Processing S3-A/B SLSTR data with SNAP

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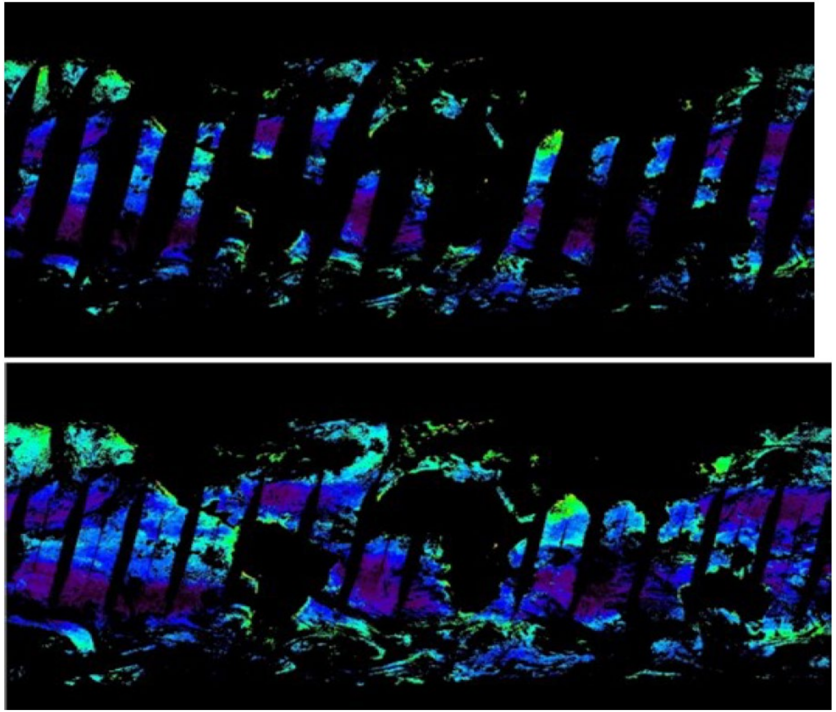
Sentinel-3 mission orbit

Type:	Sun-synchronous low earth orbit
Repeat cycle:	27 days (14 + 7/27 orbits per day)
Average altitude:	814.5 km over geoid
Mean solar time:	10:00 at descending node
Inclination:	98.65°

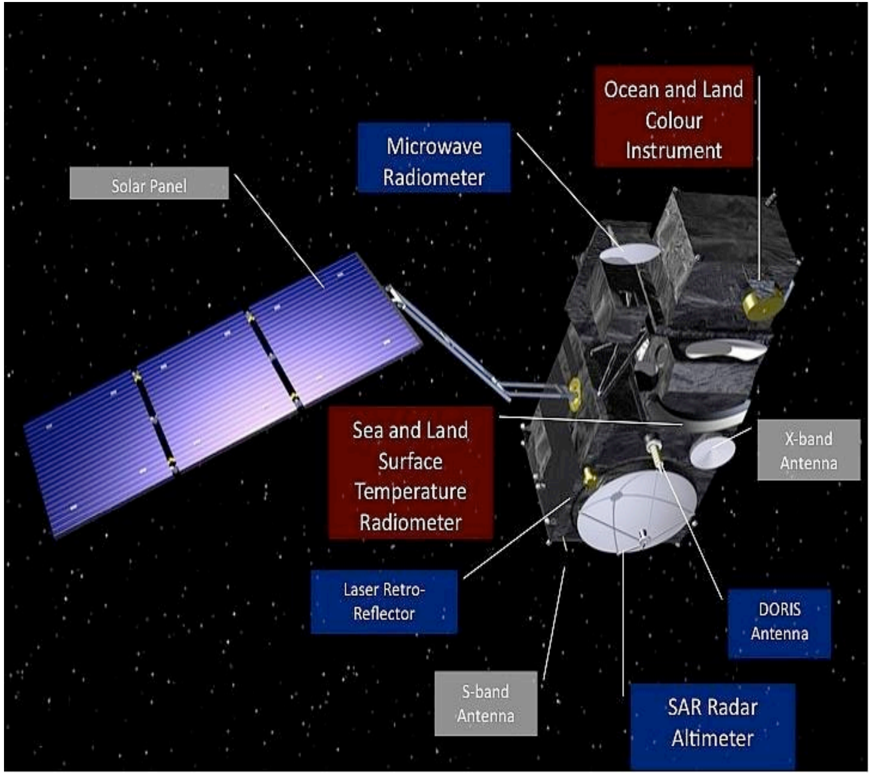
		Revisit at Equator	Revisit for latitude >30°	Specification
Ocean Colour (Sun-glint free)	1 Satellite	< 3.8 days	< 2.8 days	< 2 days
	2 Satellite	< 1.9 days	< 1.4 days	
Land Colour	1 Satellite	< 2.2 days	< 1.8 days	< 2 days
	2 Satellite	< 1.1 day	< 0.9 day	
SLST dual view	1 Satellite	< 1.8 days	< 1.5 days	< 4 days
	2 Satellite	< 0.9 day	< 0.8 day	

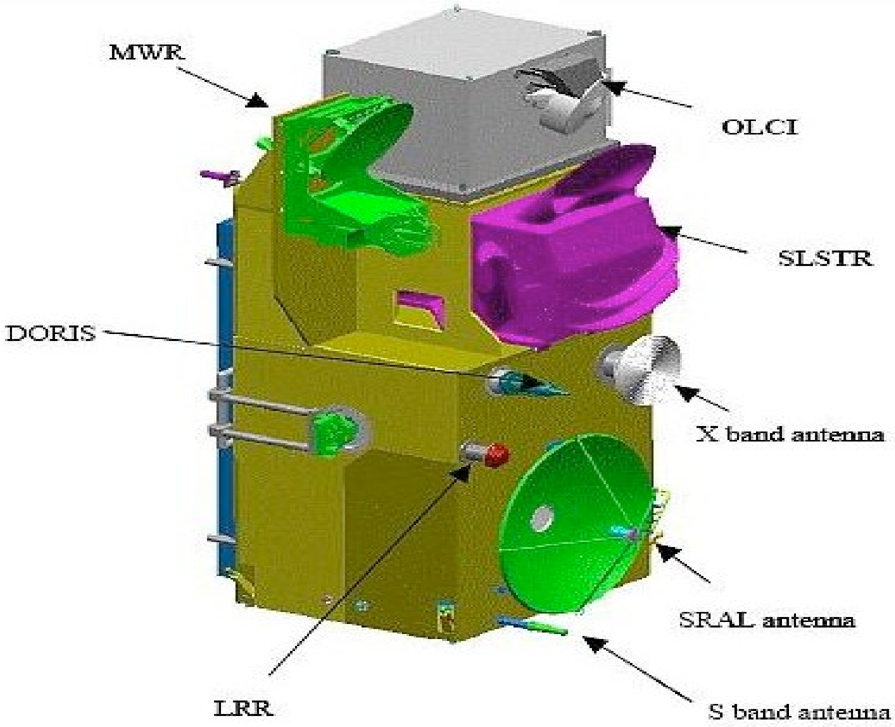
- Near-Real Time (< 3 hrs) availability of the L2 products
- Slow Time Critical (1 to 2 days) delivery of higher quality products for assimilation in models (e.g. SSH, SST)



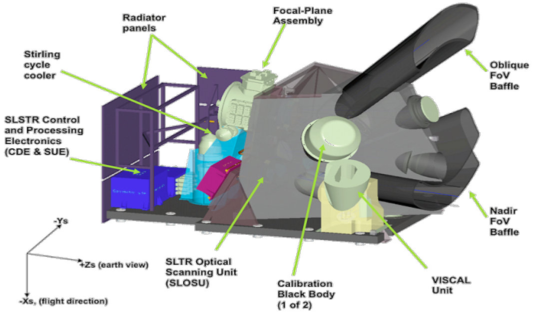
SLSTR images from the S-3A and S-3B orbit

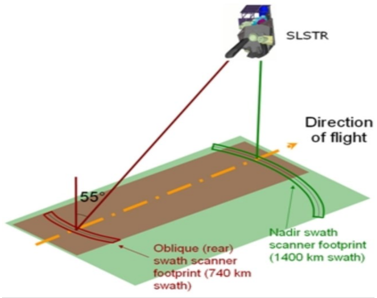
Sentinel-3 Sensors



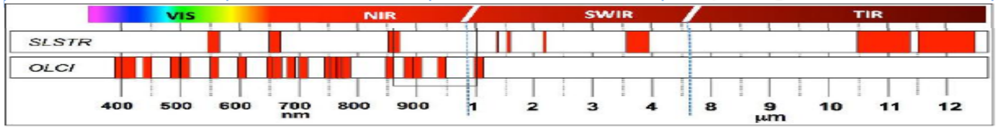


Data and Physical Units in SLSTR Products

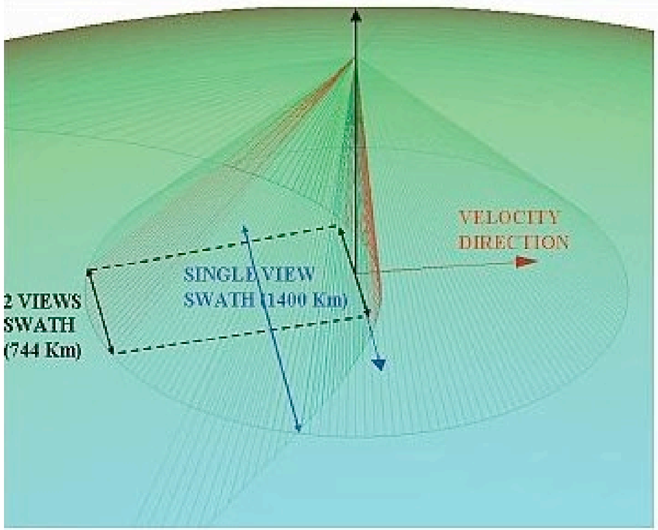


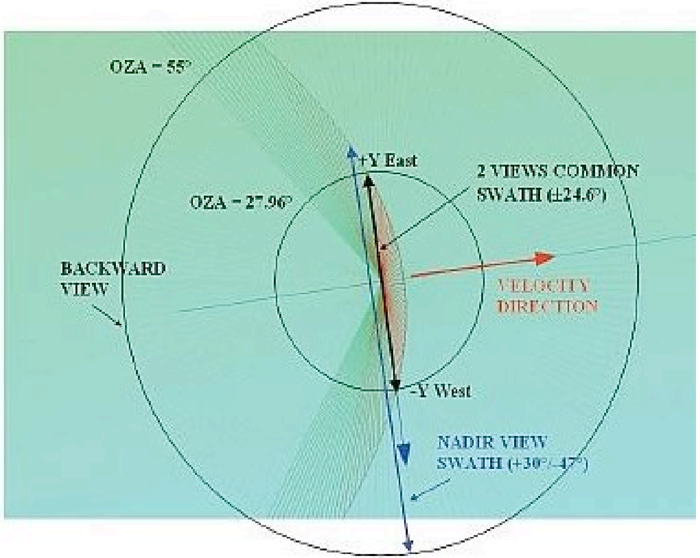


Performance	Parameters	SLSTR	AATSR & ATSR-1/2
Swaths	Nadir view	1 400 km	500 km
	Dual view	740 km	500 km
Global coverage revisit time	1 S/C (dual view)	1.9 days	7-14 days
		0.9 days	-
		1 day	7-14 days
		0.5 days	-
SSI at SSP (km)		0.5 km VIS-SWIR 1 km IR-fire	1 km
Spectral channels centre λ (μm)	VIS (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



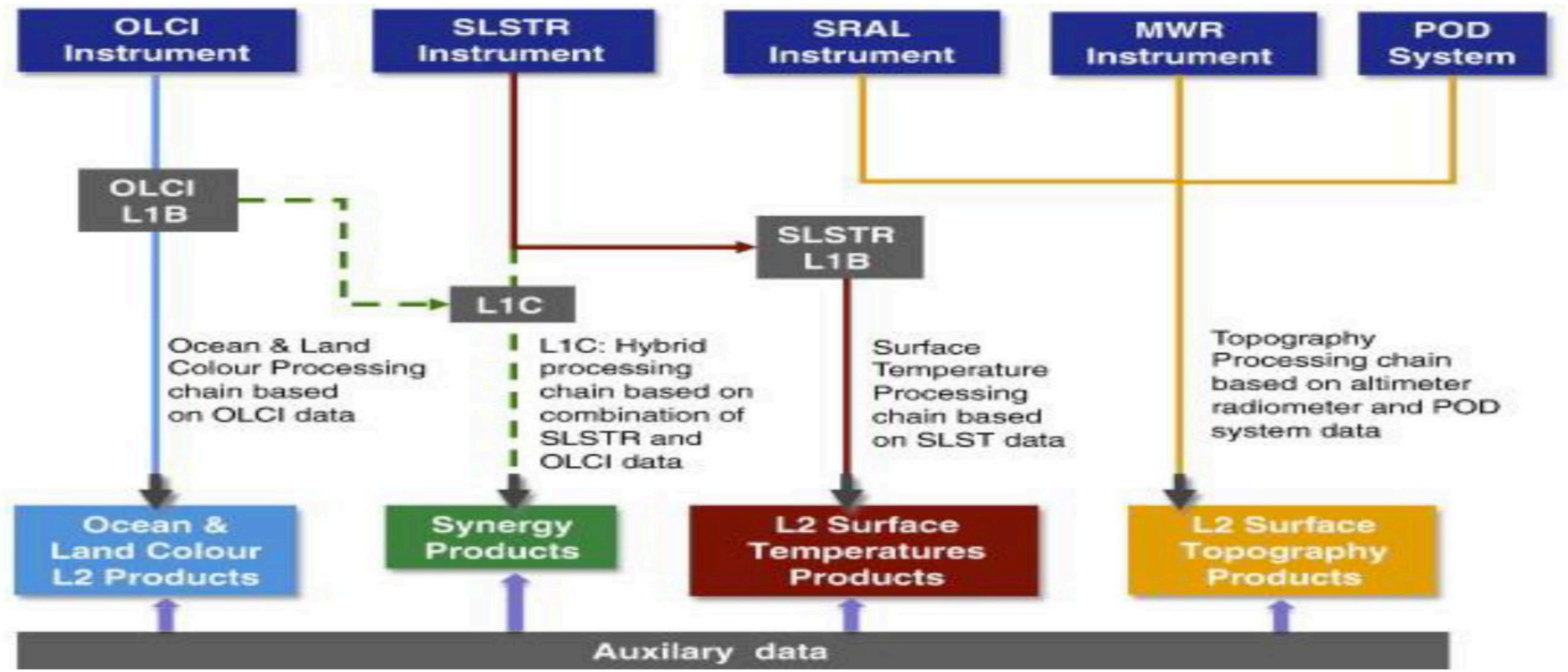
Sea and Land Surface Temperature Radiometer (SLSTR)





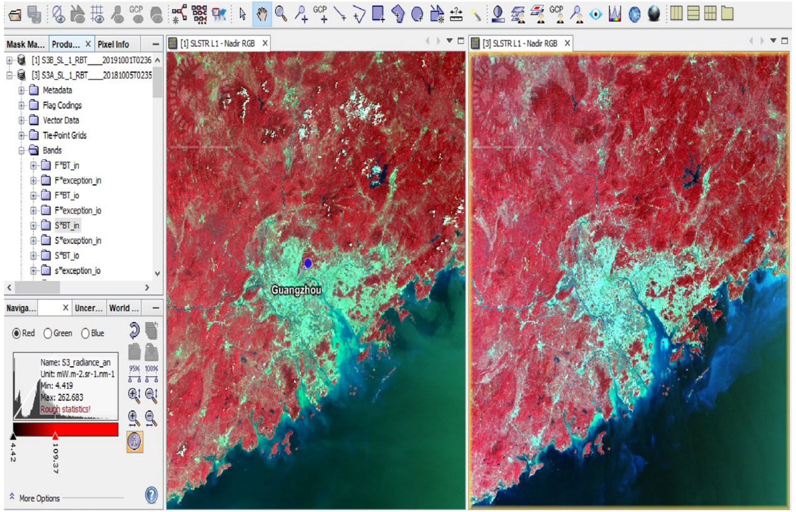
Backward inclined (left) and near nadir (right) views of the scanning mirror geometry

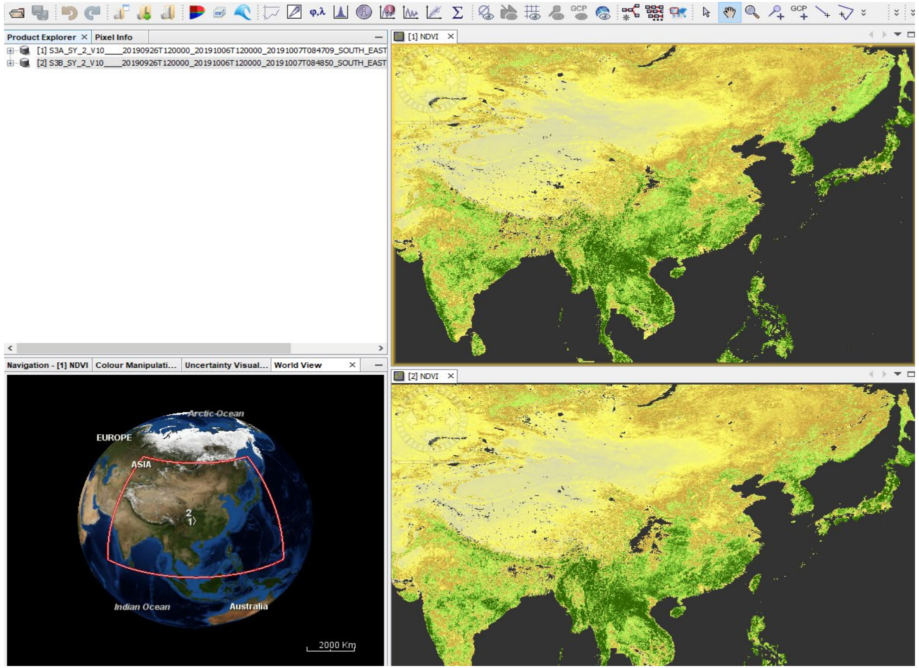
Sentinel-3 Data Processing Chains



https://sentinels.copernicus.eu/web/sentinel/user-guides/sentinel-3-slstr

Example:Sentinel-3A/B SLSTR L1-L2 images





Exercise Overview:

- Goal: To calculate Land Surface Temperatures using S-3A/B data from a split-window (SW) algorithm
- Source: Sobrino et al. (2008, 2016)
- Procedure:
  - Basic image visualization and manipulation tasks
  - Collocate products
  - Calculate LST using band maths operations
  - Compare the results obtained with SLSTR-L2 product
  - Graph builder and batch processing

Split-window equations to derive land surface temperature

$$T_S = T_i + c_1 (T_i - T_j) + c_2 (T_i - T_j)^2 + c_0$$

$$+ (c_3 + c_4 W)(1 - \varepsilon) + (c_5 + c_6 W) \Delta\varepsilon \qquad (1)$$

where Ts is the LST (in K), $T_{i,j}$ are at-sensor brightness temperatures (in K), W is the atmospheric water vapor content (in $g \cdot cm^{-2}$ or cm), ε is the mean LSE $0.5 \cdot (\varepsilon_i + \varepsilon_j)$, and Δε is the LSE difference $(\varepsilon_i - \varepsilon_j)$. Subindices 'i' and 'j' refer to two different TIR bands, thus leading to the SW algorithm, or to one TIR band but two different view angles (e.g. nadir 'n' and oblique 'o' views), thus leading to the DA algorithm. Coefficients c_0 to c_6 are obtained from statistical regressions performed over simulated data.

Synergistic use of MERIS and AATSR as a proxy for estimating Land Surface Temperature from Sentinel-3 data; Sobrino et al., 2016, RSE, http://dx.doi.org/10.1016/j.rse.2016.03.035

Land surface temperature

Numerical coefficients and errors for split window algorithm (Sobrino et al, 2016)

Parameter	Units	AATSR	SLSTR
c_0	K	-0.268 ± 0.014	-0.268 ± 0.014
c_1	Unitless	1.029 ± 0.010	1.084 ± 0.010
c_2	K^{-1}	0.2679 ± 0.0017	0.2771 ± 0.0017
c_3	K	44.9 ± 0.7	45.1 ± 0.7
c_4	$K \cdot cm^{-1}$	-0.61 ± 0.19	-0.73 ± 0.19
c_5	K	-121.5 ± 1.7	-125.0 ± 1.7
c_6	$K \cdot cm^{-1}$	16.2 ± 0.5	16.7 ± 0.5
σ	K	0.9	0.9
r	Unitless	0.975	0.976
$\delta_{NE\Delta T}$	K	0.4	0.4
$\delta\varepsilon$	K	1.2	1.2
δw	K	0.08	0.08
u_{total}	K	1.5	1.6

Data sets

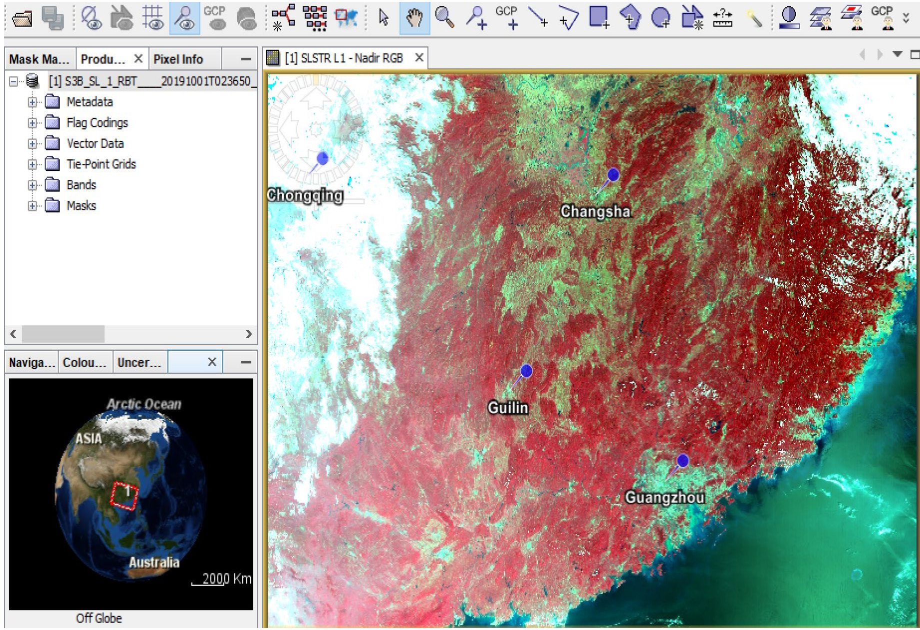
- Sentinel-3A/3B images acquired during Sepertember 2019 downloaded at https://scihub.copernicus.eu/
  - S3B_SL_1_RBT____20191001T023650_20191001T023950_20191002T070406_0179_030_260_2520_LN2_O_NT_003.SEN3
  - S3B_SL_2_LST____20191001T023650_20191001T023950_20191001T042632_0179_030_260_2520_LN2_O_NR_003.SEN3

  - S3A_SL_1_RBT____20190921T023515_20190921T023815_20190922T080924_0179_049_260_2520_LN2_O_NT_003.SEN3
  - S3A_SL_2_LST____20190921T023515_20190921T023815_20190921T042937_0179_049_260_2520_LN2_O_NR_003.SEN3

  bands selected for the calculation of the LST from SLST L1 are: nadir brightness temperatures for channel S8 at 10822.8nm and channel S9 at 12039.2 nm
- Pre-processed data for the surface emissivity
  - emissivity_20191001.dim
  - emissivity_SY_20191001.dim

Open and explore S3A/B SLSTR L-1B data

- From the folder *products exercise*, open the scene: *"S3B_SL_1_RBT____20191001T023650_20191001T023950_20191002T070406_0179_030_260_2520_LN2_O_NT_003.SEN3/xfdumanifest.xml"*
- *Open RGB Image Window* with the *SLSTR L1 Nadir* profile. Stretch the histogram for a better visualization in the *Colour Manipulation* window
- Add a pin in the approximate position of Guangzhou (23.13°N, 113.25°E)
- View image bands and check the spatial resolution for the BT and radiance bands



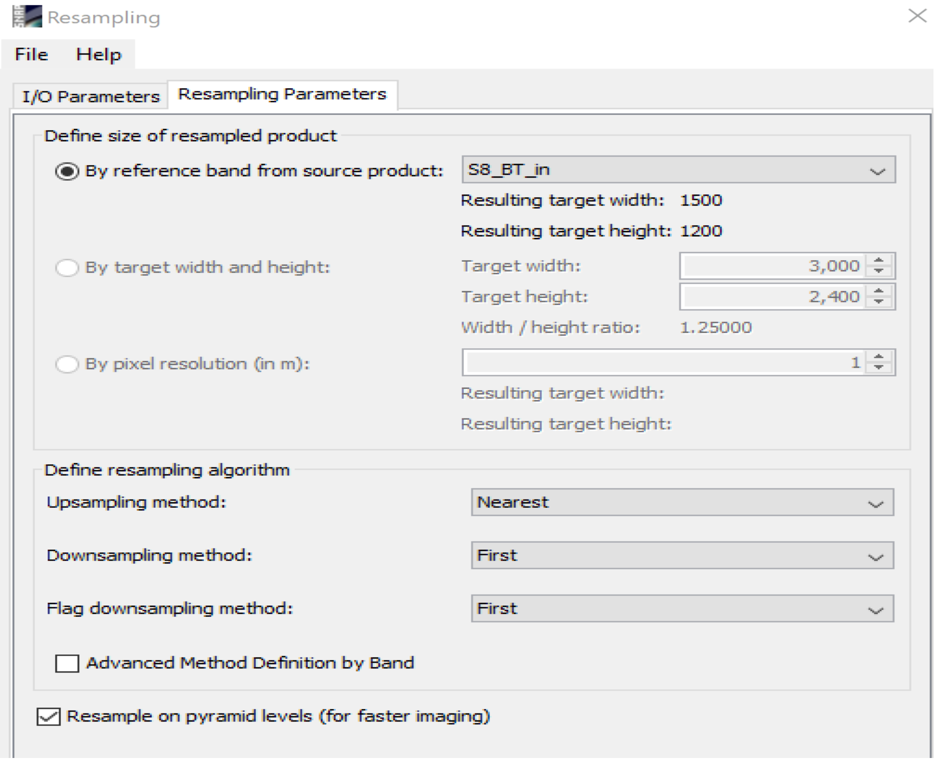
Resampling at 1km:

- Source product:

S3B_SL_1_RBT____20191001T023650_20191001T023950_20191002T070406_0179_030_260_2520_LN2_O_NT_003.SEN3

- Target product

S3B_SL_1_RBT____20191001T023650_20191001T023950_20191002T070406_0179_030_260_2520_LN2_O_NT_003_resampled



Creating spatial subset:

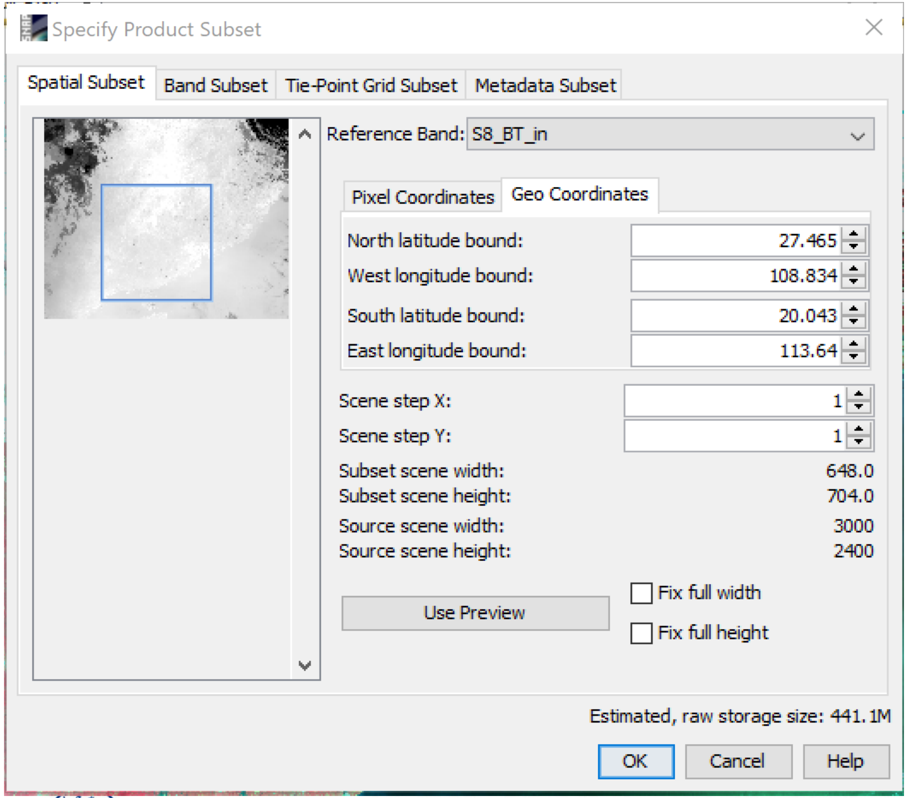
- Source product:

S3B_SL_1_RBT____20191001T023650_20191001T023950_20191002T070406_0179_030_260_2520_LN2_O_NT_003._resampled

- Save the subset image:

subset_0_of_S3B_SL_1_RBT____20191001T023650_20191001T023950_20191002T070406_0179_030_260_2520_LN2_O_NT_003.dim

- Set up the subset parameters as shown in the Figure



COLLOCATION

Use the collocation tool to group the SLSTR and emissivity bands in a single product with the same spatial resolution (1 km) and geo-location:

Raster/Geometric Operations/Collocation

Master file:

subset_0_of_S3B_SL_1_RBT____20191001T023650_20191001T023950_20191002T070406_0179_030_260_2520_LN2_O_NT_003.dim

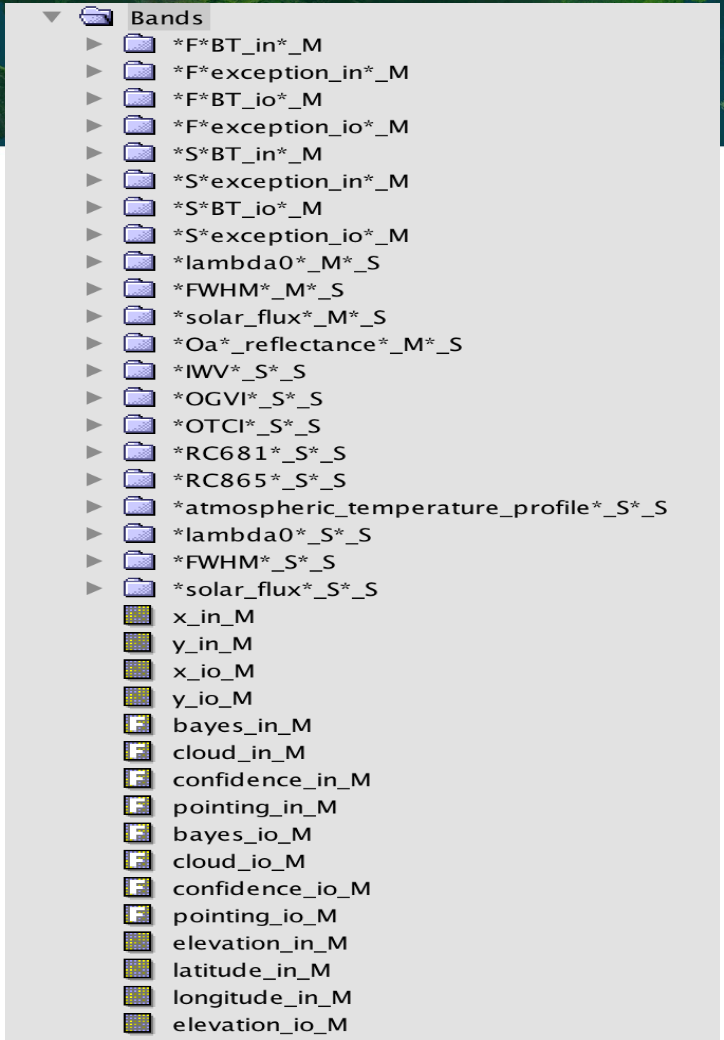
Slave file:

emissivity_20191001.dim

Target product

collocate_S3B_L1_emissivity_20191001.data

Open and view the created product



Mean LSE,difference LSE

mean LSE:

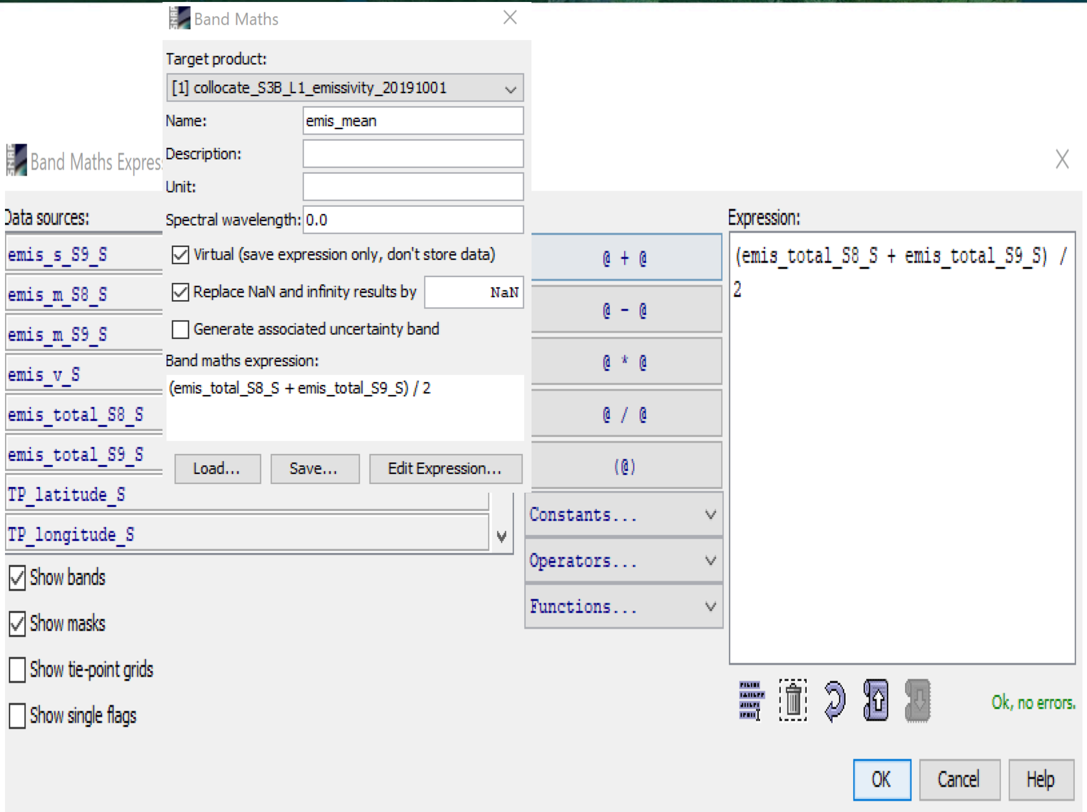
emis_mean = (emis_total_S8_S + emis_total_S9_S) / 2

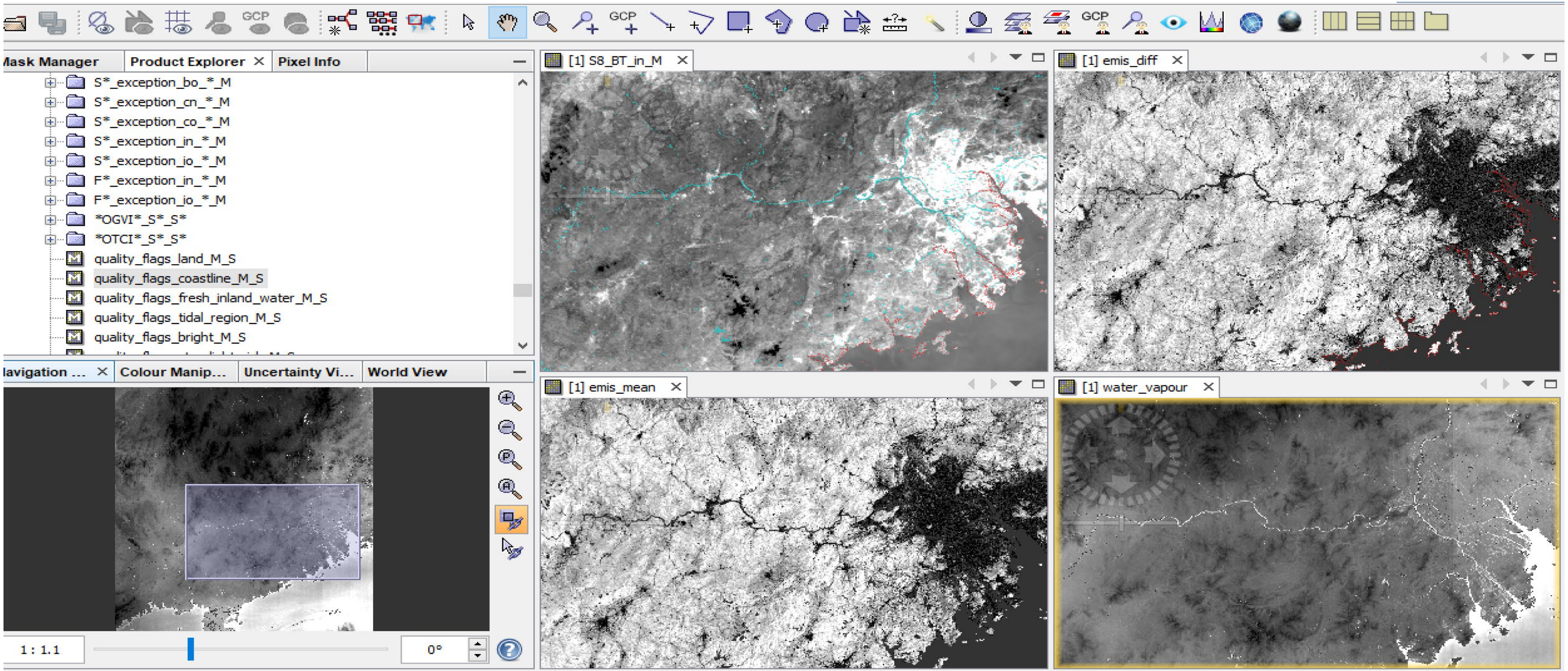
difference LSE:

emis_diff = emis_total_S8_S - emis_total_S9_S

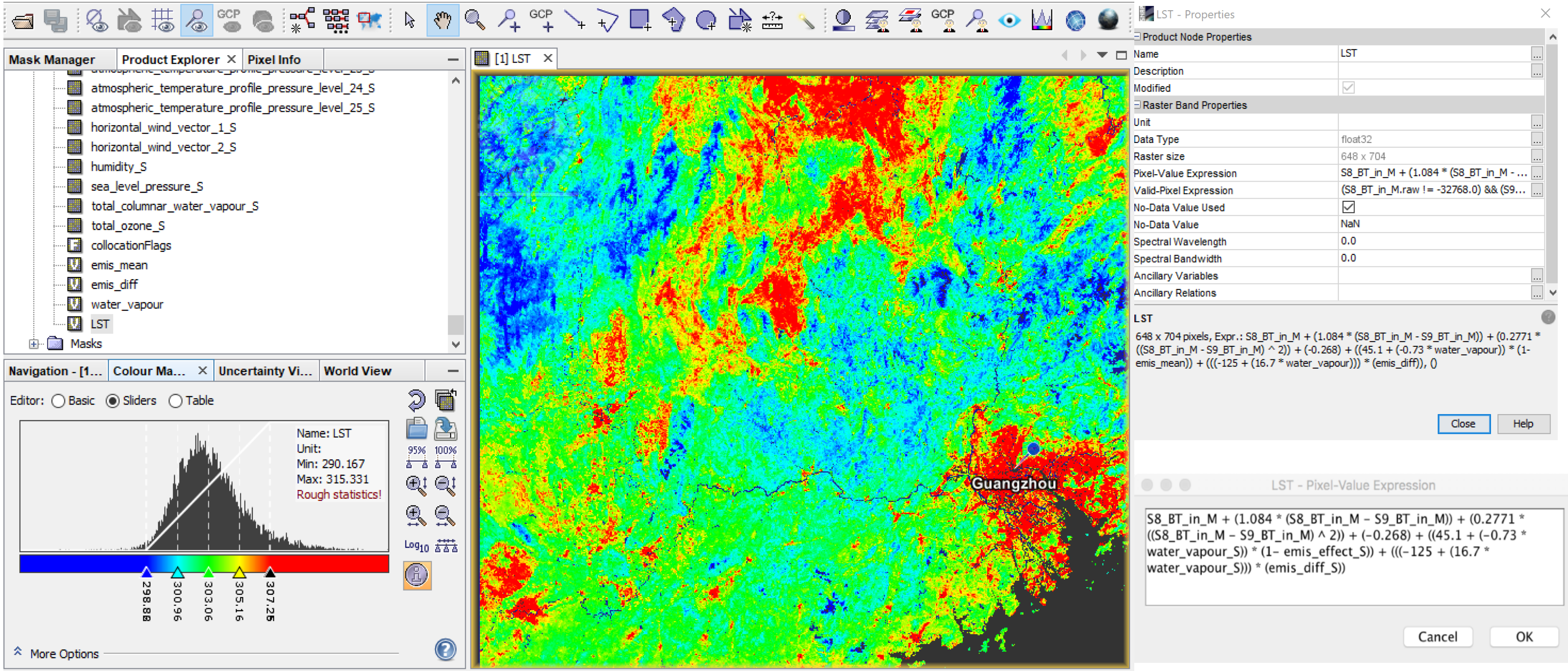
Water vapour to g*cm2

water_vapour = IWV_S_S/ 10

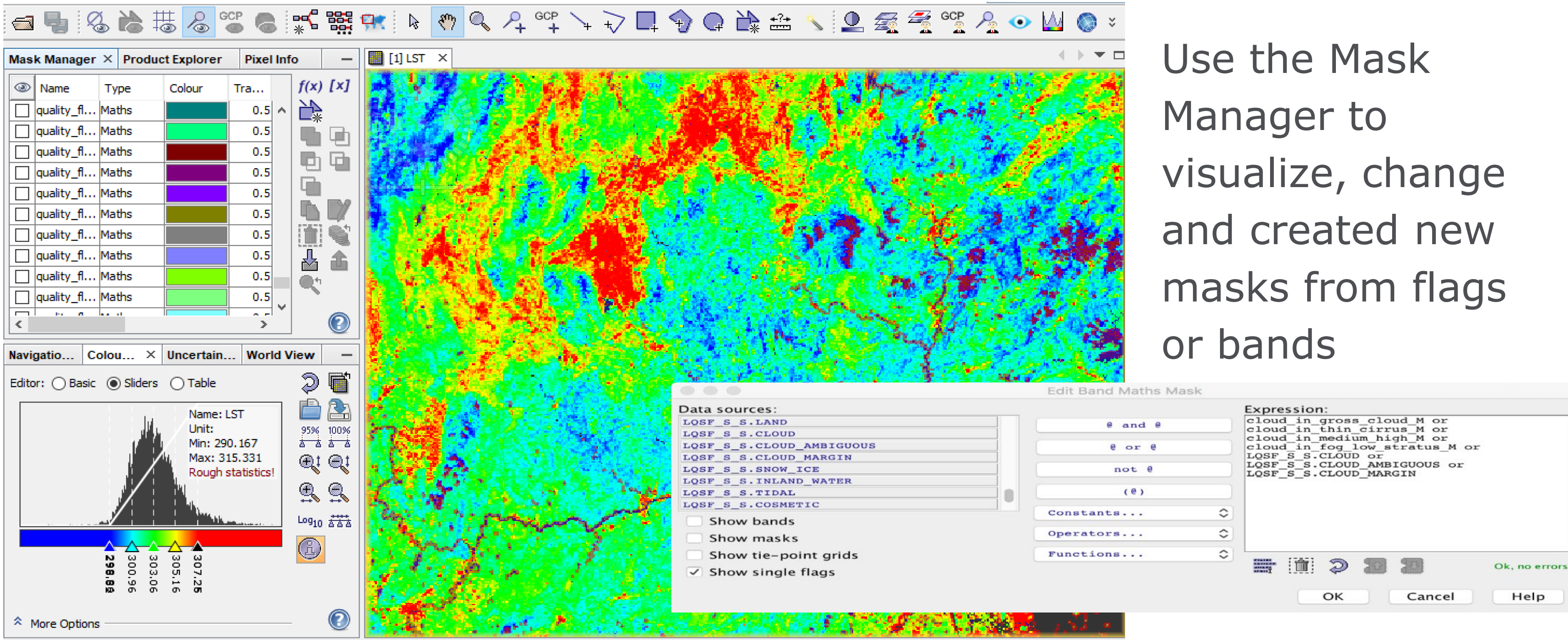



Mask Manager
Product Explorer
Pixel Info
S*_exception_bo_*_M
S*_exception_cn_*_M
S*_exception_co_*_M
S*_exception_in_*_M
S*_exception_io_*_M
F*_exception_in_*_M
F*_exception_io_*_M
*OGVI*_S*_S*
*OTCI*_S*_S*
quality_flags_land_M_S
quality_flags_coastline_M_S
quality_flags_fresh_inland_water_M_S
quality_flags_tidal_region_M_S
quality_flags_bright_M_S
Colour Manip...
Uncertainty Vi...
World View
1 : 1.1
0°
[1] S8_BT_in_M
[1] emis_diff
[1] emis_mean
[1] water_vapour

LST Algorithm in Band Maths



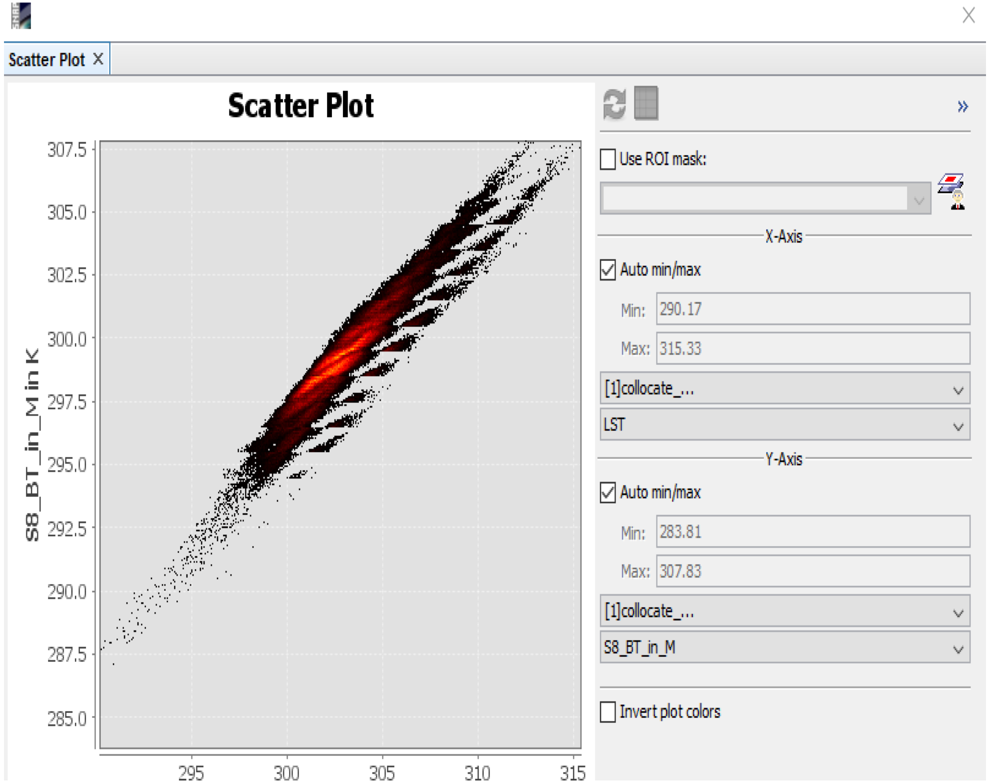
FLAGS AND MASKS



Use the Mask Manager to visualize, change and created new masks from flags or bands

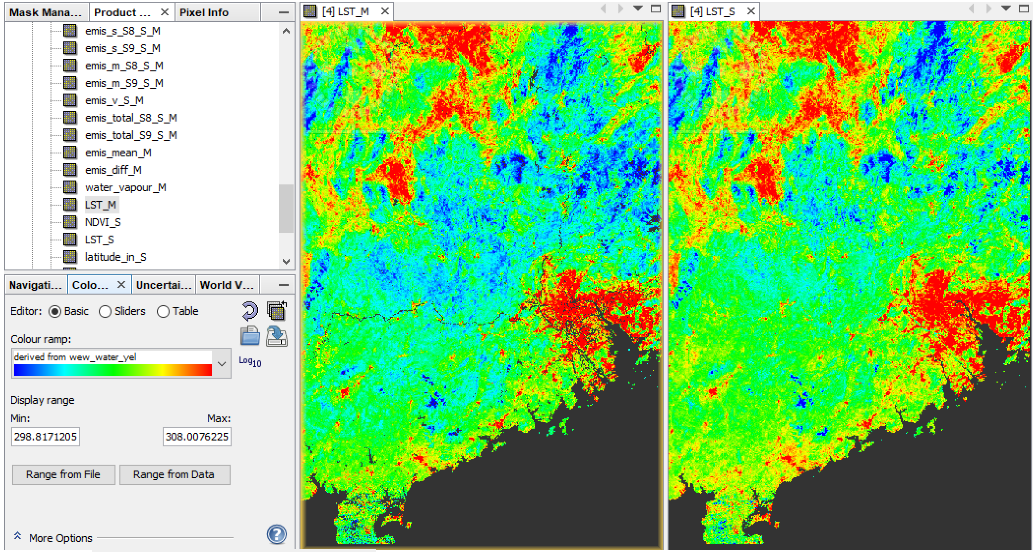
Plot of SW-LST vs BT bands

- Compare the split window calculated LST with other thermal bands using scatter plot(Analysis/Scatter Plot)

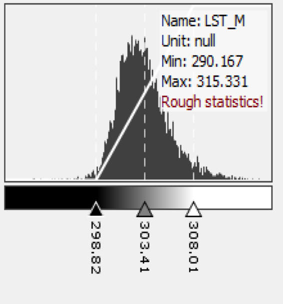


SW-LST vs SLST-L2

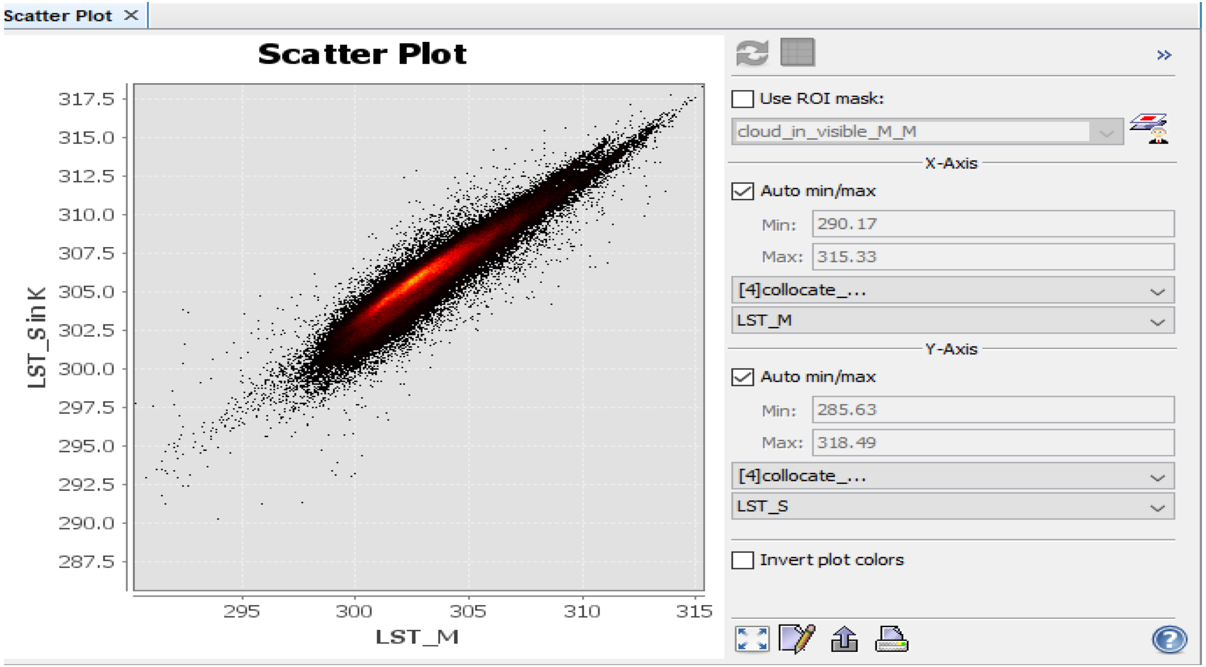
- Collocate the split window calculated LST with the SLSTR L2 LST product for comparison
  - You will use the SLSTR-L2 LST data provided: *S3B_SL_2_LST____20191001T023650_20191001T023950_20191001T042632_0179_030_260_2520_LN2_O_NR_003.SEN3*
  - Master file: SLSTR L2 LST
  - Slave file: SW based LST
- Display the two LST images, select a water, a soil and a vegetated pixel and fill in the table:



	LST_M	LST_S
Water		
Soil		
Vegetation		



Plot of Split Window LST vs. L2



For the students who like to do more...

- Calculate LST using the input data provided:
    I. At-sensor brightness temperatures:
        S3B Level-1
    II. Surface emissivities extracted from S3 Synergy product
        collocate_S3B_L1_emissivity_SY_20191001.dim
- Analysis the results obtained from both input surface emmisivities.
- Compare the results to S3/SLST Level 2 LST image.
- Understand how to use these data for estimating LST (SW algorithm).

[cont.] Batch Processing

Spatial and band subset for SLSLR L2 images