Processing Sentinel3-A/B OLCI Data

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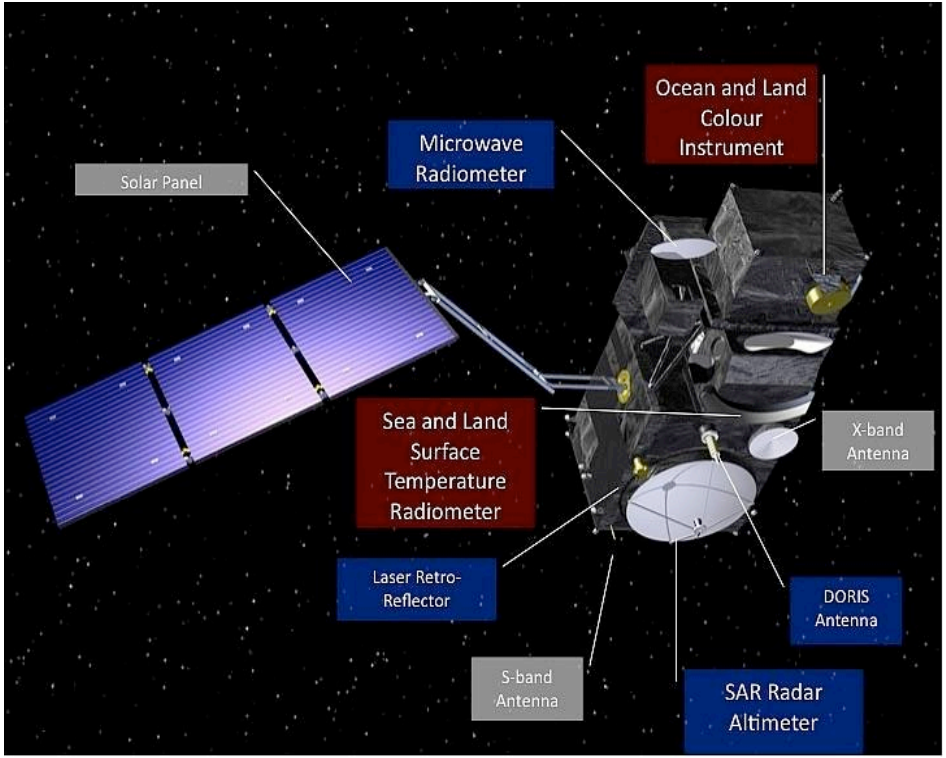
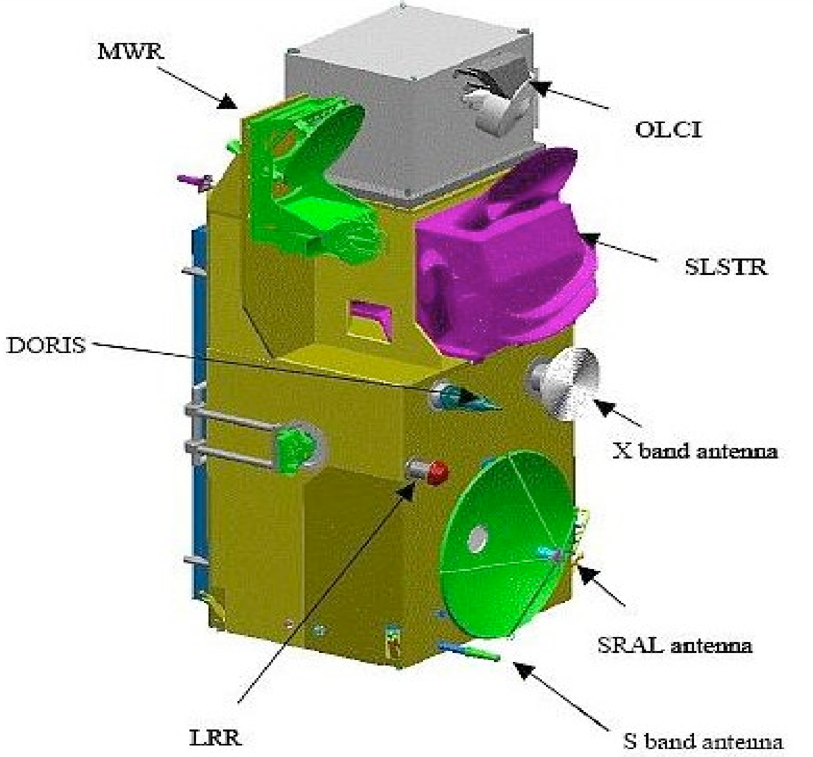
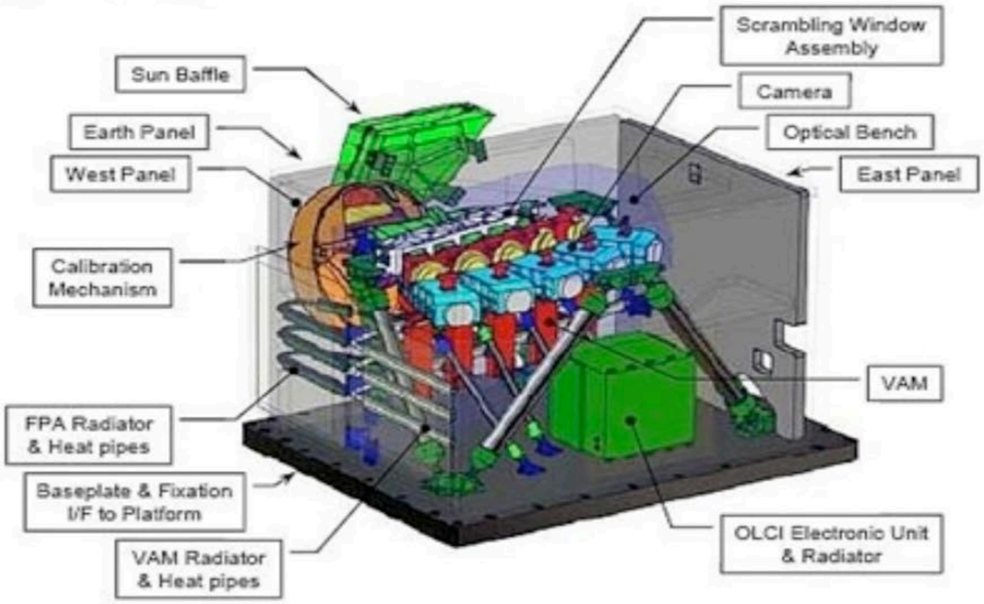
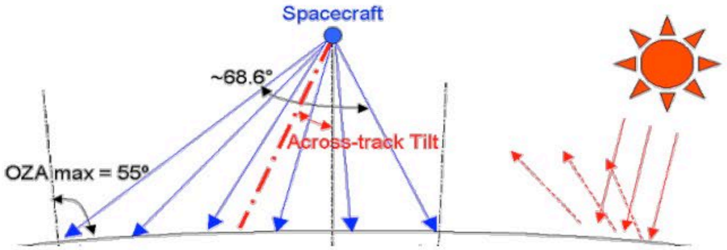
Sentinel-3 Sensors

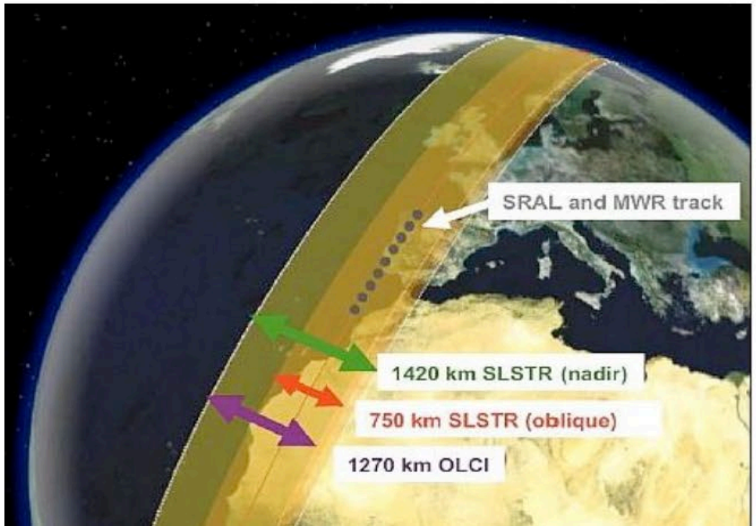




Ocean and Land Colour Instrument: OLCI







Images credit: ESA

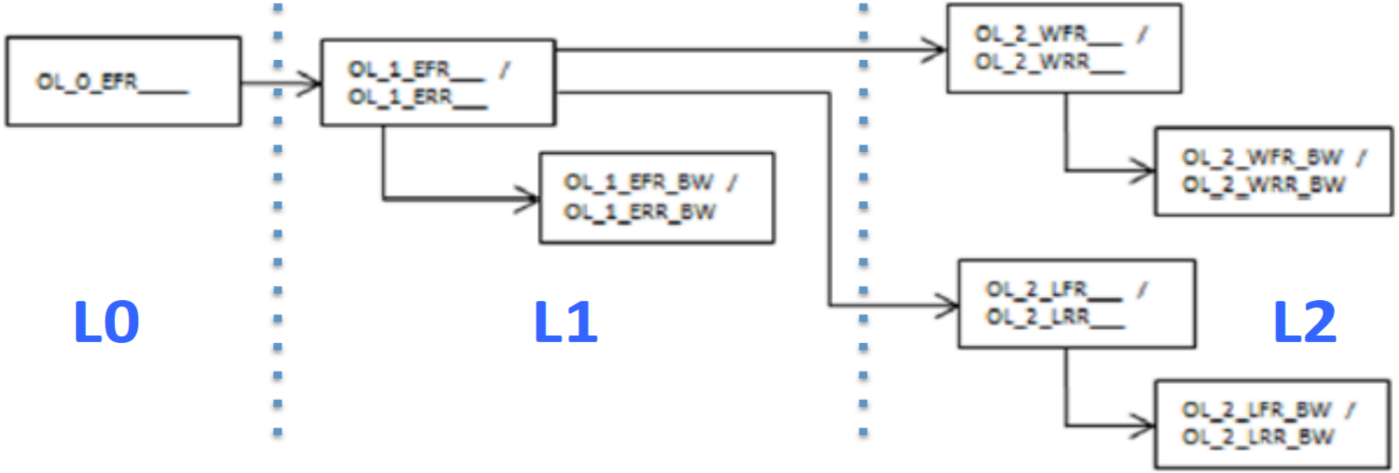
Ocean and Land Colour Instrument: OLCI

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

MERIS Bands	λ center	Width
Yellow substanace/detrital pigments	412.5	10
Chl.. Abs. Max	442.5	10
Chl & other pigments	490	10
Susp. Sediments, red tide	510	10
Chl. Abs. Min	560	10
Suspended sediment	620	10
Chl. Abs, Chl. fluorescence	665	10
Chl. fluorescence peak	681.25	7.5
Chl. fluorescence ref., Atm. Corr.	708.75	10
Vegetation, clouds	753.75	7.5
O_2 R-branch abs.	761.25	2.5
O_2 P-branch abs.	778.75	15
Atm corr	865	20
Vegetation, H_2O vap. Ref.	885	10
H_2O vap., Land	900	10
New OLCI bands	**λ center**	**Width**
Aerosol, in-water property	400	15
Fluorescence retrieval	673.75	7.5
Atmospheric parameter	764.375	3.75
Cloud top pressure	767.5	2.5
Atmos./aerosol correction	940	20
Atmos./aerosol correction	1020	40

Band #	λ center	Width
	nm	nm
Oa1	400	15
Oa2	412.5	10
Oa3	442.5	10
Oa4	490	10
Oa5	510	10
Oa6	560	10
Oa7	620	10
Oa8	665	10
Oa9	673.75	7.5
Oa10	681.25	7.5
Oa11	708.75	10
Oa12	753.75	7.5
Oa13	761.25	2.5
Oa14	764.375	3.75
Oa15	767.5	2.5
Oa16	778.75	15
Oa17	865	20
Oa18	885	10
Oa19	900	10
Oa20	940	20
Oa21	1020	40

OLCI product types



LEVEL 0

EFR	*Earth observation Full Resolution*

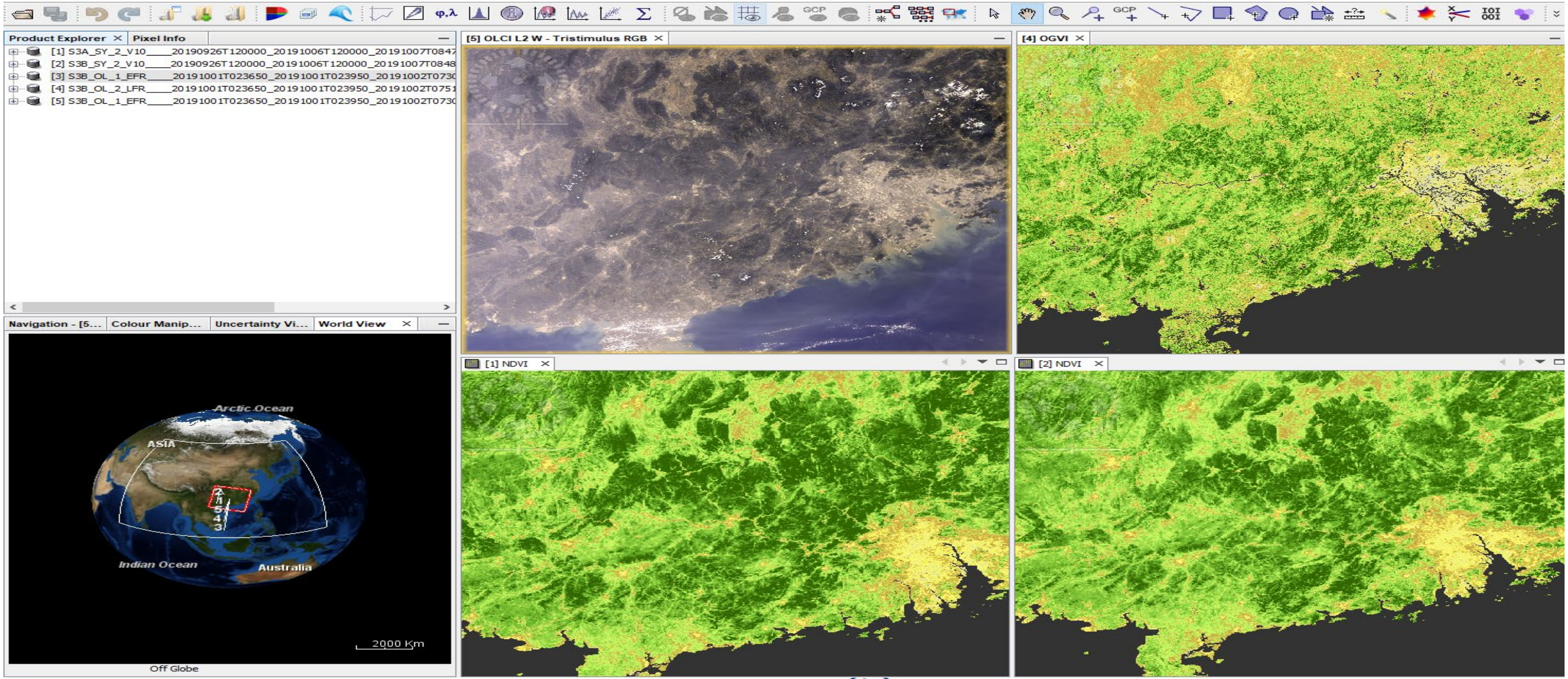
LEVEL 1

EFR	*Earth observation Full Resolution (calibrated)*
ERR	*Earth observation Reduced Resolution (cal.)*
EFR_BW	*EFR browse product*

LEVEL 2

WFR	*Water and atmosphere Full Resolution*
WFR_BW	*WFR Browse Product*
WRR	*Water and atmosphere Reduced Res.*
LFR	*Land Full Resolution*
LRR	*Land Reduced Resolution*
Etc.	

Example: Sentinel-3A/B products



Exercise Overview:

- Goal: Processing S3-A/B OLCI data for estimating emissivity using NDVI-THM.
- Source: Sobrino et al. (2008, 2016)
- Procedure:
  - Basic image visualization and manipulation tasks
  - OLCI L1 TOA radiance to reflectance conversion
  - OLCI L1/L2 product collocation
  - Emissivity calculation using the (NDVI)Thresholds Method
  - Spatial and temporal changes of NDVI (S3-SY-NDVI) using time series analysis tools
- Sentinel-3 user guide: *https://sentinels.copernicus.eu/web/sentinel/user-guides/sentinel-3-olci*

Definition of Emissivity

The emissivity, ϵ, at a given wavelength λ (units, μm) and temperature *T* (units, K), is defined as the ratio of the radiance $R_\lambda(T)$ emitted by a body at temperature *T* and the radiance $B_\lambda(T)$ emitted by a black body at the same temperature *T*, that is,

$$\varepsilon_\lambda(T) = \frac{R_\lambda(T)}{B_\lambda(T)}, \quad (1) \quad (1)$$

where $B_\lambda(T)$ refers to Planck's law, which is defined as

$$B_\lambda(T) = \frac{C_1 \lambda^{-5}}{\exp(C_2/\lambda T) - 1}, \quad (2) \quad (2)$$

in which C_1 and C_2 are constants ($C_1 = 1.191 \times 10^8$ W μm^4 sr^{-1} m^{-2}, $C_2 = 1.439 \times 10^4$ μm K).

Land surface emissivity retrieval from satellite data; Li et al., 2013, IJRS, http://dx.doi.org/10.1080/01431161.2012.716540

(NDVI)Thresholds Method

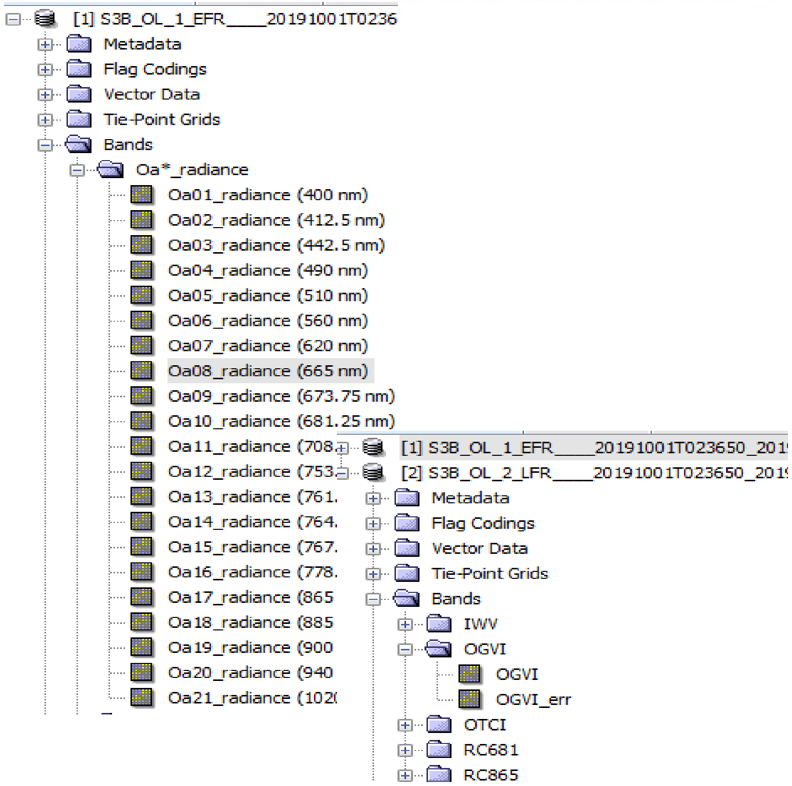
A simple method using OLCI data in the visible and near infrared bands (b8 and b9), which considers three type of pixels depending on the NDVI value:

$$\text{NDVI}<\text{NDVIs}: \quad \varepsilon = a + b\rho_{red}$$
$$\text{NDVIs} \le \text{NDVI} \le \text{NDVIv}: \quad \varepsilon = \varepsilon_s(1-Pv) + \varepsilon_v Pv + C$$
$$\text{NDVIv} > \text{NDVI}: \quad \varepsilon = 0.99$$

where ρred is the reflectance at the red band, εs = and εv = are reference values of surface emissivity for soil and vegetation, respectively. Pv is the fractional vegetation cover, which can be obtained from the scaled NDVI, given by

$$Pv = \frac{\text{NDVI} - \text{NDVIs}}{\text{NDVIv} - \text{NDVIs}}$$

Where NDVIs=0.15 and NDVIv=0.9 are reference values of NDVI for bare soil pixels and fully vegetation pixels



Exercise data

Sentinel-3B L1 and L2 images

S3B_OL_1_EFR____20191001T023650_20191001T023950_20191002T073016_0179_030_260_2520_LN1_O_NT_002.SEN3

S3B_OL_2_LFR____20191001T023650_20191001T023950_20191002T075103_0179_030_260_2520_LN1_O_NT_002.SEN3

Sentinel-3A L1 and L2 images

S3A_OL_1_EFR____20181005T023514_20181005T023814_20181006T062411_0179_036_260_2520_LN1_O_NT_002.SEN3

S3A_OL_2_LFR____20181005T023514_20181005T023814_20181006T064358_0179_036_260_2520_LN1_O_NT_002.SEN3

Sentinel-3A/3B Synergy NDVI products

S3B_SY_2_V10____20190726T163346_20190805T163346_20190815T172025_SOUTH_EAST_ASIA___LN2_O_NT_002.SEN3

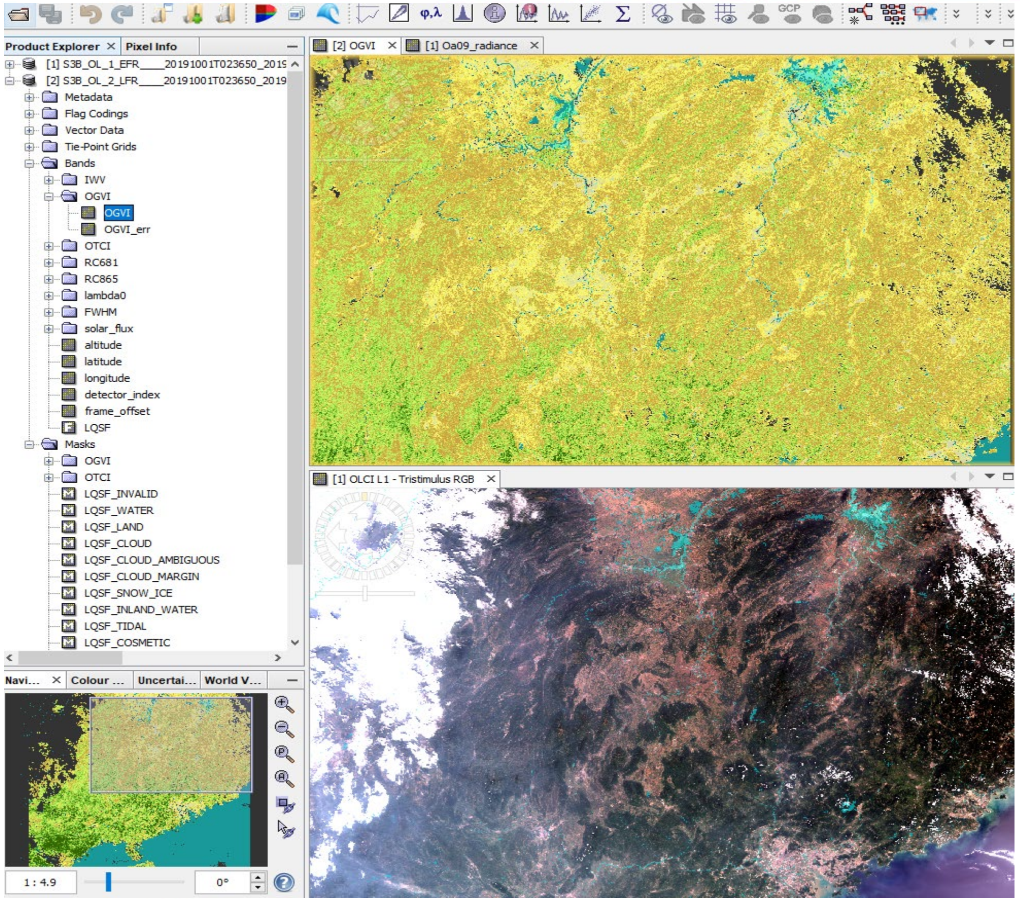
S3B_SY_2_V10____20190825T163346_20190904T163346_20190914T172004_SOUTH_EAST_ASIA___LN2_O_NT_002.SEN3

S3B_SY_2_V10____20190926T120000_20191006T120000_20191007T084850_SOUTH_EAST_ASIA___LN2_O_ST_002.SEN3

Data downloadable at https://scihub.copernicus.eu

Exploring S3A/B OLCI L-1/L-2 data:

- From the folder *products exercise*,open the scene: *"S3B_OL_1_EFR____20191001T023650_20191001T023950_20191002T073016_0179_030_260_2520_LN1_O_NT_002"*
- *Create and visualize an RGB composition image (Red: Oa08_Radiance; Green: Oa06_Radiance; Blue: Oa04_Radiancd).*
- Stretch the histogram for a better visualization in the *Colour Manipulation* window
- View image bands and check the spatial resolution for the radiance bands
- Open and explore OCLI L2 product



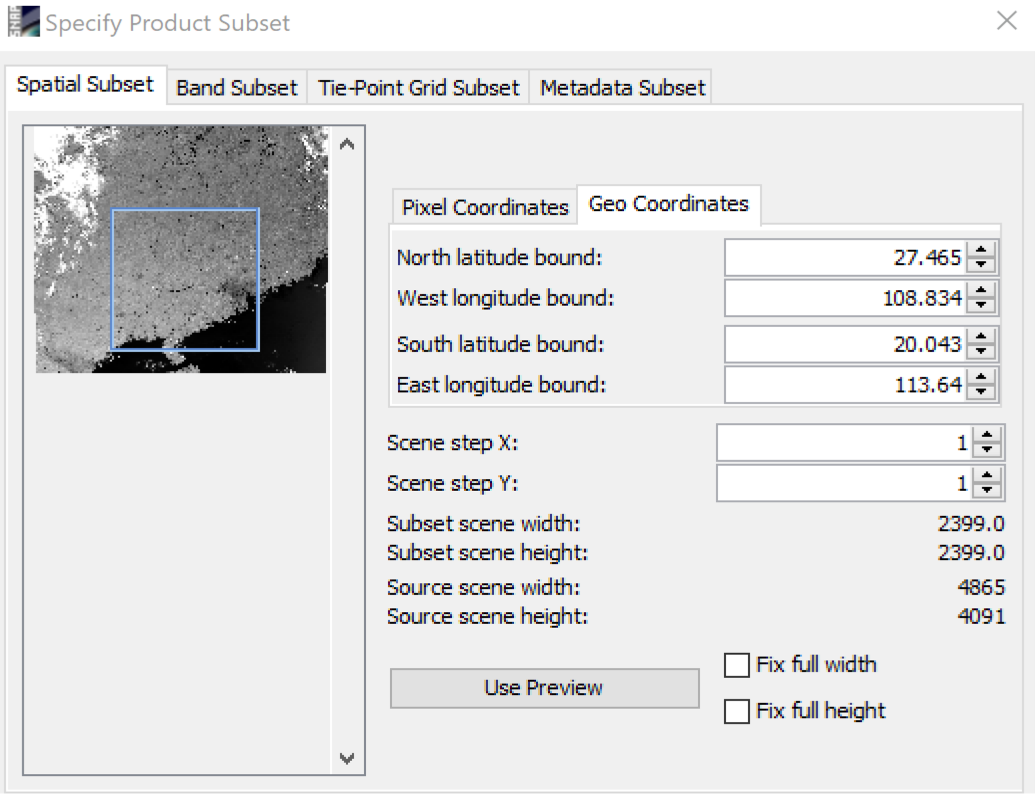
Spatial Subset

Reduce the spatial extent to focus on the study area for ***OCLI L1 & L2*** products:

Specify 'Spatial Subset' parameters (as shown in Figure)

Save the newly created subset images:

- *subset_0_of_S3B_OL_1_EFR____20191001T023650_20191001T023950_20191002T073016_0179_030_260_2520_LN1_O_NT_002.dim*
- *subset_0_of_S3B_OL_2_LFR____20191001T023650_20191001T023950_20191002T075103_0179_030_260_2520_LN1_O_NT_002.dim*



Radiance to Reflectance

From the folder *products exercise*, open the newly created OCLI L1 subset product:

"subset_0_of_S3B_OL_1_EFR____20191001T023650_20191001T023950_20191002T073016_0179_030_260_2520_LN1_O_NT_002.dim"

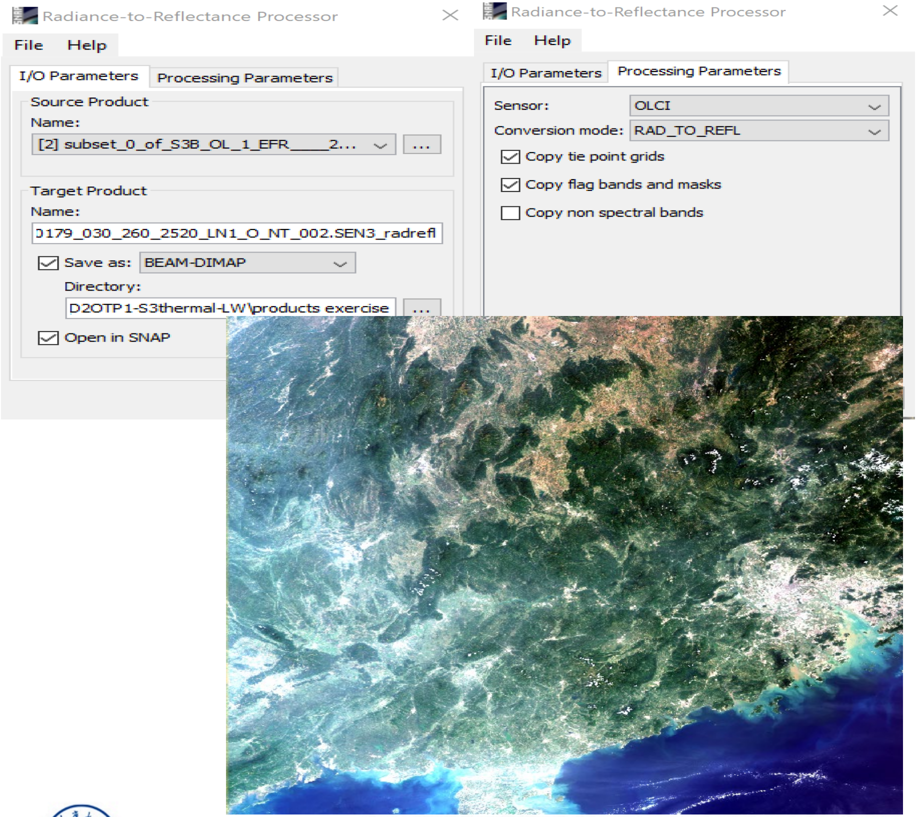
In the *Optical* label click on *Preprocessing/Radiance-to-Reflectance Processor*:

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

Specify 'Processing Parameters' (as shown in Figure)

Save the output product as:

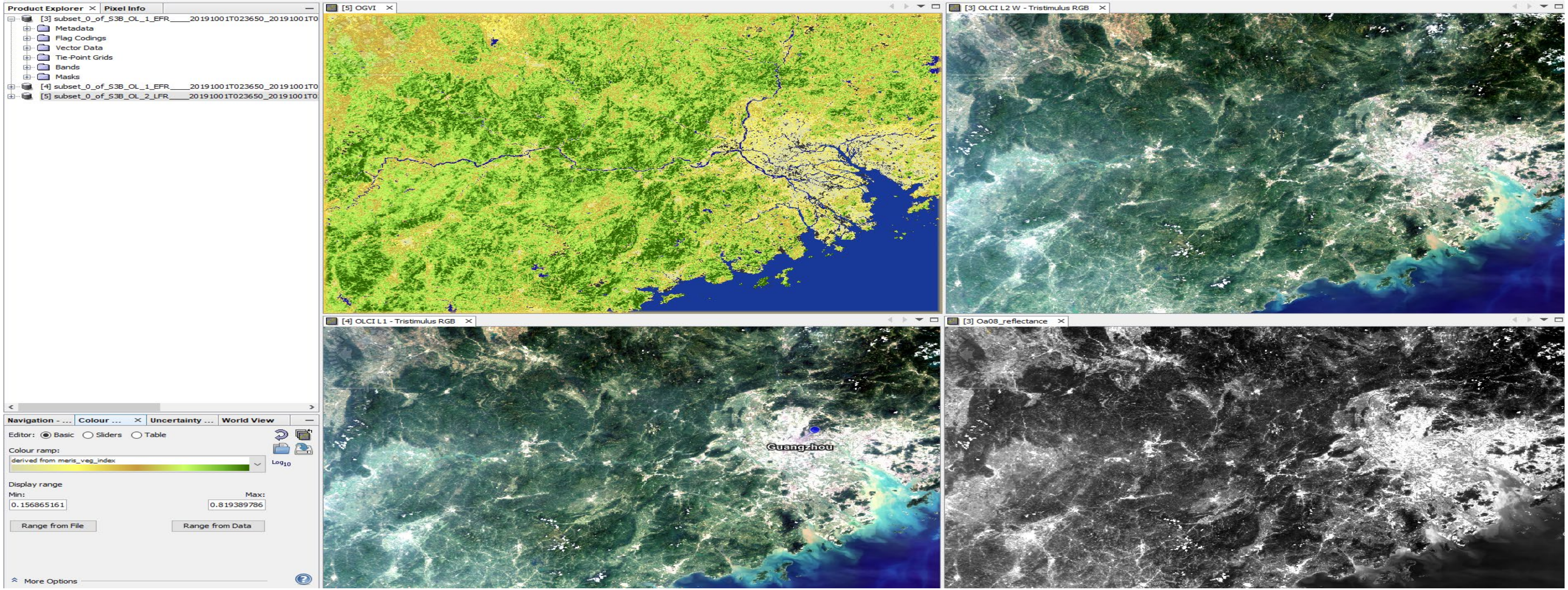
"subset_0_of_S3B_OL_1_EFR____20191001T023650_20191001T023950_20191002T073016_0179_030_260_2520_LN1_O_NT_002_radrefl.dim"



Open RGB window using band 8,6,4

subset_0_of_S3B_OL_1_EFR____20191001T023650_20191001T023950_20191002T073016_0179_030_260_2520_LN1_O_NT_002.SEN3_radrefl.dim

subset_0_of_S3B_OL_2_LFR____20191001T023650_20191001T023950_20191002T075103_0179_030_260_2520_LN1_O_NT_002.dim



OLCI L1/L2 Collocation

Use the collocation tool to group the L1 (*_radrefl) and L2 OLCI bands in one product with the same spatial resolution and geo-location

Raster/Geometric Operations/Collocation

Master file:

subset_0_of_S3B_OL_1_EFR____20191001T023650_20191001T023950_20191002T073016_0179_030_260_2520_LN1_O_NT_002_radrefl.dim

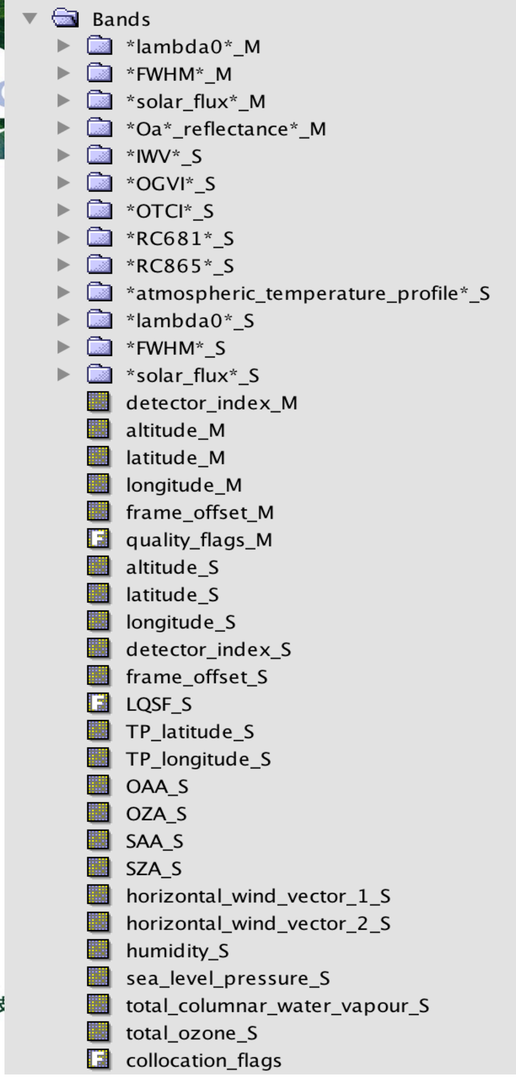
Slave file:

subset_0_of_S3B_OL_2_LFR____20191001T023650_20191001T023950_20191002T075103_0179_030_260_2520_LN1_O_NT_002.dim

Target file:

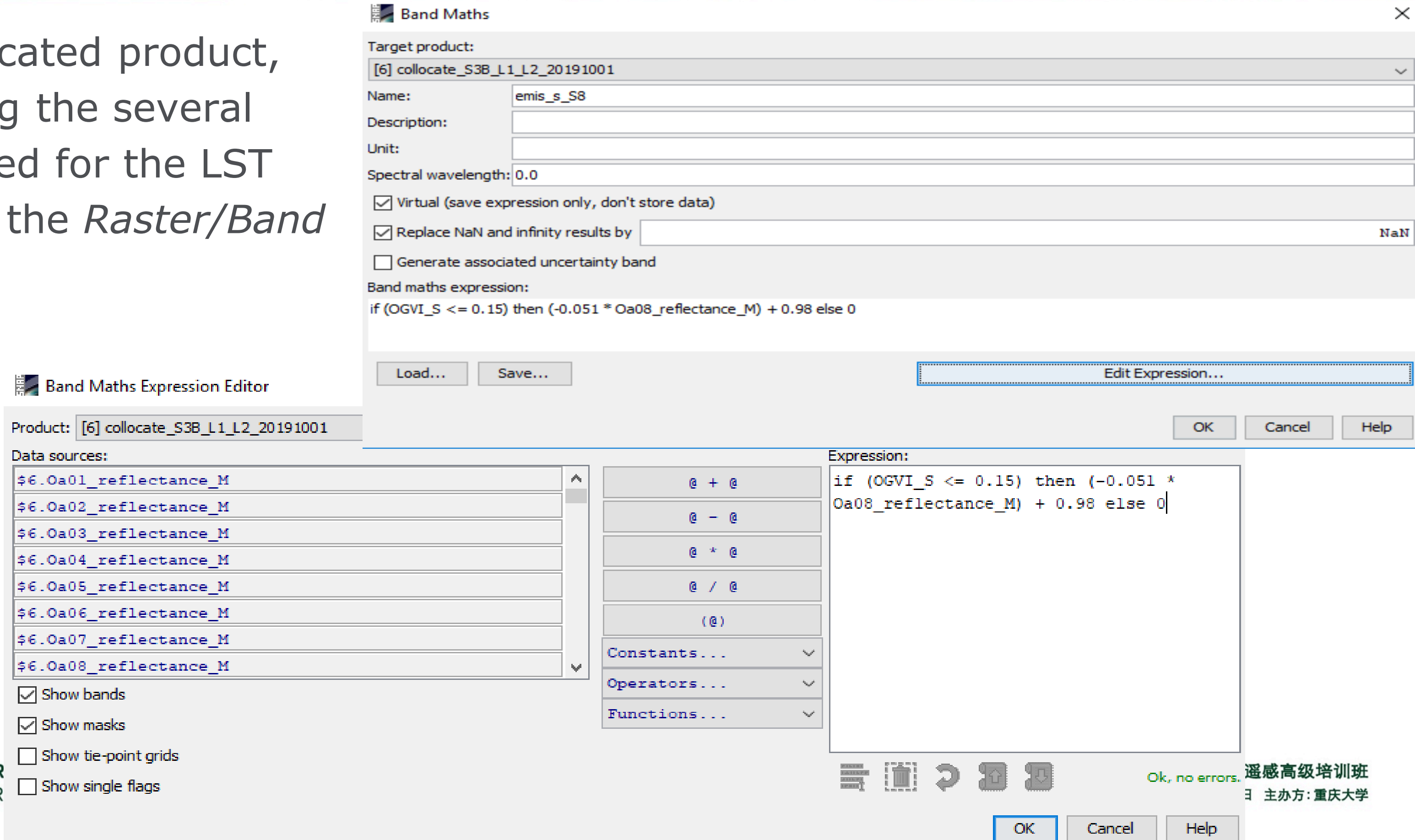
collocate_S3B_OL1_OL2_20191001.dim

Open RGB view using bands 8, 6 and 4



Emissivity Calculation using NDVI-THM

Using the collocated product, start calculating the several variables needed for the LST algorithm with the *Raster/Band Maths* tool



Emissivity calculation using (NDVI)Thresholds Method

Pv = (OGVI_S-0.15) / (0.9 - 0.15)

Emissivity for soil pixels

*emis_s_S8 = if (OGVI_S <= 0.15) then (-0.051 * Oa08_reflectance_M) + 0.98 else 0*

*emis_s_S9 = if (OGVI_S <= 0.15) then (-0.032 * Oa09_reflectance_M) + 0.983 else 0*

Emissivity for mixed pixels

*emis_m_S8 = if (OGVI_S > 0.15) and (OGVI_S < 0.9) then 0.969 * (1 - Pv) + (0.99 * Pv) else 0*

*emis_m_S9 = if (OGVI_S > 0.15) and (OGVI_S < 0.9) then 0.977 * (1 - Pv) + (0.99 * Pv) else 0*

Emissivity for vegetation pixels

emis_v = if (OGVI_S >= 0.9) then 0.99 else 0

Total emissivity

emis_total_S8 = emis_s_S8 + emis_m_S8 + emis_v

emis_total_S9 = emis_s_S9 + emis_m_S9 + emis_v

Mean emissivity

emis_mean = (emis_total_S8 + emis_total_S9) / 2

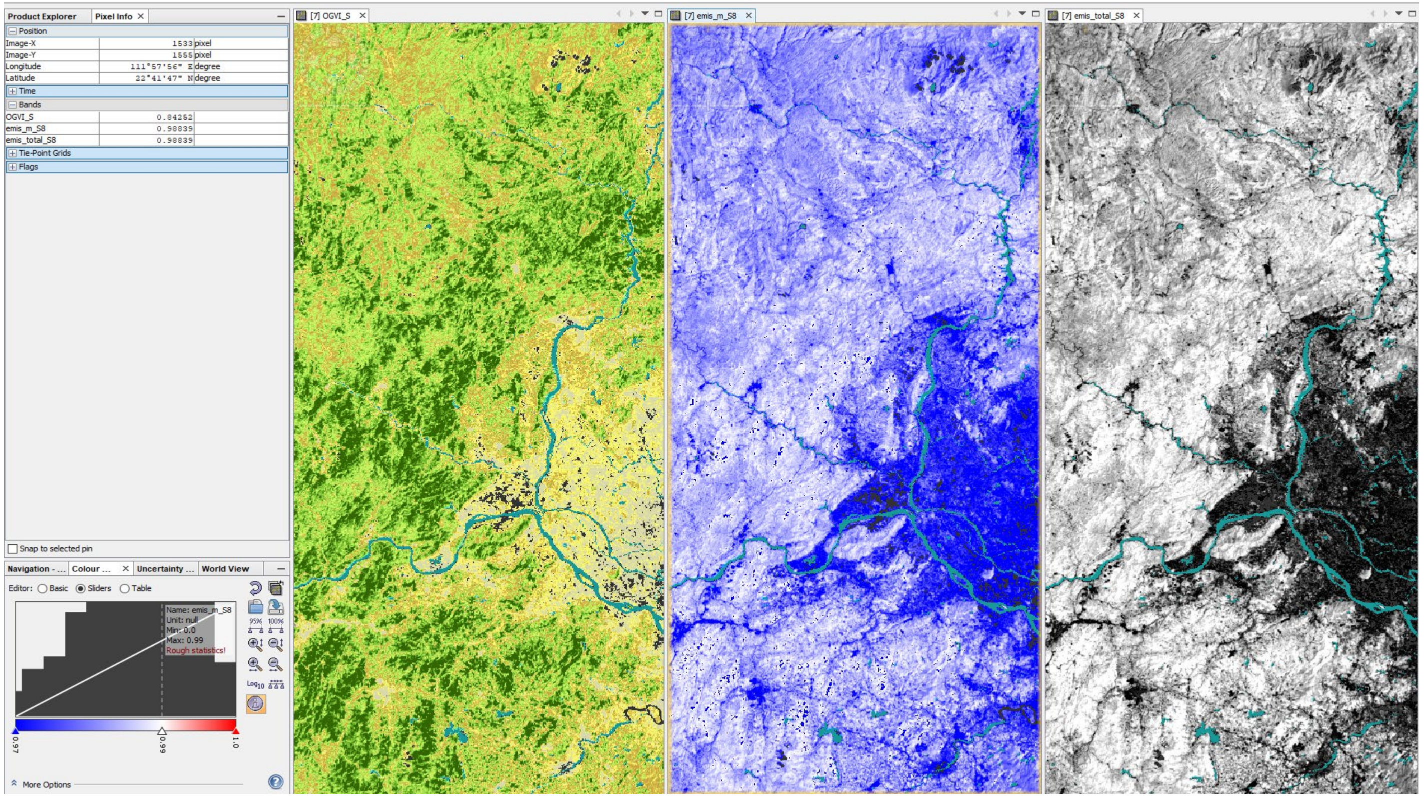
Differential emissivity

emis_diff = emis_total_S8 - emis_total_S9

Water vapour to g*cm2

water_vapour = IWV_S_S / 10

Check the newly calculated values for water, soil and vegetation pixels (display the only pixels with NDVI values above/below a specific threshold)

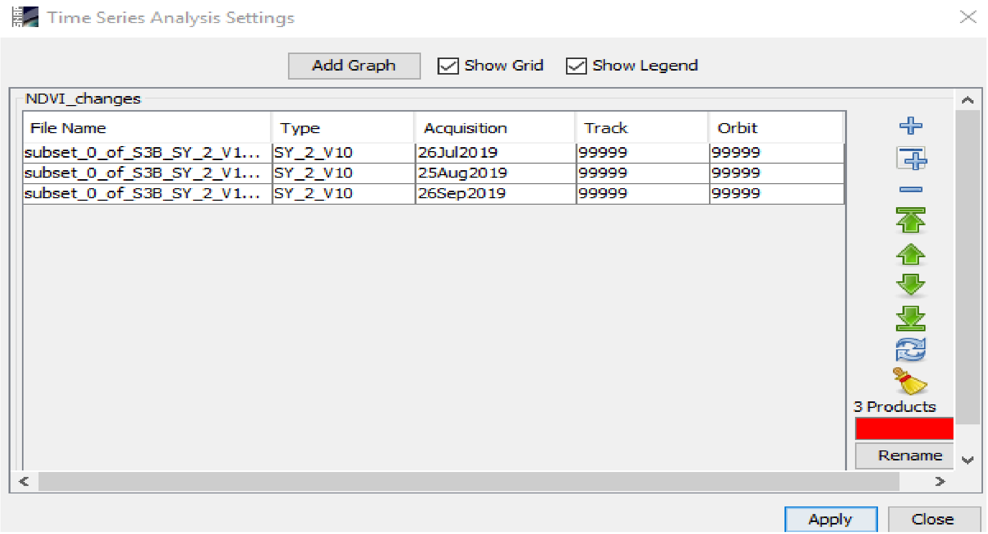


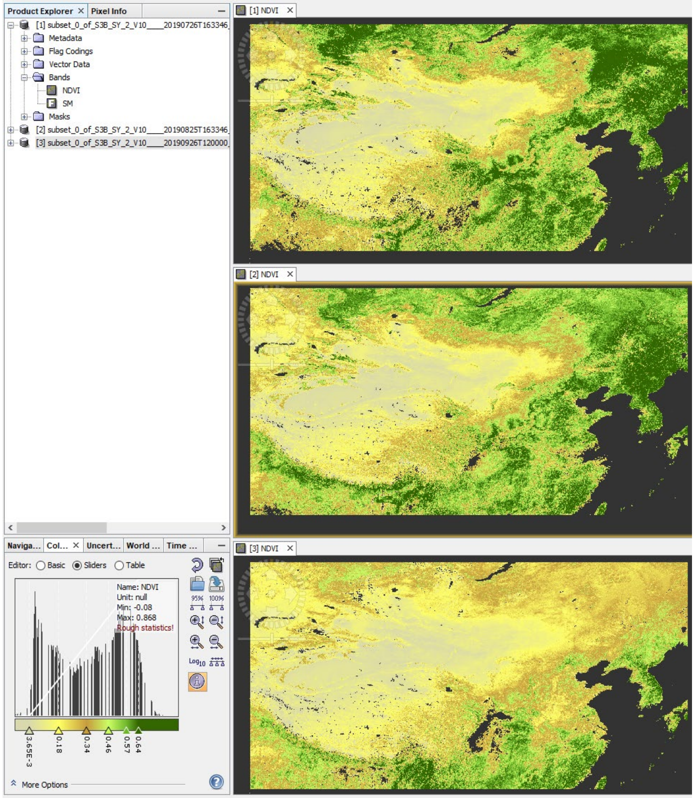
Temporal & spatial changes in NDVI

- ***Open the S3 Synergy NDVI files:***

File1: Subset_0_of_S3B_SY_2_V10____20190726T163346_20190805T163346_20190815T172025_SOUTH_EAST_ASIA___LN2_O_NT_002.dim
File2: subset_0_of_S3B_SY_2_V10____20190825T163346_20190904T163346_20190914T172004_SOUTH_EAST_ASIA___LN2_O_NT_002.dim
File3: subset_0_of_S3B_SY_2_V10____20190926T120000_20191006T120000_20191007T084850_SOUTH_EAST_ASIA___LN2_O_ST_002.dim

- ***Visualize the NDVI images of each file***
- ***Add all images in the time series analysis settings***





Temporal & spatial changes in NDVI

- *Move the cursor over the image and observe the changes in graph.*
- *The graph shows the changes in NDVI for each pixel in the image you click*