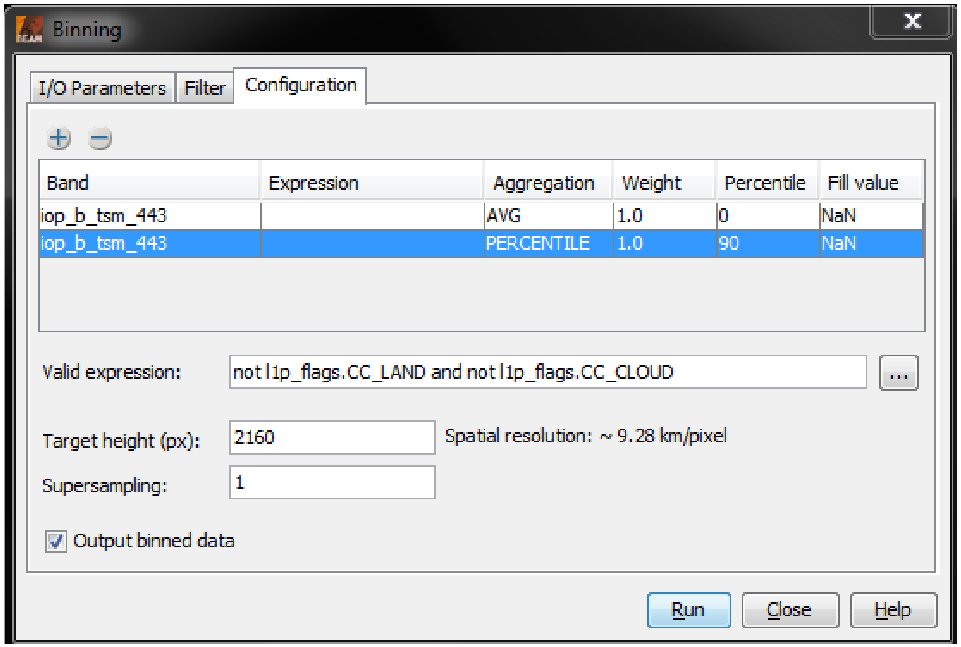


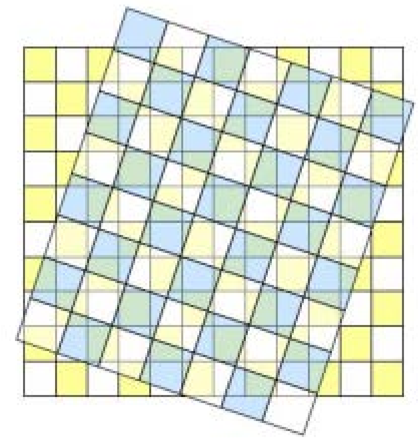
Bounds of output product can be defined using this four possibilities:

If the product has a start time and an end time, the product is filtered out if its start time lies before the specified start time or its end time lies after the specified end time.

L3 Binning Tool - Configuration

- Specify bands and statistic measures

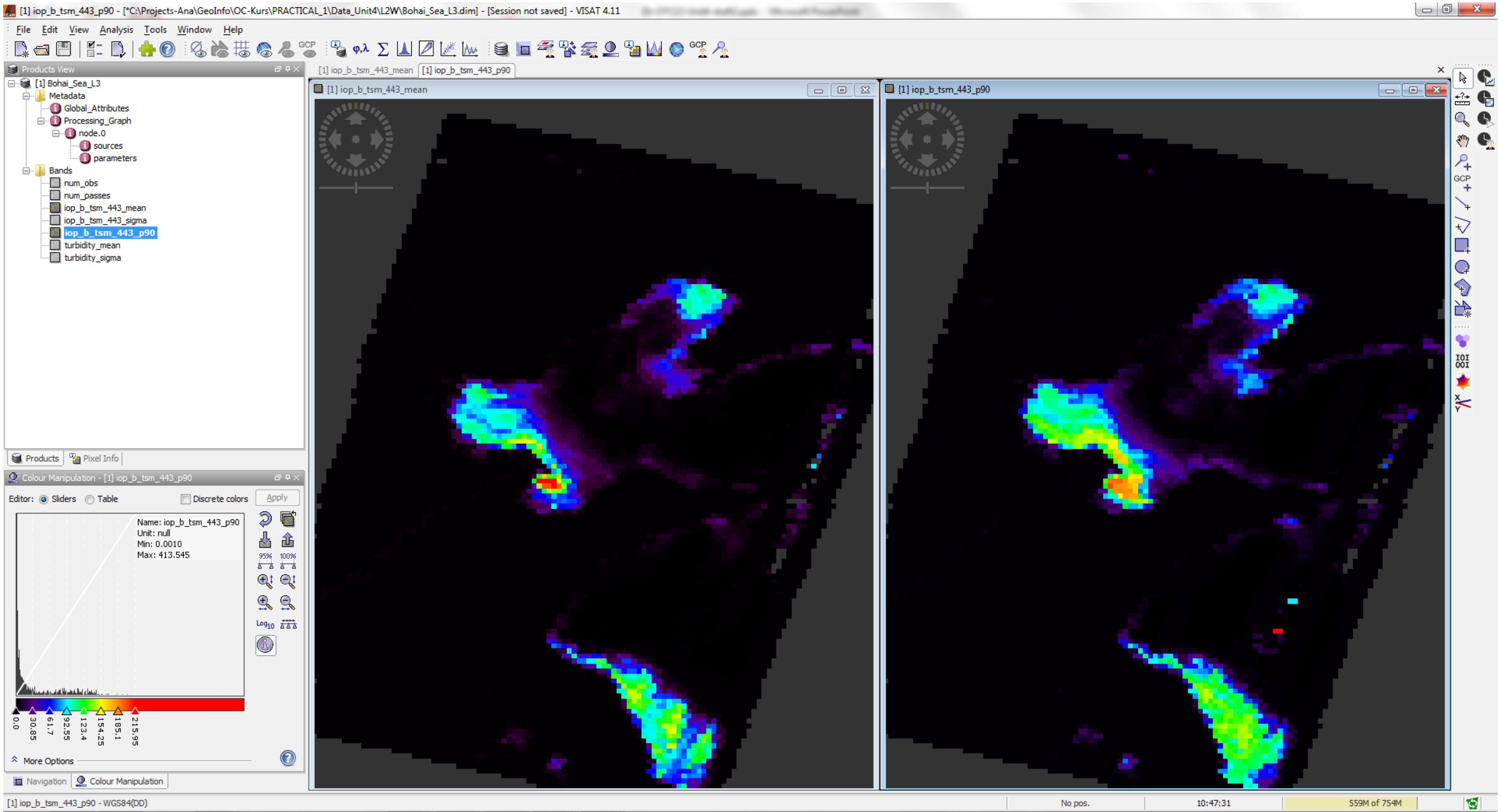




Level 2 grid (blue) and Level 3 grid (yellow)

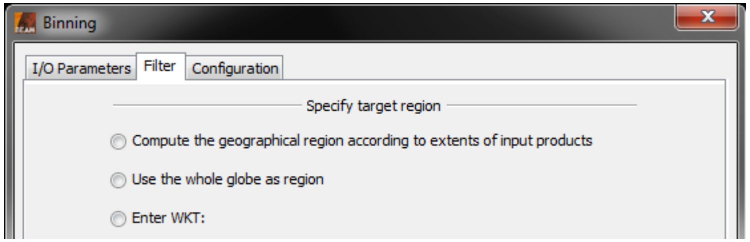
Aggregator	Description	Weight	Percentile
PERCENTILE	An aggregator that computes the p-th percentile.	not considered	integer value between 0 and 100
AVG_ML	An aggregator that computes a maximum-likelihood average.	any float value, not NaN	not considered
AVG	An aggregator that computes a maximum-likelihood average.	any float value > 0.0, not NaN	not considered
MIN_MAX	An aggregator that computes the minimum and maximum values.	not considered	not considered
ON_MAX_SET	An aggregator that sets an output if an input is maximal.	not considered	not considered

L3 binning results

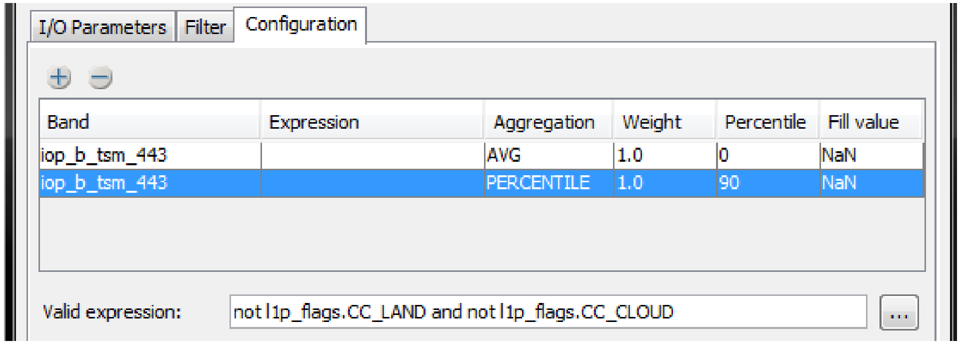


Exercise 5: Solution

- Open L3 binning tool: **`Tools/L3Binning`**
- Select input data directory:
  - **`L2W`**
- Specify region and temporal target



- Configure output products:



- Display results

Take-home messages

- Due its regular re-visit time satellite provide time series of observations that permit studying the temporal evolution of water quality parameters, if cloud coverage permits.
- The comparison with in-situ data shows the advantage of the dense temporal sampling by the satellite. The in-situ provide a precise absolute reference.
- The projection and binning tools of BEAM can be used to bring different products on the same grid for subsequent common analysis.
- The time series tools enables treating image stacks as a whole, for analysis and dynamic, movie-like display.

End of Unit

Validation

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Kerstin Stelzer

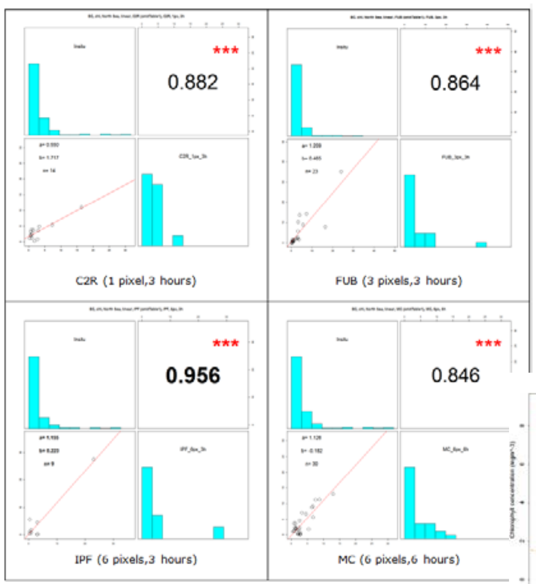
Brockmann Consult GmbH

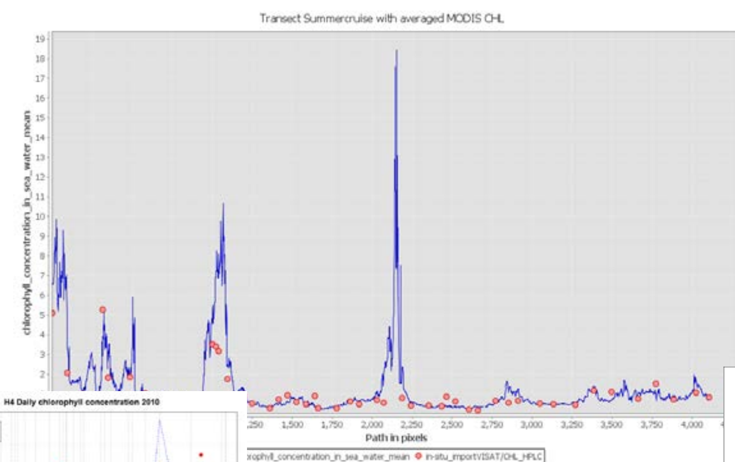
Calibration and validation activities

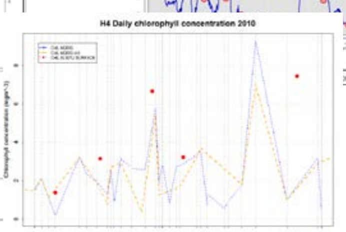
- Without independent validation, satellite data products lack credibility.
- The main problem for a good validation is the scarcity of matched data sets consisting of reliable in situ measurements, and the estimate of the same variable retrieved from satellites.
- Another problem is the mismatch between 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 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-processings and validation tests, even when the mission has ended).

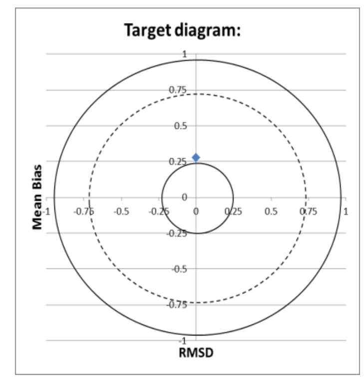
Validation of water quality parameters

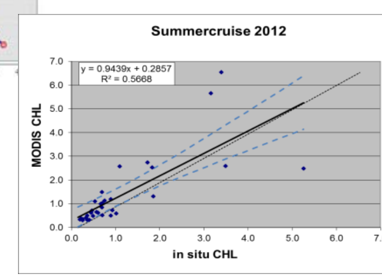
- Parameters to be validated (most common): water leaving radiance or reflectance (Lw, ρw), trasnmittance (t), inherent optical properties (absorption –a- and (back)scattering –b-of several substances), chlorophyll_a, suspended matter, yellow substance, turbidity, transparency.
- Methods used: linear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











Content

- Validation of water quality parameters. Integration of in-situ data and tools for analysis.

- BEAM exercises
  - Exercise 1: Import in situ data (vector and tabulated)
  - Exercise 2: Correlative plot analysis
  - Exercise 3: Pixel extraction tool

Formats for data import

- CSV
  - Tabstop seperated
  - 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

Example of in situ table

```
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
```

Example of 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
```

Formats for data import

- 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;M11011010101111010;1.12E-01;
MEGS_8.0;BOUSSOLE;DavidAntoine;43.367;7.9;20030908T100033Z;41.848999;P00000100;M11011010101111010;1.10E-01;
MEGS_8.0;BOUSSOLE;DavidAntoine;43.367;7.9;20030910T101533Z;41.109001;P00000100;M11011010101111010;1.05E-01;
MEGS_8.0;BOUSSOLE;DavidAntoine;43.367;7.9;20030911T110034Z;38.824001;P00000100;M11011010101111010;1.03E-01;
MEGS_8.0;BOUSSOLE;DavidAntoine;43.367;7.9;20030914T100033Z;43.737999;P00000100;M11011010101111010;9.60E-02;
MEGS_8.0;BOUSSOLE;DavidAntoine;43.367;7.9;20030916T101535Z;43.101002;P00000100;M11011010101111010;9.10E-02;
```

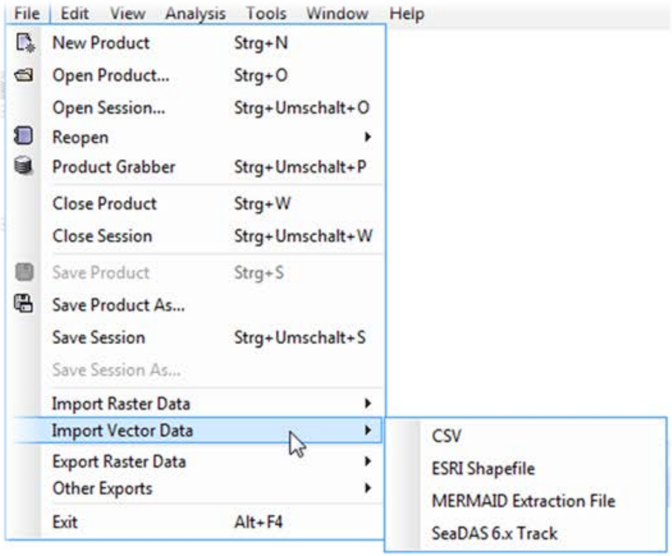
- SeaDAS 6.x Track
  - Points

Exercise 1: Import in situ data

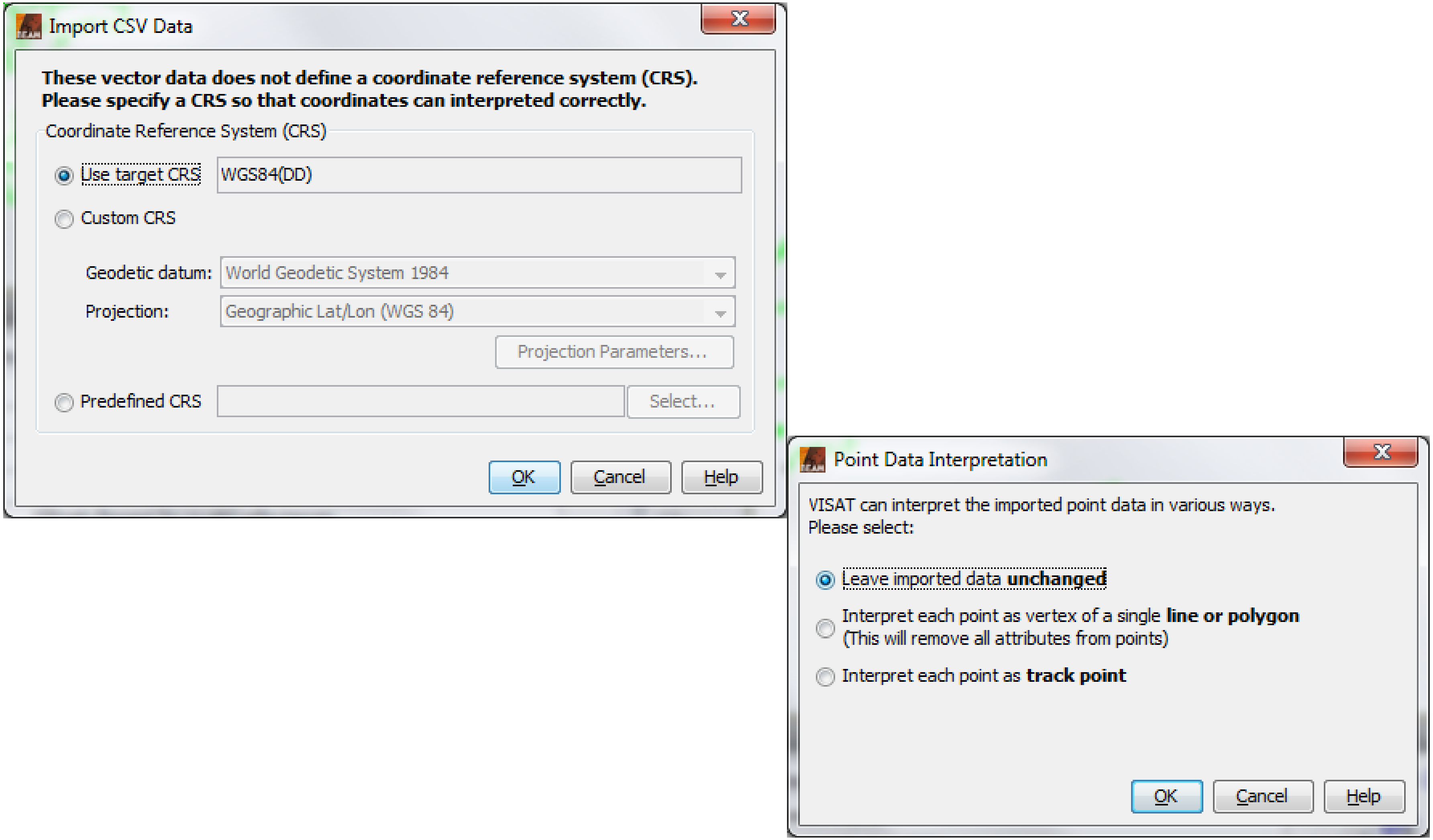
- What to do:
  - Import .csv file with in situ stations and data

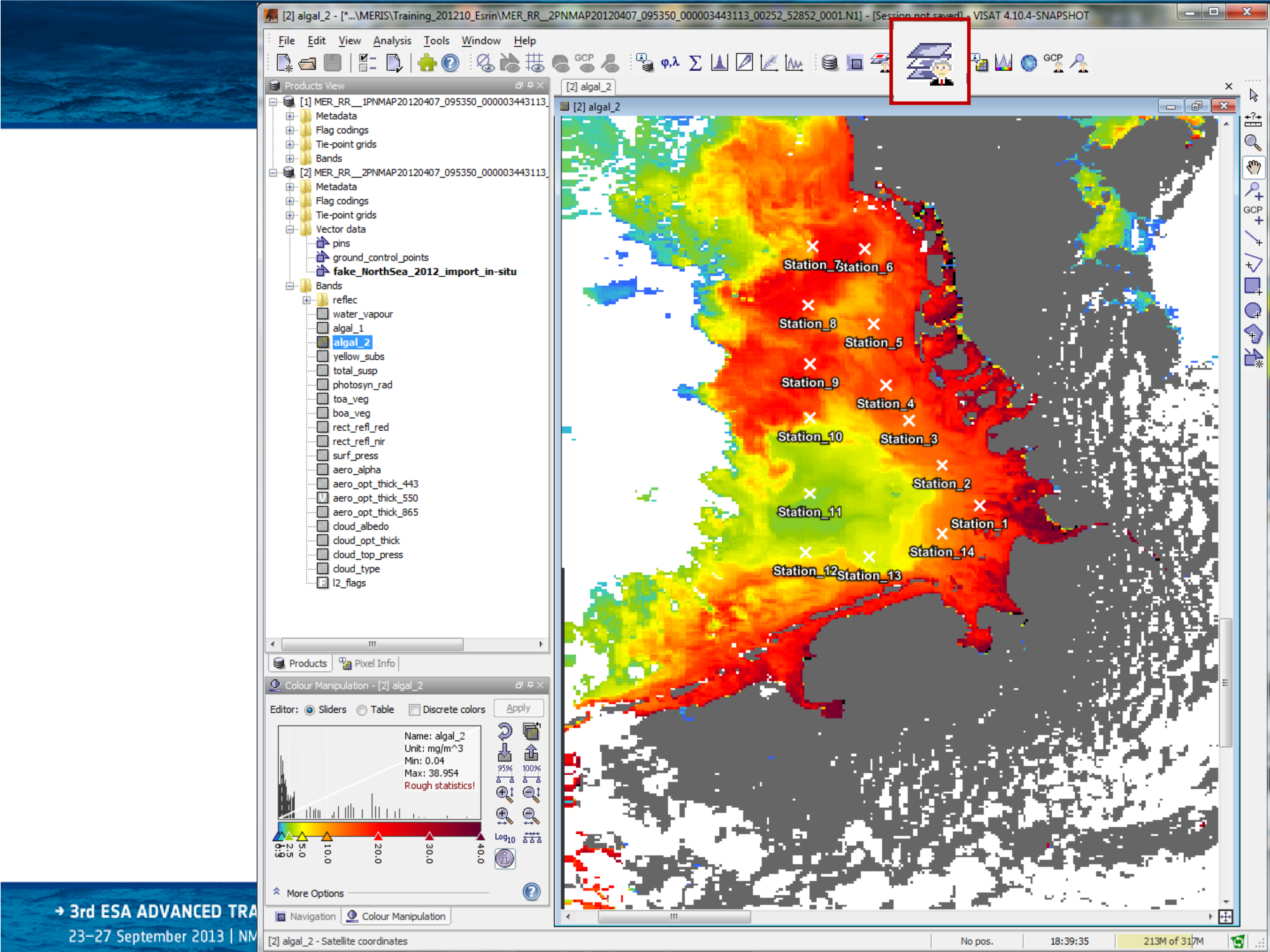
- Data:
  - MER_RR__2PNMAP20120407_095350_000003443113_00252_52852_0001.N1
  - in-situ/ fake_NorthSea_2012_import_in-situ.txt

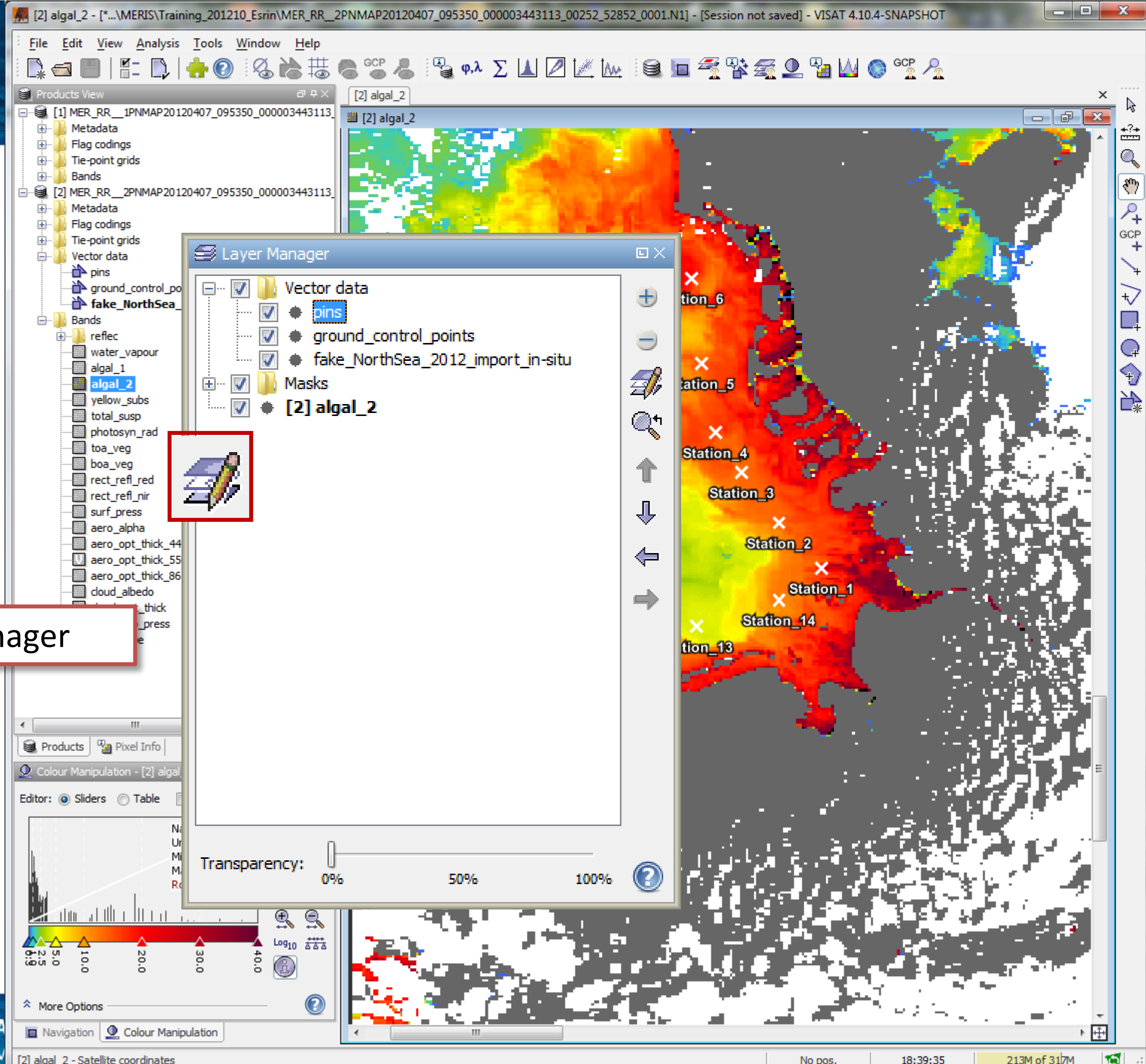
Importing vector data



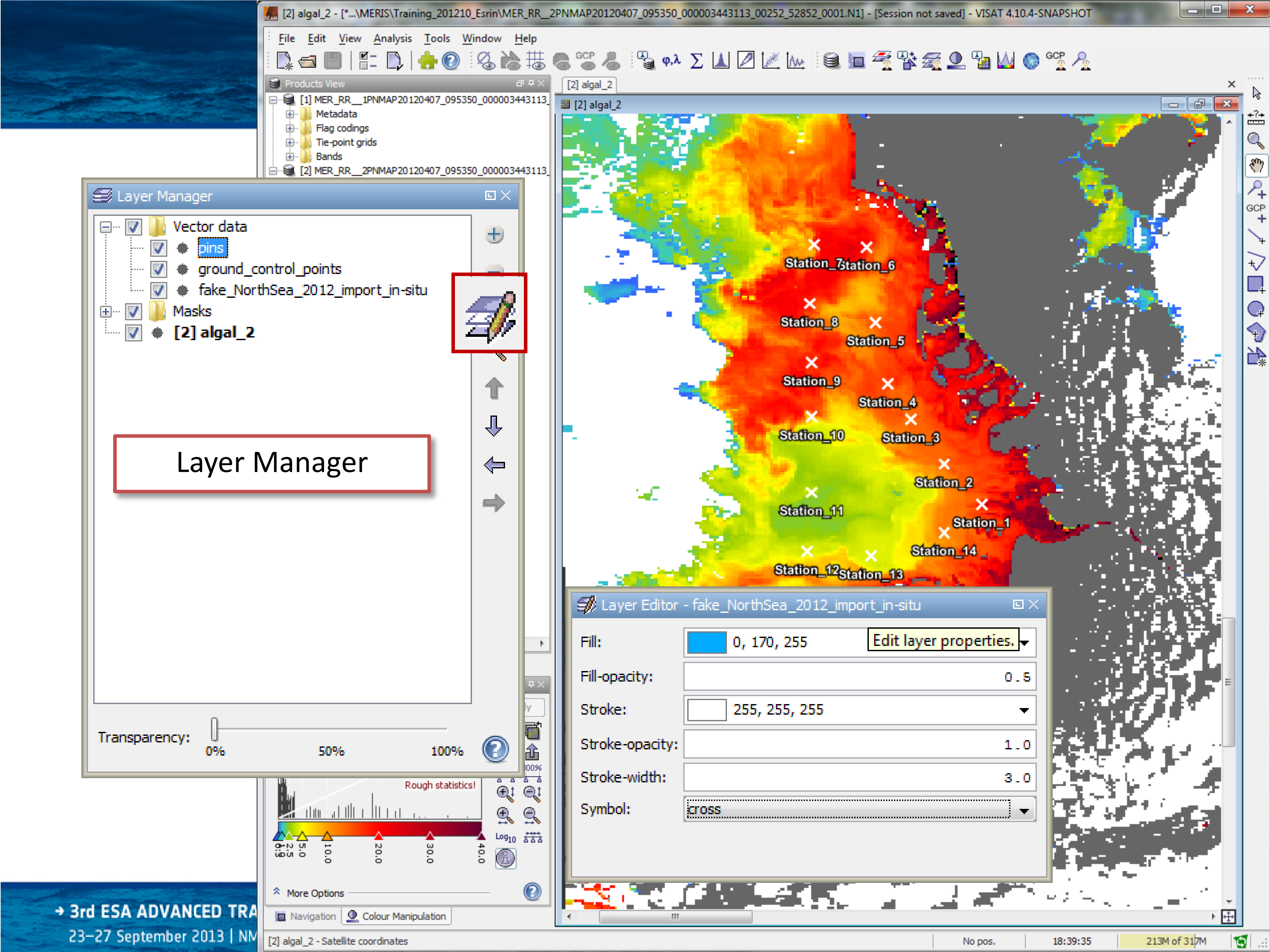
Importing vector data




[2] algal_2 - [*...\MERIS\Training_201210_Esrin\MER_RR__2PNMAP20120407_095350_000003443113_00252_52852_0001.N1] - [Session not saved] - VISAT 4.10.4-SNAPSHOT
File Edit View Analysis Tools Window Help
Products View
[1] MER_RR__1PNMAP20120407_095350_000003443113
Metadata
Flag codings
Tie-point grids
Bands
[2] MER_RR__2PNMAP20120407_095350_000003443113
Metadata
Flag codings
Tie-point grids
Vector data
pins
ground_control_points
fake_NorthSea_2012_import_in-situ
Bands
reflec
water_vapour
algal_1
algal_2
yellow_subs
total_susp
photosyn_rad
toa_veg
boa_veg
rect_refl_red
rect_refl_nir
surf_press
aero_alpha
aero_opt_thick_443
aero_opt_thick_550
aero_opt_thick_865
cloud_albedo
cloud_opt_thick
cloud_top_press
cloud_type
l2_flags
Products
Pixel Info
Colour Manipulation - [2] algal_2
Editor: Sliders Table Discrete colors Apply
Name: algal_2
Unit: mg/m^3
Min: 0.04
Max: 38.954
Rough statistics!
More Options
Navigation
Colour Manipulation
[2] algal_2
Station_7
Station_6
Station_8
Station_5
Station_9
Station_4
Station_10
Station_3
Station_2
Station_11
Station_1
Station_14
Station_12
Station_13
[2] algal_2 - Satellite coordinates
No pos.
18:39:35
213M of 317M
3rd ESA ADVANCED TRA
23–27 September 2013 | NM



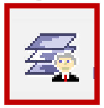
Layer Manager



[2] algal_2 - [*..\MERIS\Training_201210_Esrin\MER_RR__2PNMAP20120407_095350_000003443113_00252_52852_0001.N1] - [Session not saved] - VISAT 4.10.4-SNAPSHOT
File Edit View Analysis Tools Window Help
Products View
[1] MER_RR__1PNMAP20120407_095350_000003443113
Metadata
Flag codings
Tie-point grids
Bands
[2] MER_RR__2PNMAP20120407_095350_000003443113
Layer Manager
Vector data
pins
ground_control_points
fake_NorthSea_2012_import_in-situ
Masks
[2] algal_2
Layer Manager
Transparency:
0%
50%
100%
Rough statistics!
More Options
Navigation
Colour Manipulation
[2] algal_2
Station_7
Station_6
Station_8
Station_5
Station_9
Station_4
Station_10
Station_3
Station_2
Station_11
Station_1
Station_14
Station_12
Station_13
Layer Editor - fake_NorthSea_2012_import_in-situ
Fill:
0, 170, 255
Edit layer properties.
Fill-opacity:
0.5
Stroke:
255, 255, 255
Stroke-opacity:
1.0
Stroke-width:
3.0
Symbol:
cross
[2] algal_2 - Satellite coordinates
No pos.
18:39:35
3rd ESA ADVANCED TRA
23–27 September 2013 | NM

Exercise 1: Solution

- Open MERIS L2 data:
  - File/Open product 
- Display algal_2 and add colour palette:
  - Double click on algaL-2 band
  - Add CHL_Colours.cpd in the Colour manipulation box

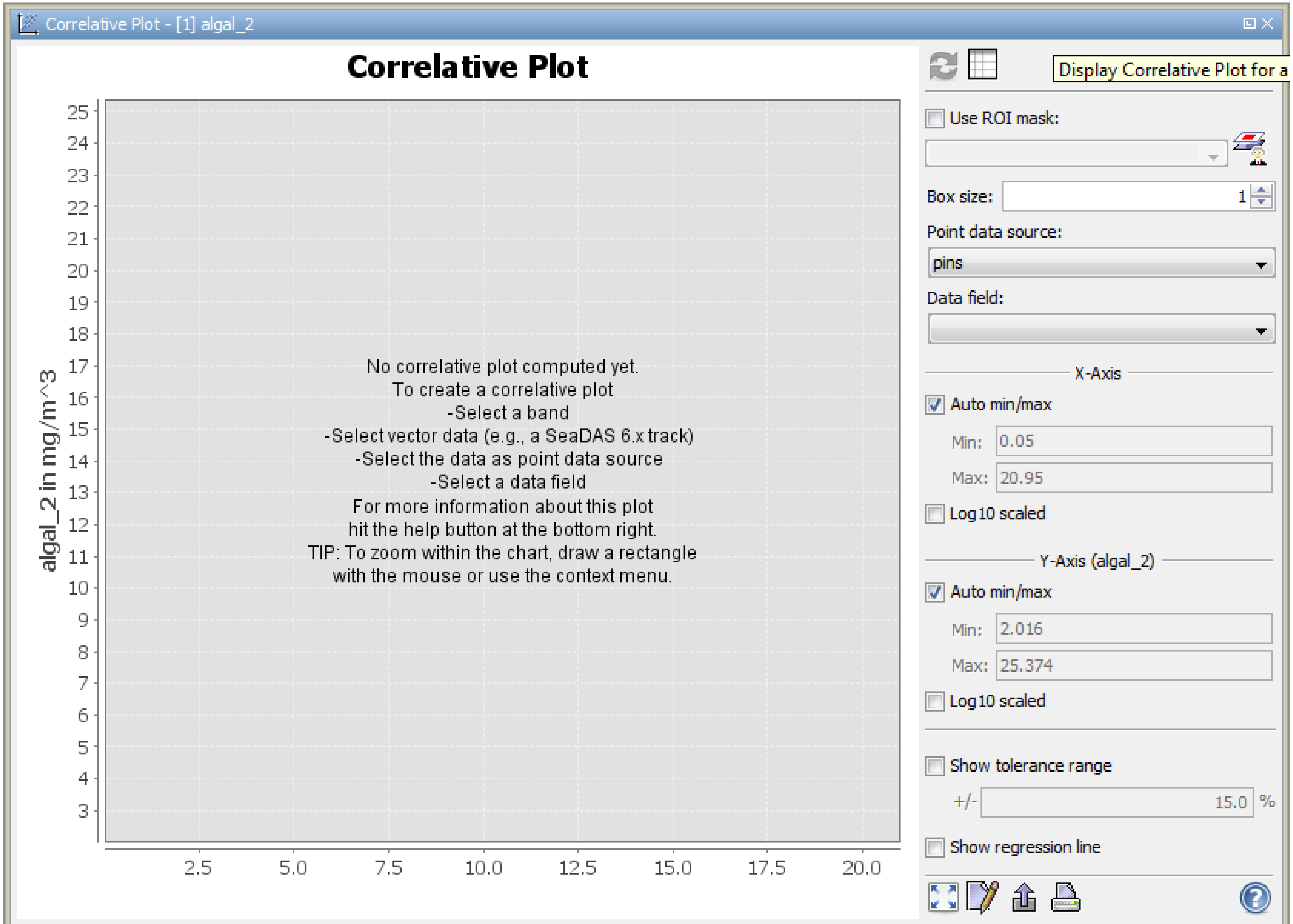
- Import .csv as vector file:
  - Import vector data/CSV
- Visualize in situ stations in algal 2:
  - Zoom in on display view
- Experience the layer management tool to change the layout of the stations 

Exercise 2: Correlative plot

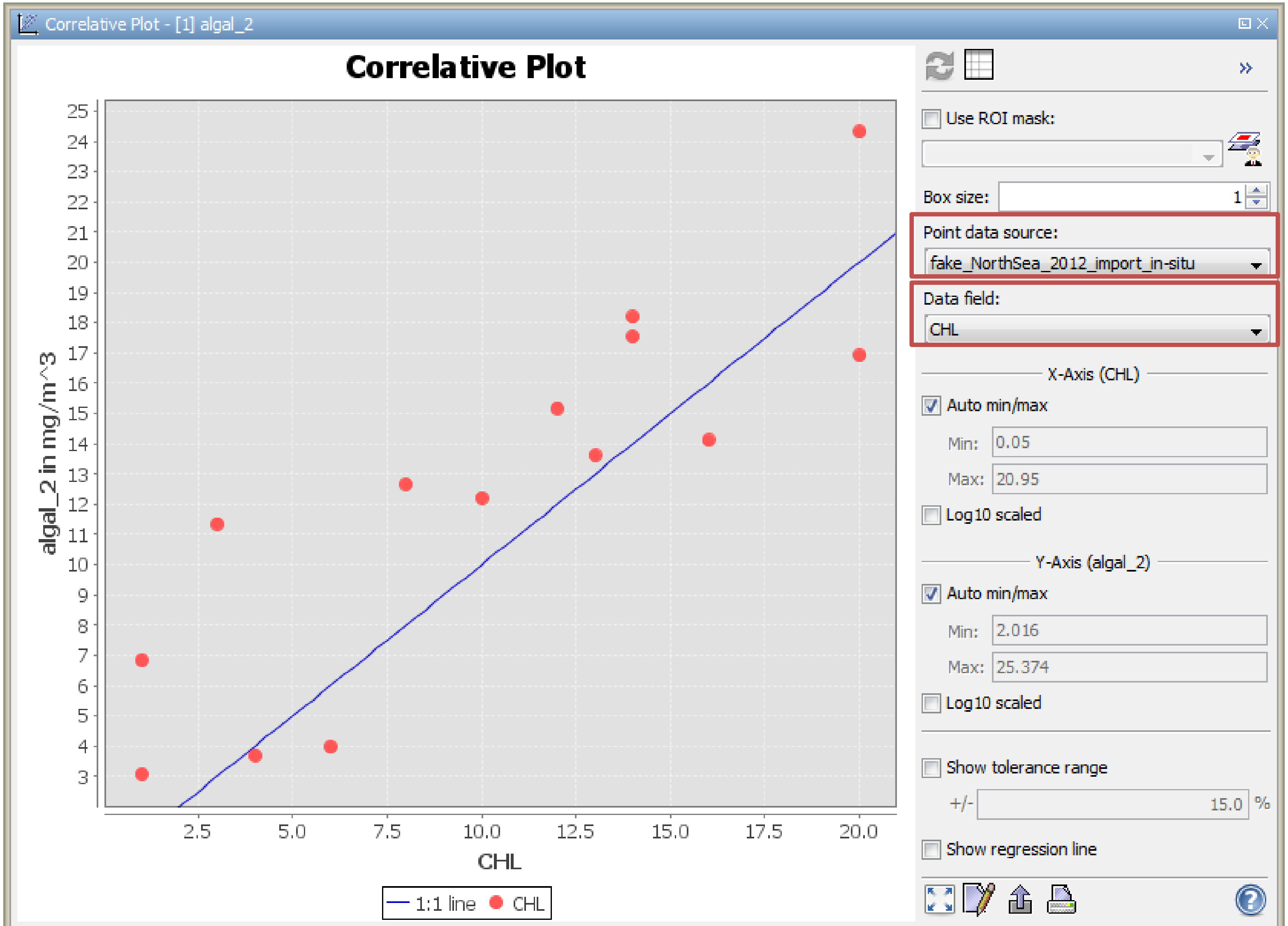
- What to do:
  - Investigate how the satellite data and in situ data match by using the correlative plot

- Products:
  - Data_Unit5/Unit5.1/MER_RR__2PNMAP20120407_095350_000003443113_00252_52852_0001.N1
  - Data_Unit5/Unit5.1/in-situ/fake_NorthSea_2012_import_in-situ.txt

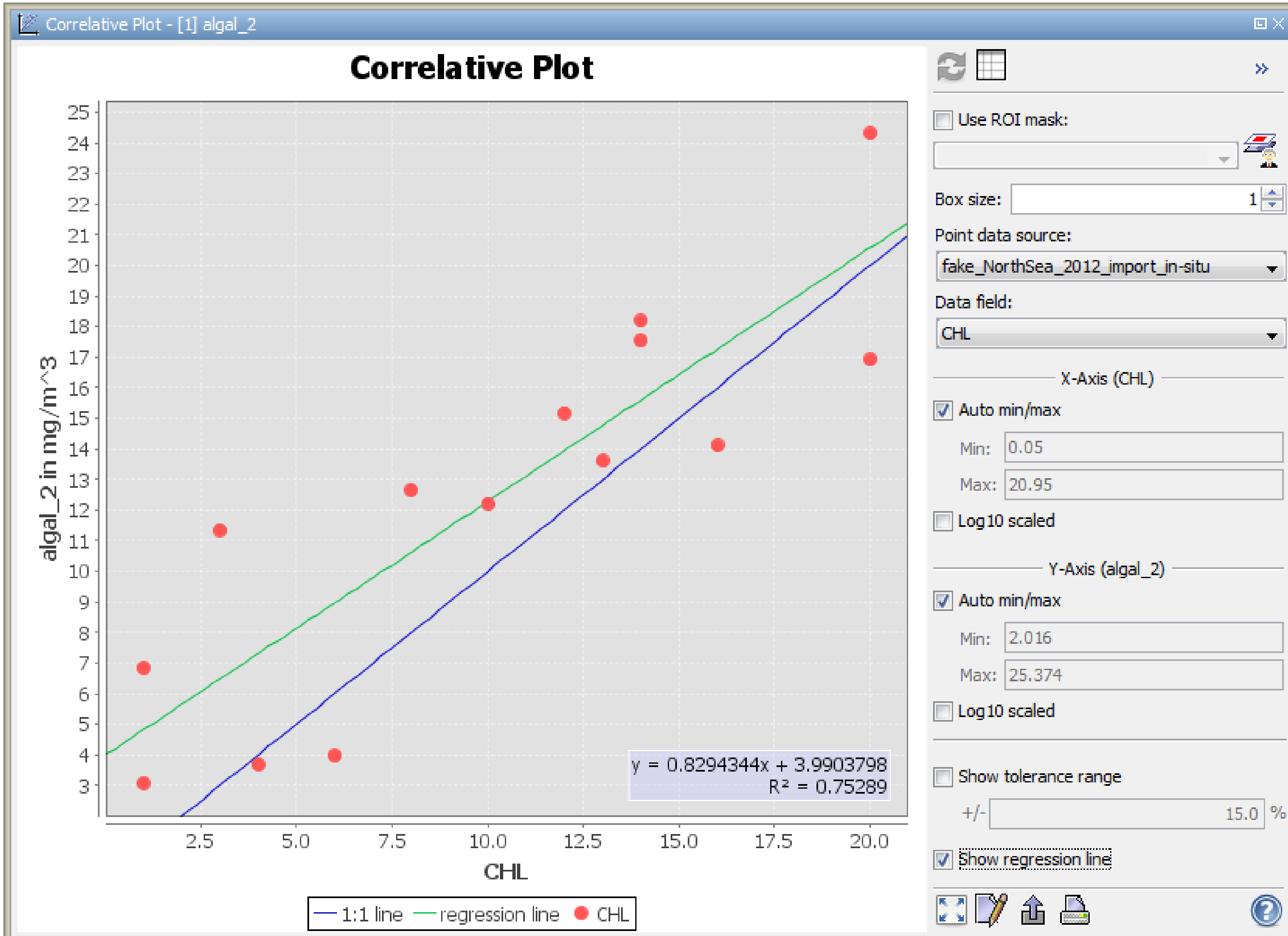
Correlative Plot



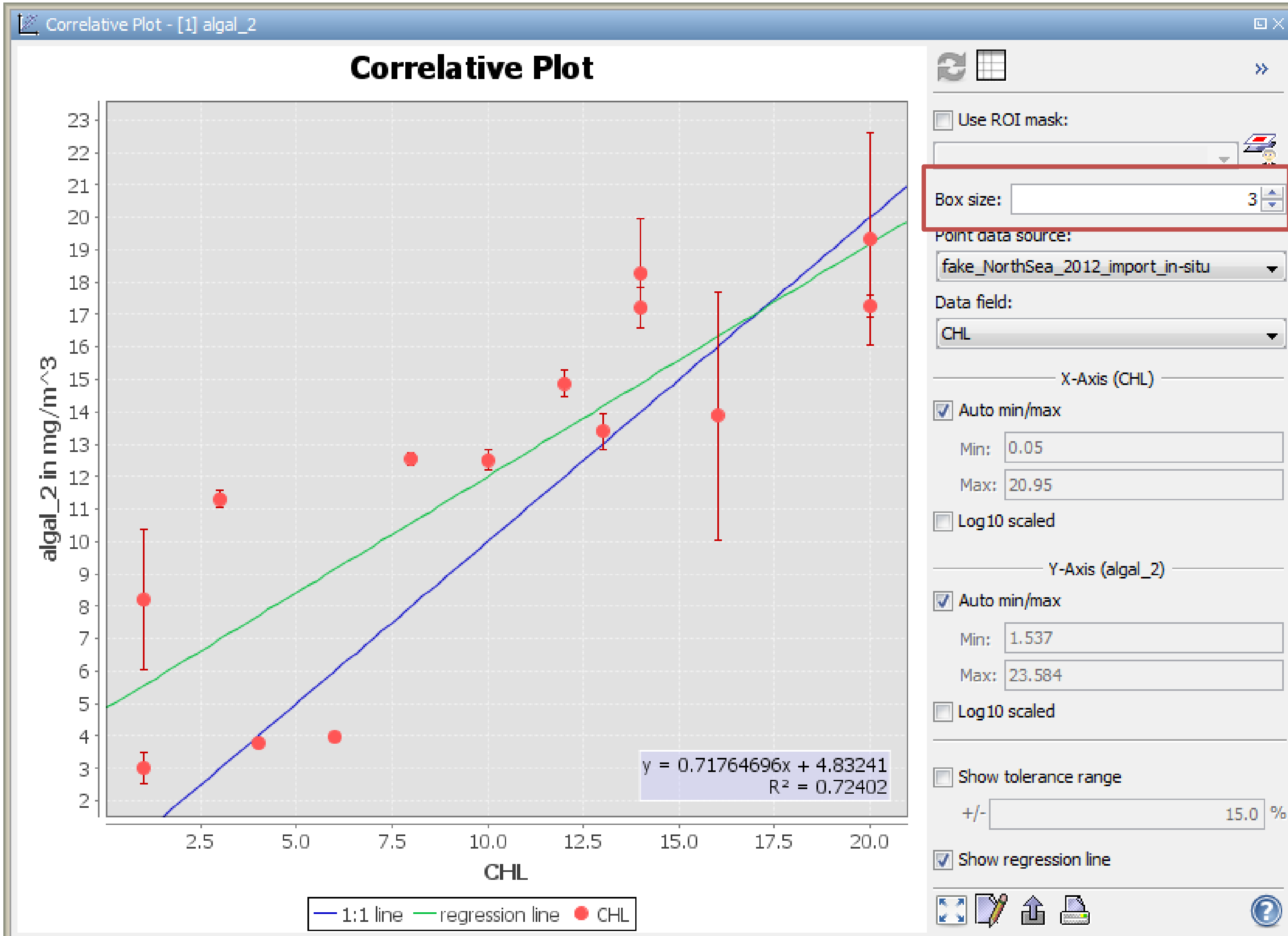
Correlative Plot



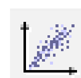
Correlative Plot

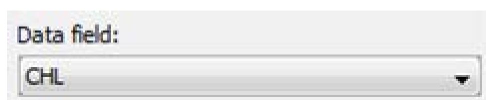


Correlative Plot

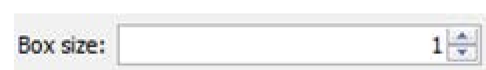


Exercise 2: Solution

- Open MERIS L2 data:
  - File/Open product
- Display algal_2 and add colour palette:
  - Double click on algaL-2 band
  - Add CHL_Colours.cpd in the Colour manipulation box
- Open correlative plot: 
  - Add point data source: 

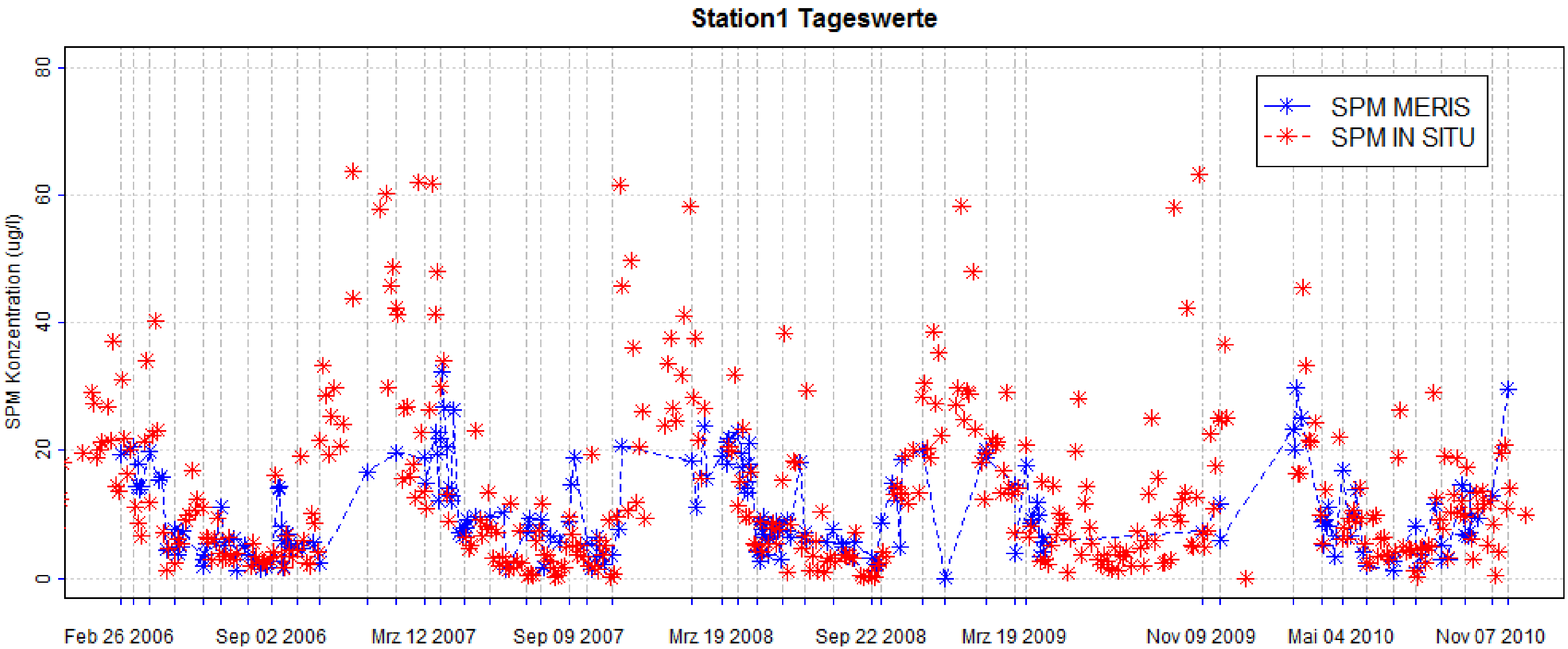
  - Add data field: 

  - Show regression line: 

  - Change macro-pixel size to see errors: 

Time Series EO – in-situ

- Extraction of data with Pixel Extraction Tool
- Time series generation using external tools or VISAT Time series tool

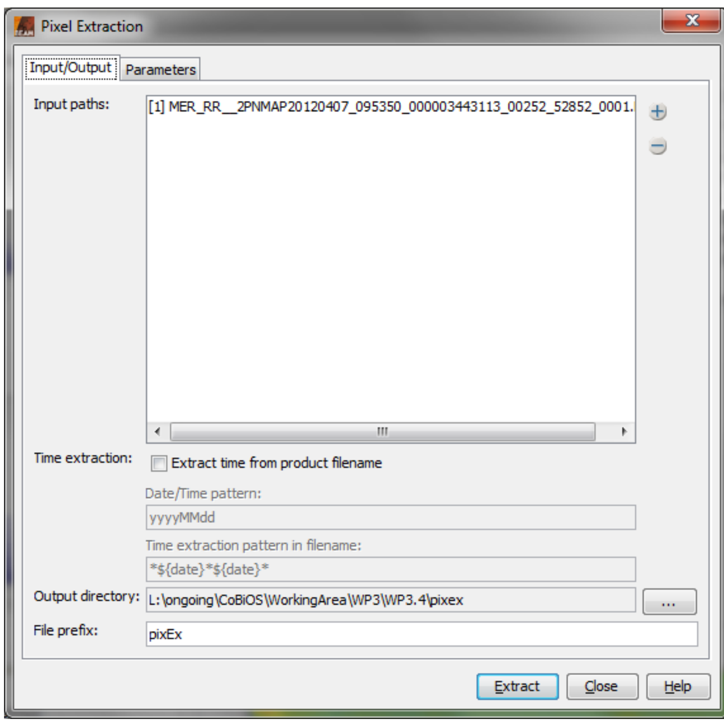


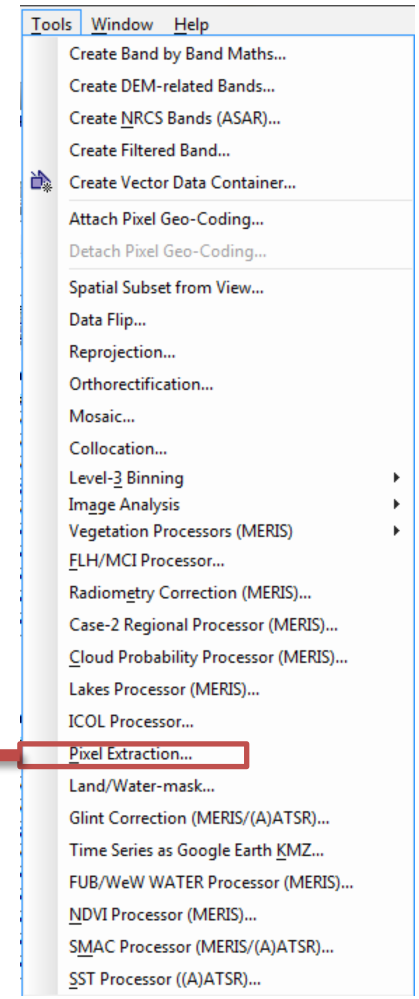
Exercise 3: Pixel Extraction tool

- What to do:
  - Using the pins location, extract information from the image and export in a .csv or text file.
  - For extraction of match ups and time series analysis

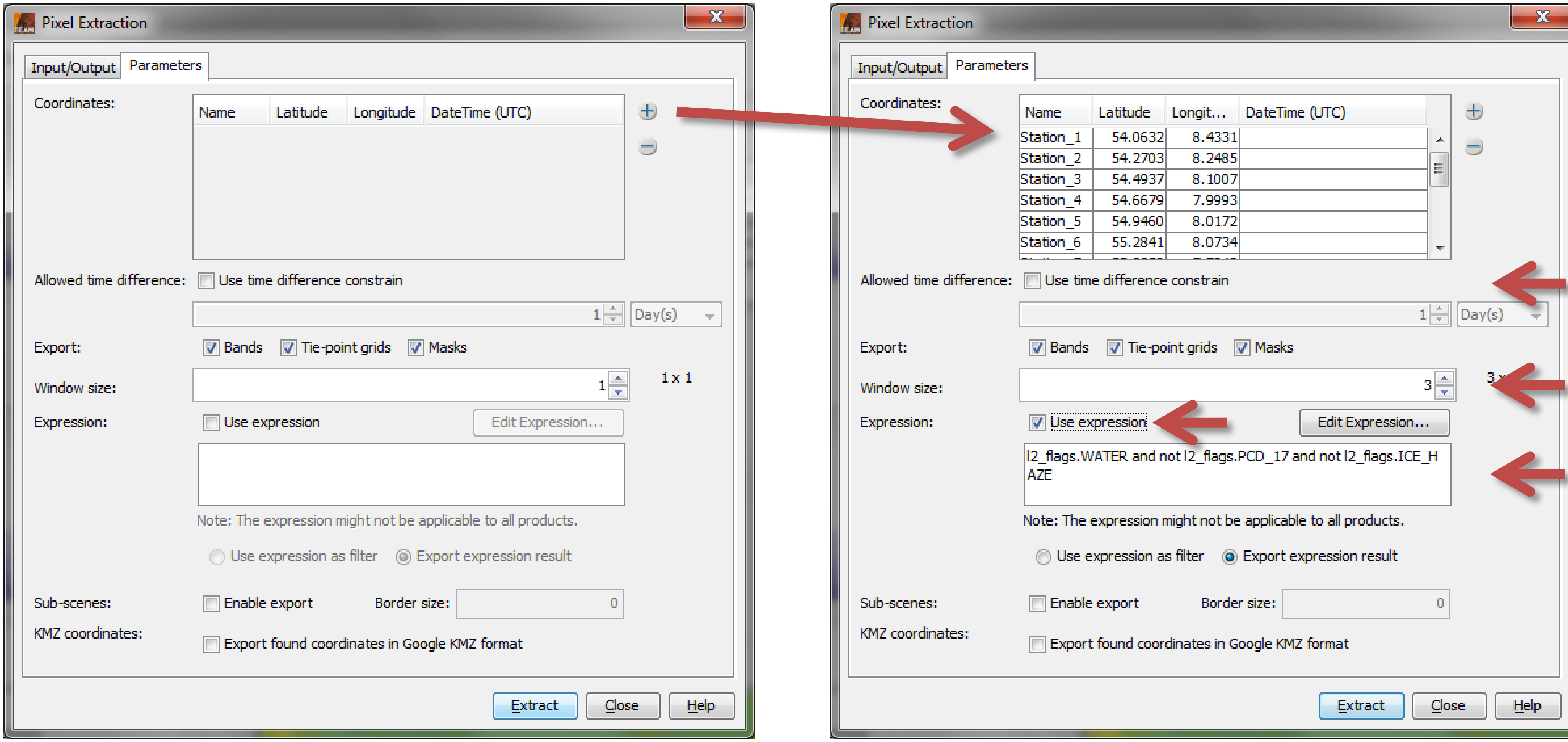
- Data:
  - L2_of_MER_FSG_1PNBCG20120106_025207_000003383110_00219_51526_0001
  - in-situ/ fake_NorthSea_2012_import_in-situ.txt

Pixel Extraction tool





Pixel Extraction tool



Pixel Extraction - Output

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

```
# BEAM pixel extraction export table
#
# Window size: 3
# Created on: 2012-05-04 11:26:39

# Wavelength:                1.0 2.0 3.0 440.0 550.0 670.0 870.0 412.5 442.5 490.0 510.0 560.0 620.0 665.0 708.75  0.
ProdID  CoordID Name  Latitude  Longitude PixelX  PixelY  Date(yyyy-MM-dd)  Time(HH:mm:ss)  algal_2 yellow_subs total_
0 1 Stat_30 57.122513 14.030147 362.500 278.500    -0.024291038513183594 -0.5011708736419678 -0.6712477207183838 0.71
0 1 Stat_30 57.121769 14.034220 363.500 278.500    0.08650398254394531 -0.3762936592102051 -0.6608905792236328 0.6347
0 1 Stat_30 57.121021 14.038292 364.500 278.500    0.2988358736038208  -0.356042742729187  -0.6964569687843323 0.6282
0 1 Stat_30 57.119987 14.028601 362.500 279.500    0.05376100540161133 -0.43862223625183105  -0.6669691205024719 0.70
0 1 Stat_30 57.119240 14.032673 363.500 279.500    0.12134408950805664 -0.3545032739639282 -0.6419369578361511 0.6023
0 1 Stat_30 57.118496 14.036745 364.500 279.500    0.26473093032836914 -0.3152179718017578 -0.6015998721122742 0.6425
0 1 Stat_30 57.117458 14.027056 362.500 280.500    0.12704408168792725 -0.45264554023742676  -0.7054343223571777 0.63
0 1 Stat_30 57.116714 14.031128 363.500 280.500    -0.10196006298065186  -0.5452677011489868 -0.6245840787887573 0.66
0 1 Stat_30 57.115971 14.035198 364.500 280.500    0.1744828224182129  -0.2971940040588379 -0.6729031801223755 0.6333
0 2 Stat_510  56.860992 13.678182 319.500 394.500    0.1657717227935791  -0.765121579170227  -0.5592461228370667 0.45
0 2 Stat_510  56.860256 13.682229 320.500 394.500    0.10509037971496582 -0.6452360153198242 -0.5588843822479248 0.48
0 2 Stat_510  56.859524 13.686276 321.500 394.500    0.23415625095367432 -0.600823163986206  -0.5622285008430481 0.40
0 2 Stat_510  56.858459 13.676668 319.500 395.500    -0.002189040184020996 -0.44395971298217773  -0.5836474299430847
0 2 Stat_510  56.857727 13.680715 320.500 395.500    0.0040056705474853516 -0.6788367033004761 -0.5861891508102417 0.
```

Pixel Extraction - Output

```
# Product ID Map
ProductID ProductType ProductLocation
0 MER_FSG_1N_FLH_MCI  U:\OutputPool\MERIS\FRS\WAQS-WeW\sweden\LakeBolmen\MER_FRS_WeW_20110410_100226_000000763101_47637
1 MER_FSG_1N_FLH_MCI  U:\OutputPool\MERIS\FRS\WAQS-WeW\sweden\LakeBolmen\MER_FRS_WeW_20110418_100912_000000763101_47752
2 MER_FSG_1N_FLH_MCI  U:\OutputPool\MERIS\FRS\WAQS-WeW\sweden\LakeBolmen\MER_FRS_WeW_20110419_093237_000000873101_47766
3 MER_FSG_1N_FLH_MCI  U:\OutputPool\MERIS\FRS\WAQS-WeW\sweden\LakeBolmen\MER_FRS_WeW_20110423_102559_000000613101_47824
4 MER_FSG_1N_FLH_MCI  U:\OutputPool\MERIS\FRS\WAQS-WeW\sweden\LakeBolmen\MER_FRS_WeW_20110424_094915_000000873101_47838
5 MER_FSG_1N_FLH_MCI  U:\OutputPool\MERIS\FRS\WAQS-WeW\sweden\LakeBolmen\MER_FRS_WeW_20110427_093920_000000903102_47881
6 MER_FSG_1N_FLH_MCI  U:\OutputPool\MERIS\FRS\WAQS-WeW\sweden\LakeBolmen\MER_FRS_WeW_20110430_092927_000000873102_47924
7 MER_FSG_1N_FLH_MCI  U:\OutputPool\MERIS\FRS\WAQS-WeW\sweden\LakeBolmen\MER_FRS_WeW_20110508_093613_000000873102_48039
8 MER_FSG_1N_FLH_MCI  U:\OutputPool\MERIS\FRS\WAQS-WeW\sweden\LakeBolmen\MER_FRS_WeW_20110510_100253_000000783102_48068
9 MER_FSG_1N_FLH_MCI  U:\OutputPool\MERIS\FRS\WAQS-WeW\sweden\LakeBolmen\MER_FRS_WeW_20110530_092957_000000873103_48355
10  MER_FSG_1N_FLH_MCI  U:\OutputPool\MERIS\FRS\WAQS-WeW\sweden\LakeBolmen\MER_FRS_WeW_20110603_102318_000000643103_484
11  MER_FSG_1N_FLH_MCI  U:\OutputPool\MERIS\FRS\WAQS-WeW\sweden\LakeBolmen\MER_FRS_WeW_20110604_094634_000000903103_484
12  MER_FSG_1N_FLH_MCI  U:\OutputPool\MERIS\FRS\WAQS-WeW\sweden\LakeBolmen\MER_FRS_WeW_20110626_094016_000000903104_487
13  MER_FSG_1N_FLH_MCI  U:\OutputPool\MERIS\FRS\WAQS-WeW\sweden\LakeBolmen\MER_FRS_WeW_20110628_100703_000000733104_487
14  MER_FSG_1N_FLH_MCI  U:\OutputPool\MERIS\FRS\WAQS-WeW\sweden\LakeBolmen\MER_FRS_WeW_20110629_093024_000000873104_487
15  MER_FSG_1N_FLH_MCI  U:\OutputPool\MERIS\FRS\WAQS-WeW\sweden\LakeBolmen\MER_FRS_WeW_20110630_103345_000000563104_488
16  MER_FSG_1N_FLH_MCI  U:\OutputPool\MERIS\FRS\WAQS-WeW\sweden\LakeBolmen\MER_FRS_WeW_20110709_100352_000000763104_489
17  MER_FSG_1N_FLH_MCI  U:\OutputPool\MERIS\FRS\WAQS-WeW\sweden\LakeBolmen\MER_FRS_WeW_20110916_093337_000001543106_499
18  MER_FSG_1N_FLH_MCI  U:\OutputPool\MERIS\FRS\WAQS-WeW\sweden\LakeBolmen\MER_FRS_WeW_20110929_095811_000001153107_501
19  MER_FSG_1N_FLH_MCI  U:\OutputPool\MERIS\FRS\WAQS-WeW\sweden\LakeBolmen\MER_FRS_WeW_20111023_101719_000002843108_504
```

Exercise 3: Solution

- Open the pixel extraction tool
- Select the MERIS L2 image on the input/output label
  - Include coordinates of the in situ stations or points of interest: add coordinates from file (fake_NorthSea_2012_import_in-situ.txt)
- Use time difference constrain (or not)
- Select macro pixel size (1, 3, 5…)
- Introduce (or not) valid pixel expression
- Click “Extract”

Take-home message

- Without independent validation, satellite data products lack credibility
- Different types of in-situ data require different analysis techniques.
- The scientist needs to understand his EO data (flags!) and in-situ data very well
- BEAM supports the comparative analysis of EO and in-situ data in the statistical analysis tools, the transects and scatter plots.

Thanks to NASA / OBPG group!

End of Unit

→ 3rd ESA ADVANCED TRAINING ON OCEAN REMOTE SENSING

Ocean Colour Processors

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Content

- Exploring alternative methods for ocean colour processing
  - Understanding Case2Regional, FUB and QAA approaches
  - Exploring differences

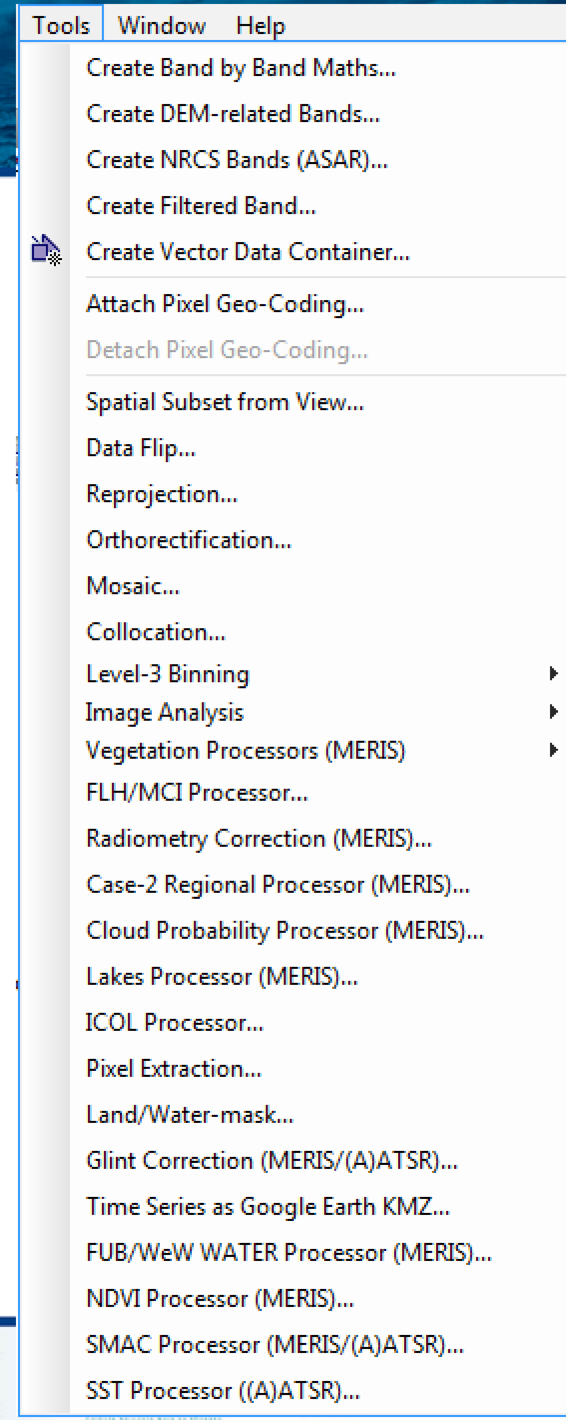
- BEAM exercises
  - Exercise 4: Processors in BEAM
  - Exercise 5: Transfer product bands
  - Exercise 6: Overlay different bands

Water processors in BEAM

- Processors: C2R Lakes, FUB, QAA, etc.
- Using the C2R and the FUB processors
- Using the cloud probability processor
- Processing chain: CloudProb + C2R + L3 (??)

BEAM Processors

- Generic Processors
  - Cluster Analyses
  - Reprojection / Orthorectification
  - Mosaic
  - Collocation
  - Level-3 Binning
  - Pixel Extraction
  - …
- Dedicated Processors
  - Radiometric Correction
  - Case-2 Regioal Processor
  - ICOL Processor
  - FUB/WeW Water Processor
  - MERIS Case-2 Waters Processors
  - QAA for IOPs
  - FLH/MCI Processor
  - …



Case2Regional processor

- Developed by GKSS Research Center under ESA contracts; part of the standard BEAM distribution
- Based on the inversion of radiative transfer modelling using artificial neural networks (ANN)
- Including atmospheric correction, IOPs retrieval and derived quantities (concentrations, Kd,…)

FUB processor

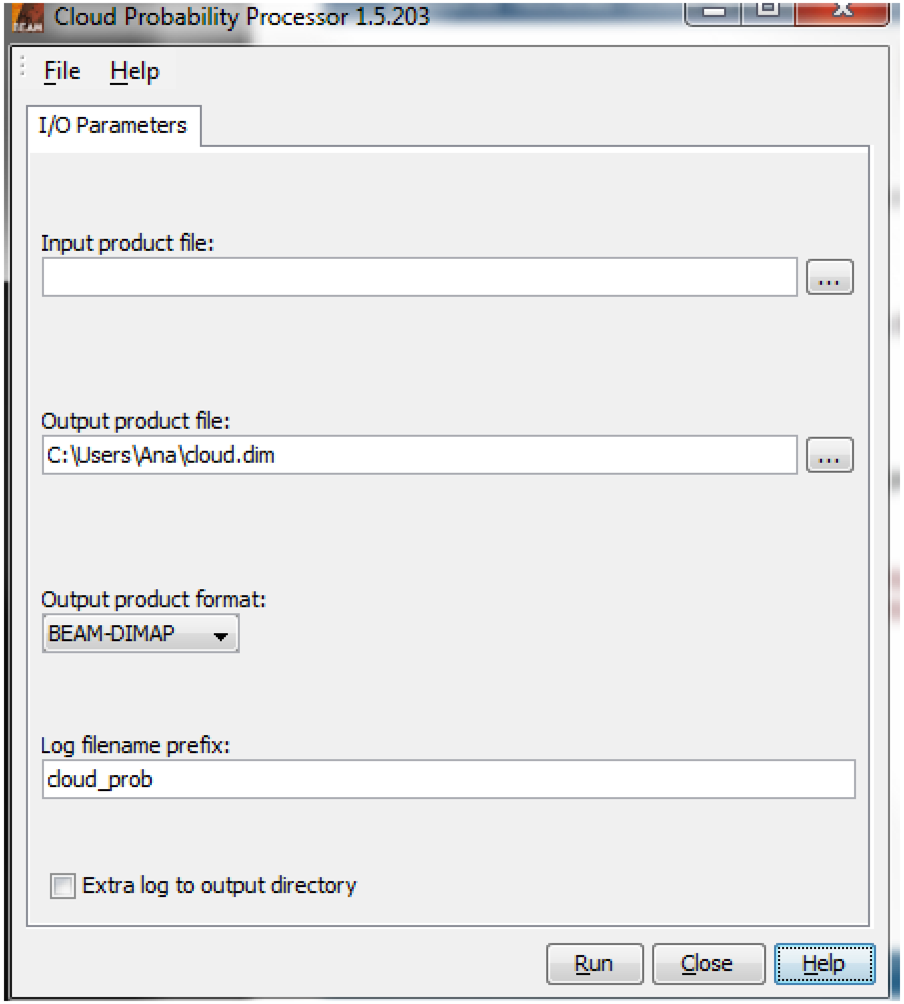
- Developed by Freie Universtätet Berlin

- Uses Level-1b TOA radiances in the bands 1-7, 9-10 and 12-14 to retrieve Case 2 water and atmospheric properties.

- The retrieval is based on 4 separate artificial NN which were trained based on extensive radiative transfer simulations with MOMO code

Cloud probability processor

The BEAM Cloud Probability Processor implements the detection of clouds in a MERIS L1b product. The created output product contains one raster indicating the probability that the current pixel is a cloud pixel, and three additional flags to the already present l1_falgs. The three flags indicate pixels which are cloudy (probability > 80%), cloud free (probability < 20%) or where it is uncertain (20% < probability < 80%).

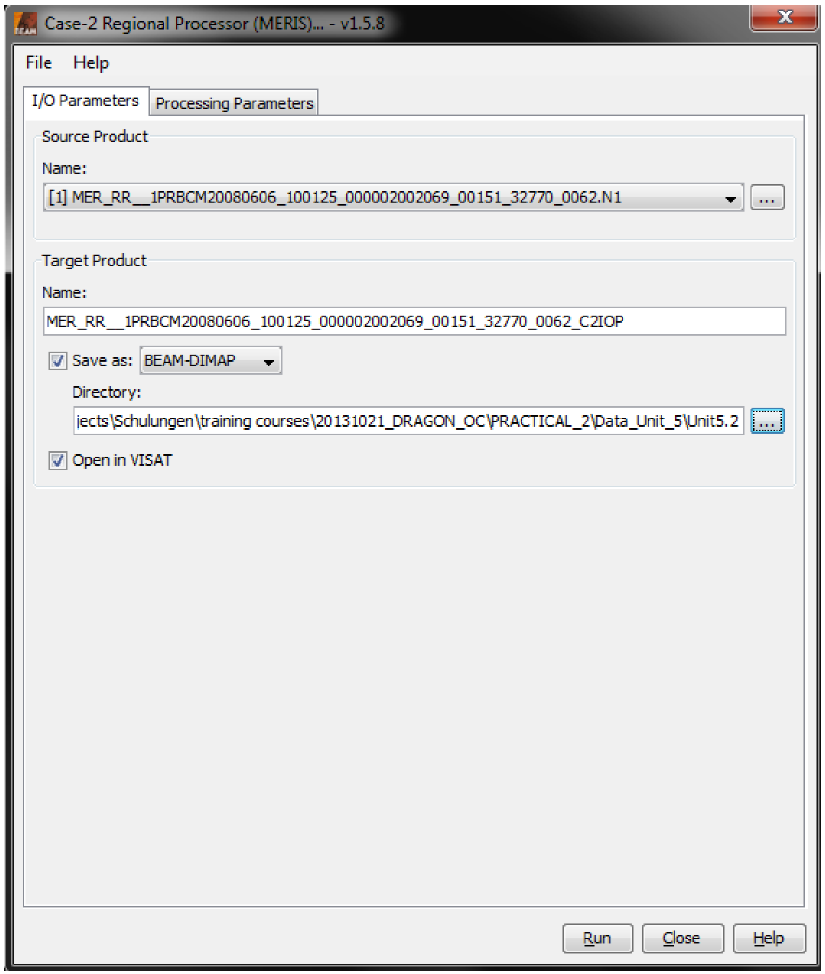


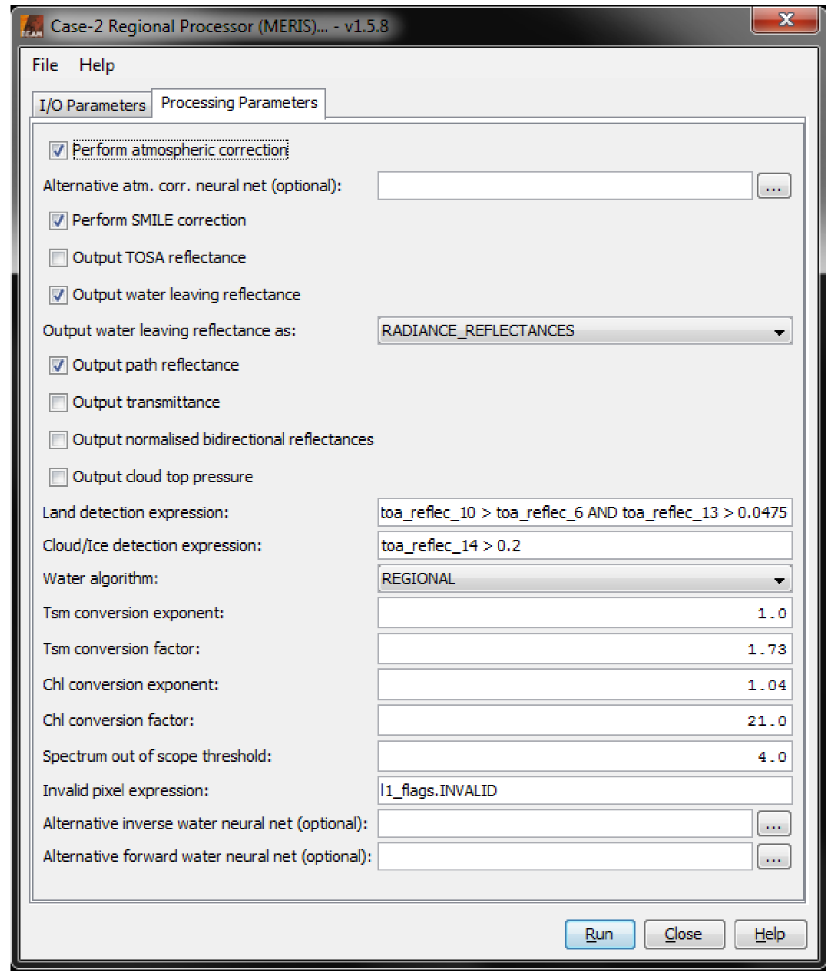
Exercise 1: Compare processor results

- What to do:
  - Apply the Case2Regional Processor and inspect results
  - Apply the FUB WEW Processor and inspect results
  - Open the CC L2W product
  - Compare water products (by using the tools that have been introduced):
    - Case2Regional product
    - FUB WEW product
    - CoastColour L2W product

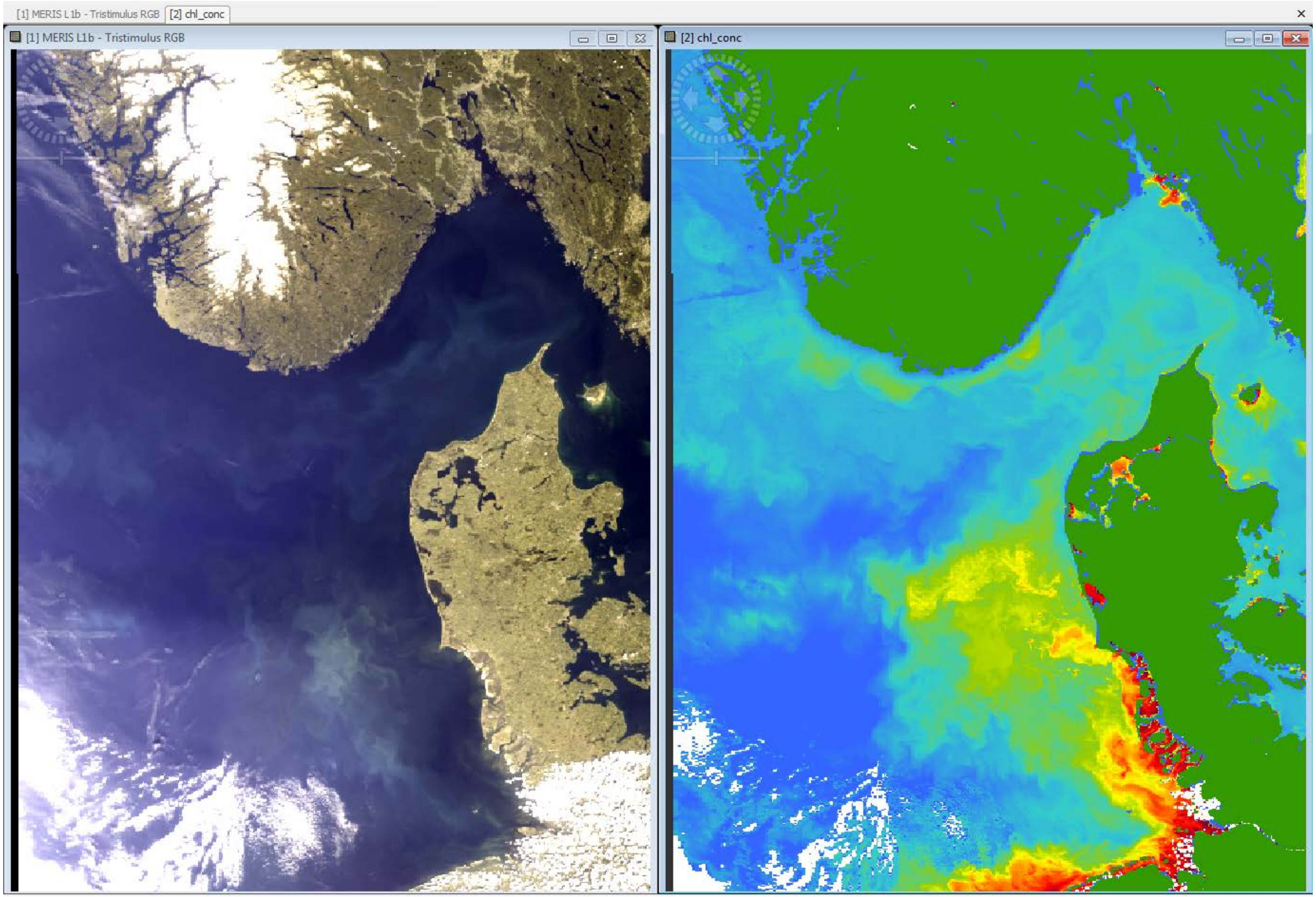
- Data:
  - MER_RR__1PRBCM20080606_100125_000002002069_00151_32770_0062.N1

Case2Regional processor

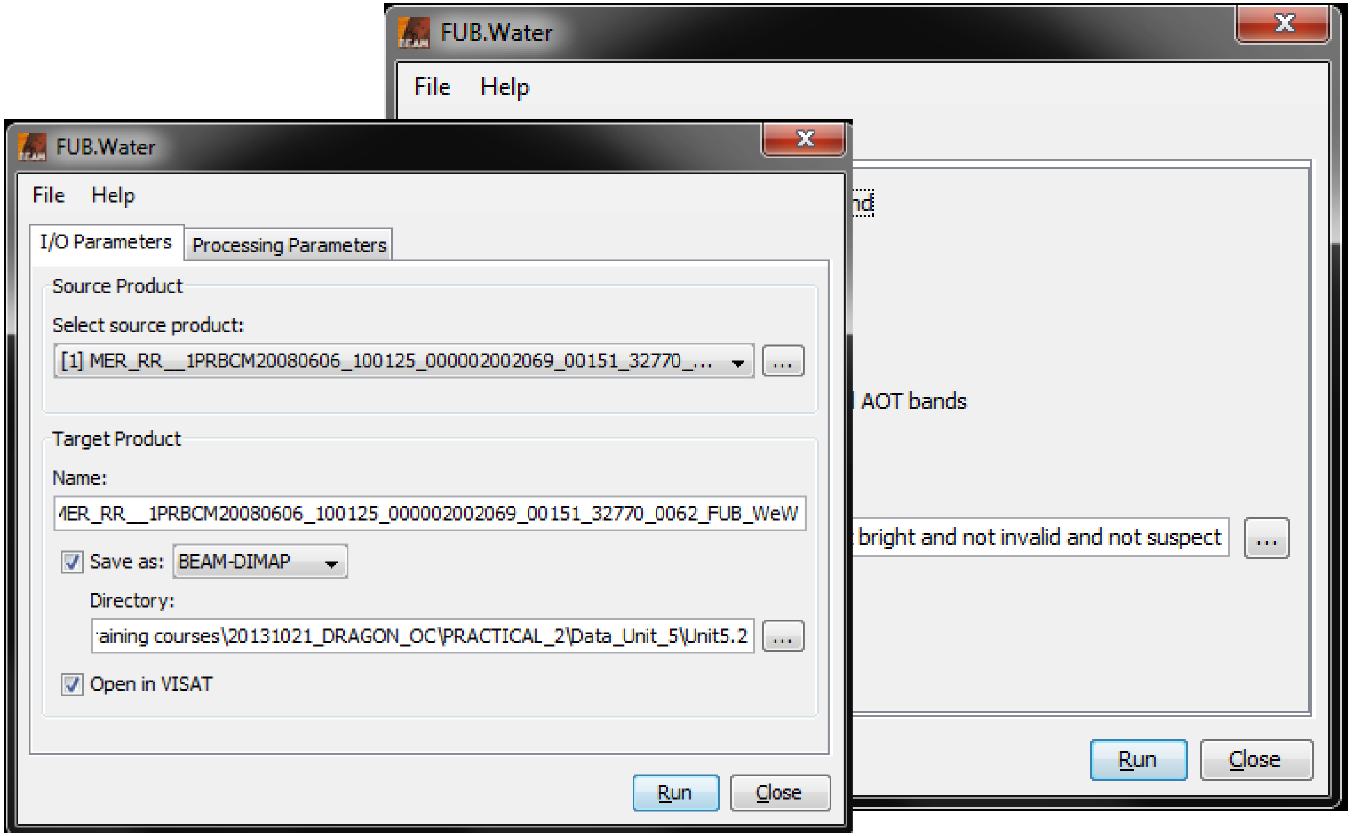




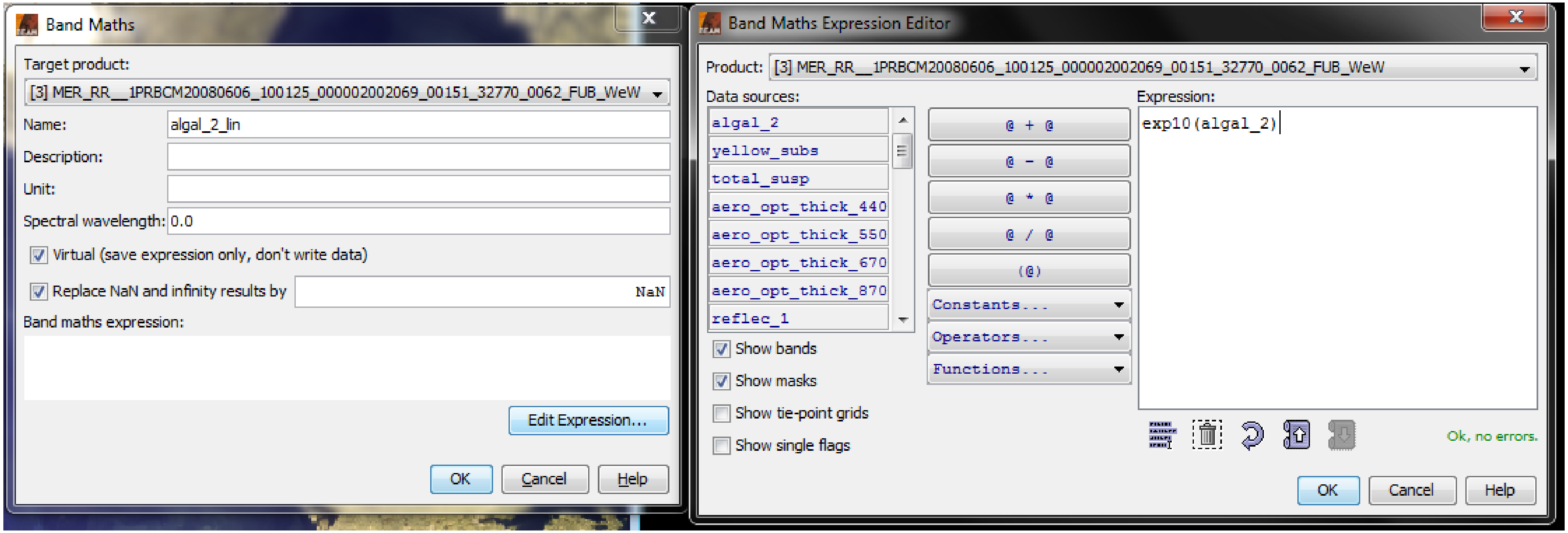
C2Regional processor - results



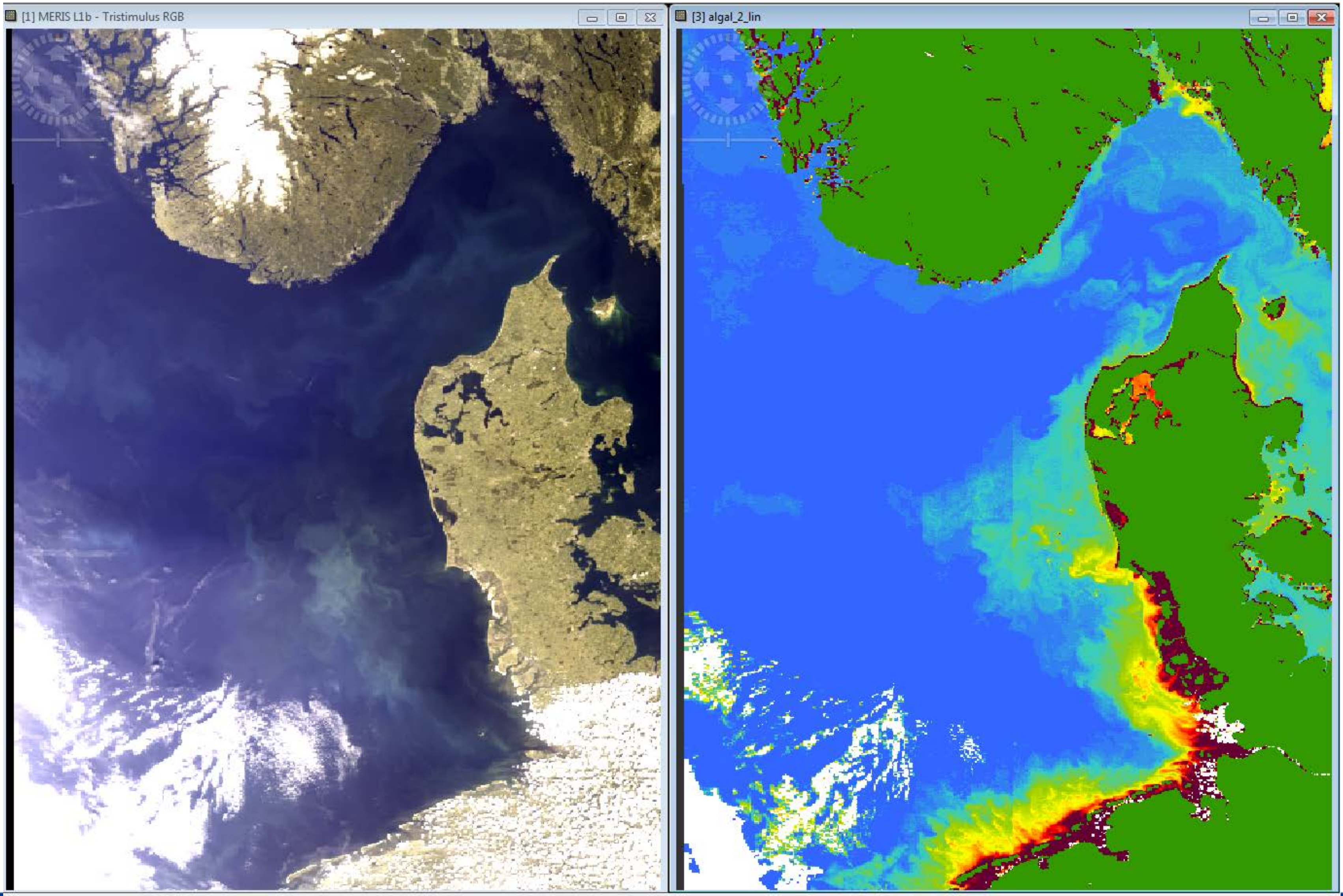
FUB water retrieval processor



Convert FUB from log10 to linear

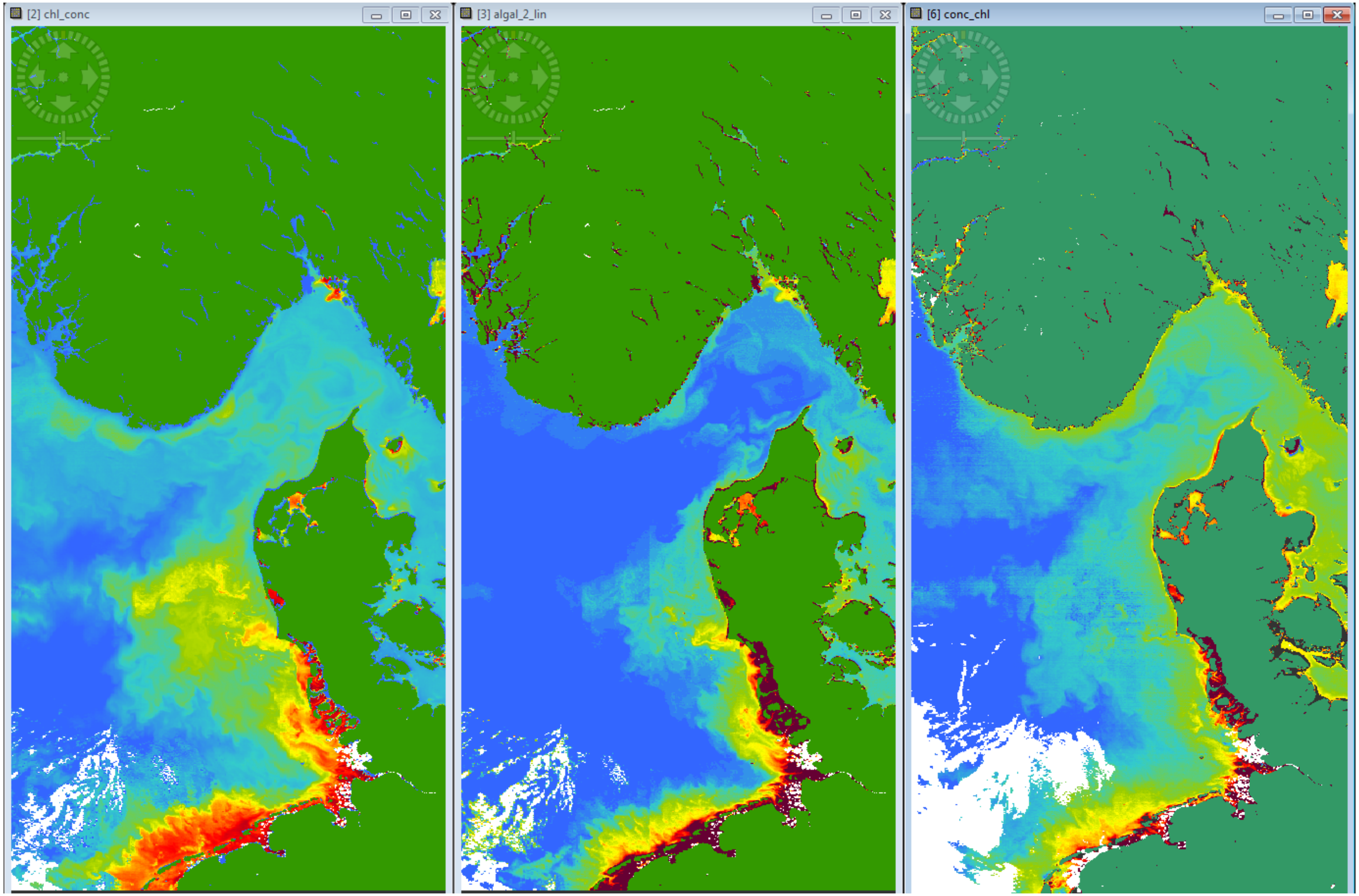


FUB water retrieval processor - results



Results of different water retrieval algorithms

C2R FUB L2W-CC



Exercise 1: Solution

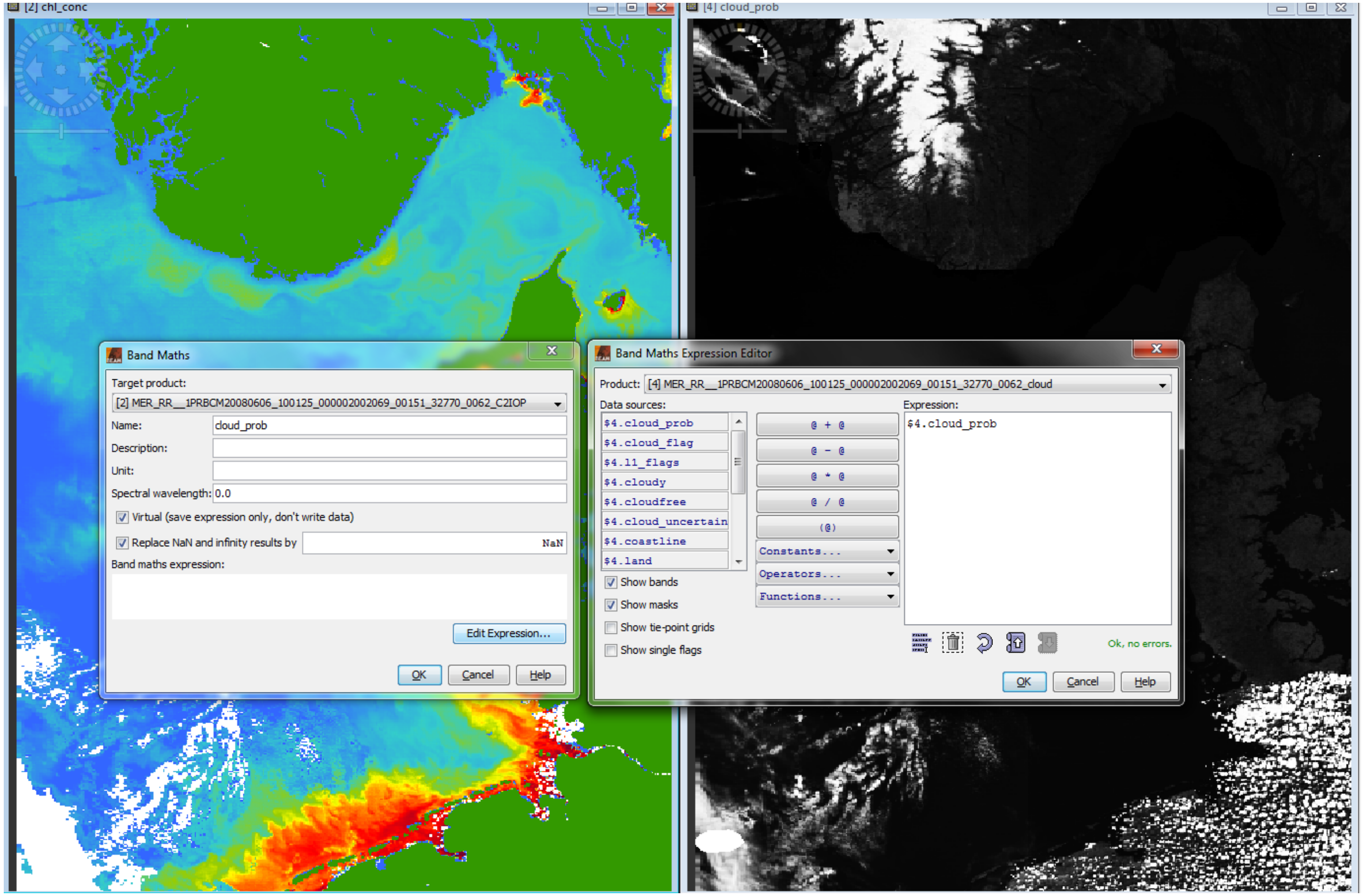
- Run the C2Regional processor: → Tools/Case-2 regional Processor (MERIS)
- Run the FUB WEW processor:→ Tools/FUB/WeW WATER Processor (MERIS)
- Convert FUB algal_2 product from log10 to linear using band math: exp10(algal_2)
- Display L2W conc_chl product and the conc_chlc product from C2R and algal_2_lin from FUB

Exercise 2: Transfer product bands

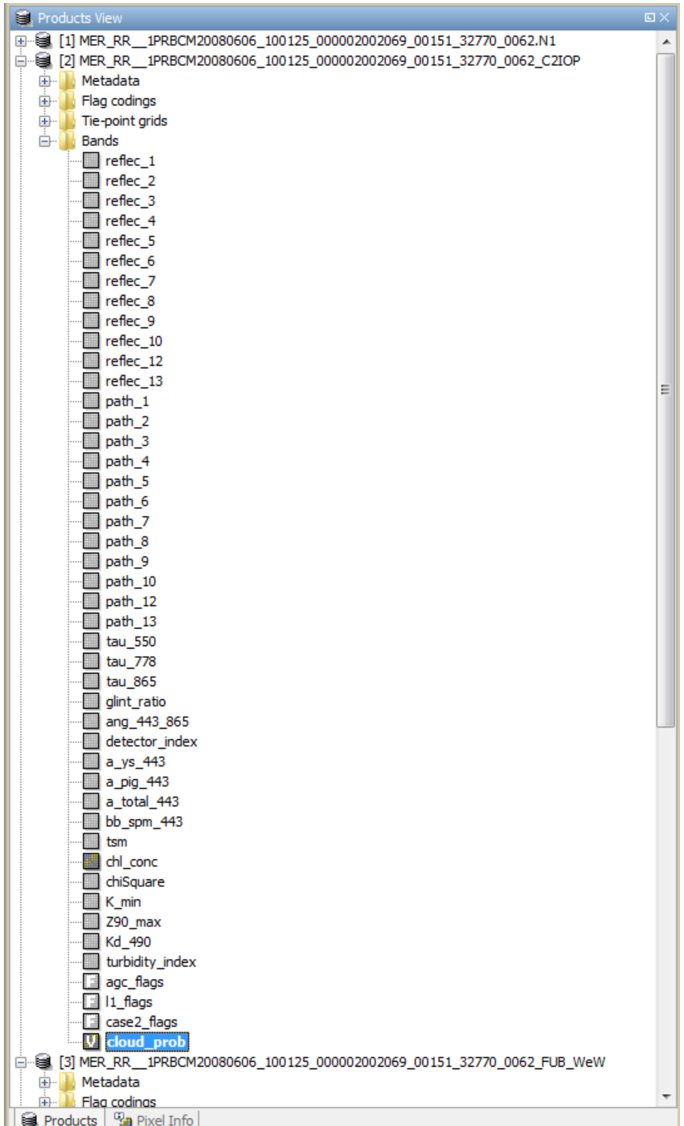
- What to do:
  - Apply the Cloud Probability Processor on all three input products
    - inspect results
  - Transfer the cloudprob band into the Case2R products
    - save the product
  - Inspect the result

- Data:
  - MER_RR__1PRBCM20080606_100125_000002002069_00151_32770_0062_cloud.N1
  - MER_RR__1PRBCM20080606_100125_000002002069_00151_32770_0062_C2IOP.dim

Cloud probability transfer with band maths



Cloud probabilty processor – result band

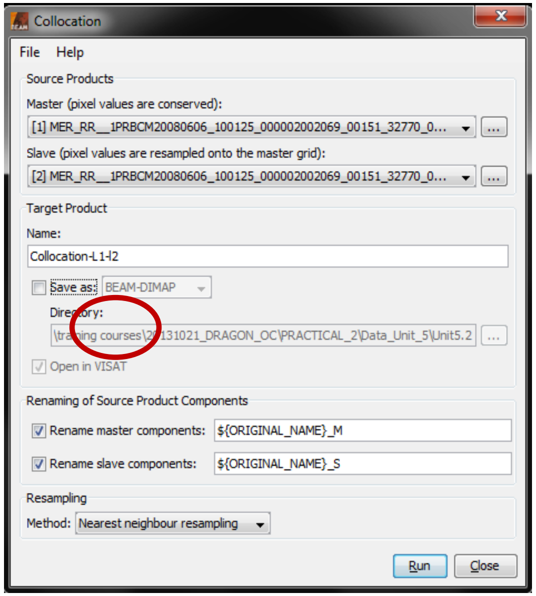


Exercise 2: Solution

- Open Tools → Cloud Probability Tool (change output directory)
- Display C2R product generated before
- Transfer the cloudprob band into the Case2R products:
  - use band arithmetic
  - Choose the Case2R product as target product
  - disable Virtual
  - select cloud_prob band from Cloud Probability output product

Exercise 3: Overlay different bands

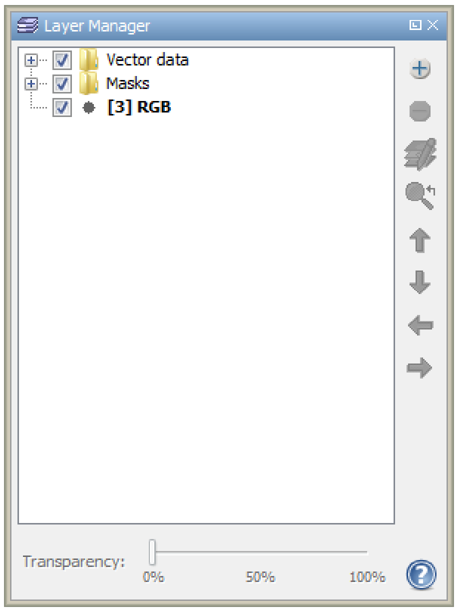
- Overlay an RGB (L1) with a coloured chlorphyll band (L2)
- Steps:
  - Collocate the MERIS Level 1 and the Level 2 products
    - Tools → Collocation…
    - Specify both input products
    - Define scheme for renaming of bands
    - DON'T Save output product
  - Open RGB from L1 spectral bands (b7b5b2)
  - Open chl_conc band
    - Import colour palette "CHL_colours"

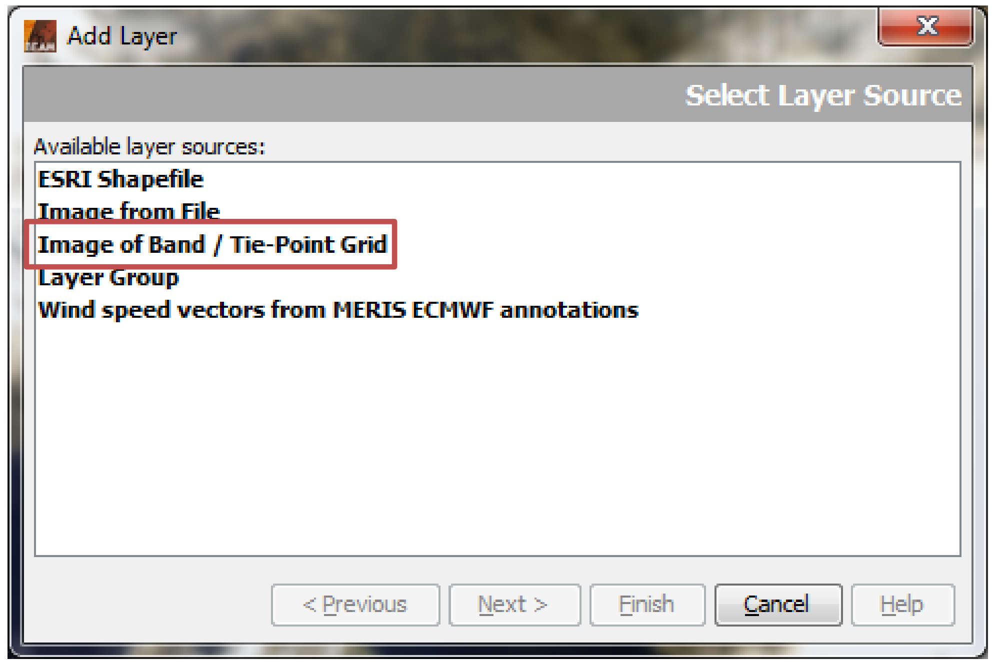


- Data:
  - MER_RR__1PRBCM20080606_100125_000002002069_00151_32770_0062.N1
  - MER_RR__1PRBCM20080606_100125_000002002069_00151_32770_0062_C2IOP.dim

Overlay bands

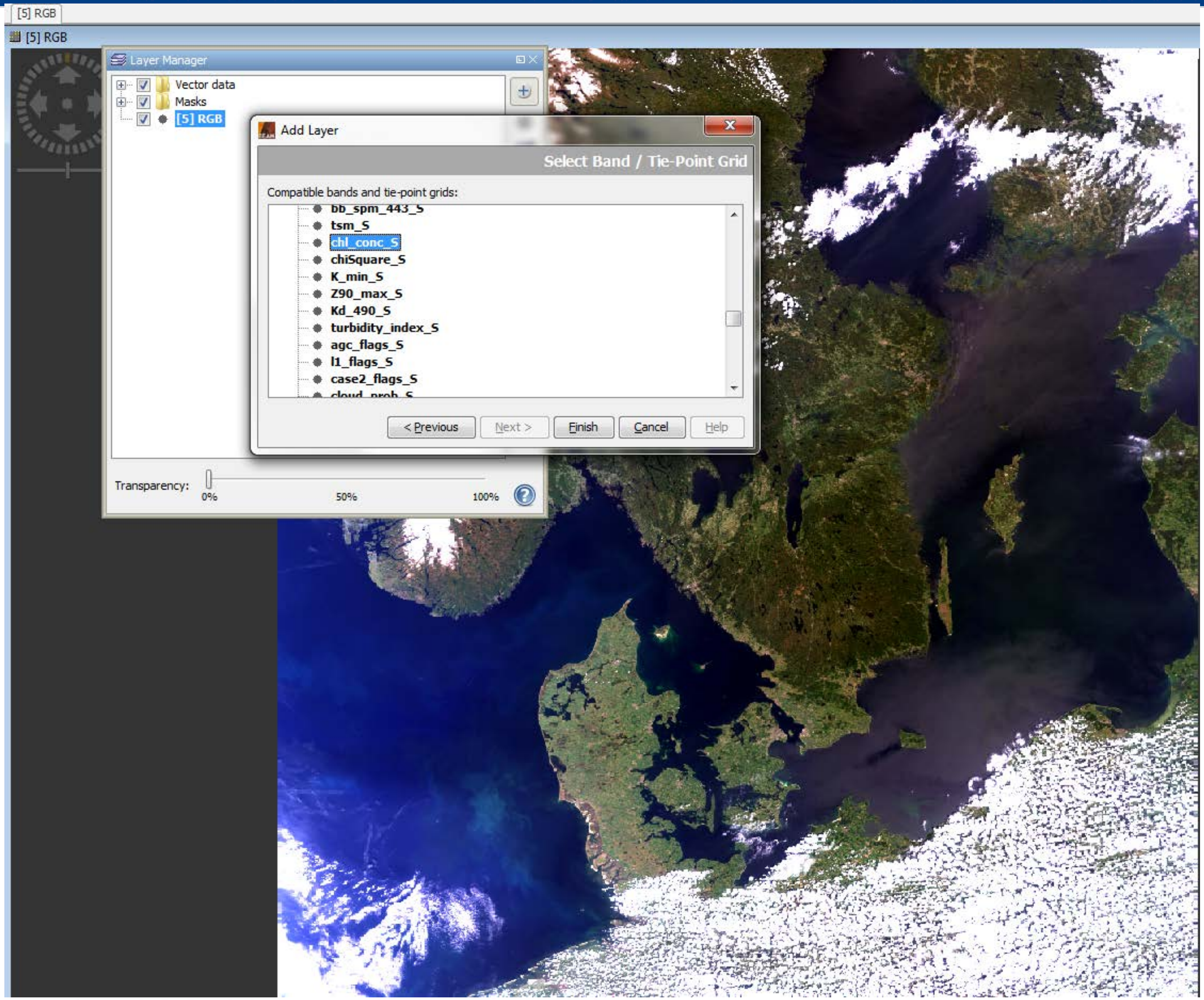
– Open Layer Manager 
  - Add layer by clicking
  - Choose Image of Band / tie-Point Grid



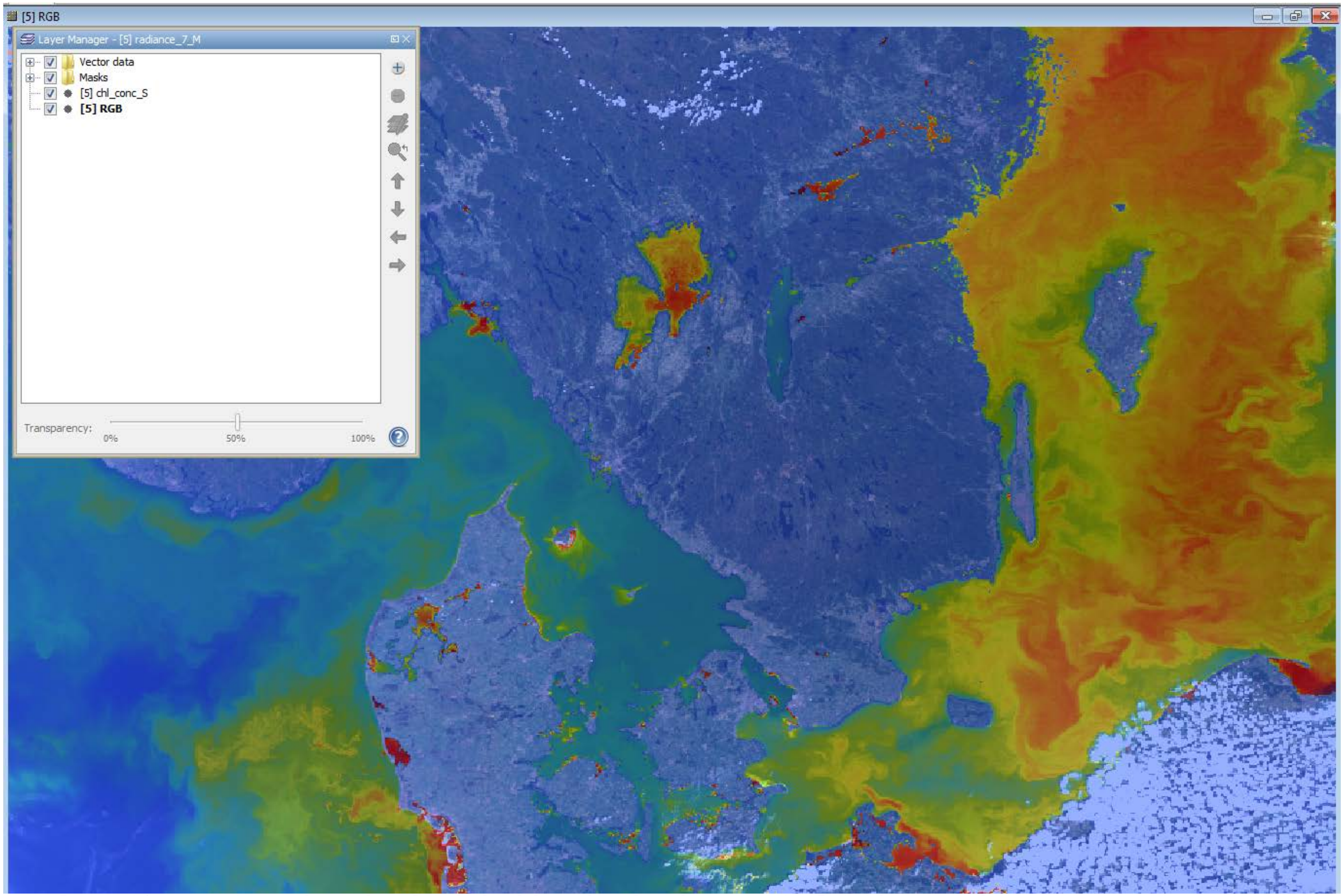


  - Select band with the total suspended matter
  - Change transparency of iop_b_tsm _443band (Layer manager)

Overlay bands

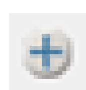


Overlay bands



Exercise 3: Solution

- Open L1 image:
  - MER_RR__1PRBCM20080606_100125_000002002069_00151_32770_0062.N1
- Open L2 image:
  - MER_RR__1PRBCM20080606_100125_000002002069_00151_32770_0062_C2IOP.dim
- Collocate L1 and L2 products: Tools/Collocation
- Open RGB from collocated L1 spectral bands:(*_M) RGB(752)
- Open conc_chl-S band from collocated product (*_S)
- Open layer manager and choose Image of band. Select: conc_chl-S



Take-home message

- The inversion of the radiative transfer in ocean and atmosphere is a complex problem, with more unknowns than information contained in satellite data.
- Different algorithms make different assumptions in order to decrease the number of unknowns, and use different mathematical approaches to solve the non-linear inversion problem.
- Each algorithm has its own strength and weakness; the user needs to carefully study, understand and respect the algorithm’s validity range, the limitations and the strengths.
- BEAM processors are software that take an EO product as input and generate a new output product.
- Different alternative methods for water quality retrieval and related problems (cloud screening, adjacency correction) have been developed by scientists and made available open-source in BEAM to other users.

End of Unit

Spatial statistics for marine protected areas

Carsten Brockmann

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Content

- Studying the spatial statistics of water quality parameters within a water body, identified by the marine protected areas

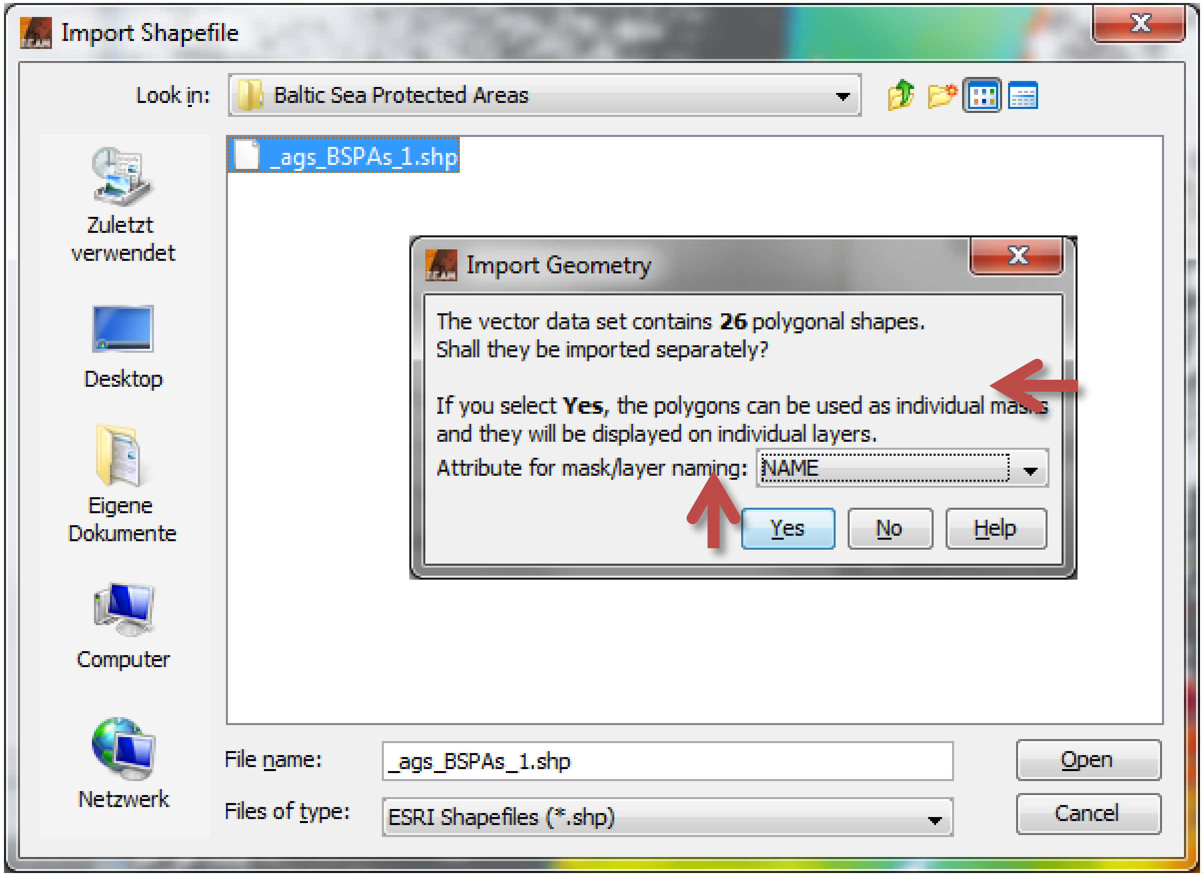
- BEAM exercises
  - Exercise 1: Statistics by areas, importing shape files
  - Exercise 2: Identifying and excluding invalid values; working with ROIs, masks and statistics

Exercise 1: Area statistics using shapefiles

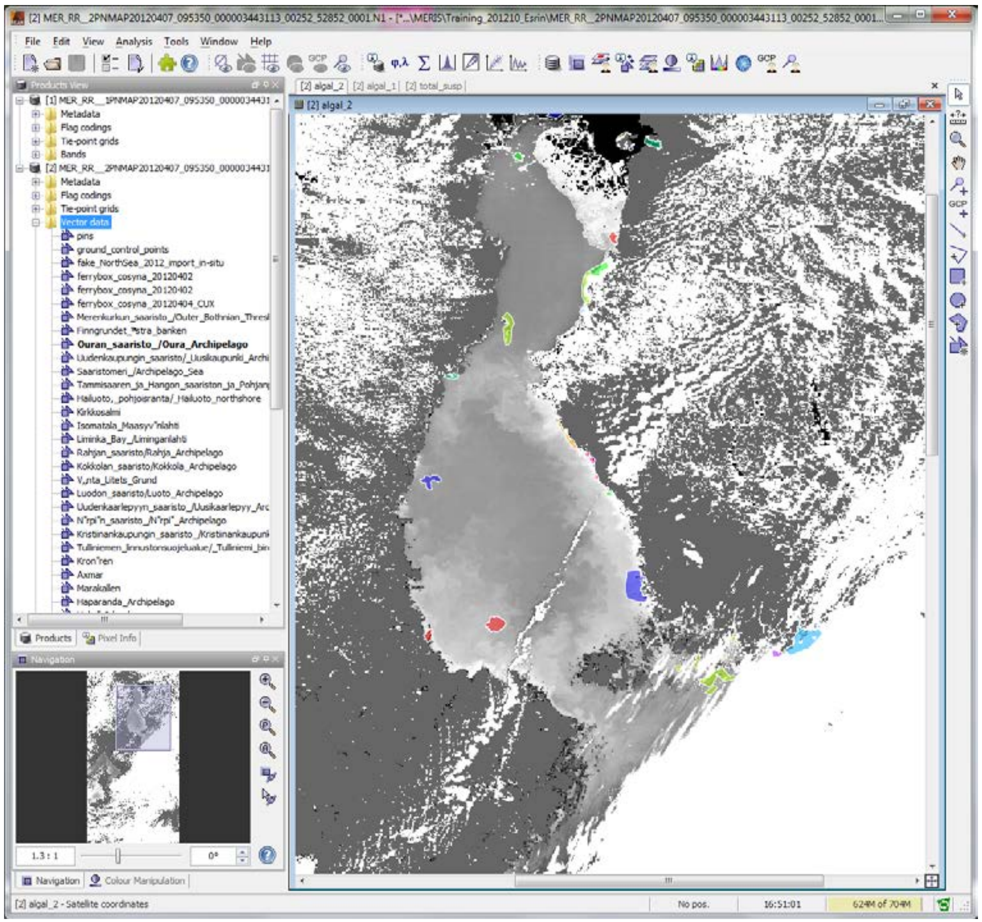
- Show the distribution if Chlorophyll values for Marine Protected Areas in the Baltic Sea*
- Steps:
  - Open MERIS L2 product: MER_RR__2PNMAP20120407_095350_000003443113_00252_52852_0001.N1
  - Open band algal_2 and pan to the Baltic Sea
  - Import shapefile (import polygons as separated ROIs)
    - …\in-situ\Baltic Sea Protected Areas\ _ags_BSPAs_1.shp
  - Open statistic tool
  - Display the statistics for selected areas

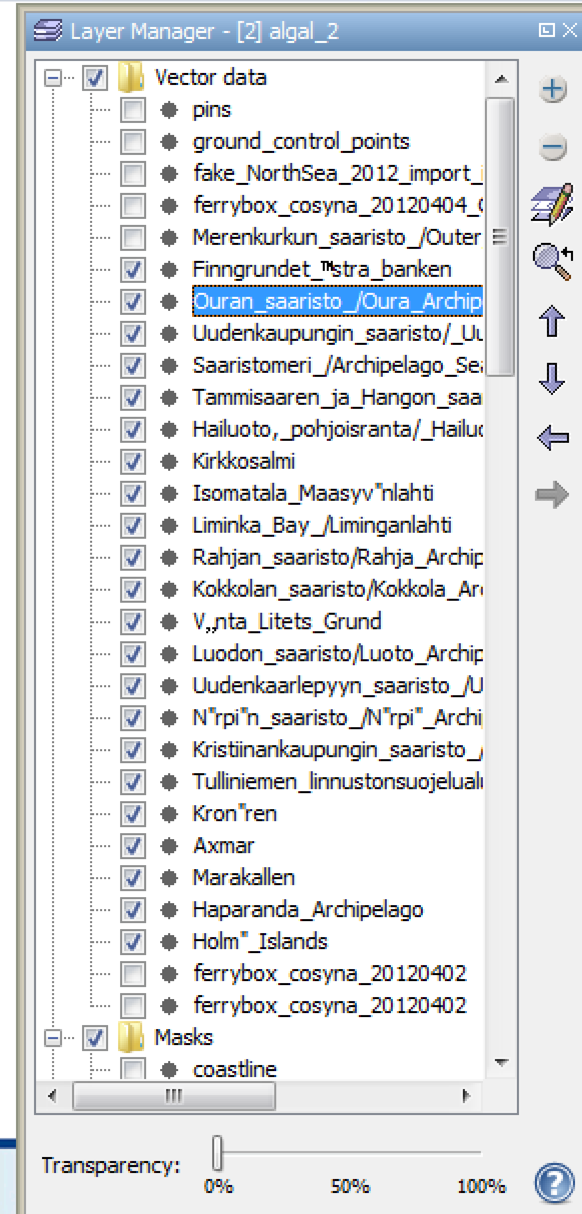
*The shapefile of Protected Areas has been downloaded from the HELCOM Maps and Data Service: http://maps.helcom.fi/website/mapservice/index.html

Importing a shapefile

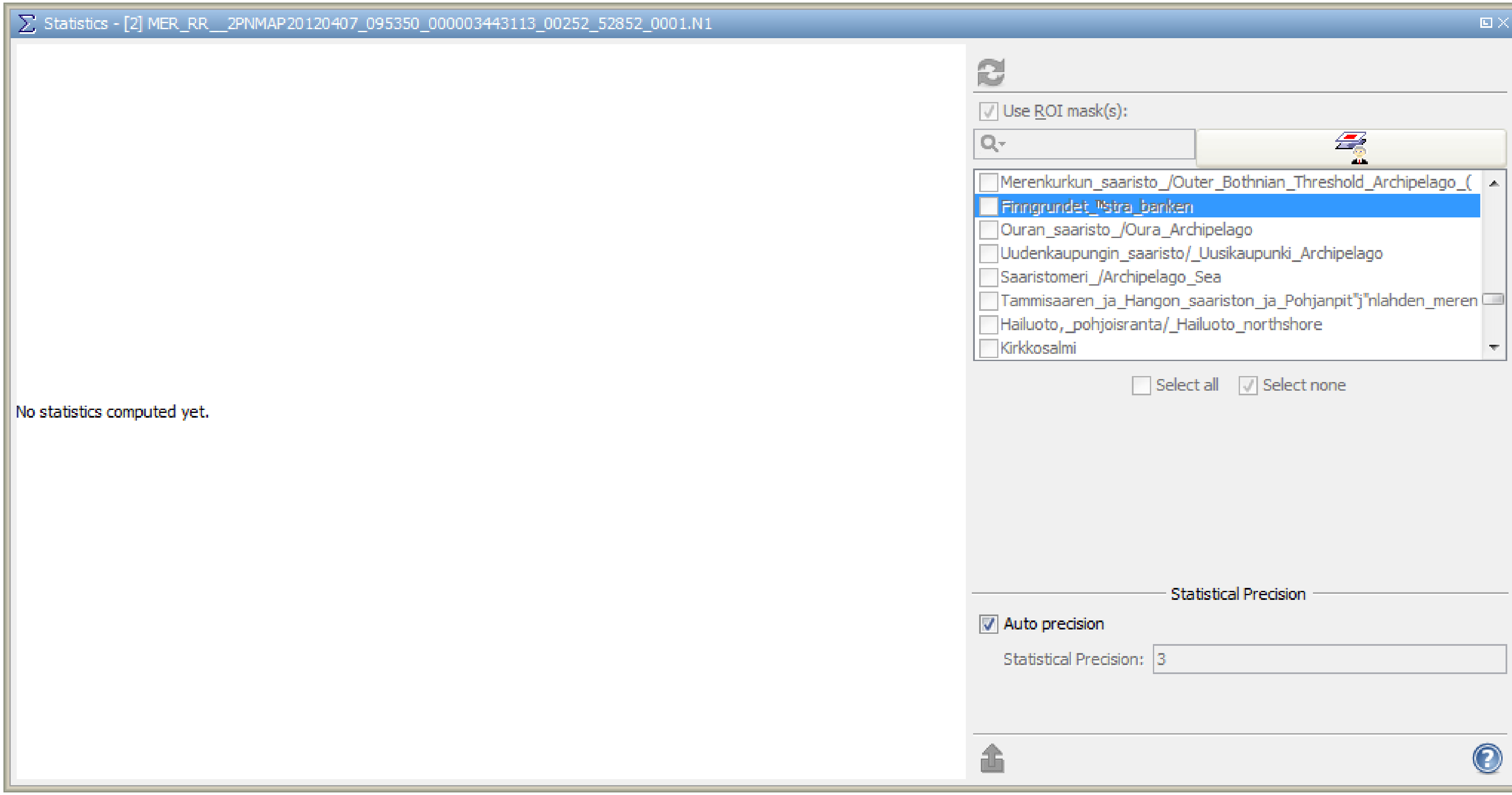


Layer Manager





Derive statistics for individual protected areas

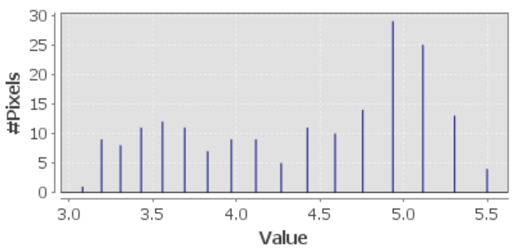


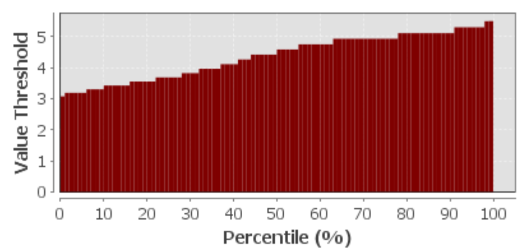
Statistics Tool

Statistics - [1] algal_2

algal_2 with ROI-mask **Finngrundet_™stra_banken**

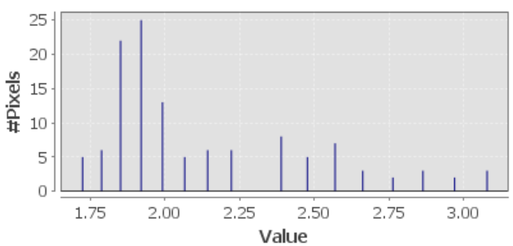
#Pixels total:	188
Minimum:	3.0774
Maximum:	5.4974
Mean:	4.3750
Sigma:	0.6992
Median:	4.5852
P75 threshold:	4.9302
P80 threshold:	5.1098
P85 threshold:	5.1098
P90 threshold:	5.1098
P95 threshold:	5.2989

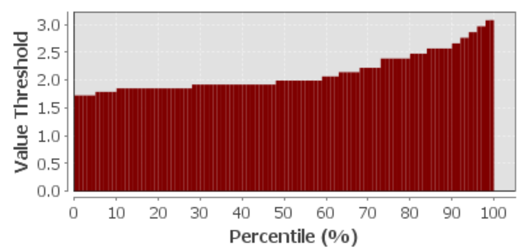




algal_2 with ROI-mask **V„nta_Litets_Grund**

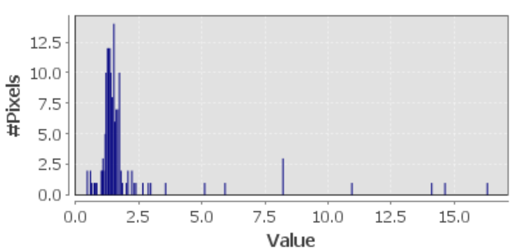
#Pixels total:	121
Minimum:	1.7227
Maximum:	3.0774
Mean:	2.1241
Sigma:	0.3459
Median:	1.9900
P75 threshold:	2.3869
P80 threshold:	2.4742
P85 threshold:	2.5668
P90 threshold:	2.6594
P95 threshold:	2.8605

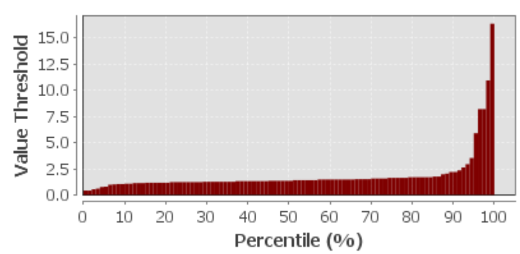




algal_2 with ROI-mask **Holm"_Islands**

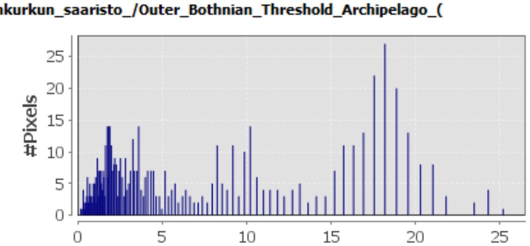
#Pixels total:	153
Minimum:	0.4343
Maximum:	16.3154
Mean:	1.9382
Sigma:	2.2865
Median:	1.3648
P75 threshold:	1.6440
P80 threshold:	1.7060
P85 threshold:	1.7681
P90 threshold:	2.2023
P95 threshold:	5.8934

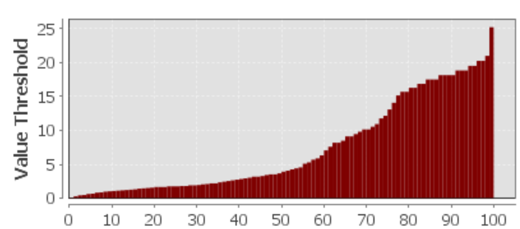




algal_2 with ROI-mask **Merenkurkun_saaristo_/Outer_Bothnian_Threshold_Archipelago_(**

#Pixels total:	644
Minimum:	0.0913
Maximum:	25.2101
Mean:	7.4174
Sigma:	6.8333
Median:	3.9180
P75 threshold:	13.0923
P80 threshold:	16.2812
P85 threshold:	17.5077
P90 threshold:	18.1455
P95 threshold:	19.5191





Display Sta

Use ROI mask(s):

Filter masks here

- [ ] Axmar
- [ ] Marakallen
- [ ] Haparanda_Archipelago
- [x] Holm"_Islands
- [ ] High_Coast
- [ ] Gr"s"/Sing"_Archipelago
- [ ] Per"meren_kansallispuisto_/Bothnian_Bay_National_Park
- [x] Merenkurkun_saaristo_/Outer_Bothnian_Threshold_Archipelago_(

Select all   Select none

Exercise 1: Solution

– Open MERIS L2 product

– Open band algal_2 and pan to the Baltic Sea

– Import shapefile (import polygons as separated ROIs)

  - →File/Import Vector Data/ESRI shapefile
  - (by NAME) Σ

– Open statistics tool

– Display the statistics for selected areas (note: algal_2 band needs to be selected in the band list)

Exercise 2: Erase invalid pixels from statistics

- Show statistics for only valid pixels within the protected area „ Merenkurkun_…“
- Steps 
  - Open Mask Manager
  - Select masks for „Merenkurkun_“ AND „ice_haze“
  - Select option: difference of selected mask
  - OR use band math expression:
  - Rename the new mask: valid_Merenkurkun
  - Apply statistsics for Valid_Merenkurkun and Merenkurkun

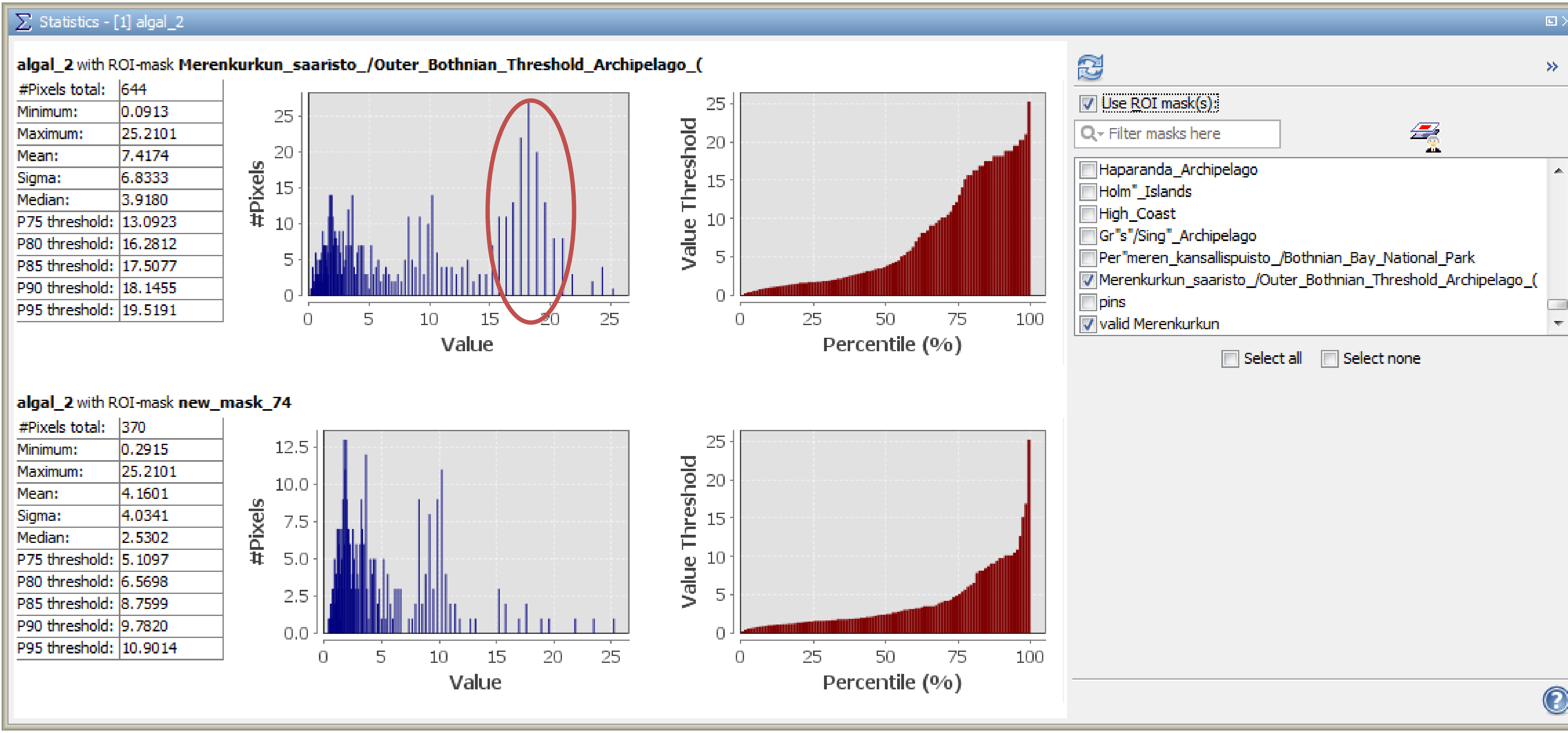
Mask Manager – combining masks

Mask Manager - [1] algal_2

	Name	Type	Colour	Tra...	Description
	invalid_cloud_opt_thick_and_type	Maths	0, ...	0	Cloud pixels flagged for invalid cloud_opt_thick and clou
	invalid_cloud_top_press	Maths	0, ...	0	Cloud pixels flagged for invalid cloud_top_press
	low_sun	Maths	15...	0.5	Sun low above horizon (or conversely high sun zenith ar
	high_glint	Maths	20...	0.5	High (uncorrected) glint (water)
	medium_glint	Maths	25...	0.5	Corrected for glint (water)
	ice_haze	Maths	25...	0	Ice or high aerosol load pixel
	land_aerosol_on	Maths	51...	0.25	Land aerosol remote sensing turned on
	absoa_dust	Maths	0, ...	0.5	Dust-like absorbing aerosol selected for atmosphere cor
	High_Coast	Geometry	25...	0.5	Mask derived from geometries in 'High_Coast'
	Gr"s"/Sing"_Archipelago	Geometry	25...	0.5	Mask derived from geometries in 'Gr"s"/Sing"_Archipelag
	Per"meren_kansallispuisto_/Bothn...	Geometry	25...	0.5	Mask derived from geometries in 'Per"meren_kansallispu
	Merenkurkun_saaristo_/Outer_Bo...	Geometry	25...	0.5	Mask derived from geometries in 'Merenkurkun_saaristo
	pins	Geometry	25...	0.5	Mask derived from geometries in 'pins'

f(x) [x]

Statistics for ROIs



algal_2 with ROI-mask **Merenkurkun_saaristo_/Outer_Bothnian_Threshold_Archipelago_(**

#Pixels total:	644
Minimum:	0.0913
Maximum:	25.2101
Mean:	7.4174
Sigma:	6.8333
Median:	3.9180
P75 threshold:	13.0923
P80 threshold:	16.2812
P85 threshold:	17.5077
P90 threshold:	18.1455
P95 threshold:	19.5191

algal_2 with ROI-mask **new_mask_74**

#Pixels total:	370
Minimum:	0.2915
Maximum:	25.2101
Mean:	4.1601
Sigma:	4.0341
Median:	2.5302
P75 threshold:	5.1097
P80 threshold:	6.5698
P85 threshold:	8.7599
P90 threshold:	9.7820
P95 threshold:	10.9014

Exercise 2: Solution

- Steps
  - Open Mask Manager
  - Select masks for „Merenkurkun_“ AND „ice_haze“
  - Select option: difference of selected mask
  - OR use band math expression: 'Merenkurkun_saaristo_/Outer_Bothnian_Threshold_Archipelago_(' and not l2_flags.ICE_HAZE
  - Rename the new mask: valid_Merenkurkun
  - Apply statistsics for Valid_Merenkurkun and Merenkurkun

Take-home messages

- The marine protected areas in the Baltic Sea differ in their water quality parameters.
- Proper screening of invalid pixels is of very high importance.
- BEAM offers shape file important for area selection and treats these as ROIs.
- Statistics for multiple ROIs can be generated at once.

End of Unit

Scripting of BEAM

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Options

- Use BEAM's command-line tools:
  - From a command-line shell
  - From shell scripts
  - From Python, IDL, MatLab…using dedicated systems

- Use the BEAM Java API to call BEAM functions:
  - From your Java program
  - From your Python program

BEAM command-line tools

- Have a look into the **${BEAM-HOME}/bin directory**
- **gpt** –Used to execute various “BEAM operators” and chains of operators.
- **pconvert** – Used to convert product files into other data and images formats (will become a gpt opertaor)
- binning
- **meris-smac** – Envisat MERIS smile correction
- **meris-cloud** – Envisat MERIS cloud screening
- **flhmci** – Envisat MERIS/AATSR FLH/MCI processors
- **aatsr-sst** – ATSR/AATSR SST processor
- **mosaic** – deprecated, use **gpt Reproject**
- **mapproj** – deprecated, use **gpt Mosaic**

BEAM gpt

- Most important BEAM batch-mode tool
- Other command-line tools will become BEAM operators in the future
- Usage
  - **gpt <op>|<graph-file> [options] [<source-file-1> <source-file-2> ...]**
- Which operators are available?
  - **gpt –h**
  - Note that list of operators may vary depending on the installed BEAM plug-ins

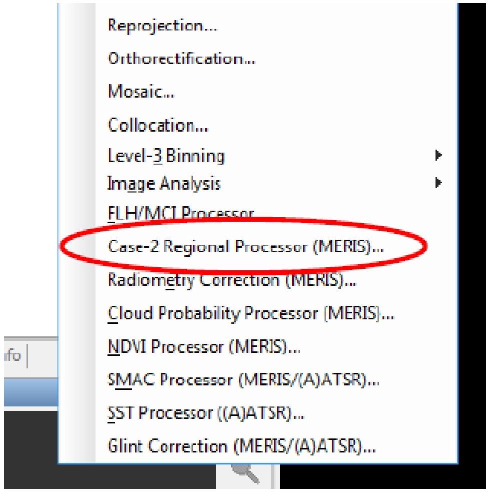
BEAM gpt operator index

- Refer to gpt documentation in BEAM VISAT help
- Operator index lists only standard operators

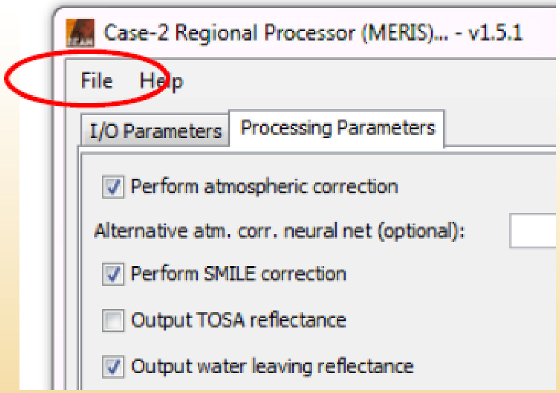
BandMaths	Create a product with one or more bands using mathematical expressions.
Collocate	Collocates two products based on their geo-codings.
EMClusterAnalysis	Performs an expectation-maximization (EM) cluster analysis.
KMeansClusterAnalysis	Performs a K-Means cluster analysis.
Meris.CorrectRadiometry	Performs radiometric corrections on MERIS L1b data products.
Meris.N1Patcher	Copies an existing N1 file and replaces the data for the radiance bands
Mosaic	Creates a mosaic out of a set of source products.
PixEx	Extracts pixels from given locations and source products.
Read	Reads a product from disk.
Reproject	Reprojection of a source product to a target Coordinate Reference System.
Subset	Create a spatial and/or spectral subset of a data product.
Unmix	Performs a linear spectral unmixing.
Write	Writes a data product to a file.

BEAM gpt parameterisation

- Many of the BEAM gpt operators and command-line tools have a counterpart in the VISAT tools menu



- You can save a parameter file from an oprator's GUI in VISAT and use it with BEAM gpt on the command-line



Calling BEAM gpt from shell scripts

- input-path = ‘~/eodata/MER_RR__1P.N1’
- gpt.sh Reproject –Pcrs = AUTO: 42001 –f NetCDF $input-path

Calling BEAM gpt from Python

```
import subprocess
gpt = '~/software/beam-4.9/bin/gpt.sh'
operator = 'Reproject'
parameters = '-Pcrs=AUTO:42001 -f NetCDF'
input_path = '~/eodata/MER_RR__1P.N1'
process = subprocess.Popen(gpt + ' ' + operator \
                           + ' ' + parameters + ' '+ input_path,\
                           shell=True, \
                           bufsize=1 ,\
                           stdout=subprocess.PIPE, \
                           stderr=subprocess.STDOUT)
trace = open('gpt.stdout', 'w')
for line in process.stdout:
    trace.write(line)
    trace.flush()
trace.close()
process.stdout.close()
code = process.wait()
```

Processing chain: using gpt graphs

- Advantages:
  - no intermediate files written, no I/O overhead
  - reusability of processing chains
  - simple and comprehensive operator configuration
  - reusability of operators configurations
- Usage example
  - **gpt iop-graph.xml**

BEAM gpt graph XML example 1

- Single operator = single node:

```
<graph id="someGraphId">
  <version>1.0</version>
  <node id="someNodeId">
    <operator>Meris.Case2Regional</operator>
    <sources>
      <source>${source}</source>
    </sources>
    <parameters>
      <doSmileCorrection>false</doSmileCorrection>
      <outputReflecAs>IRRADIANCE_REFLECTANCES</outputReflecAs>
      <outputNormReflec>true</outputNormReflec>
      <cloudIceExpression>toa_reflec_14 > 0.025</cloudIceExpression>
    </parameters>
  </node>
</graph>
```

BEAM gpt graph XML example 2

- Two operator chain: (1) IOP, (2) subset

```
<graph id="Case2RGraph">
  <version>1.0</version>
  <node id="case2r">
    <operator>Meris.Case2Regional</operator>
    <sources>
      <source>${source}</source>
    </sources>
    <parameters>
      <doSmileCorrection>false</doSmileCorrection>
      <outputReflecAs>IRRADIANCE_REFLECTANCES</outputReflecAs>
      <outputNormReflec>true</outputNormReflec>
      <cloudIceExpression>toa_reflec_14 > 0.025</cloudIceExpression>
    </parameters>
  </node>

  <node id="subsetNode">
    <operator>Subset</operator>
    <sources>
      <source>case2r</source>
    </sources>
    <parameters>
      <geoRegion>POLYGON((119.0 36.0, 125.0 35.0, 122.0 30.0, 117.0 30.0, 119.0 36.0))</geoRegion>
      <copyMetadata>true</copyMetadata>
    </parameters>
  </node>
</graph>
```

Getting help – Command Line

- Using **gpt**
  - **gpt –h**
  - **In BEAM VISAT Help Topics: Graph Processing Framework (GPF)**
- Setting up a **gpt** processing chain:
  - http://www.brockmann-consult.de/beam-wiki/display/BEAM/Creating+a+GPF+Graph

Getting help - Java

- BEAM Java API Documentation:
  - http://www.brockmann-consult.de/beam/doc/apidocs/index.html
  - BEAM home page / downloads
- BEAM Java Programming:
  - http://www.brockmann-consult.de/beam-wiki/display/BEAM/Development

Integrating BEAM code in Python

- To call BEAM API functions from C-Python
  JPipe: http://jpype.sourceforge.net/
- It is very easy to use the BEAM API with Jython: http://jpype.sourceforge.net/

End of Unit