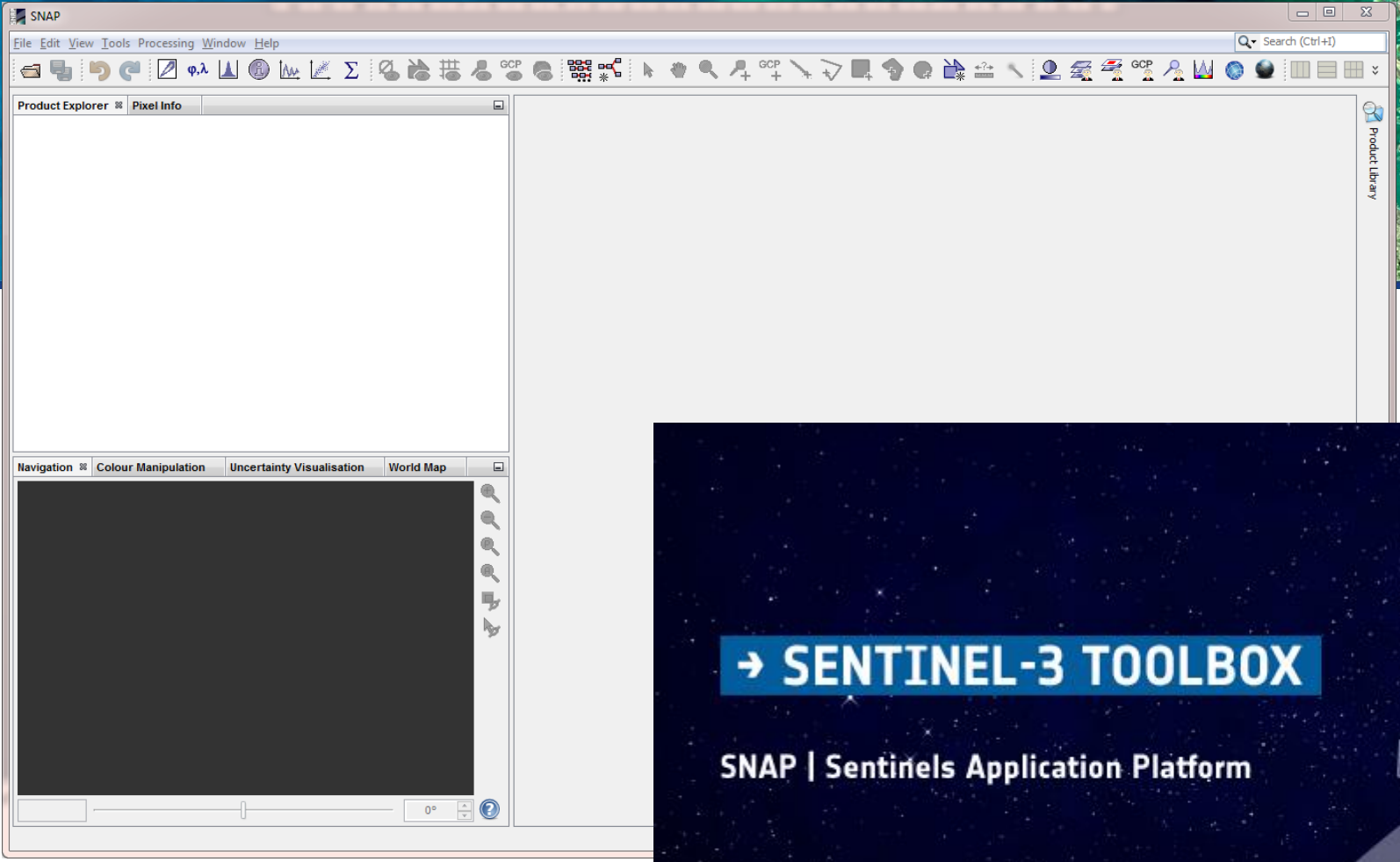
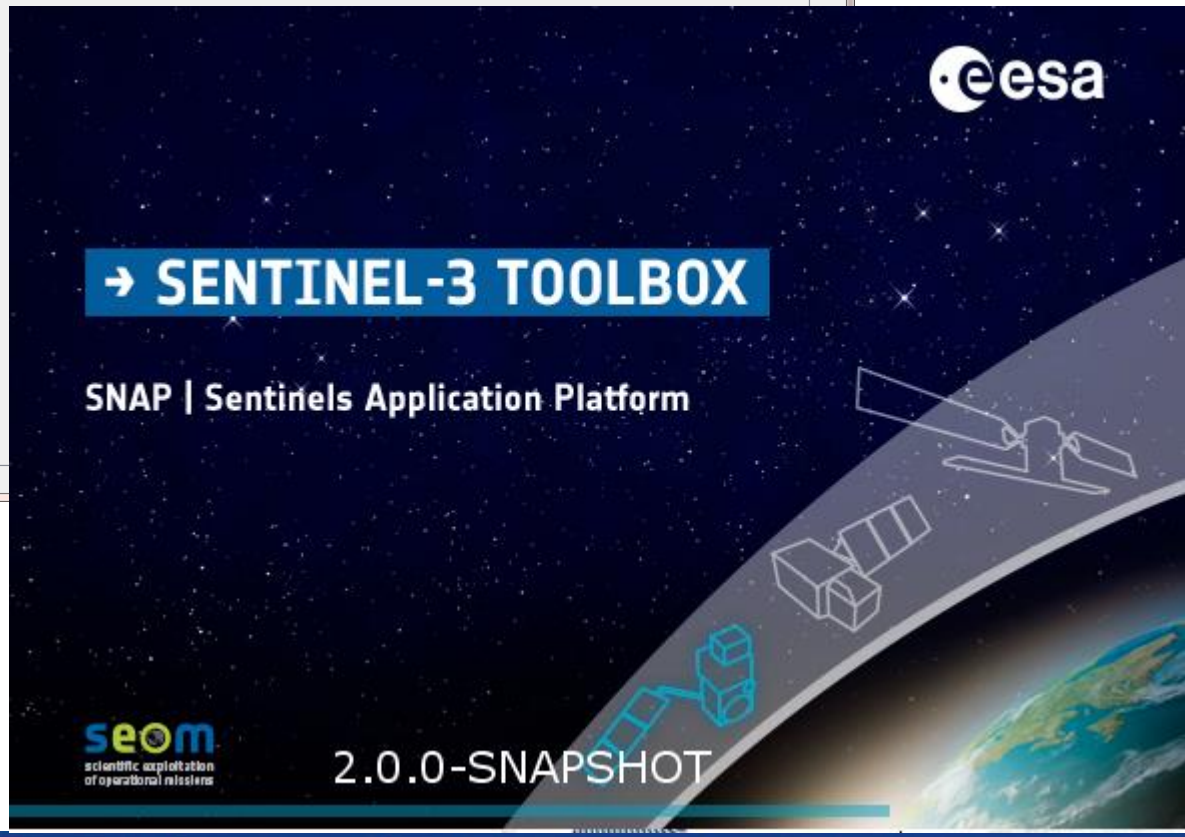
Norman Fomferra, Ana Ruescas, Tonio Fincke, Thomas Storm

SENTINEL-3 TOOLBOX


SNAP
File Edit View Tools Processing Window Help
Search (Ctrl+I)
Product Explorer
Pixel Info
Product Library
Navigation
Colour Manipulation
Uncertainty Visualisation
World Map
0°


esa


esa
SENTINEL-3 TOOLBOX
SNAP | Sentinels Application Platform
seom
scientific exploitation of operational missions
2.0.0-SNAPSHOT

Sentinel-3 Toolbox - Cardinal Req.

- Openness
  - Open source, GNU Public License v3
  - Source code: https://github.com/senbox-org/snap
  - Multi-Mission Support
  - S-1, S-2, S-3, Envisat, MODIS, Landsat, SeaWiFS, AVHRR, SMOS, Chris-PROBA, SPOT VGT, …
  - NetCDF CF, GeoTIFF, HDF, ESRI Shapefile, …
- Extendibility & Modularity
  - Modular architecture, install, update, uninstall extension modules
  - Java, Python, C/C++ APIs
  - Stand-Alone Tools Adapter, Web Services
- Portability
  - Installers for Windows, Mac OS, and Linux
  - Platform independency through Java and Python
- Easy Operability
  - Desktop Graphical User Interface
  - Command line tool for batch mode processing
- Heritage
  - BEAM – Earth Observation Toolbox and Development Platform
  - NEST – Nest ESA SAR Toolbox

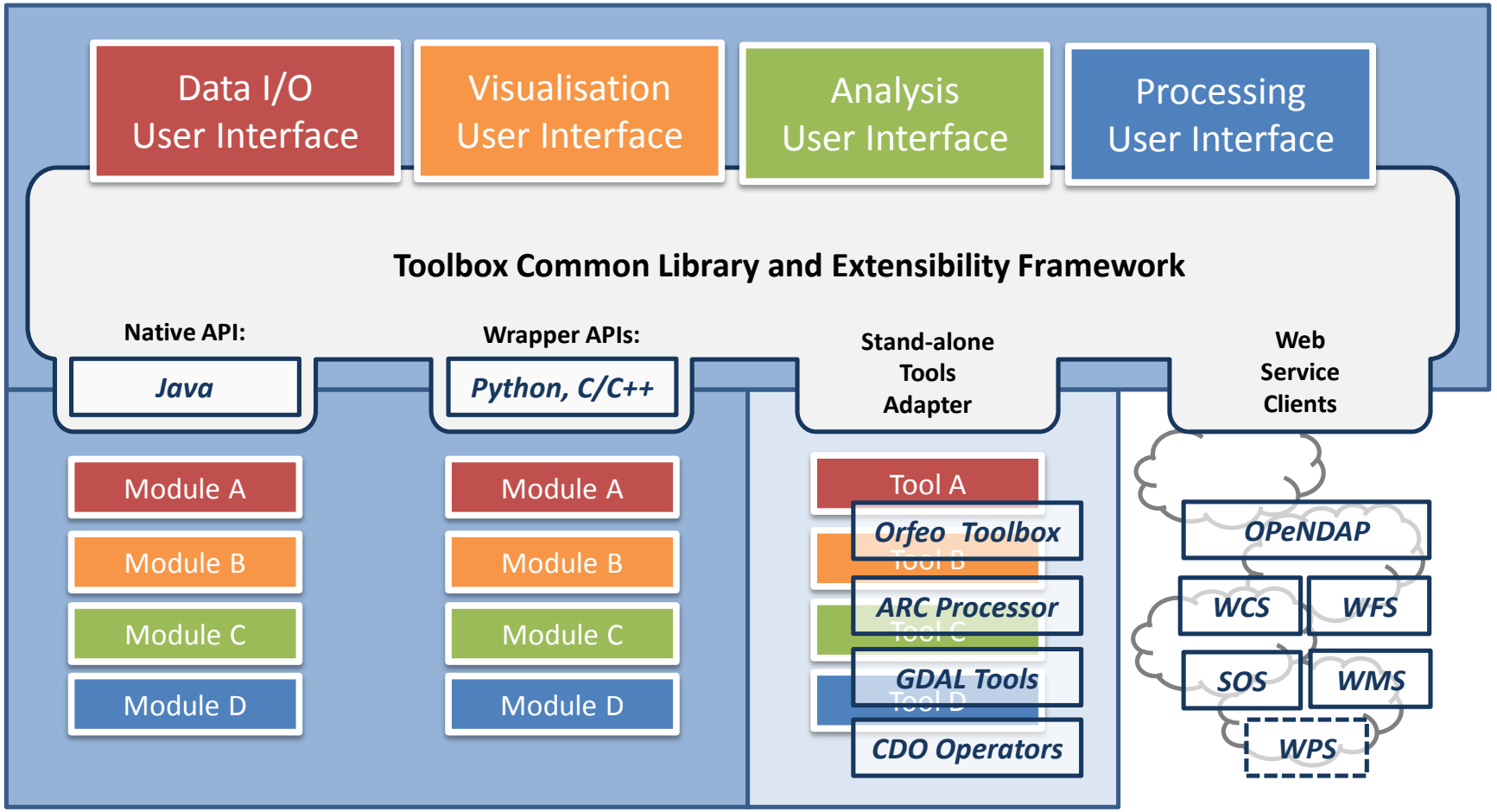
Sentinel-3 Toolbox – Features

- Visualisation
  - Fast image display
  - Multi-layer
  - Tiled image pyramids
  - Advanced colouring
  - No-data, masks, uncertainty
- Analysis
  - Pixel-level analysis
  - Spectrum view
  - Histogram plots
  - Profile plots
  - Correlative plots
  - Scatter & density plots
  - Pins & GCPs
- Processing
  - Clustering
  - Spectral Unmixing
  - Reprojection
  - Binning
  - Mosaicking
  - Many sensor-specific processors & plug-ins
  - Graph processing
- Data I/O
  - Subsets of data
  - ESRI shape files
  - Many sensor-specific formats
  - NetCDF, GeoTIFF

Sentinel-3 Toolbox – Features

- GUI Enhancements
  - Undo / Redo
  - Scripting and Macro Recording
- Analysis
  - Access to Remote In-Situ Databases
  - Image Segmentation Tools
  - Generic Classification Tools
  - Pixel Extraction Tool
  - Pixel Uncertainty Propagation
- Cloud Exploitation Platform
- Processing
  - Digital Elevation Models
  - Image Filters in graphs
  - Orthorectification
  - OLCI/SLSTR Collocation
  - OLCI Tools
    - L2 FAPAR
    - L2 SDR/BBDR
    - L2 Water IOP (from OC-CCI)
    - …
  - SLSTR Tools
    - L1B Regridding
    - L2 LST
    - L2 SST (ARC from SST-CCI)
    - …

Sentinel-3 Toolbox - Snap



Sentinel-3 Toolbox

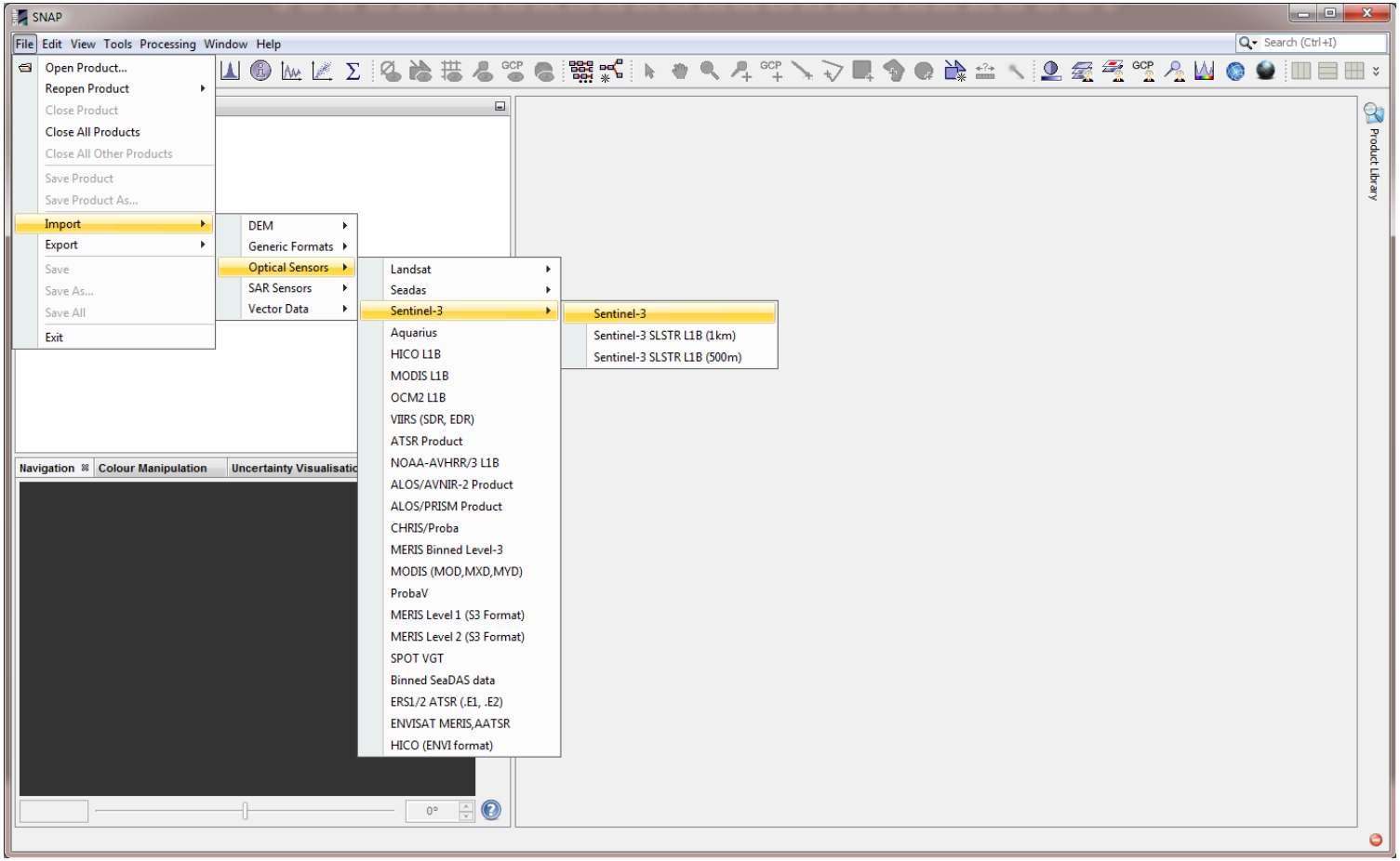
Sentinel-3 products are provided not as single files but as a collection of files contained within a folder. The folder name is the actual product name, ending on **.SEN3**. Each folder contains a metadata file named **xfdumanifest.xml** and at least one netcdf-file. Each netcdf-file contains a subset of a Sentinel-3 product's content.

To open a Sentinel-3 product you can

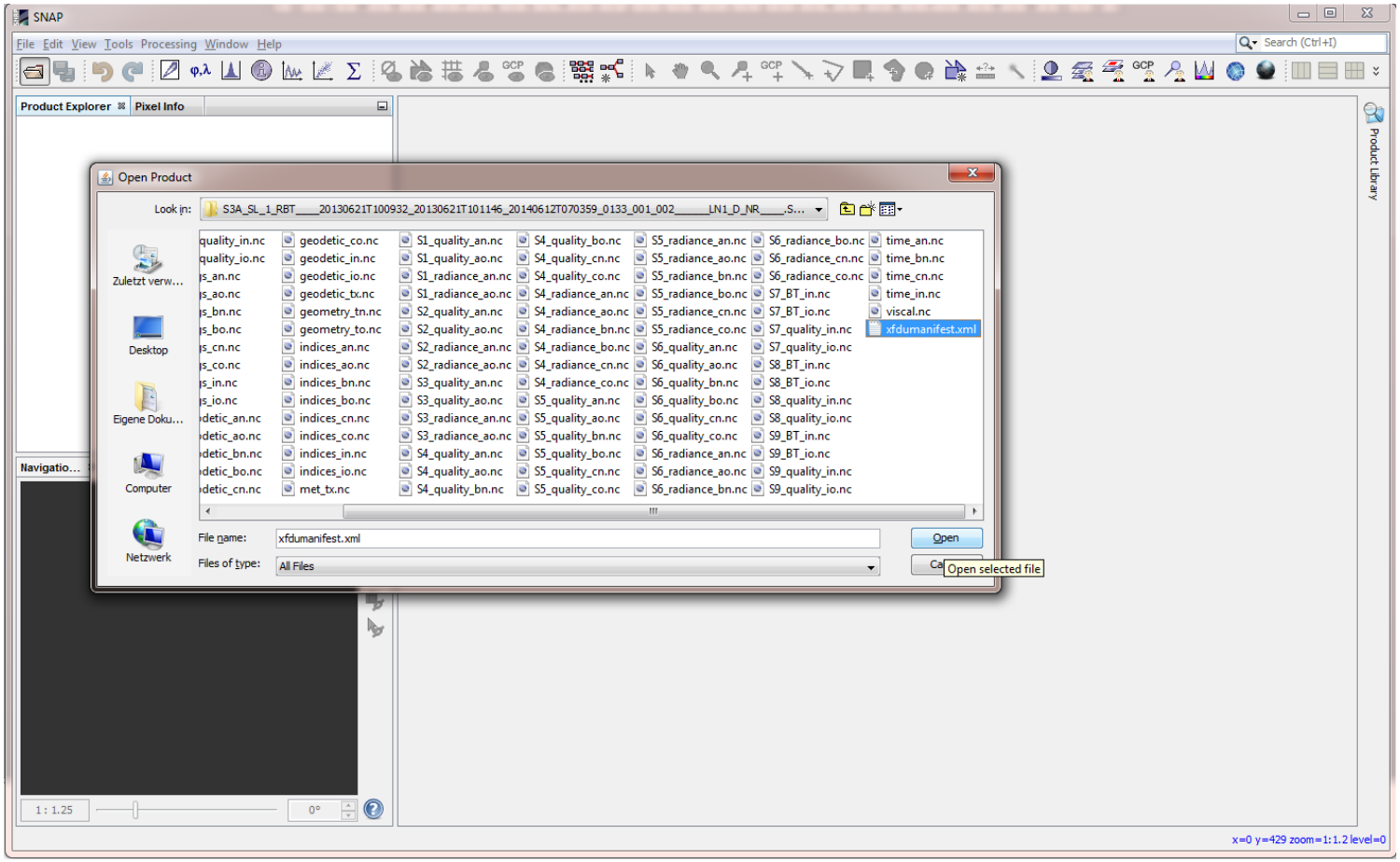
- Drag and drop the whole folder into the "Products View"
- Drag and drop the **xfdumanifest.xml**-file into the "Products View"
- Choose "File->Open Product", navigate to the **xfdumanifest.xml** file and click "Open Product"
- Choose "File->Import->Optical Sensors ->SENTINEL-3", navigate to the **xfdumanifest.xml** file and click "Open Product"

You can also open single netcdf-files. Just keep in mind that these will only show a part of the Sentinel-3 product and, in most cases, lack a geocoding.

OPEN A FILE


SNAP
File Edit View Tools Processing Window Help
Search (Ctrl+I)
Open Product...
Reopen Product
Close Product
Close All Products
Close All Other Products
Save Product
Save Product As...
Import
Export
Save
Save As...
Save All
Exit
DEM
Generic Formats
Optical Sensors
SAR Sensors
Vector Data
Landsat
Seadas
Sentinel-3
Aquarius
HICO L1B
MODIS L1B
OCM2 L1B
VIIRS (SDR, EDR)
ATSR Product
NOAA-AVHRR/3 L1B
ALOS/AVNIR-2 Product
ALOS/PRISM Product
CHRIS/Proba
MERIS Binned Level-3
MODIS (MOD,MXD,MYD)
ProbaV
MERIS Level 1 (S3 Format)
MERIS Level 2 (S3 Format)
SPOT VGT
Binned SeaDAS data
ERS1/2 ATSR (.E1, .E2)
ENVISAT MERIS,AATSR
HICO (ENVI format)
Sentinel-3
Sentinel-3 SLSTR L1B (1km)
Sentinel-3 SLSTR L1B (500m)
Navigation
Colour Manipulation
Uncertainty Visualisatic
Product Library

OPEN A FILE


SNAP
File Edit View Tools Processing Window Help
Search (Ctrl+I)
Product Explorer
Pixel Info
Product Library
Open Product
Look in:
S3A_SL_1_RBT____20130621T100932_20130621T101146_20140612T070359_0133_001_002_____LN1_D_NR____.S...
Zuletzt verw...
Desktop
Eigene Doku...
Computer
Netzwerk
quality_in.nc
quality_io.nc
s_an.nc
s_ao.nc
s_bn.nc
s_bo.nc
s_cn.nc
s_co.nc
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detic_bo.nc
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geodetic_in.nc
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geodetic_tx.nc
geometry_tn.nc
geometry_to.nc
indices_an.nc
indices_ao.nc
indices_bn.nc
indices_bo.nc
indices_cn.nc
indices_co.nc
indices_in.nc
indices_io.nc
met_tx.nc
S1_quality_an.nc
S1_quality_ao.nc
S1_radiance_an.nc
S1_radiance_ao.nc
S2_quality_an.nc
S2_quality_ao.nc
S2_radiance_an.nc
S2_radiance_ao.nc
S3_quality_an.nc
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S3_radiance_an.nc
S3_radiance_ao.nc
S4_quality_an.nc
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S4_radiance_an.nc
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S4_radiance_cn.nc
S4_radiance_co.nc
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S5_quality_bn.nc
S5_quality_bo.nc
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S5_radiance_an.nc
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S5_radiance_cn.nc
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S6_radiance_co.nc
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S7_quality_in.nc
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S9_quality_in.nc
S9_quality_io.nc
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time_bn.nc
time_cn.nc
time_in.nc
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xfdumanifest.xml
File name:
xfdumanifest.xml
Files of type:
All Files
Open
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Navigatio...
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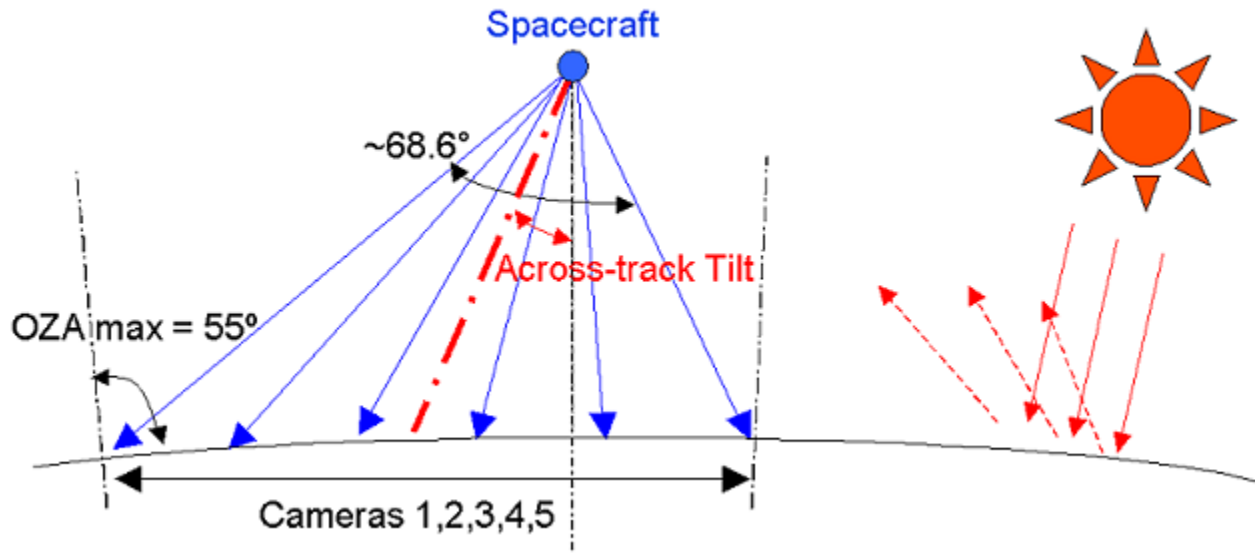
0°
x=0 y=429 zoom=1:1.2 level=0

OLCI OVERVIEW

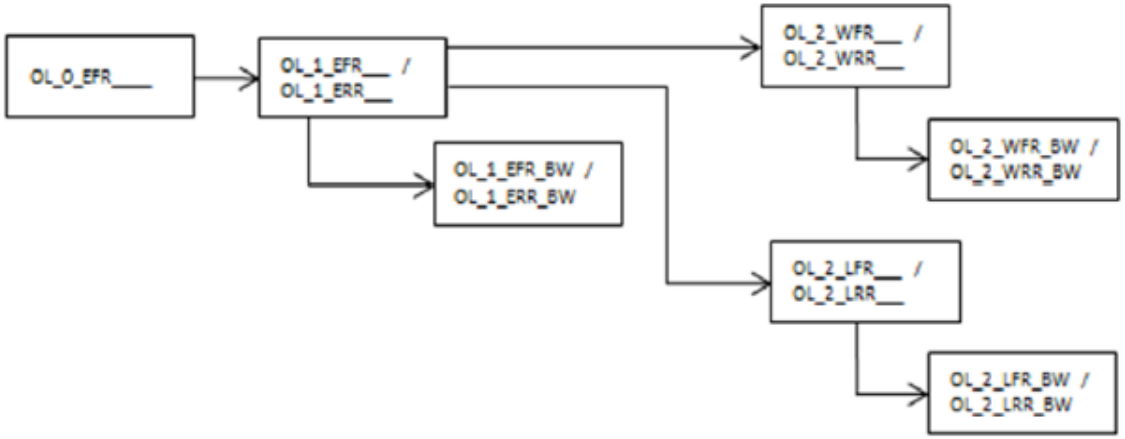


- The OLCI instrument baseline is the successor to ENVISAT MERIS.
- The OLCI is a push-broom instrument with five camera modules sharing the field of view.
- Each camera has an individual field of view of 14.2° and a 0.6° overlap with its neighbours.
- The whole field of view is shifted across track by 12.6° away from the sun to minimise the impact of sun glint.

OLCI SPECIFICATIONS

Swath	1 440 km
SSI at SSP (km)	300 m
Calibration	MERIS type calibration arrangement with spectral calibration using a doped Erbium diffuser plate, PTFE diffuser plate and dark current plate viewed approximately every 2 weeks at the South Pole ecliptic. Spare diffuser plate viewed periodically for calibration degradation monitoring
Detectors	ENVISAT MERIS heritage back-illuminated CCD55-20 frame-transfer imaging device (780 columns by 576 row array of 22.5 µm square active elements).
Optical scanning design	Push-broom sensor. Five cameras recurrent from MERIS dedicated Scrambling Window Assembly (SWA) supporting five Video Acquisition Modules (VAM) for analogue to digital conversion
Spectral resolution	1.25 nm (MERIS heritage), 21 bands.
Radiometric accuracy	< 2% with reference to the sun for the 400-900 nm waveband and < 5% with reference to the sun for wavebands > 900 nm. 0.1% stability for radiometric accuracy over each orbit and 0.5% relative accuracy for the calibration diffuser BRDF.
Radiometric resolution	< 0.03 W m^{-2} sr^{-1} mm^{-1} (MERIS baseline)
Mass	150 kg
Size	1.3 m^3
Design lifetime	7.5 years

OLCI PRODUCTS OVERVIEW

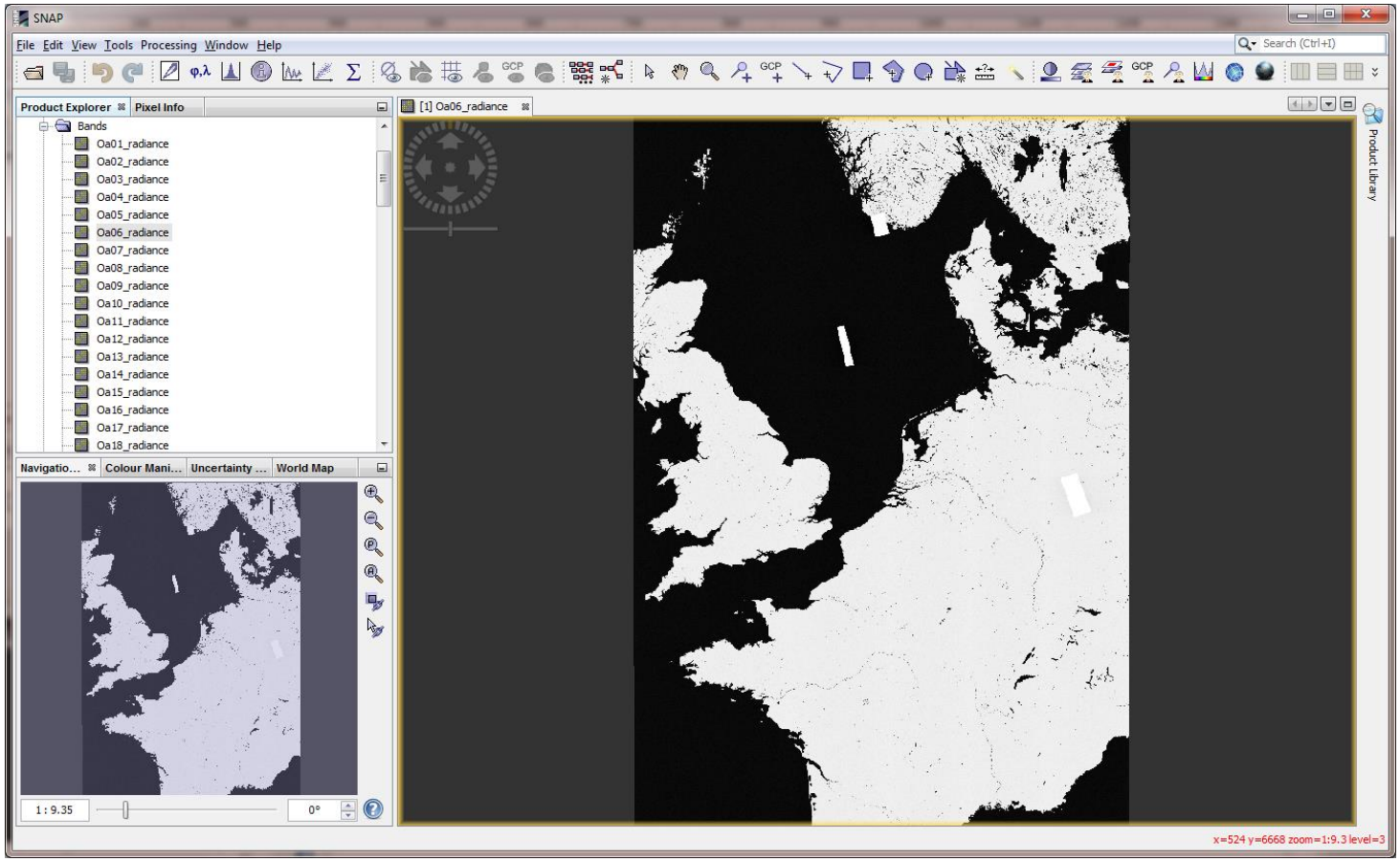


Product type	Description	Level
OL_1_EFR___	Full Resolution top of atmosphere radiance	Level 1
OL_1_ERR___	Reduced Resolution top of atmosphere radiance	Level 1
OL_1_RAC___	Dark offset and gain coefficients from radiometric calibration	Level 1
OL_1_SPC___	Wavelength characterization from spectral calibration	Level 1
OL_2_WFR___	Full Resolution Water & Atmosphere geophysical products	Level 2
OL_2_LFR	Full Resolution Land & Atmosphere geophysical products	Level 2
OL_2_WRR___	Reduced Resolution Water & Atmosphere geophysical products	Level 2
OL_2_LRR___	Reduced Resolution Land & Atmosphere geophysical products	Level 2

Main Product	Subsampled Parameters
OL_1_EFR___	FR radiances
OL_1_ERR___	RR radiances
OL_2_WFR___	• Total Backscattering coefficient • Total Absorption coefficient • Phytoplankton absorption coefficient • Algal Pigment Concentration • Total Suspended Matter Concentration
OL_2_WRR___	• Total Backscattering coefficient • Total Absorption coefficient • Phytoplankton absorption coefficient • Algal Pigment Concentration • Total Suspended Matter Concentration
OL_2_LFR___	• Global Vegetation Index • Terrestrial Chlorophyll Index
OL_2_LRR___	• Global Vegetation Index • Terrestrial Chlorophyll Index

OPEN OLCI PRODUCTS IN THE TOOL

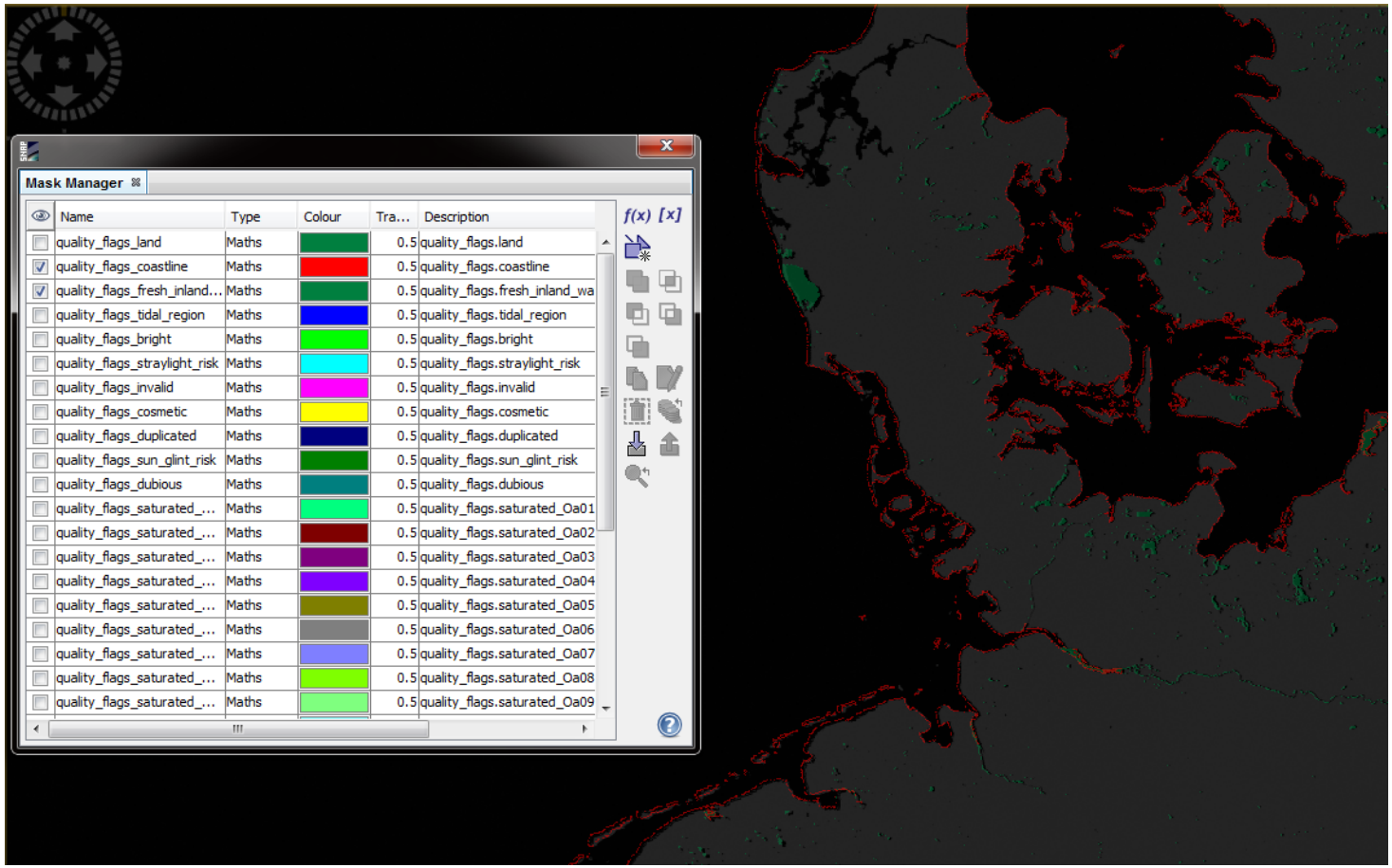
- L1 Full resolution top of atmosphere reflectance



File/Open Product/xfdumanifest.xml

OPEN OLCI PRODUCTS IN THE TOOL

- L1 Full resolution top of atmosphere reflectance



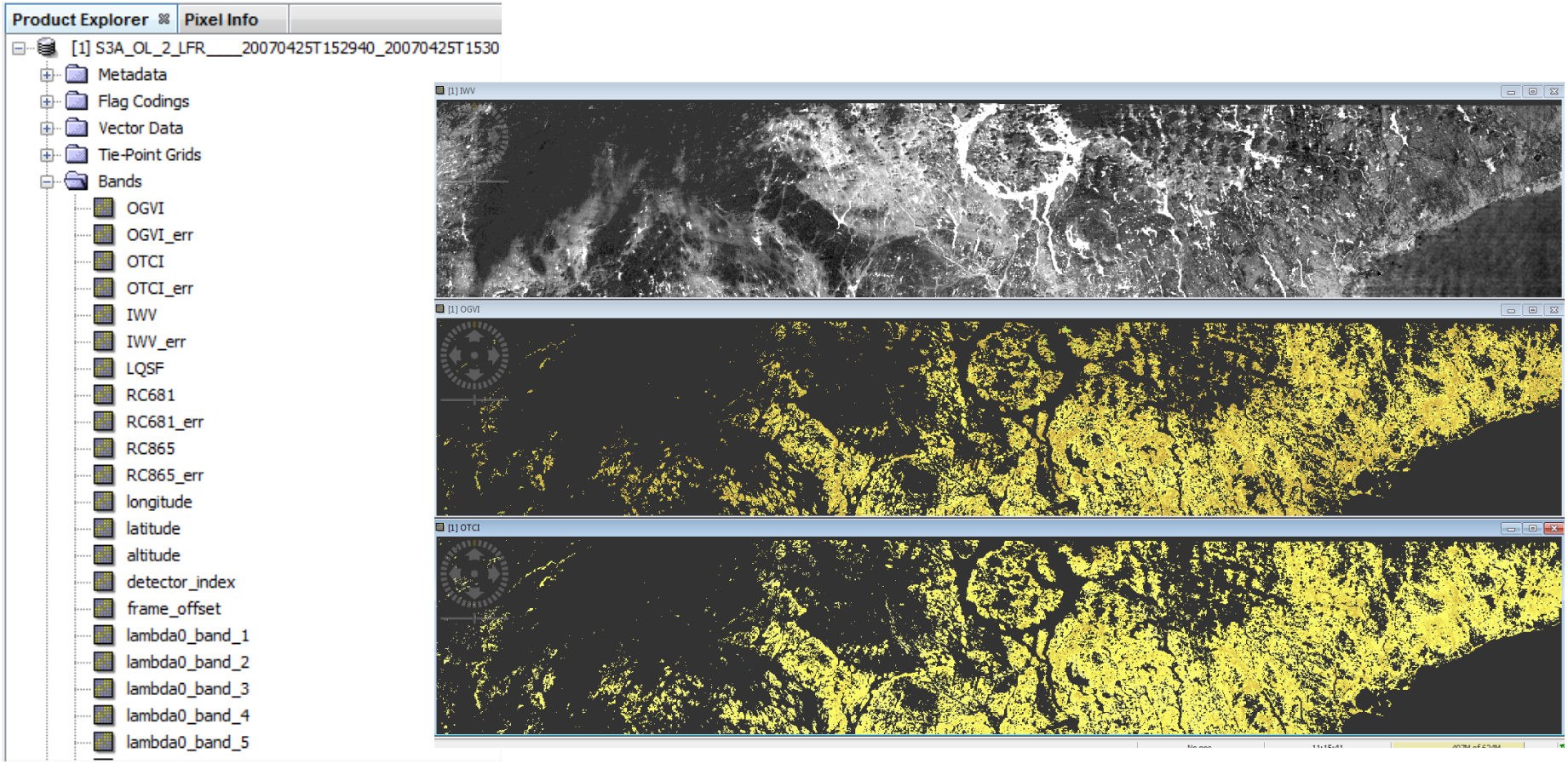
File/Open Product/xfdumanifest.xml

Quality flag details

Bit	Flag Name	Flag Description	Applicability
		Classification and Quality Flags	
00	INVALID	Invalid flag: instrument data missing or invalid	All
01	WATER	Clear sky water	All
02	LAND	Clear sky land	All
03	CLOUD	Cloudy pixel.	All
04	SNOW_ICE	Possible sea ice or snow contamination	All
05	INLAND_WATER	Fresh inland waters flag: based on Level 1 land_water flag.	All
06	TIDAL	Pixel is in shallow water; based on Level 1 land_water flag.	All
07	COSMETIC	Cosmetic flag (from level-1b): Missing data filled in by interpolation.	All
08	SUSPECT	Suspect flag (from level-1b): Transmission errors means measurements may be unreliable.	All
09	HISOLZEN	High solar zenith; θs > 70 degrees	All
10	SATURATED	Saturation flag; saturated within any band from 400 to 754 nm or in bands 779, 865, 885 and 1020 nm.	Band dependent
11	WV_FAIL	Suspect values derived for the Water Vapour over land; see ATBD SD-03-C02 for details. Set when the following internal flags are raised: ORINPWV_F or OROUTWV_F or L_WV_FAIL	IWV
12	OGVI_FAIL	Suspect values derived for the OGVI (FAPAR); see ATBD SD-03-C13 for details. Set when the following internal flags are raised: ORINP1_F or OROUT1_F	OGVI, RC681, RC865
13	OTCI_FAIL	Suspect values derived for the OTCI; see ATBD for SD-03-C14 details. Set when the following internal flags are raised: ORINP2_F (OTCI input out of range) or OROUT2_F (OTCI output out of range) or LRAYFAIL_F (problems deriving Rayleigh reflectance).	OTCI
		Science Flags	
14	LRAYFAIL	Problems deriving the Rayleigh reflectance over the land. See ATBD SD-03-C15 for details.	
15	OGVI_CLASS_BAD	Flag Bad data from OGVI spectral tests	
16	OGVI_CLASS_WS	Flag water or deep shadow from OGVI spectral tests	
17	OGVI_CLASS_CSI	Flag Cloud, snow or ice from OGVI spectral tests	
18	OGVI_CLASS_BRIGHT	Flag bright from OGVI spectral tests	
19	OGVI_CLASS_INVAL_REC	Flag invalid rectification	
20	OTCI_BAD_IN	Input data bad quality: (at least one of B12, B11, B10 is not Valid) or (B12-B11)<Threshold1 or (B11-B10)<Theshold2	
21	OTCI_CLASS_ANG	View angle flag: OTCI_CLASS_IN OK AND view angle> Threshold (TBD) AND Sun angle > Threshold (TBD)	
22	OTCI_CLASS_CLSN	Cloud and snow flag: Input data quality flag OK but Cloud shadow or partial snow detected	
23-31	SPARE	Reserved for future use	

OPEN OLCI PRODUCTS IN THE TOOL

- L2 Full resolution Land product



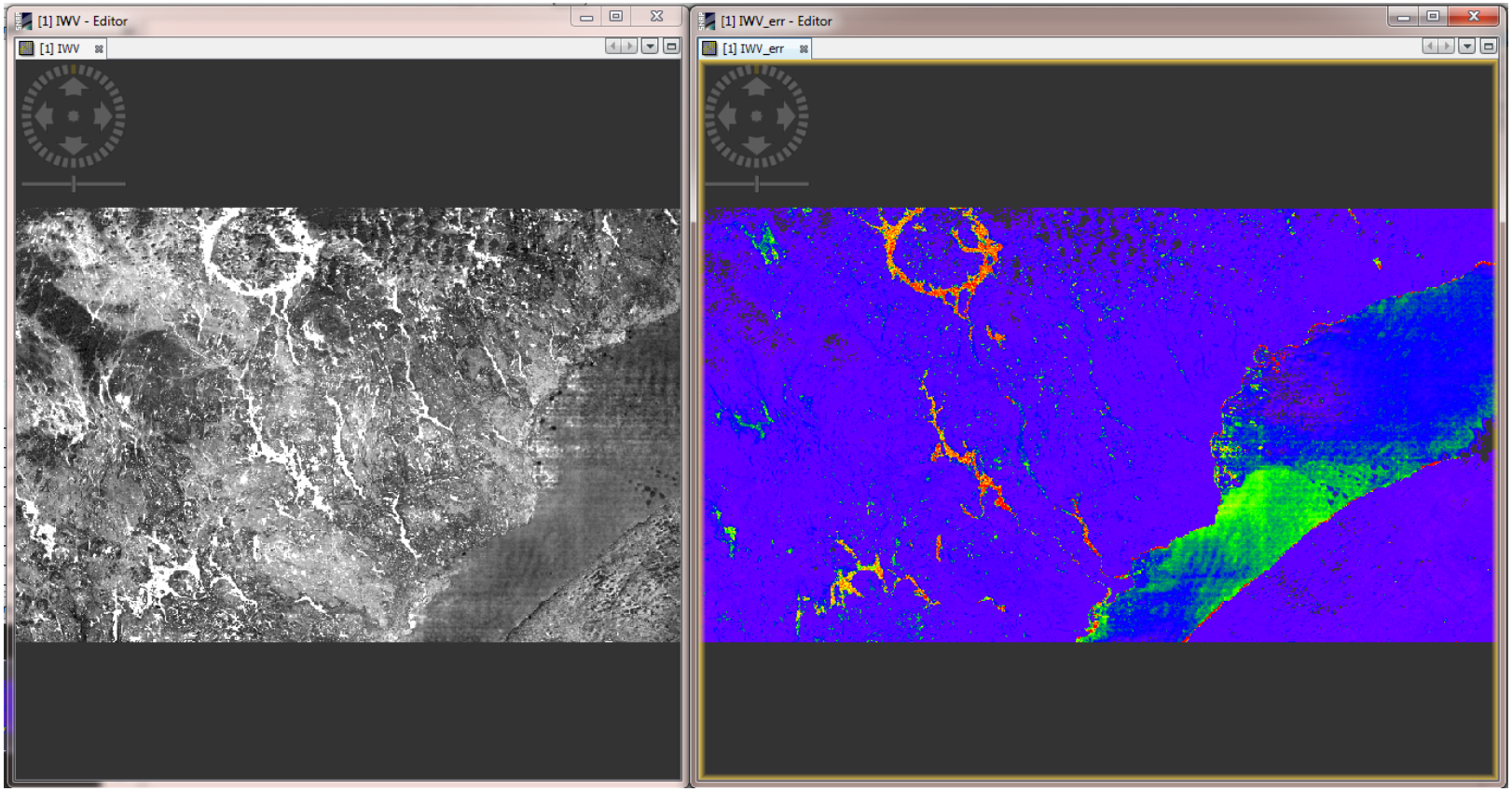
File/Open Product/xfdumanifest.xml

Uncertainty bands

- Several of the Sentinel-3 products contain bands with assigned error or uncertainty bands (OLCI L2 L, OLCI L2 W, SLSTR L2 WST). Each uncertainty band is assigned to one non-uncertainty band from the product.
- The Sentinel-3 Toolbox allows to simultaneously display image data along with its uncertainty through use of the "Uncertainty Visualisation" tool, which is by default located in the lower left panel.

OPEN OLCI PRODUCTS IN THE TOOL

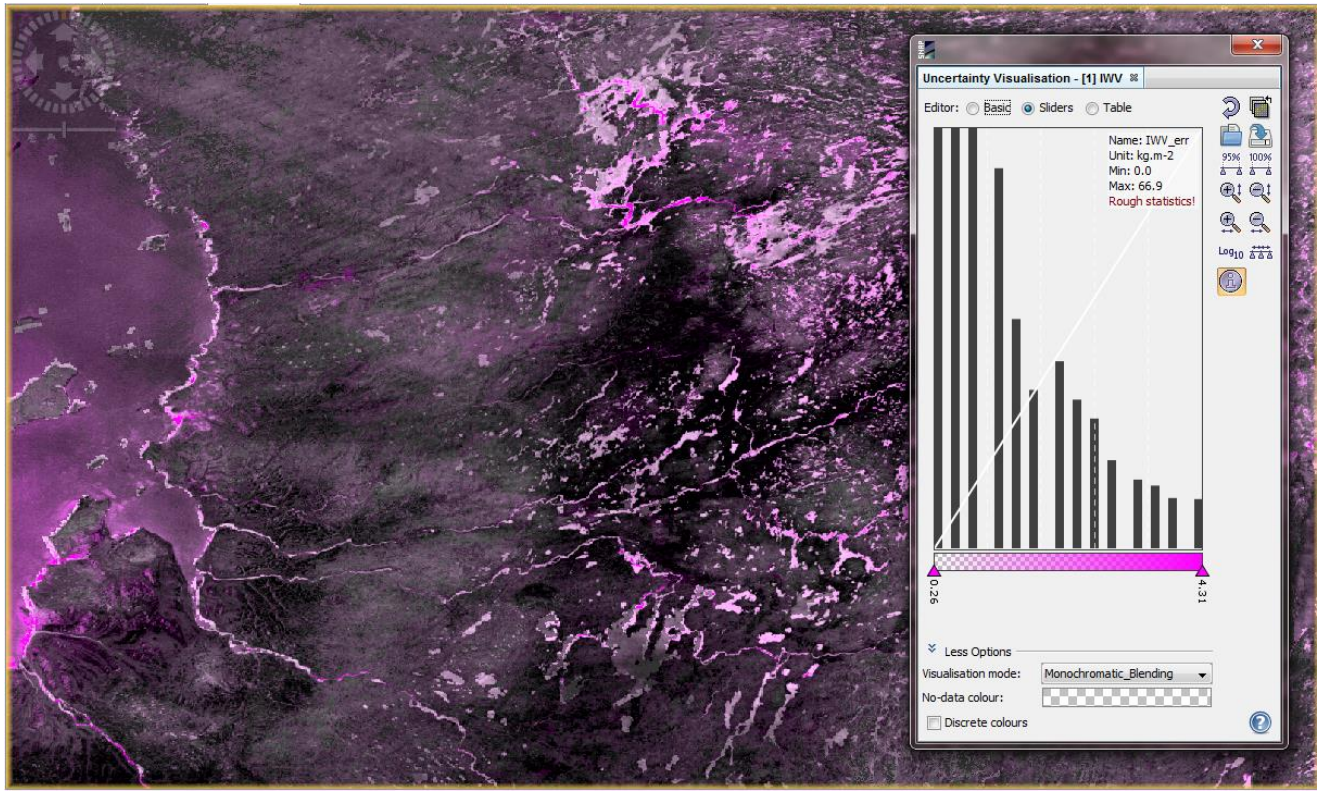
- L2 Full resolution Land product: uncertainties



Open in viewer: right IWV and IWV_error (the warmer the colour the higher the error)

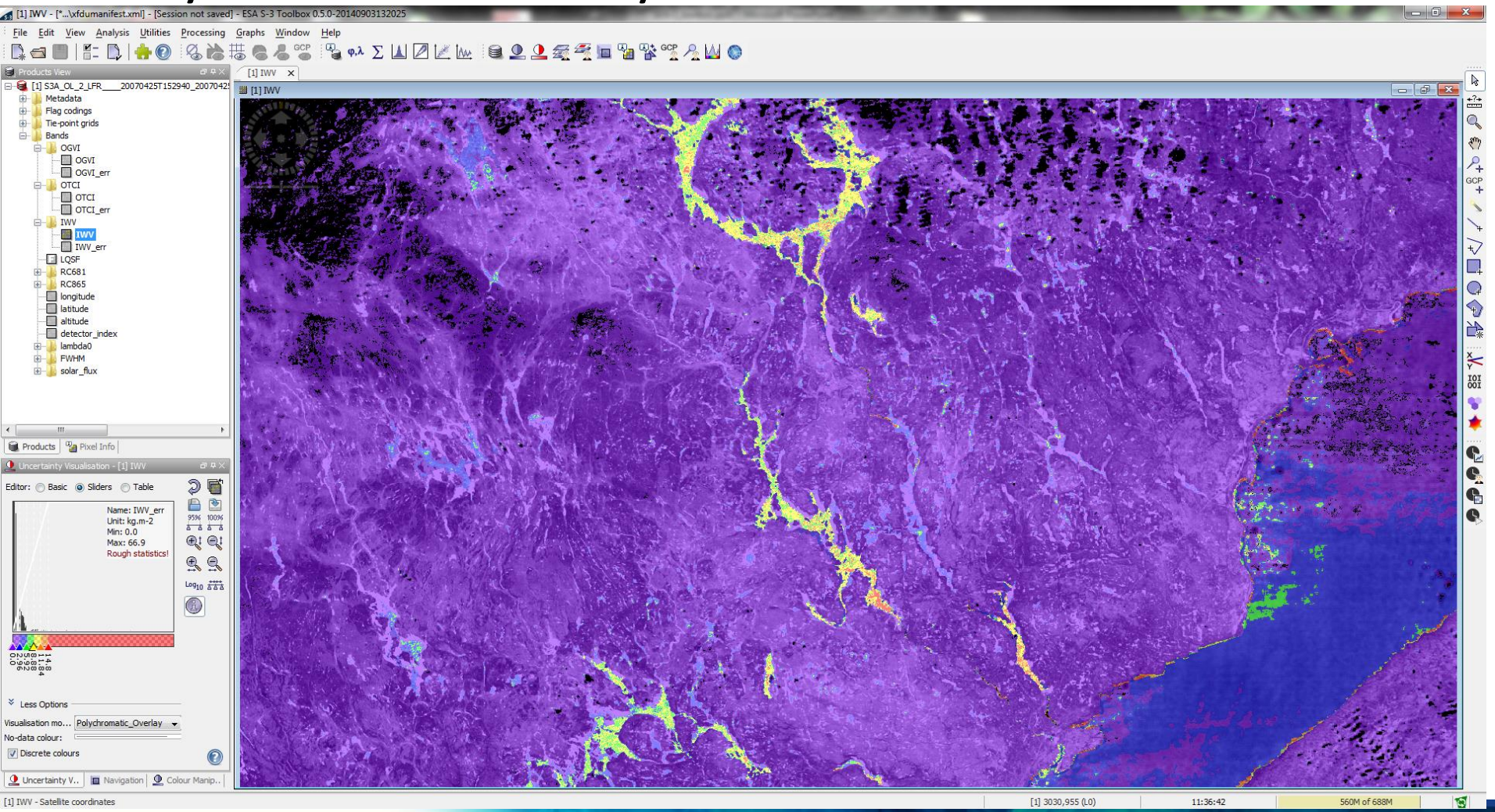
OPEN OLCI PRODUCTS IN THE TOOL

- Visualised uncertainties overlaid on product



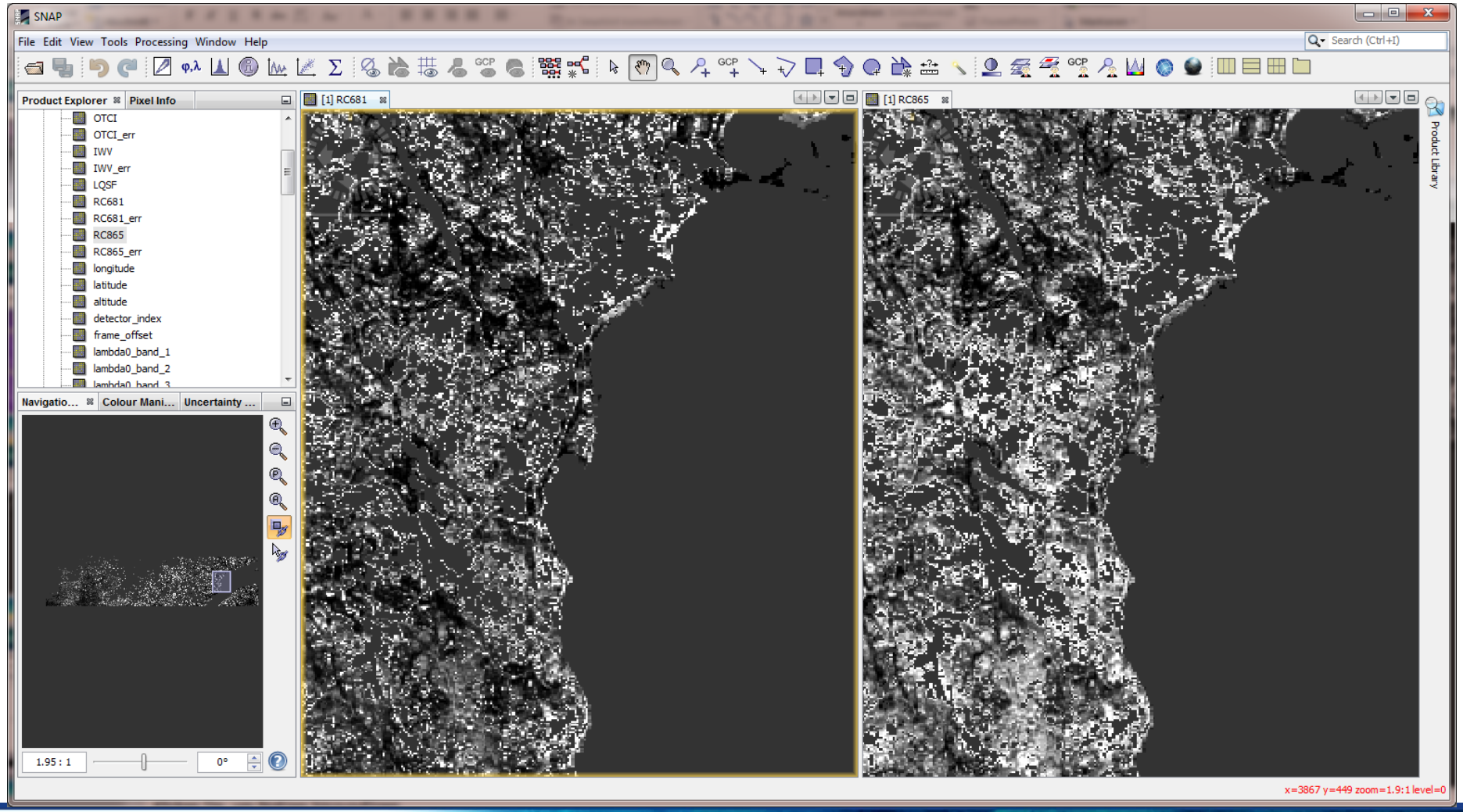
OPEN OLCI PRODUCTS IN THE TOOL

- Polychromatic overlay



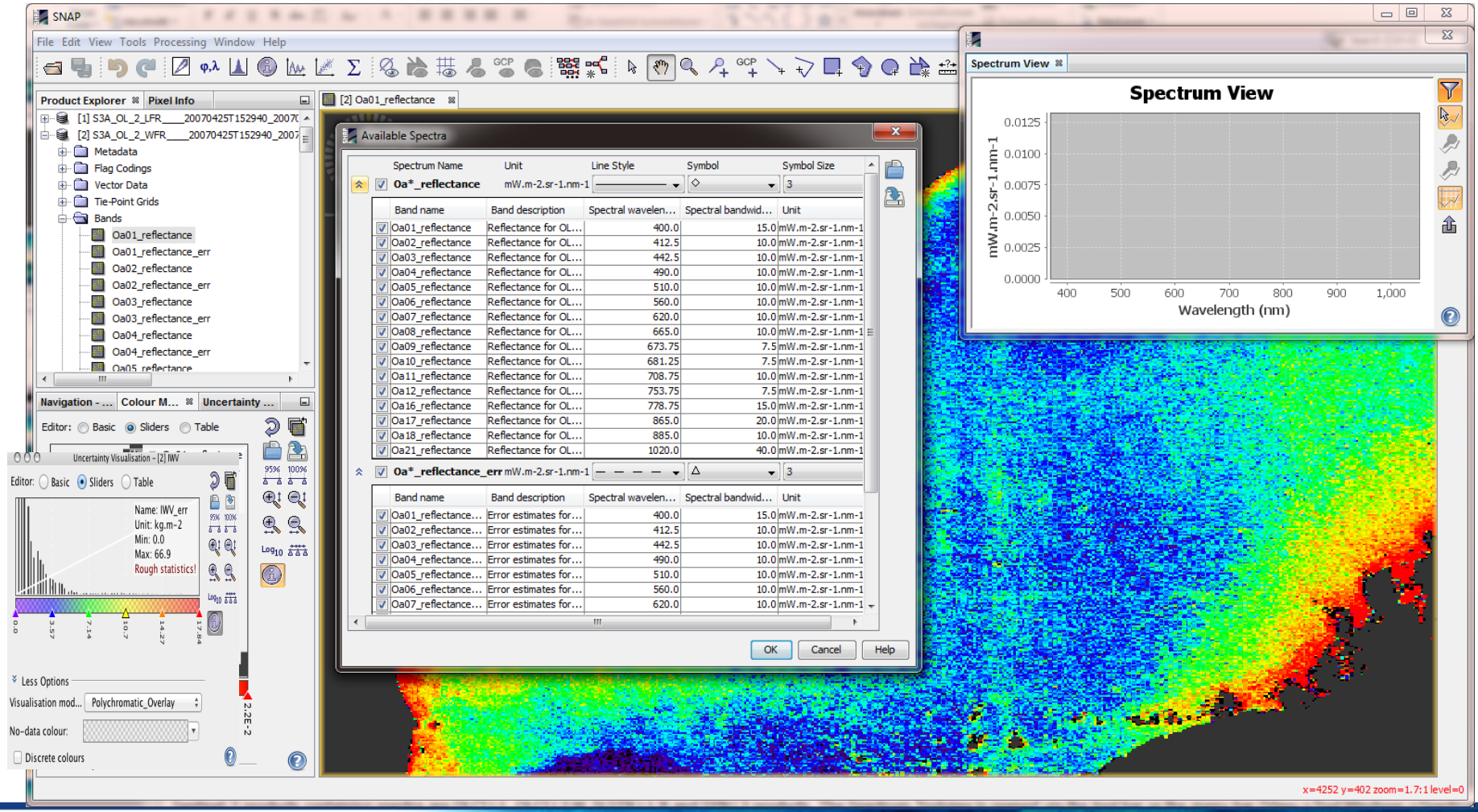
OPEN OLCI PRODUCTS IN THE TOOL

- Other bands: rectified reflectances in band 10 & 17 and associated error bands

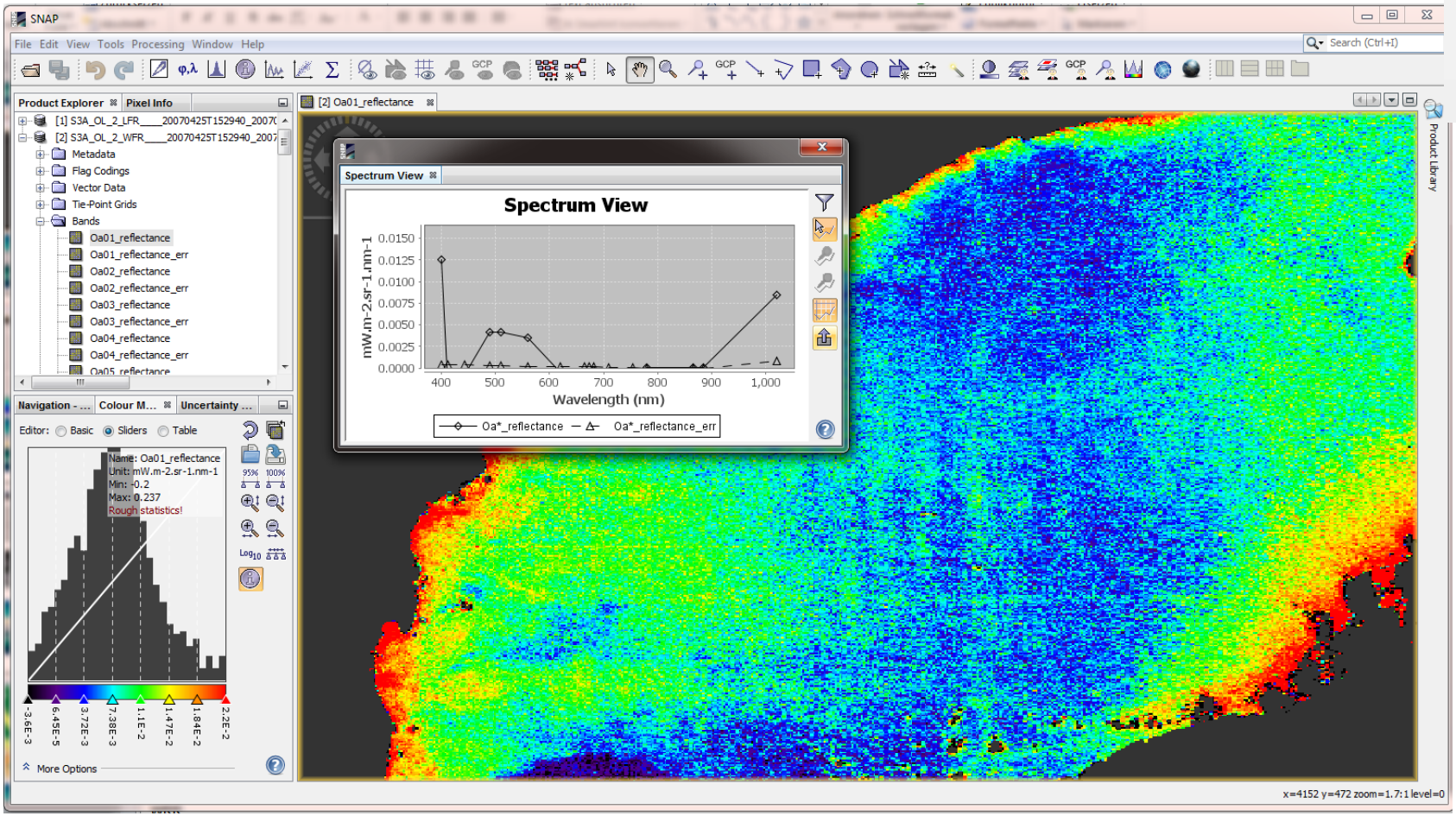


OPEN OLCI PRODUCTS IN THE TOOL

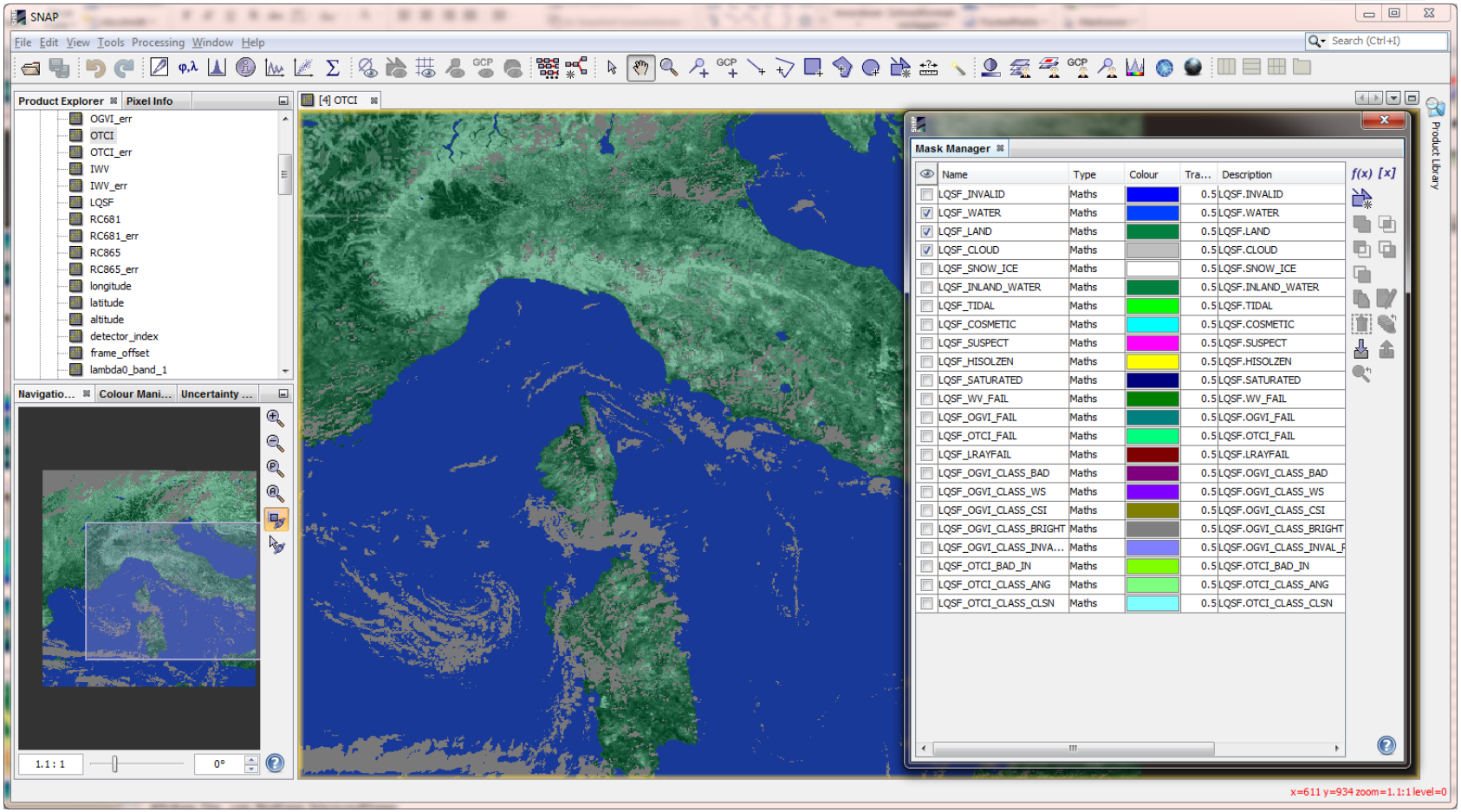
- L2 Full resolution Water product: reflectances and associated errors



Spectrum view



Flags: land and cloud masks

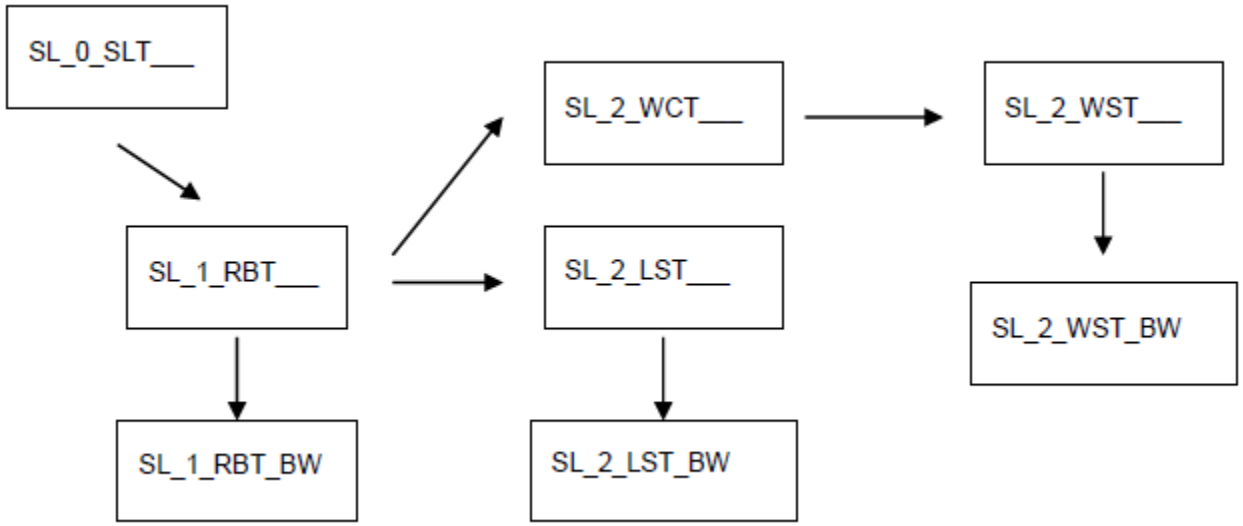


SLSTR OVERVIEW

- Sea and Land Surface Temperature Radiometer:

Performance	Parameters	SLSTR	AATSR & ATSR-1/2
Swaths	Nadir view	1 400 km	500 km
	Dual view	740 km	500 km
Global coverage revisit time	1 S/C (dual view)	1.9 days	7-14 days
		0.9 days	-
		1 day	7-14 days
		0.5 days	-
SSI at SSP (km)		0.5 km VIS-SWIR 1 km IR-fire	1 km
Spectral channels centre λ (µm)	VIS (not ATSR-1): SWIR: MWIR/TIR: Fire-1/2:	0.555; 0.659; 0.865; 1.375; 1.610; 2.25; 3.74; 10.85; 12; 3.74; 10.85	0.555; 0.659; 0.865; 1.610; 3.74; 10.85; 12; -
Radiometric resolution	VIS (a=0.5%): SWIR (a=0.5%):	SNR > 20 SNR > 20	SNR > 20 SNR > 20
	MWIR (T=270K): TIR (T=270K): Fire-1 (<500 K): Fire-2 (<400 K):	NeΔT < 80 mK NeΔT < 50 mK NeΔT < 1K NeΔT < 0.5 K	NeΔT < 80 mK NeΔT < 50 mK
Radiometric accuracy	VIS-SWIR: (a=2-100%)	< 2% (BOL) < 5% (EOL)	< 5%
	MWIR-TIR (265-310K): Fire (<500k):	< 0.1 k (goal) < 3 K	< 0.1 K
Life time (in orbit)		7.5 years	AATSR: 5 year design, operative since 2002; ATSR-2: 3 year design, operating from 1995 to 2008; ATSR-1: 3 year design, operating from 1991 to 2000

SLSTR MAIN PRODUCTS

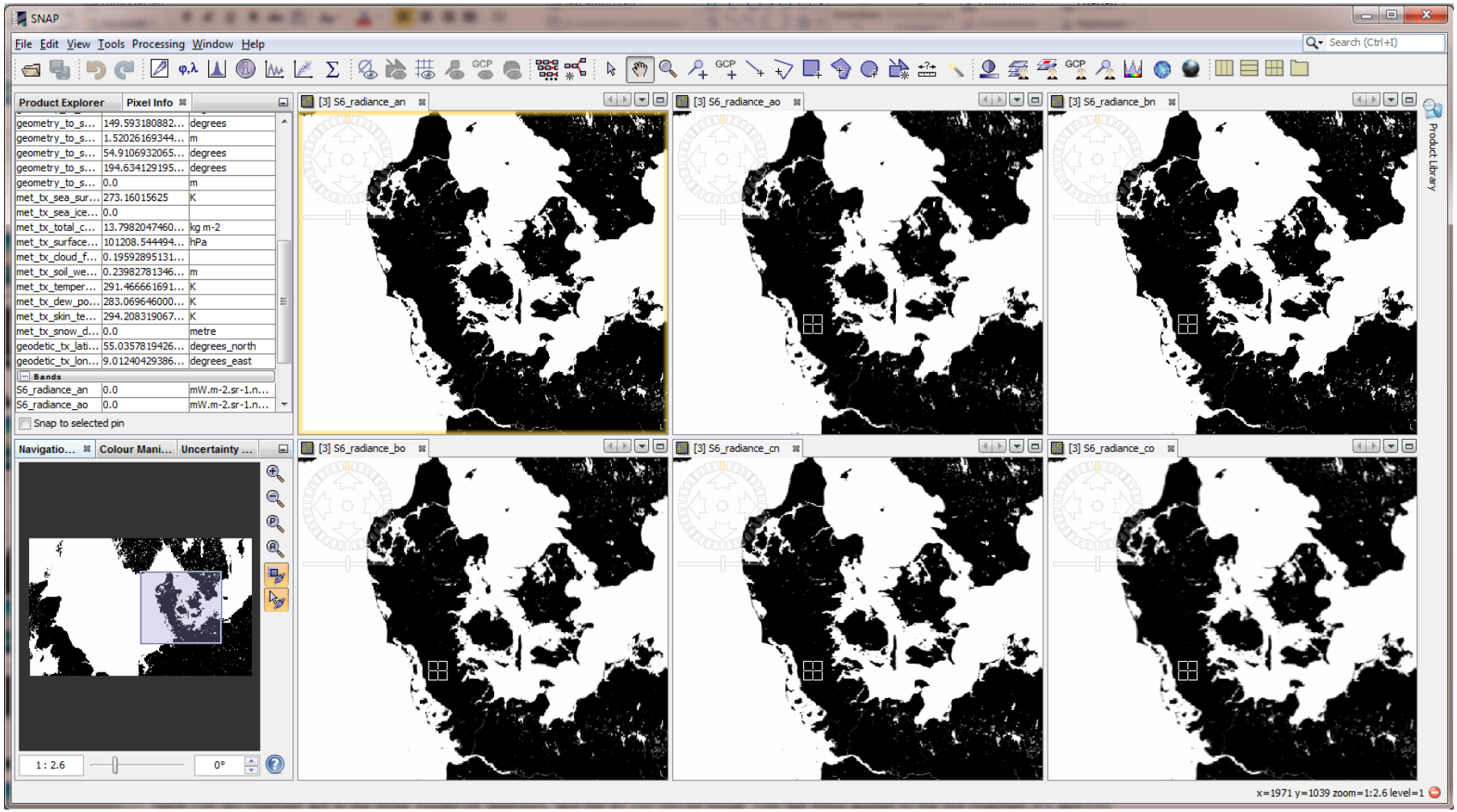


Product type	Description	Level	Subsampled Parameters
SL_1_RBT___	Brightness temperatures and radiances	Level 1	• Nadir View Brightness Temperature • Nadir View Radiance
SL_2_WCT___	Sea Surface Temperatures (single view/ channels 2 and 3; dual view/ channels 2 and 3; aerosol-robust/ channel 3)	Level 2	
SL_2_WST___	Level 2P Sea Surface Temperature (GHRSST like)	Level 2	• Sea Surface Temperature
SL_2_LST___	Land Surface Temperature geophysical parameters	Level 2	• Land Surface Temperature

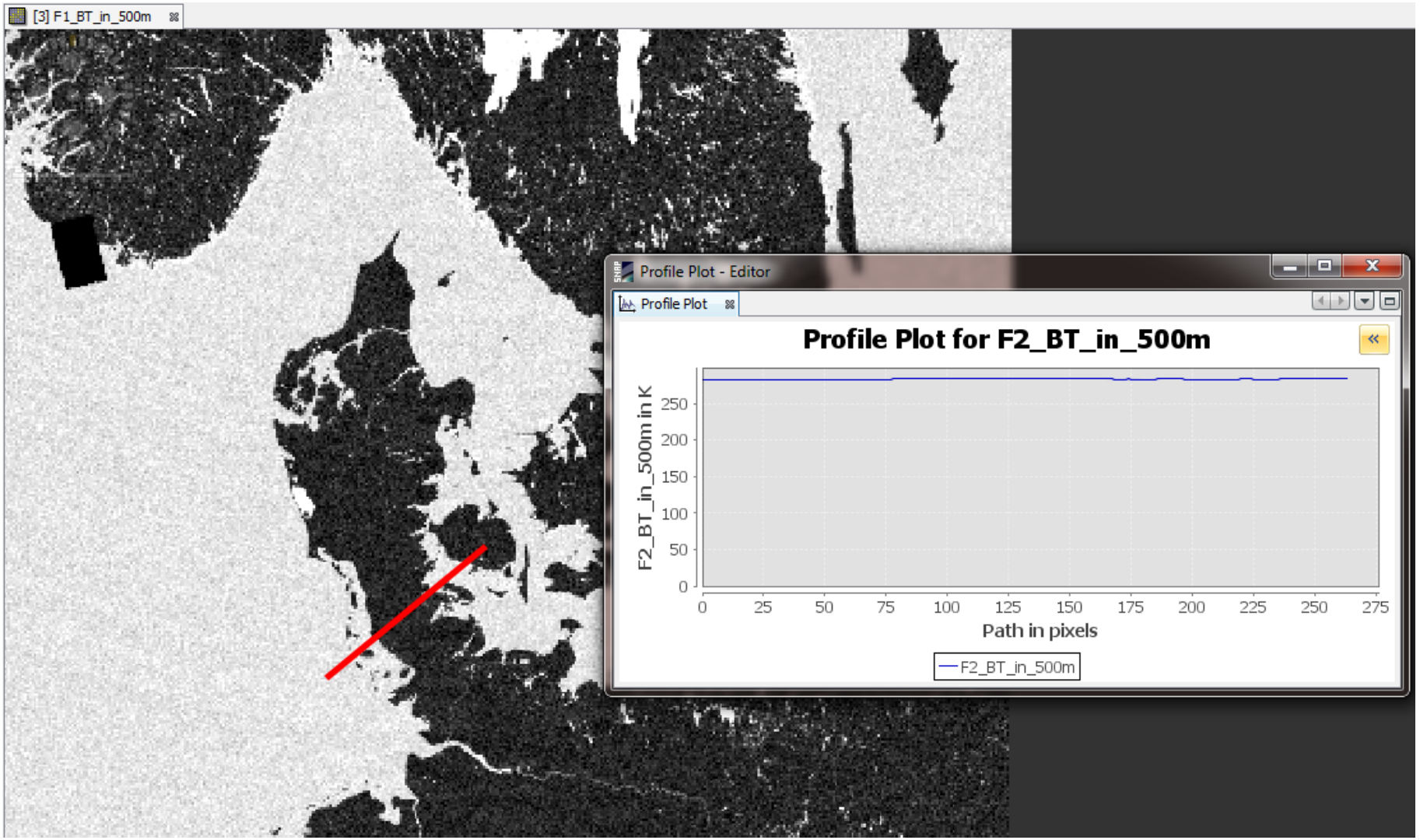
SLSTR L1 PRODUCTS

Variable	Placeholder	Possible Values
band	<b>	S1 – S9, F1, F2
grid	<g>	'i' – 1km Thermal Infra-Red grid 'a' – 500m visibile and SWIR "A stripe" grid 'b' – 500m visible and SWIR "B stripe" grid 'c' – 500m TDI grid 't' – Tie point grid
view	<v>	'n' – nadir view 'o' – oblique view 'x' – view agnostic

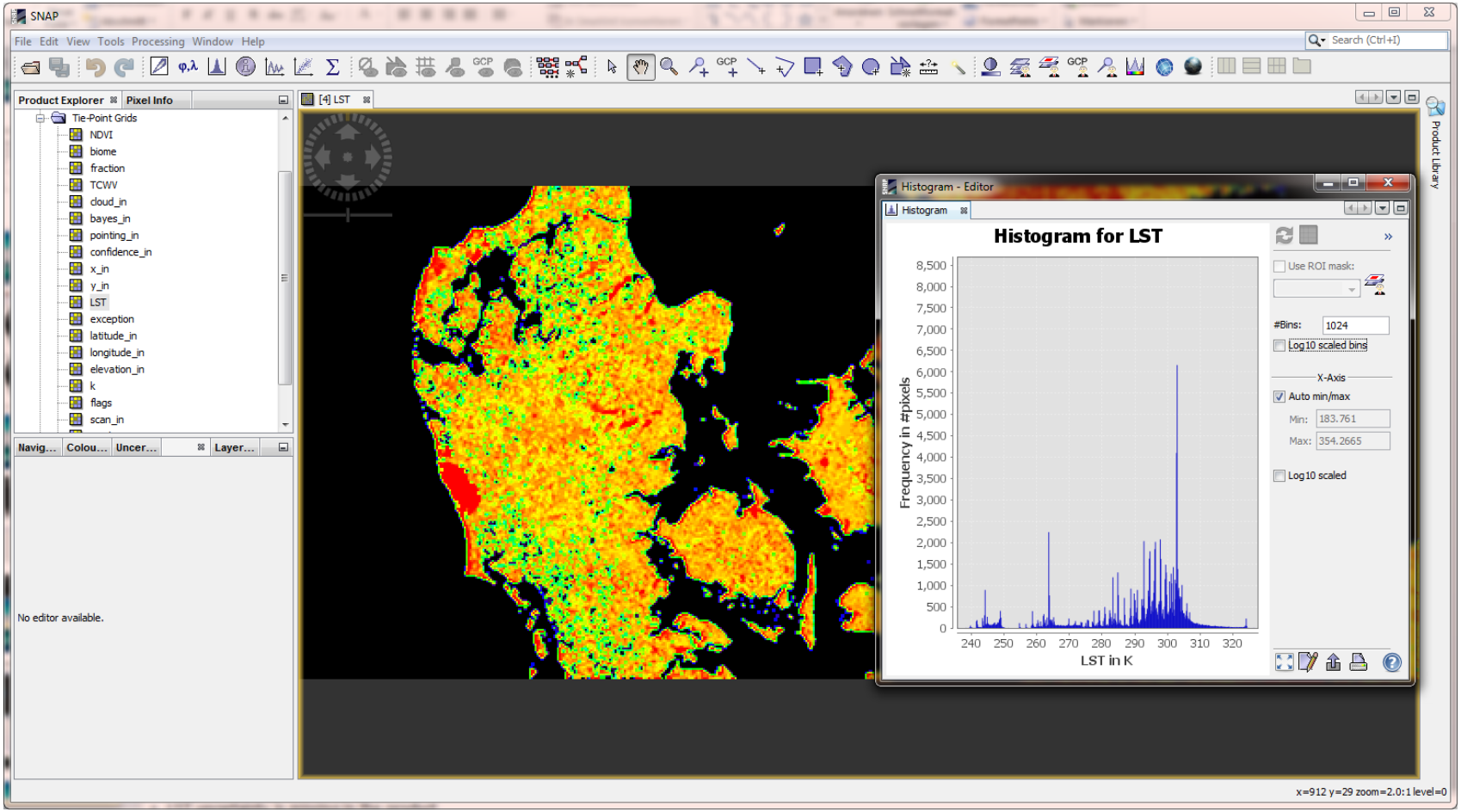
S6 Radiance in a, b stripes, c grid, nadir and oblique view (500 m)



Fire bands in nadir view

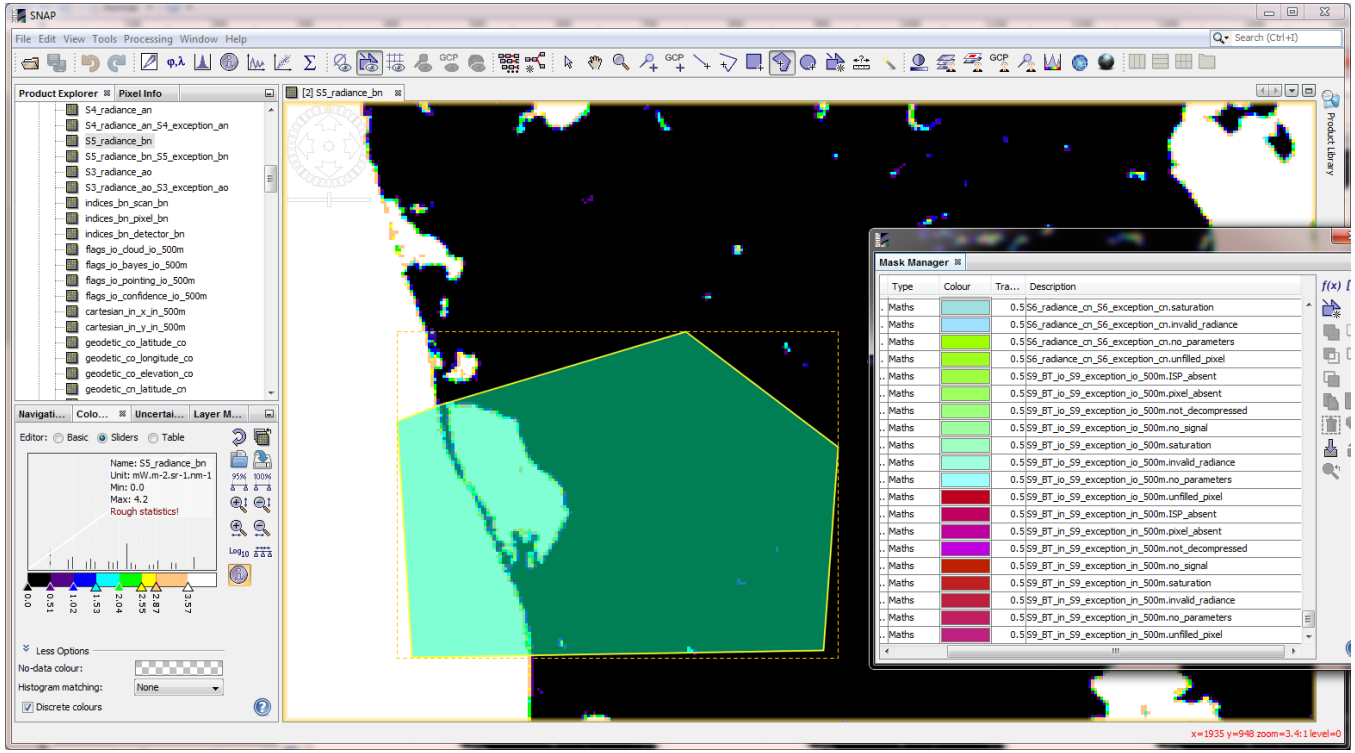


SLSTR_L2_LST


SNAP
File Edit View Tools Processing Window Help
Search (Ctrl+I)
Product Explorer
Pixel Info
Tie-Point Grids
NDVI
biome
fraction
TCWV
cloud_in
bayes_in
pointing_in
confidence_in
x_in
y_in
LST
exception
latitude_in
longitude_in
elevation_in
k
flags
scan_in
Navig...
Colou...
Uncer...
Layer...
No editor available.
[4] LST
Histogram - Editor
Histogram
Histogram for LST
Frequency in #pixels
LST in K
Use ROI mask:
#Bins:
1024
Log10 scaled bins
X-Axis
Auto min/max
Min:
183.761
Max:
354.2665
Log10 scaled
Product Library
x=912 y=29 zoom=2.0:1 level=0

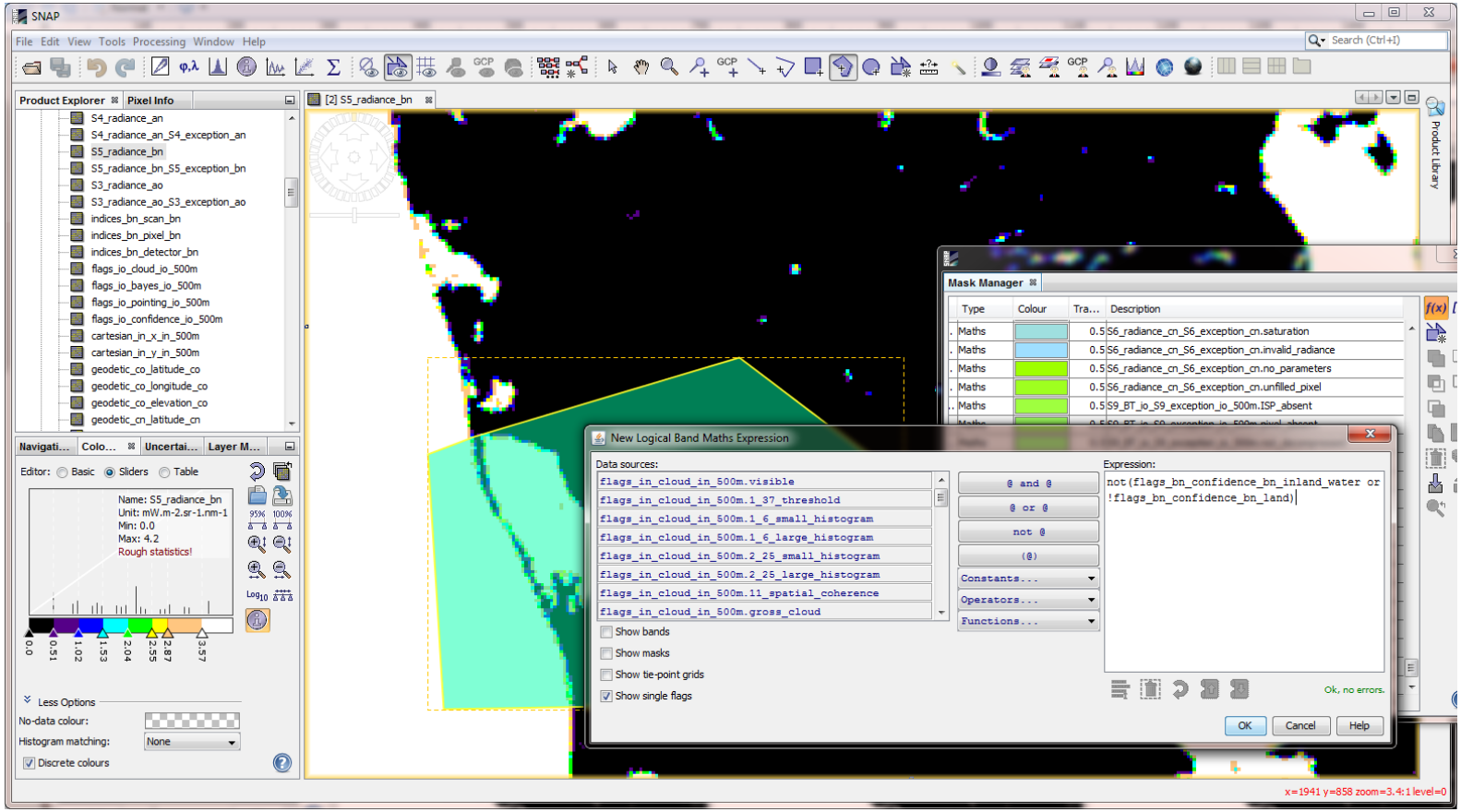
SLSTR

- Exercise: create an S5 radiance histogram and statistics without inland water

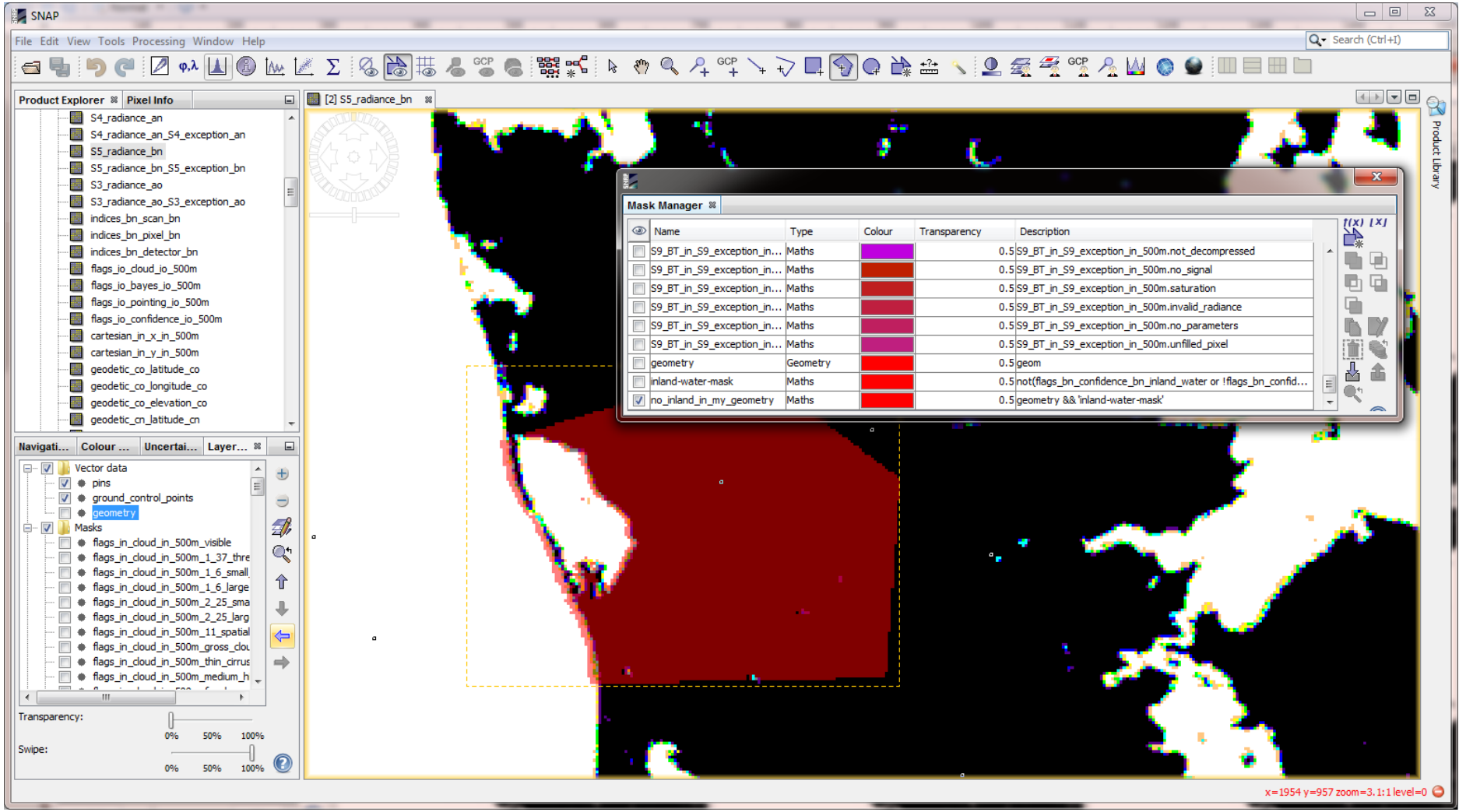


SLSTR

- Create new mask

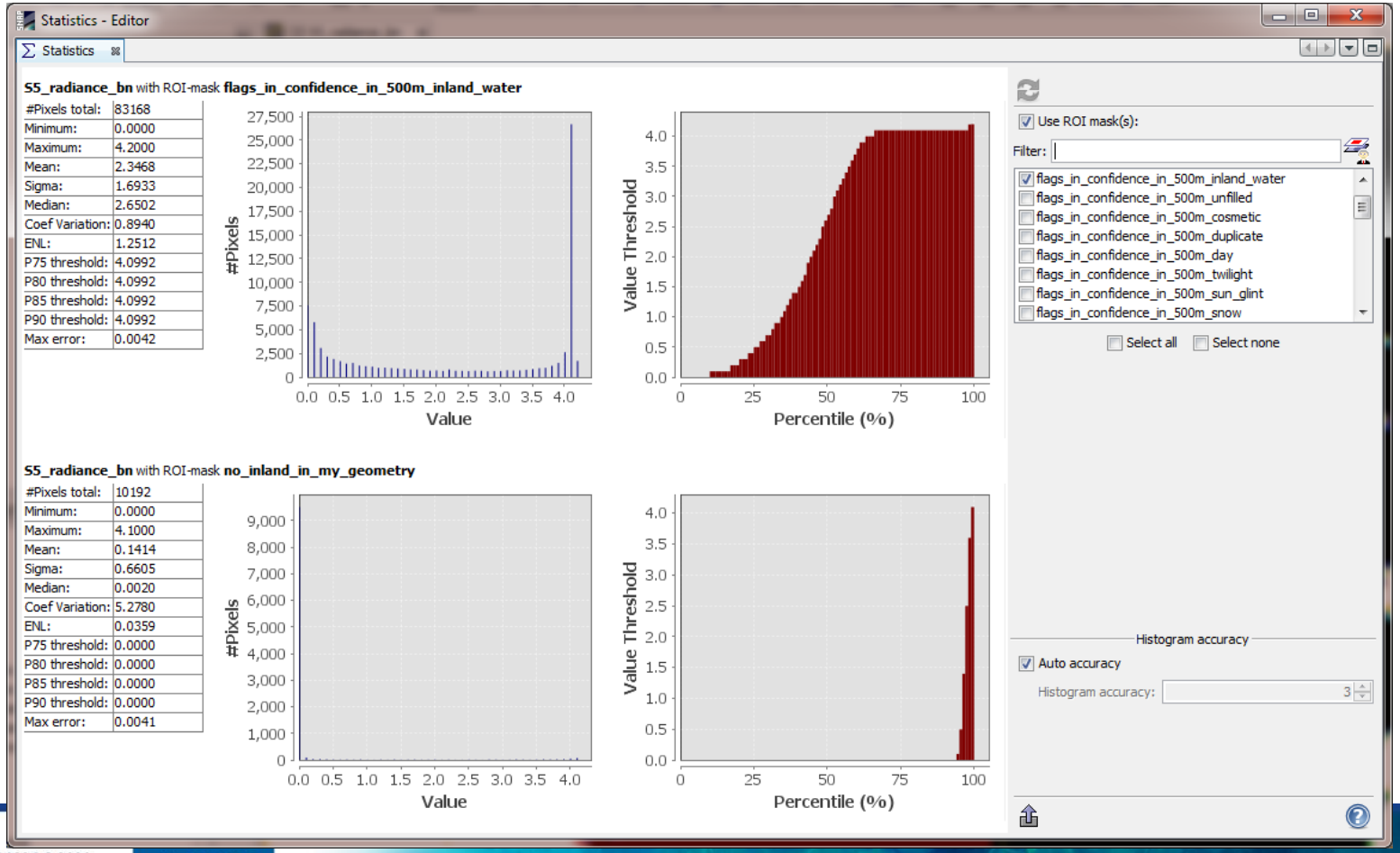


MASK in a ROI

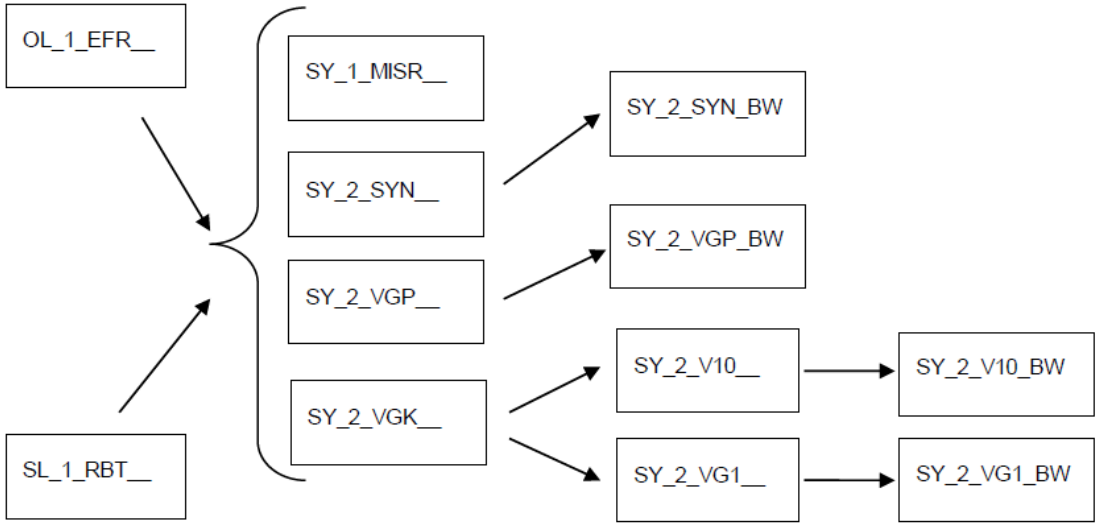

SNAP
File Edit View Tools Processing Window Help
Search (Ctrl+I)
Product Explorer
Pixel Info
[2] S5_radiance_bn
S4_radiance_an
S4_radiance_an_S4_exception_an
S5_radiance_bn
S5_radiance_bn_S5_exception_bn
S3_radiance_ao
S3_radiance_ao_S3_exception_ao
indices_bn_scan_bn
indices_bn_pixel_bn
indices_bn_detector_bn
flags_io_cloud_io_500m
flags_io_bayes_io_500m
flags_io_pointing_io_500m
flags_io_confidence_io_500m
cartesian_in_x_in_500m
cartesian_in_y_in_500m
geodetic_co_latitude_co
geodetic_co_longitude_co
geodetic_co_elevation_co
geodetic_cn_latitude_cn
Navigati...
Colour ...
Uncertai...
Layer...
Vector data
pins
ground_control_points
geometry
Masks
flags_in_cloud_in_500m_visible
Transparency:
Swipe:
0%
50%
100%
Mask Manager
Name
Type
Colour
Transparency
Description
S9_BT_in_S9_exception_in...
Maths
0.5
S9_BT_in_S9_exception_in_500m.not_decompressed
S9_BT_in_S9_exception_in_500m.no_signal
S9_BT_in_S9_exception_in_500m.saturation
S9_BT_in_S9_exception_in_500m.invalid_radiance
S9_BT_in_S9_exception_in_500m.no_parameters
S9_BT_in_S9_exception_in_500m.unfilled_pixel
geometry
Geometry
geom
inland-water-mask
not(flags_bn_confidence_bn_inland_water or !flags_bn_confid...
no_inland_in_my_geometry
geometry && 'inland-water-mask'
Product Library
x=1954 y=957 zoom=3.1:1 level=0

SLSTR

- S5 radiance histogram and statistics without inland water



SYNERGY PRODUCTS

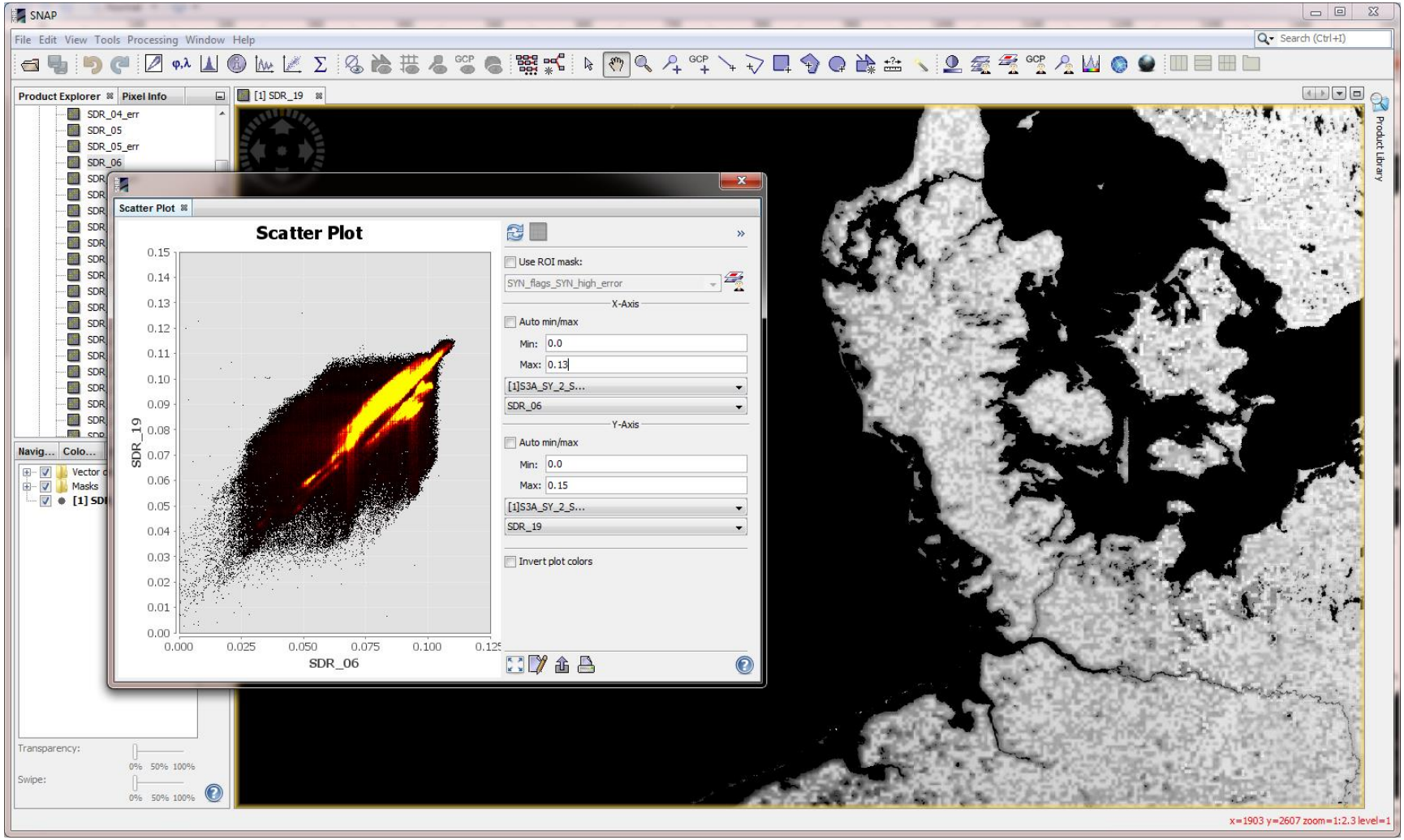


Main Product	Subsampled Parameters
SY_2_SYN___	• Aerosol optical depth or angstrom exponent • Combination of reflectances
SY_2_VGP___	Vegetation-like-P product
SY_2_VG1___	NDVI Vegetation-

SYNERGY PRODUCTS: SY_2_SYN

SYN Level 2 channel	Associated channel in OLCI/SLSTR L1b product	Central Wavelength (nm)	Bandwidth (nm)	SYN Level 2 channel	Associated channel in OLCI/SLSTR L1b product	Central Wavelength (nm)	Bandwidth (nm)
1	Oa1	400	15	16	Oa18	885	10
2	Oa2	412.5	10	17	Oa19	900	10
3	Oa3	442.5	10	18	Oa21	1020	40
4	Oa4	490	10	19	S1 for nadir view	555	20
5	Oa5	510	10	20	S2 for nadir view	659	20
6	Oa6	560	10	21	S3 for nadir view	865	20
7	Oa7	620	10	22	S4 for nadir view	1375	15
8	Oa8	665	10	23	S5 for nadir view	1610	60
9	Oa9	673.75	7.5	24	S6 for nadir view	2250	50
10	Oa10	681.25	7.5	25	S1 for oblique view	555	20
11	Oa11	708.75	10	26	S2 for oblique view	659	20
12	Oa12	753.75	7.5	27	S3 for oblique view	865	20
13	Oa13	761.25	2.5	28	S4 for oblique view	1375	15
14	Oa16	778.75	15	29	S5 for oblique view	1610	60
15	Oa17	865	20	30	S6 for oblique view	2250	50

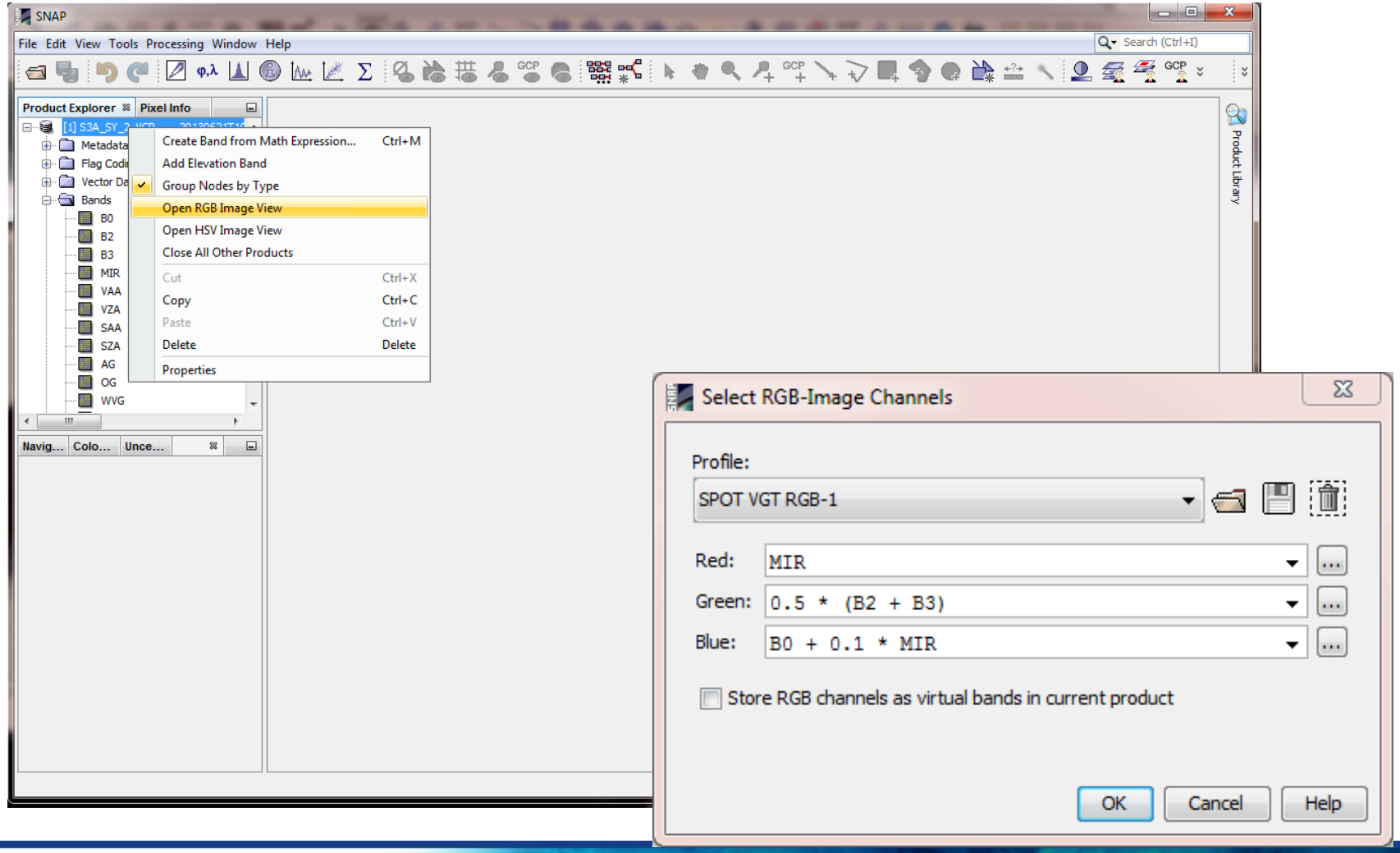
SYNERGY PRODUCTS: SY_2_SYN



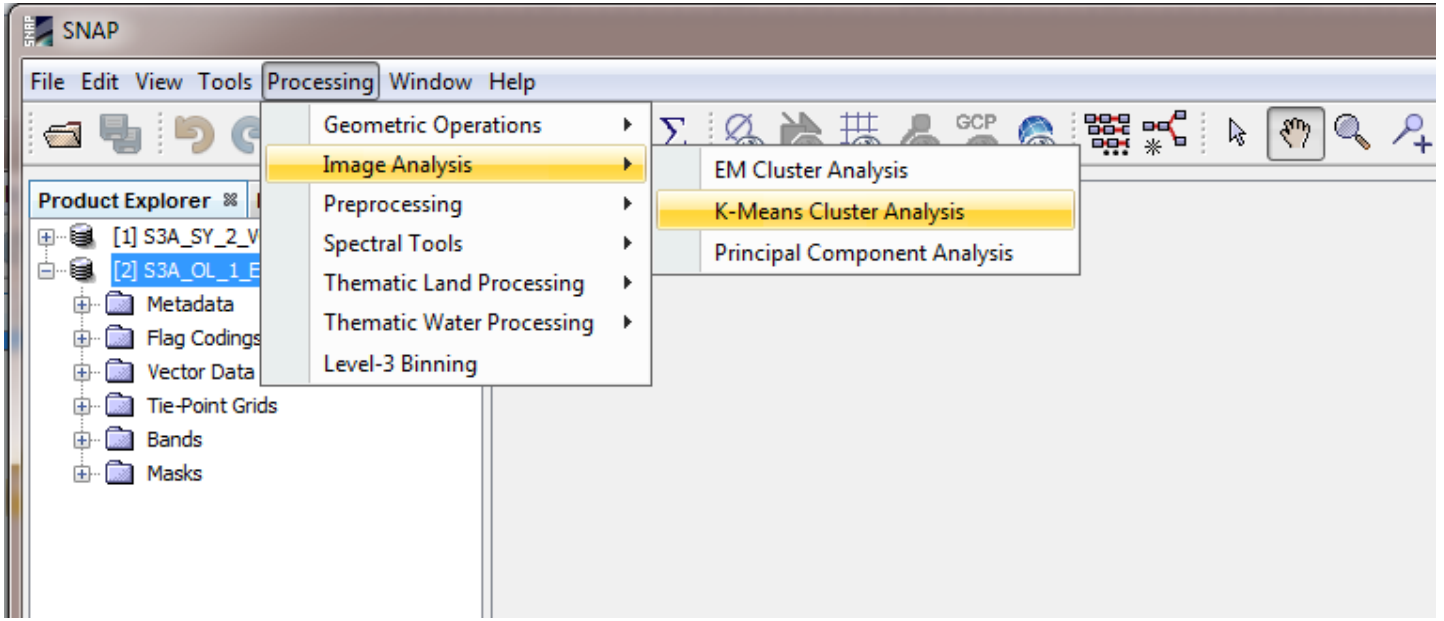
SYNERGY PRODUCTS: SY_2_VGP

VGT channel	Central Wavelength (nm)	Bandwidth (nm)	Conbined SYN Level 2 channels (see Table 12)
B0	450	20	SYN channel 2 and channel 3
B2	645	35	SYN channels 6 to 10
B3	835	55	SYN channels 14 to 18
MIR	1665	85	SYN channel 23 and channel 24

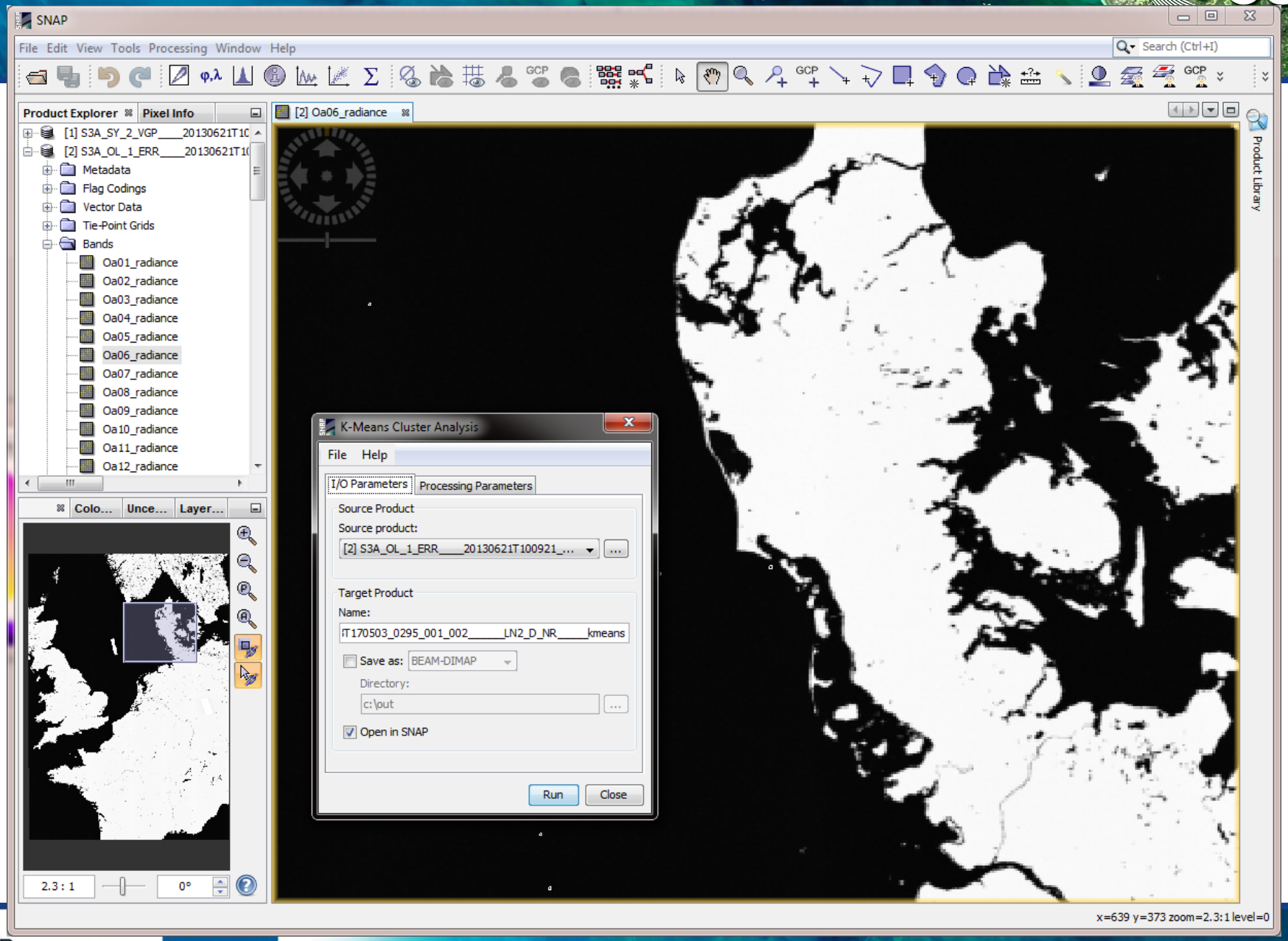
SYNERGY PRODUCTS: SY_2_VGP



Sentinel-3 Toolbox: unsupervised classification

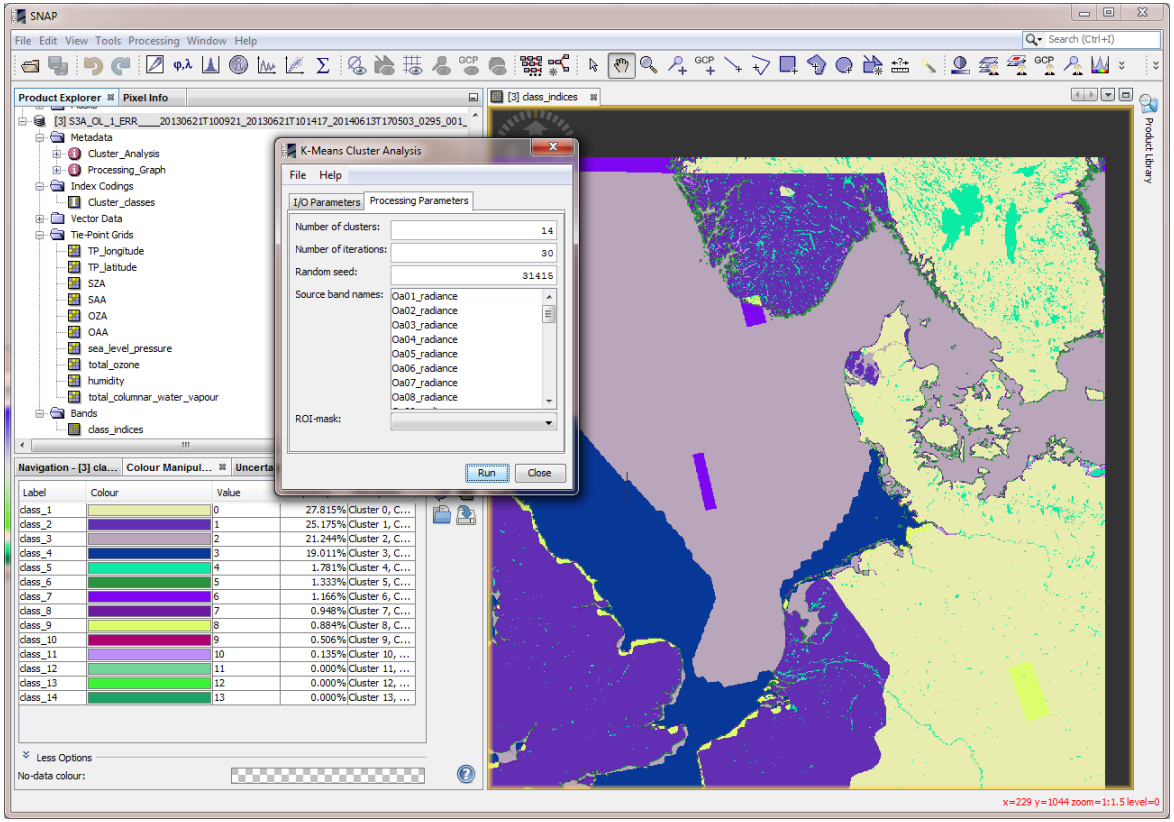


Sentinel-3 Toolbox: unsupervised

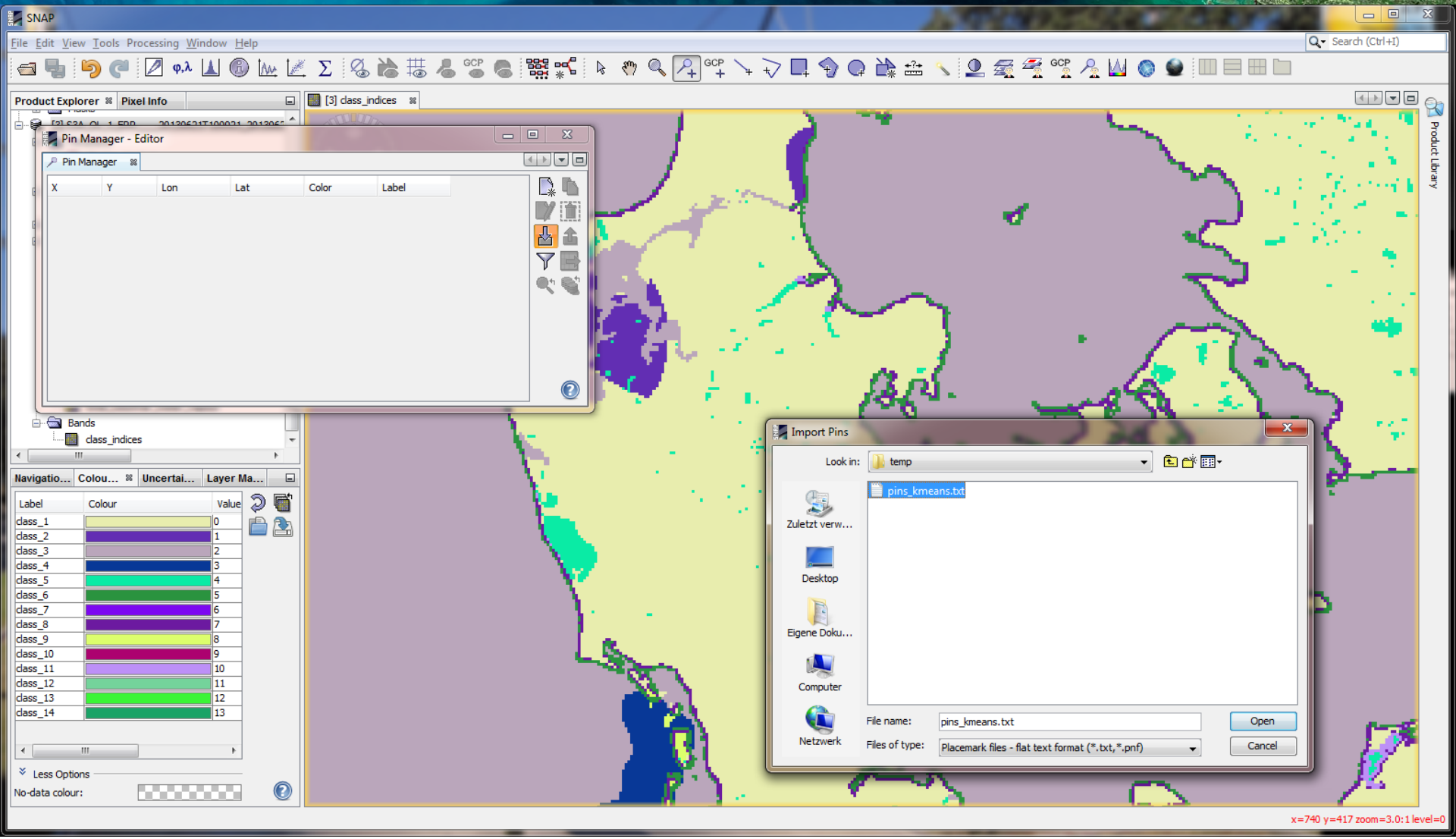


Sentinel-3 Toolbox: unsupervised classification

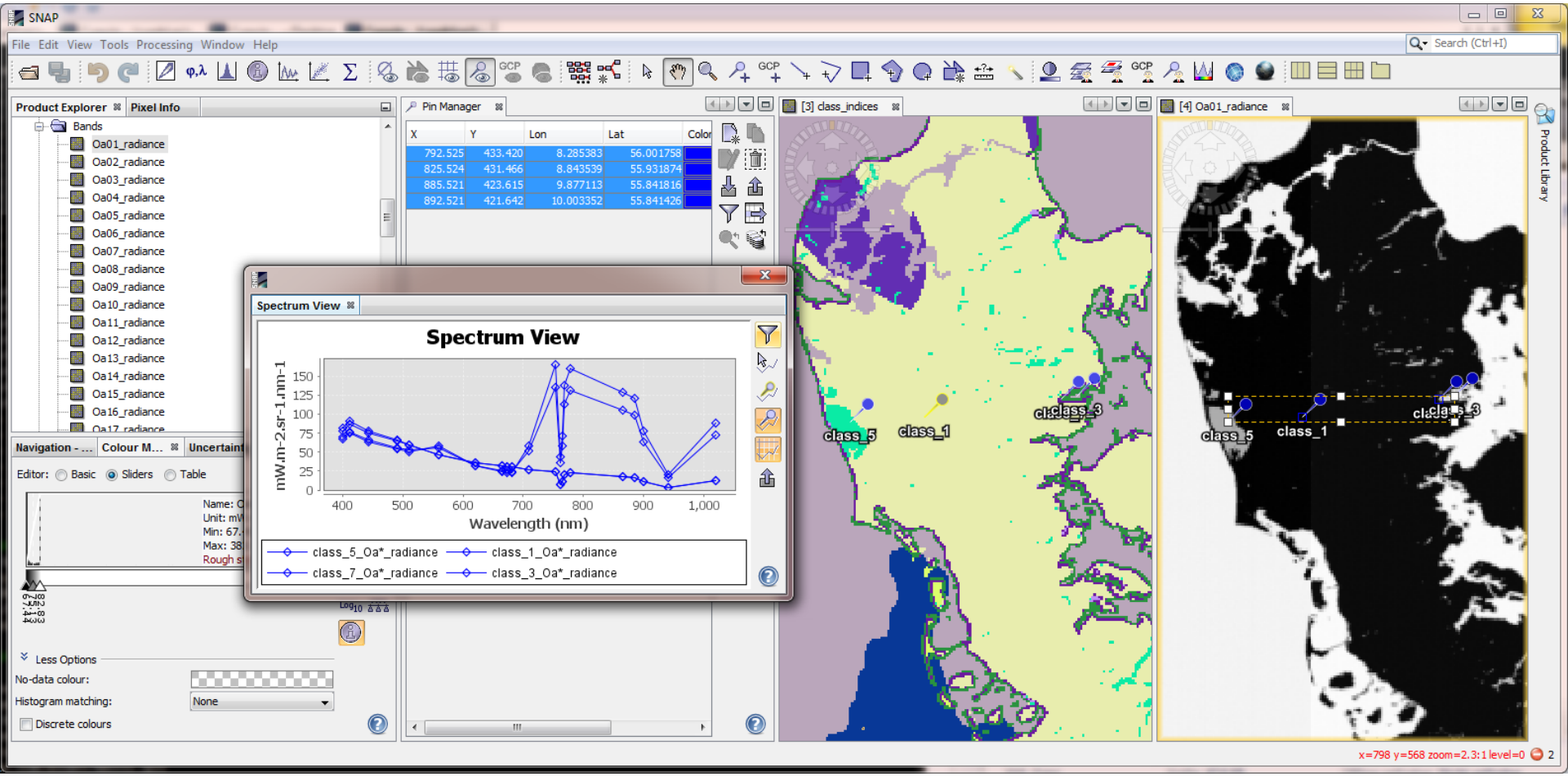
- EM or K-means cluster analysis on land using exclusively radiance bands



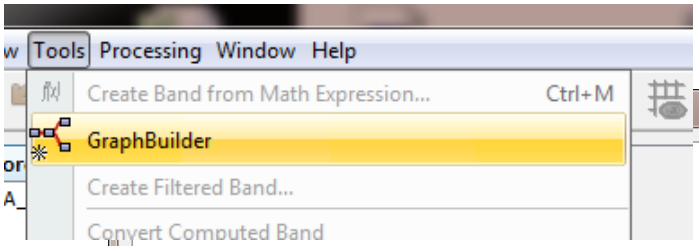
Test of classification - import pins

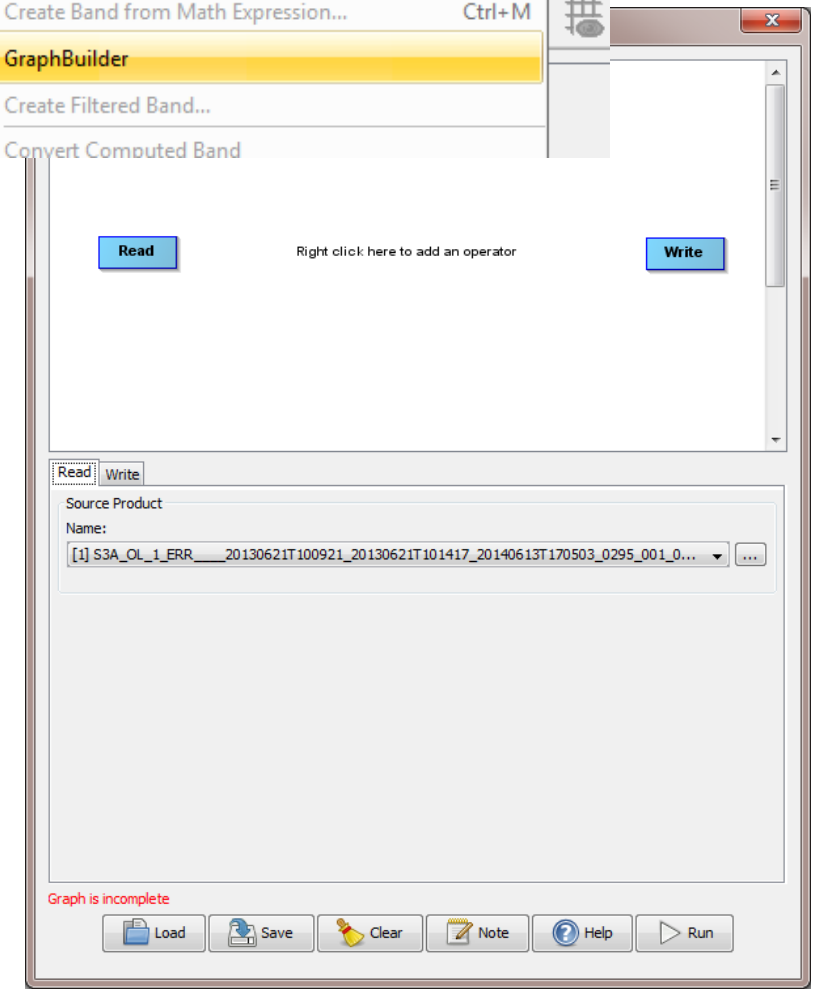


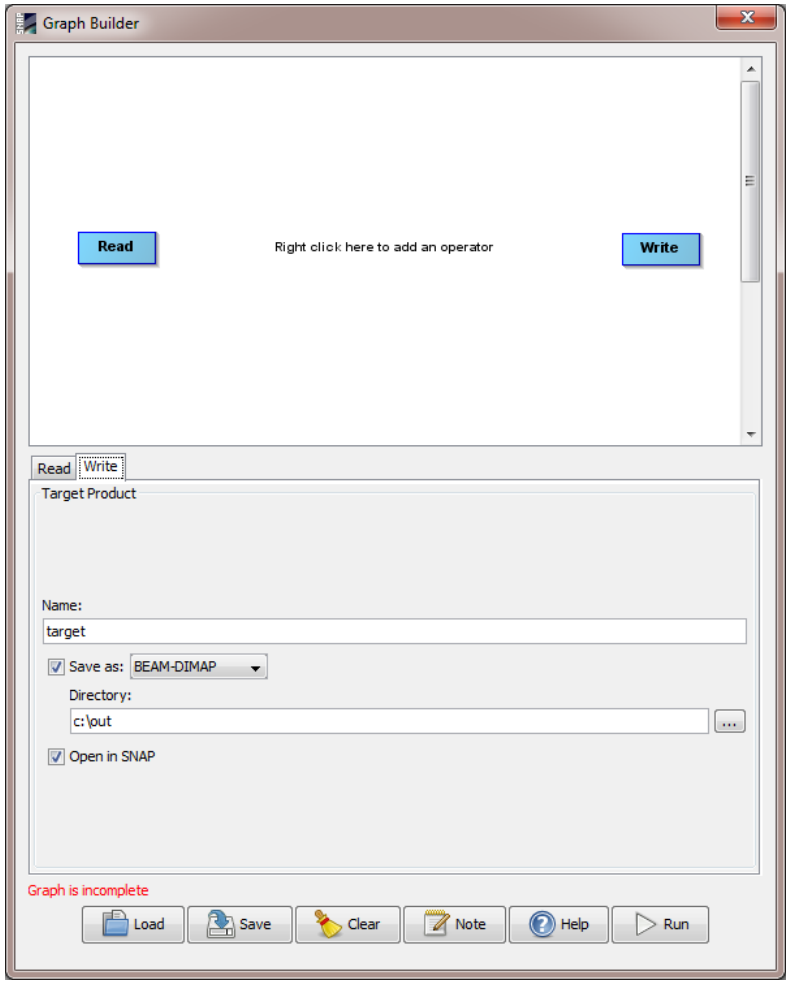
Test of classification



Sentinel-3 Toolbox: the Graph Builder







Sentinel-3 Toolbox: Batch Processing