



Processing S3-A/B SLSTR data with SNAP

Lichun Wang

ESA–MOST China Dragon 4 Cooperation

2019 ADVANCED INTERNATIONAL TRAINING COURSE IN LAND REMOTE SENSING

中欧科技合作“龙计划”第四期 **2019年陆地遥感高级培训班**

18 to 23 November 2019 | Chongqing University, P.R. China



培训时间: 2019年11月18日-23日 主办方: 重庆大学



Processing Sentinel-3A/B SLSTR Data with SNAP

Prepared by Daniel Odermatt¹, Ana B. Ruescas^{2,3} and Juan C. Jimenez-Muñoz³
Updated by Lichun Wang

1 Odermatt & Brockmann (Germany) 2 Brockmann Consult (Germany) 3 Image Processing Laboratory (UV, Spain)

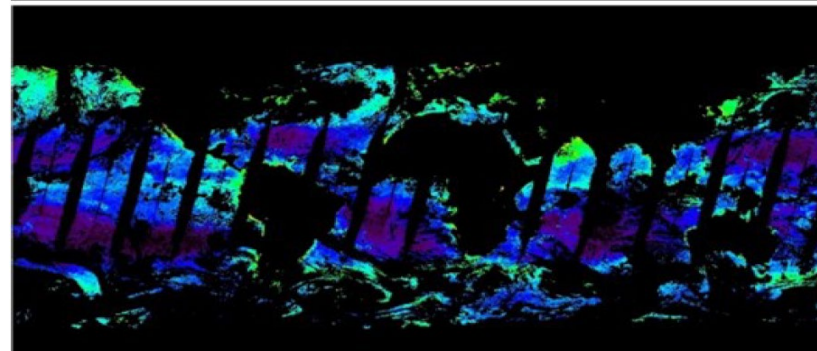
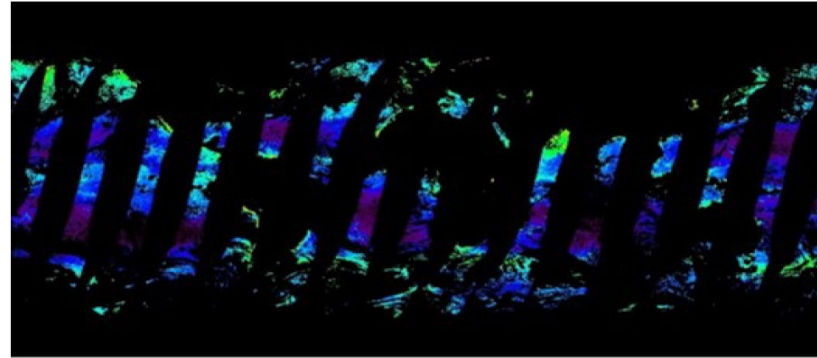


Sentinel-3 mission orbit

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°

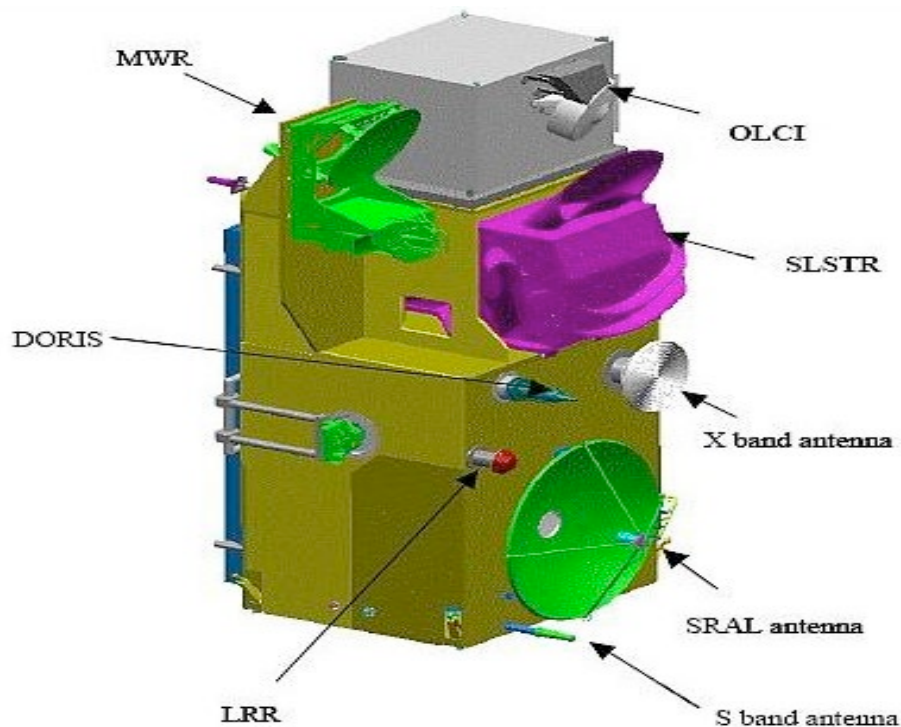
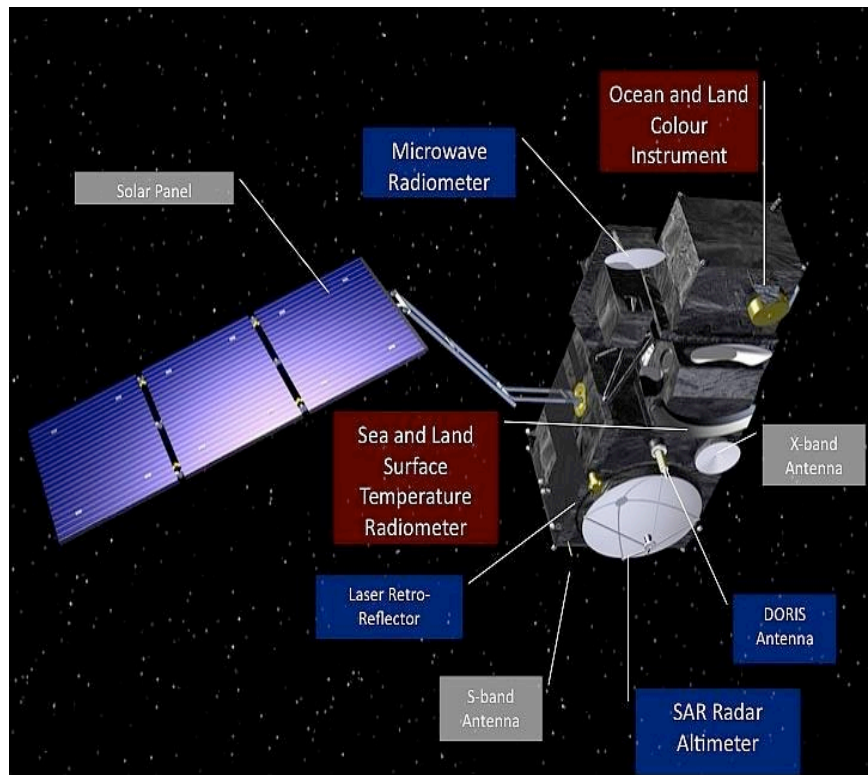
		Revisit at Equator	Revisit for latitude >30°	Specification
Ocean Colour (Sun-glitter free)	1 Satellite	< 3.8 days	< 2.8 days	< 2 days
	2 Satellite	< 1.9 days	< 1.4 days	
Land Colour	1 Satellite	< 2.2 days	< 1.8 days	< 2 days
	2 Satellite	< 1.1 day	< 0.9 day	
SLSTR dual view	1 Satellite	< 1.8 days	< 1.5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

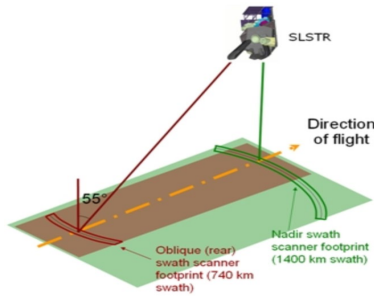
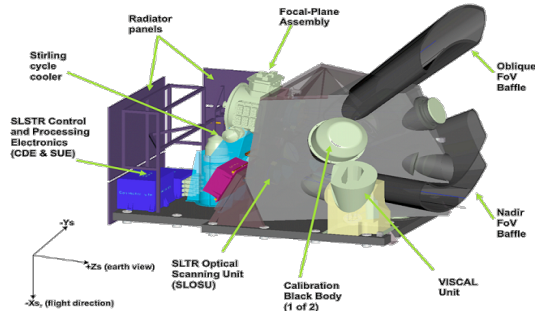


SLSTR images from the S-3A and S-3B orbit

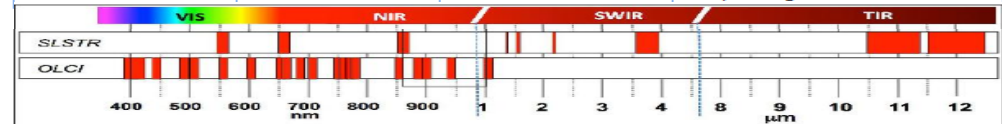
Sentinel-3 Sensors



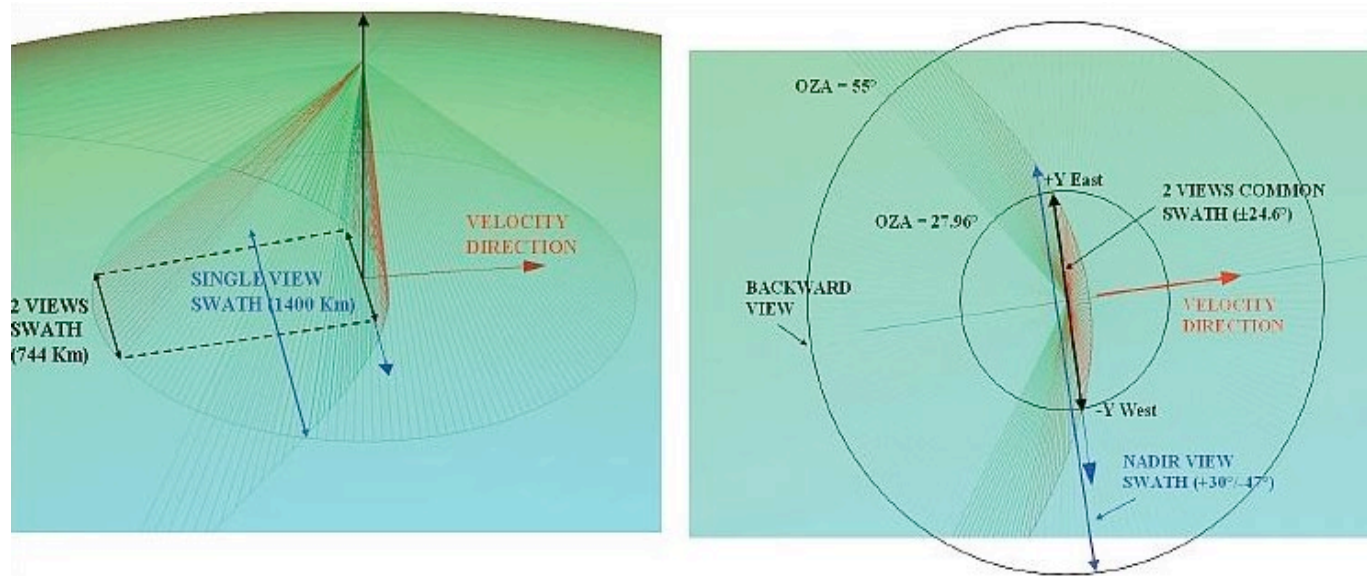
Data and Physical Units in SLSTR Products



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 ($T=270\text{K}$): TIR ($T=270\text{K}$): Fire-1 (<500 K): Fire-2 (<400 K):	Ne Δ T < 80 mK Ne Δ T < 50 mK Ne Δ T < 1K Ne Δ T < 0.5 K	Ne Δ T < 80 mK Ne Δ T < 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

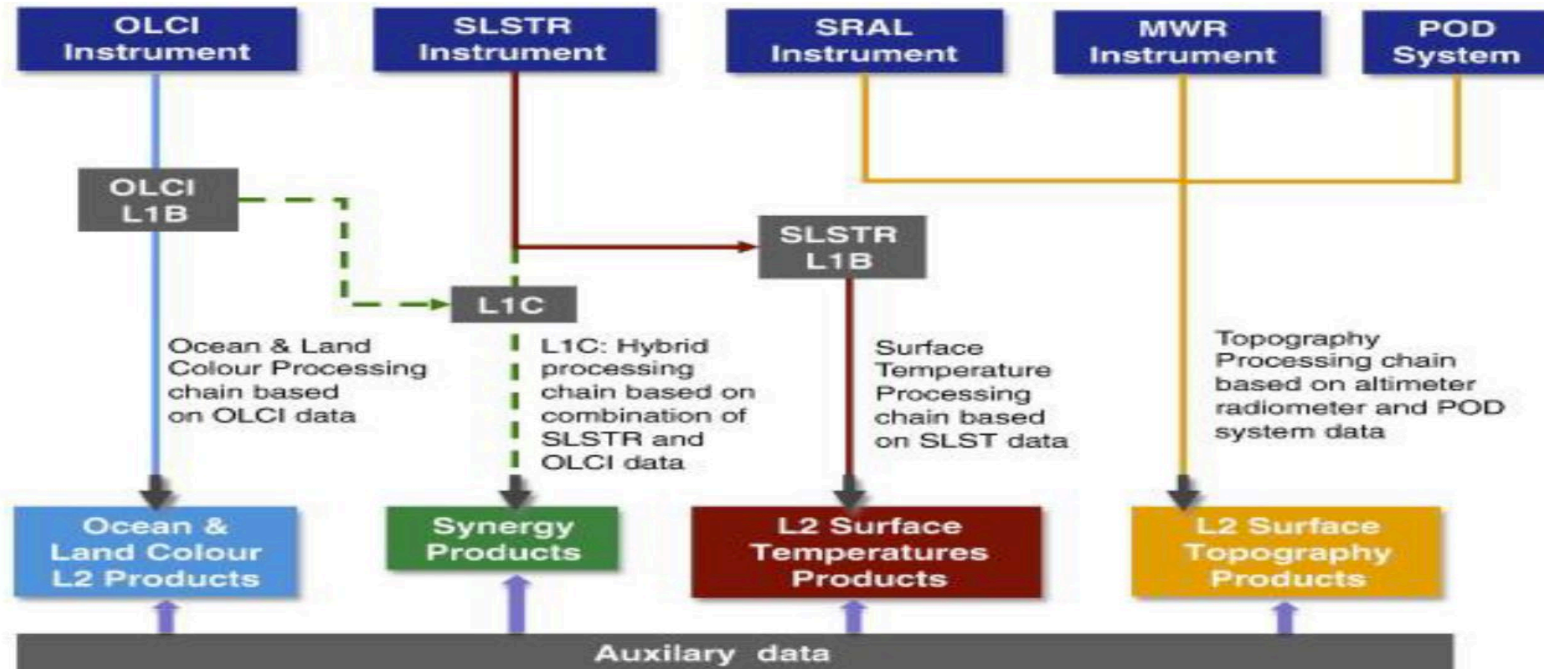


Sea and Land Surface Temperature Radiometer (SLSTR)



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

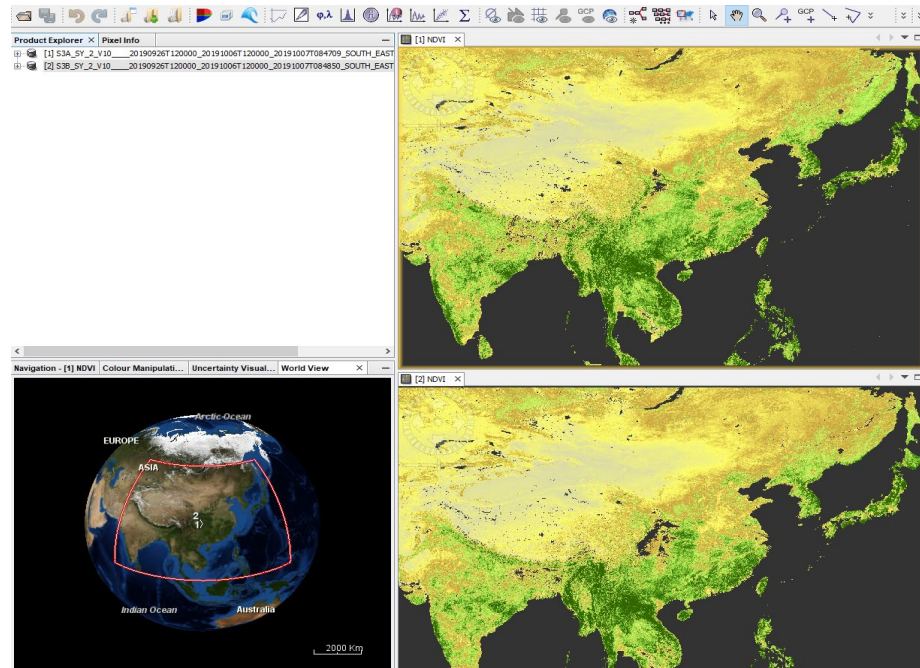
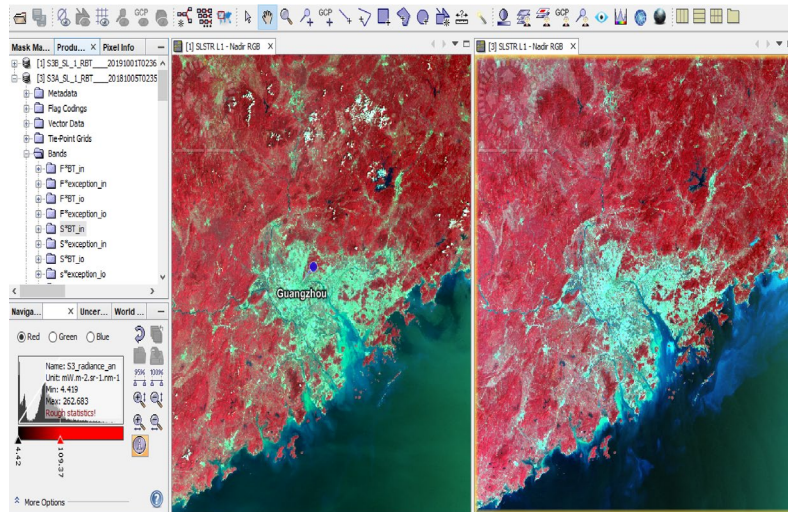
Sentinel-3 Data Processing Chains



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



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



- 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

$$T_S = T_i + c_1 (T_i - T_j) + c_2 (T_i - T_j)^2 + c_0 + (c_3 + c_4 W) (1 - \varepsilon) + (c_5 + c_6 W) \Delta\varepsilon \quad (1)$$

where T_s is the LST (in K), $T_{i,j}$ are at-sensor brightness temperatures (in K), W is the atmospheric water vapor content (in $\text{g}\cdot\text{cm}^{-2}$ or cm), ε is the mean LSE $0.5\cdot(\varepsilon_i + \varepsilon_j)$, and $\Delta\varepsilon$ 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>

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
Γ	Unitless	0.975	0.976
$\delta_{NE\Delta T}$	K	0.4	0.4
$\delta\epsilon$	K	1.2	1.2
δW	K	0.08	0.08
U_{total}	K	1.5	1.6

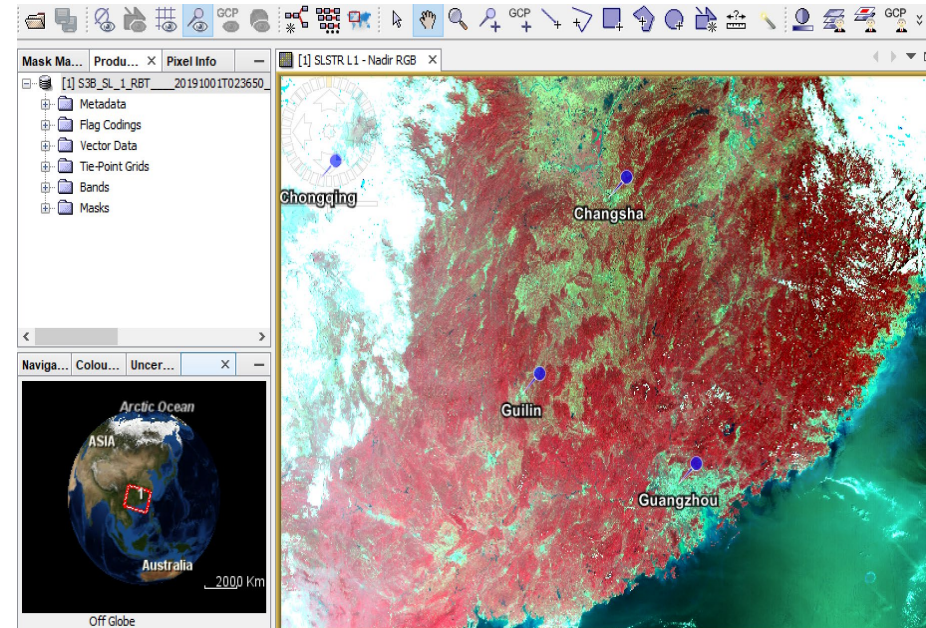
- Sentinel-3A/3B images acquired during September 2019 downloaded at <https://scihub.copernicus.eu/>
 - S3B_SL_1_RBT____20191001T023650_20191001T023950_20191002T070406_0179_03_0_260_2520_LN2_O_NT_003.SEN3
 - S3B_SL_2_LST____20191001T023650_20191001T023950_20191001T042632_0179_030_260_2520_LN2_O_NR_003.SEN3
 - S3A_SL_1_RBT____20190921T023515_20190921T023815_20190922T080924_0179_04_9_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:

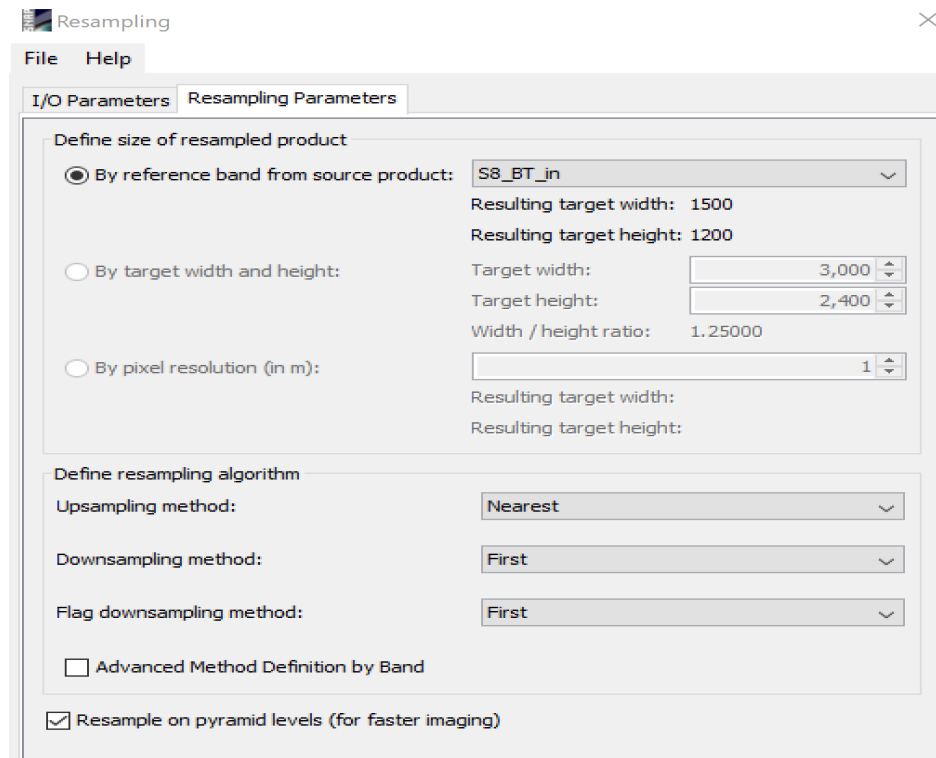


- Source product:

*S3B_SL_1_RBT_____20191001T0236
50_20191001T023950_20191002T0
70406_0179_030_260_2520_LN2_O
_NT_003.SEN3*

- Target product

*S3B_SL_1_RBT_____20191001T0236
50_20191001T023950_20191002T0
70406_0179_030_260_2520_LN2_O
_NT_003_resampled*



Creating spatial subset:



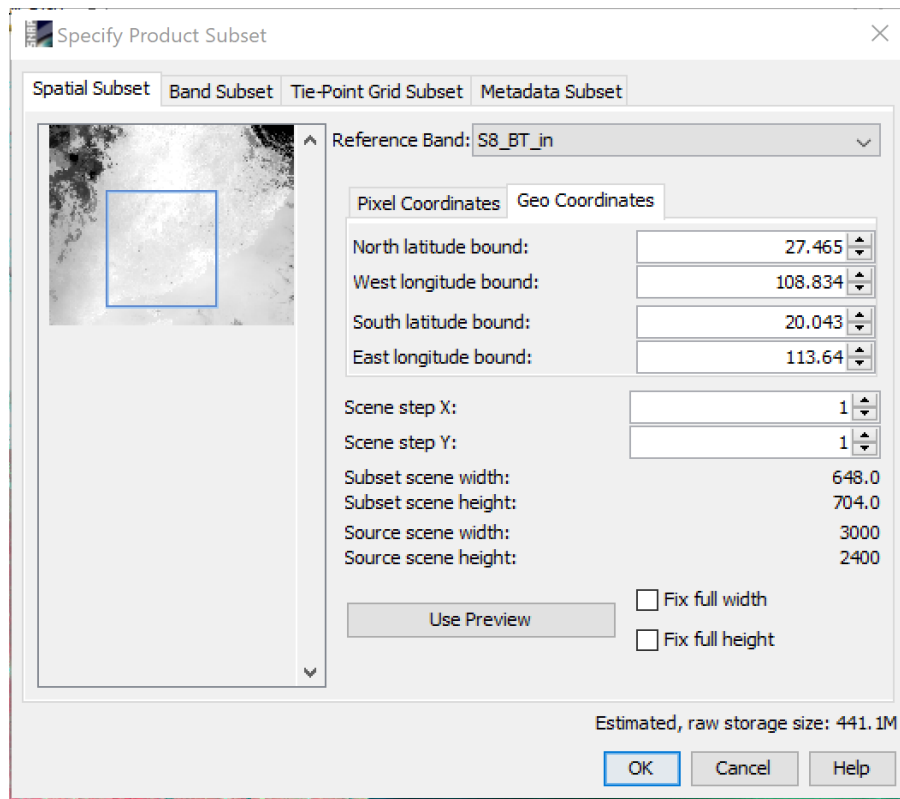
- Source product:

*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_____20191
001T023650_20191001T023950_20191
002T070406_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 geolocation:

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

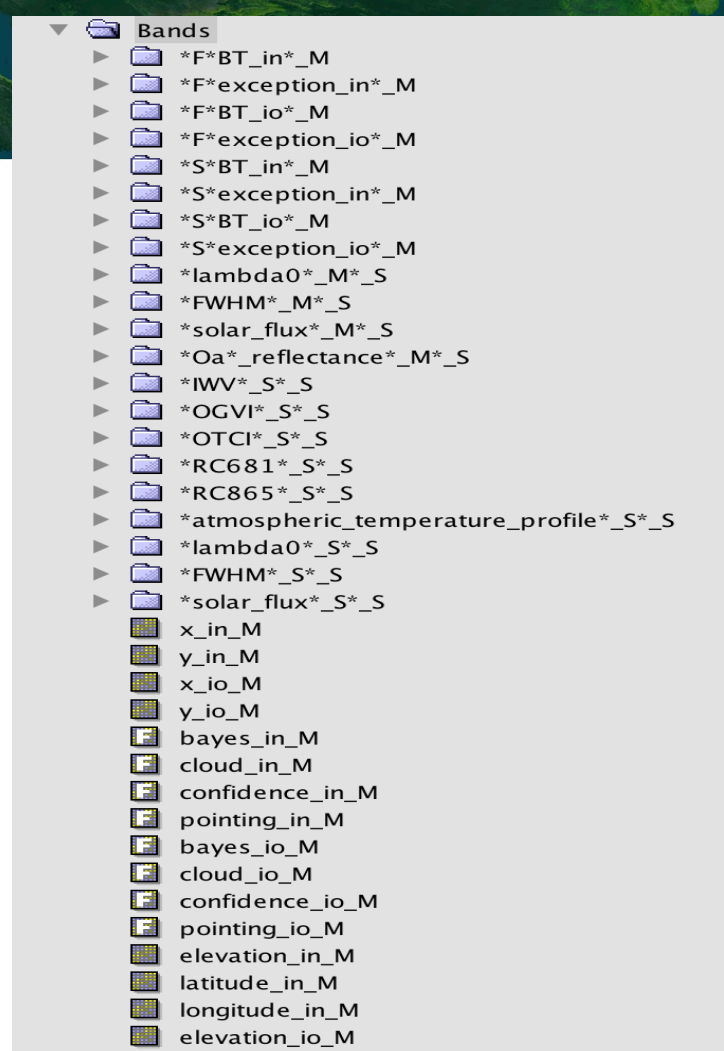
Slave file:

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

$$water_vapour = IWV_S_S / 10$$

Band Maths

Target product:
[1] collocate_S3B_L1_emissivity_20191001

Name: emis_mean

Description:

Unit:

Spectral wavelength: 0.0

Virtual (save expression only, don't store data)

Replace NaN and infinity results by NaN

Generate associated uncertainty band

Band maths expression:
(emis_total_S8_S + emis_total_S9_S) / 2

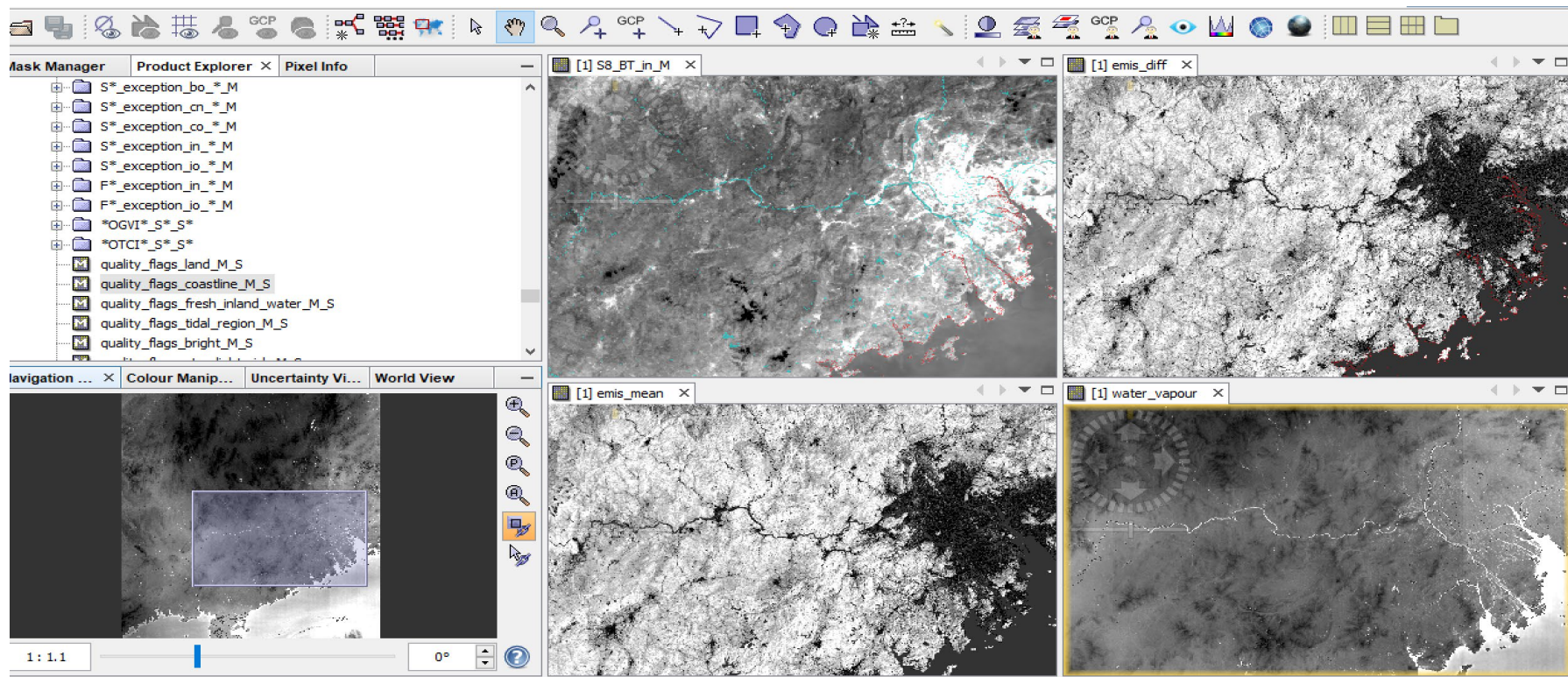
Load... Save... Edit Expression...

Expression:
(emis_total_S8_S + emis_total_S9_S) / 2

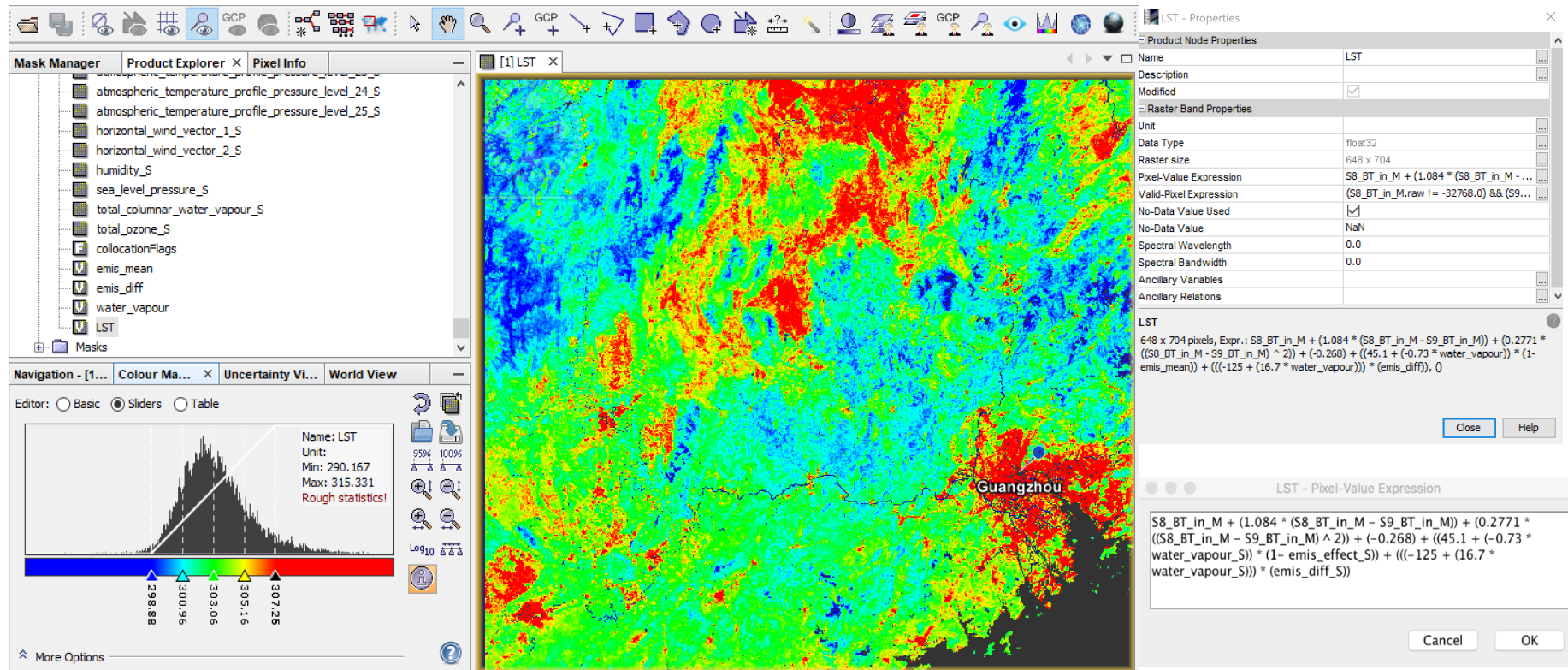
Constants... Operators... Functions...

OK Cancel Help





LST Algorithm in Band Maths



FLAGS AND MASKS



Mask Manager

Name	Type	Colour	Tra...
quality_fi...	Maths	[Green]	0.5
quality_fi...	Maths	[Red]	0.5
quality_fi...	Maths	[Purple]	0.5
quality_fi...	Maths	[Blue]	0.5
quality_fi...	Maths	[Yellow]	0.5
quality_fi...	Maths	[Cyan]	0.5
quality_fi...	Maths	[Magenta]	0.5
quality_fi...	Maths	[Black]	0.5
quality_fi...	Maths	[White]	0.5
quality_fi...	Maths	[Grey]	0.5
quality_fi...	Maths	[Light Blue]	0.5
quality_fi...	Maths	[Light Green]	0.5

Product Explorer

Pixel Info

[1] LST

Navigation... **Colou...** **Uncertain...** **World View**

Editor: Basic Sliders Table

Name: LST
Unit:
Min: 290.167
Max: 315.331
Rough statistics!

95% 100%

Log10

298.88 300.96 303.06 305.16 307.28

Edit Band Maths Mask

Data sources:

- LQSF_S_S.LAND
- LQSF_S_S.CLOUD
- LQSF_S_S.CLOUD_AMBIGUOUS
- LQSF_S_S.CLOUD_MARGIN
- LQSF_S_S.SNOW_ICE
- LQSF_S_S.INLAND_WATER
- LQSF_S_S.TIDAL
- LQSF_S_S.COSMETIC

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

Expression:

```
cloud in gross cloud M or  
cloud in thin Cirrus M or  
cloud in medium high M or  
cloud in fog_low_stratus M or  
LQSF_S_S.CLOUD or  
LQSF_S_S.CLOUD_AMBIGUOUS or  
LQSF_S_S.CLOUD_MARGIN
```

OK Cancel Help

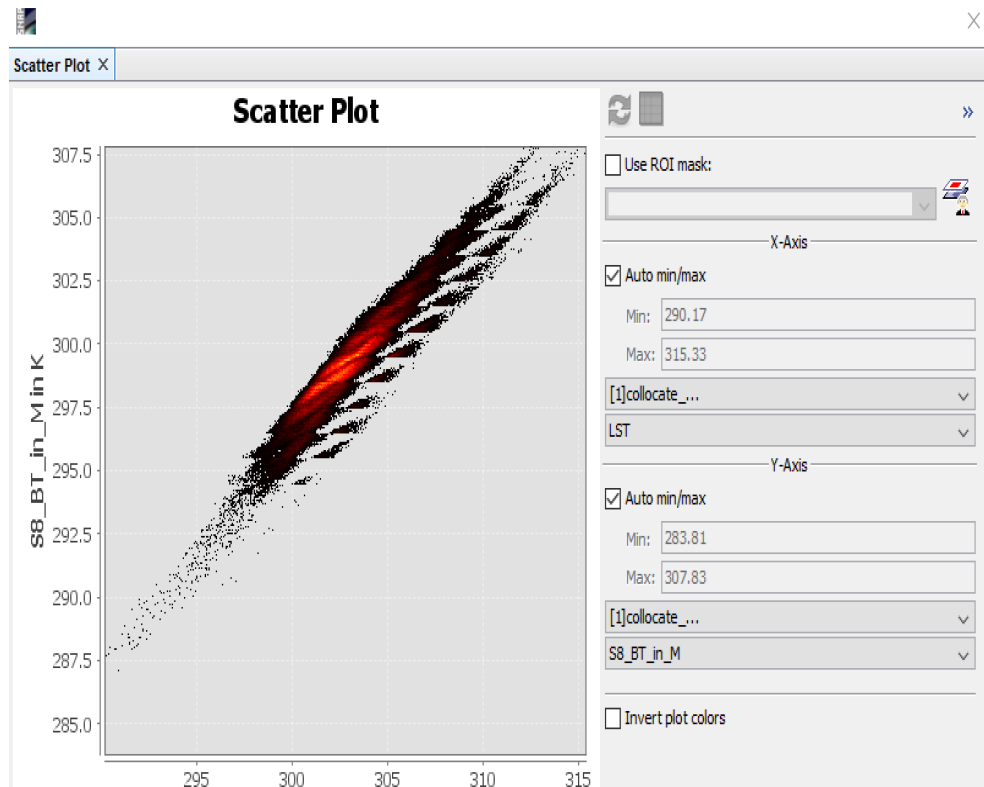
Use the Mask Manager to visualize, change and created new masks from flags or bands



Plot of SW-LST vs BT bands



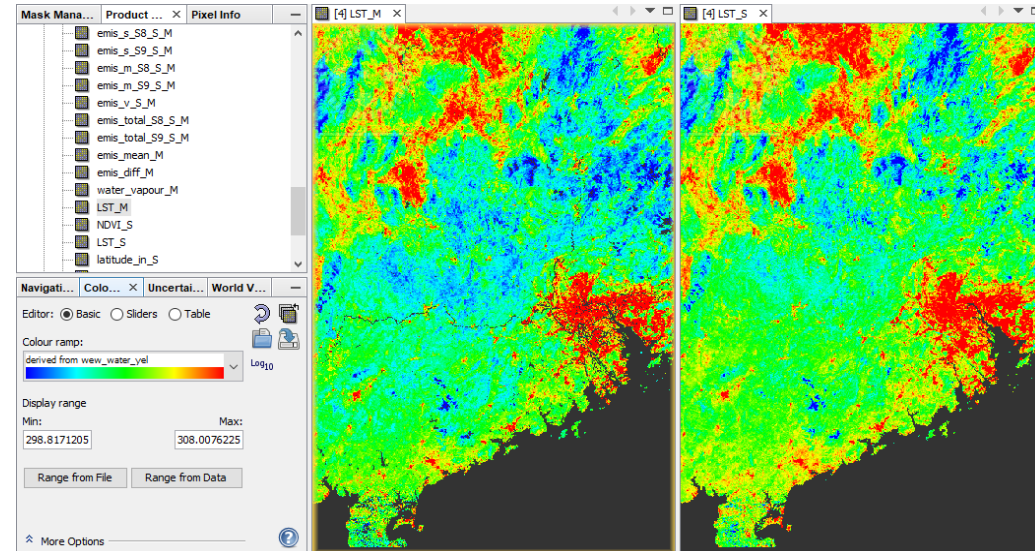
- Compare the split window calculated LST with other thermal bands using scatter plot(Analysis/Scatter Plot)



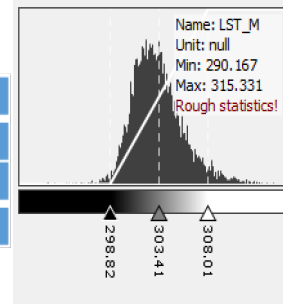
SW-LST vs SLST-L2



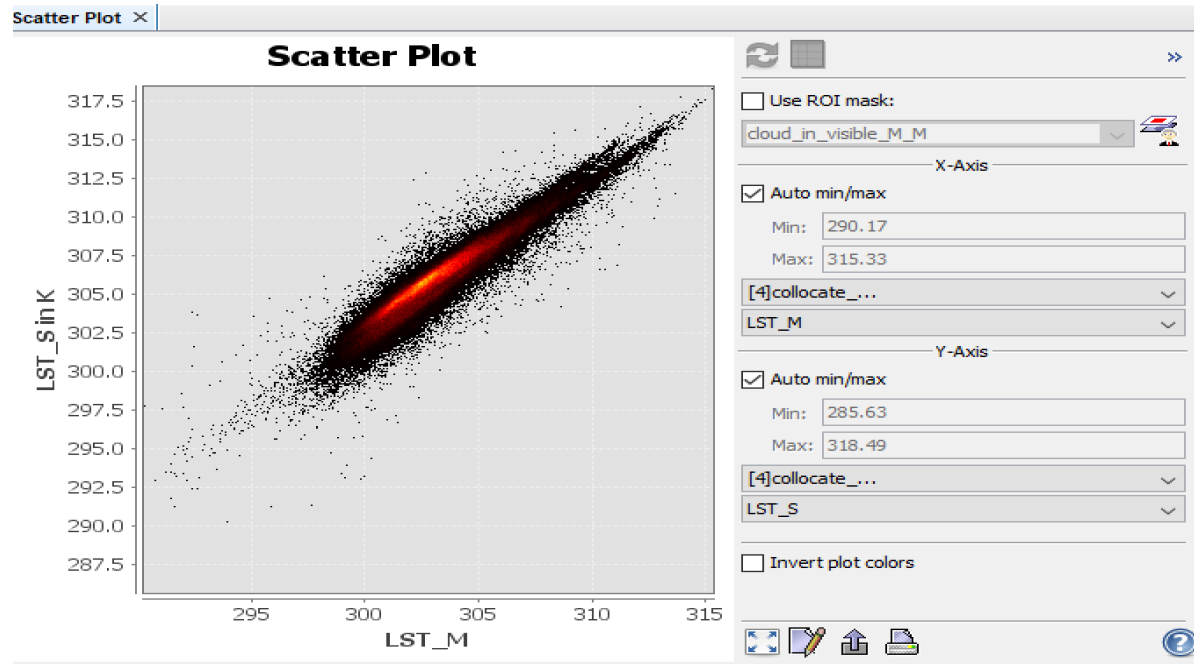
- Collocate the split window calculated LST with the SLSTR L2 LST product for comparison
 - You will use the SLSTR-L2 LST data provided:
S3B_SL_2_LST_20191001T023650_20191001T023950_20191001T042632_0179_030_260_2520_LN2_O_NR_003.SEN3
 - Master file: SLSTR L2 LST
 - Slave file: SW based LST
- Display 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
- Analyse the results obtained from both input surface emissivities.
- 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

Specify Product Subset

Spatial Subset Band Subset Tie-Point Grid Subset Metadata Subset

Reference Band: S8_BT_in

Pixel Coordinates Geo Coordinates

North latitude bound: 27.465

West longitude bound: 108.834

South latitude bound: 20.043

East longitude bound: 113.64

Scene step X: 1

Scene step Y: 1

Subset scene width: 648.0

Subset scene height: 704.0

Source scene width: 3000

Source scene height: 2400

Use Preview Fix full width Fix full height

Estimated, raw storage size: 441.1M

OK Cancel Help

Graph Builder: myGraph.xml

File Graphs

Read Subset Write

Source Bands: NDVI TC1WV biome fraction LST LST_uncertainty exception x_in

Copy Metadata

Pixel Coordinates Geographic Coordinates

Reference band: NDVI

20.6335544586 18164, 110.90668487548828 26.6517276763916, 110.90668487548828 26.6517276763916

Load Save Clear Note Help Run

Batch Processing: myGraph.xml

File Graphs

I/O Parameters Subset

File Name	Type	Acquisition	Track	Orbit
xfdumanifest.xml				
xfdumanifest.xml				

Target Folder

Save as: BEAM-DIMAP

Directory: D:\Dragon2019\Q20TP1-S3\thermal-LW\GraphBuilder

Skip existing target files Keep source product name

Run remote Load Graph Run Close Help

