



ESA-MOST Dragon 4 Cooperation

ADVANCED LAND REMOTE SENSING INTERNATIONAL TRAINING COURSE

“龙计划4”高级陆地遥感国际培训班

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Kunming, Yunnan Province, P.R. China

2017年11月20日—11月25日
云南师范大学，中国，昆明

Advanced Thermal Applications Using SNAP and Sentinel-3A SLSTR Data

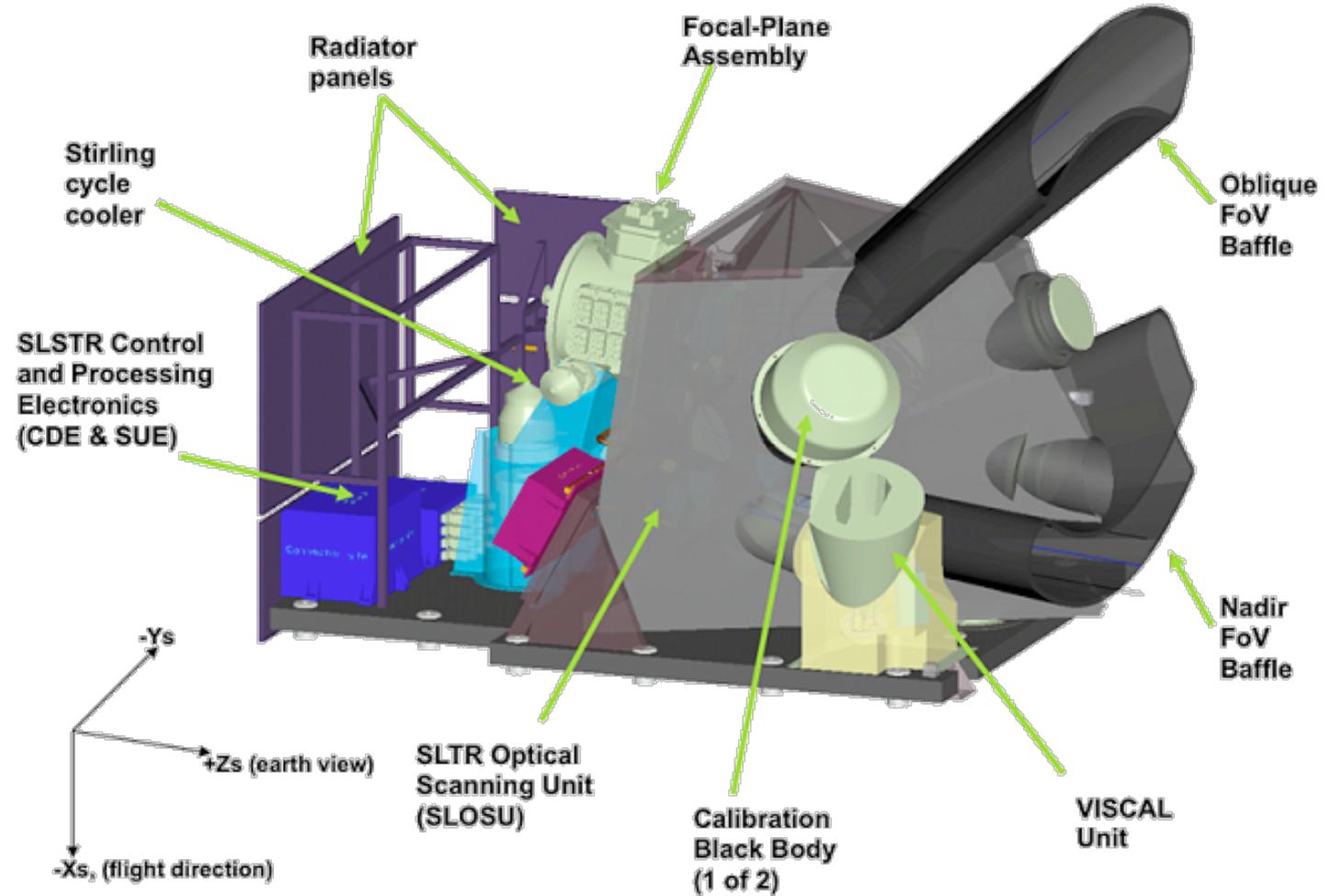
Prepared by Daniel Odermatt¹, Ana B. Ruescas^{2,3} and Juan C. Jimenez-Muñoz³

1 Odermatt & Brockmann (Germany)

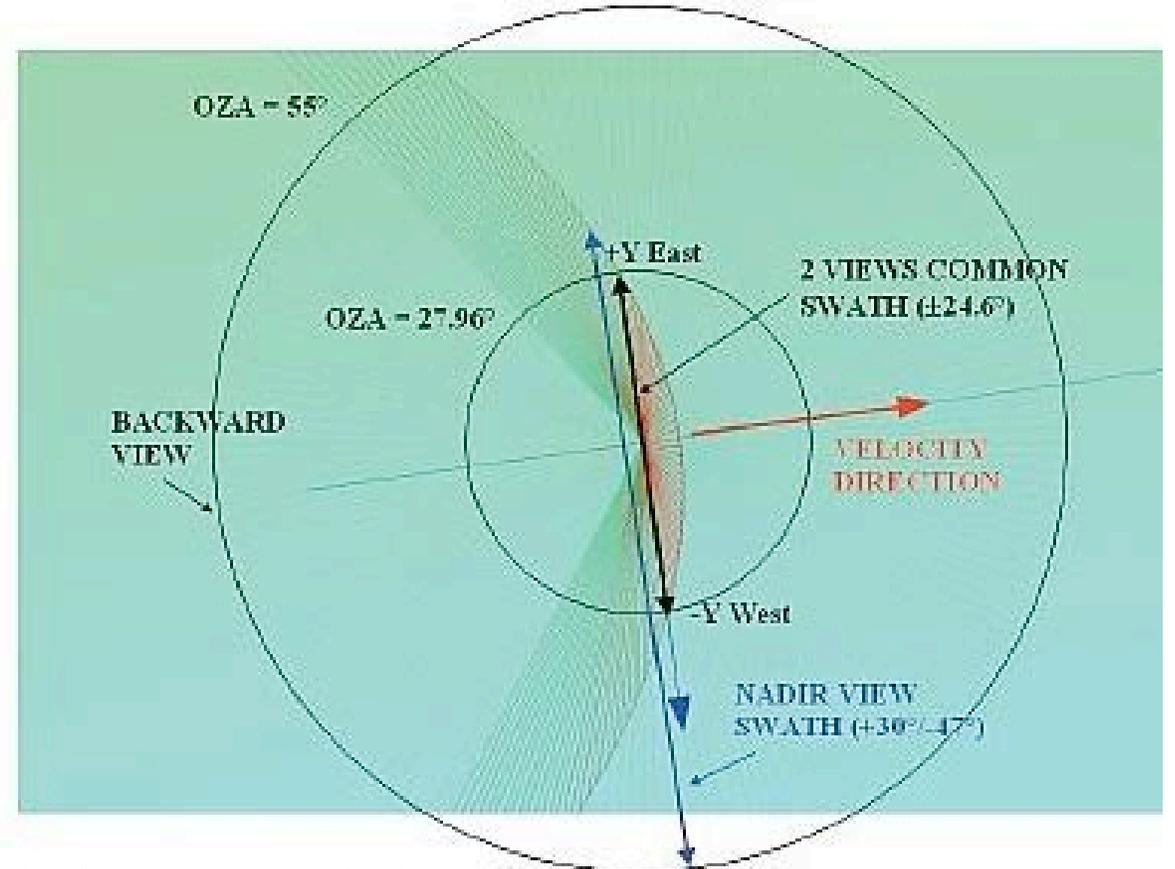
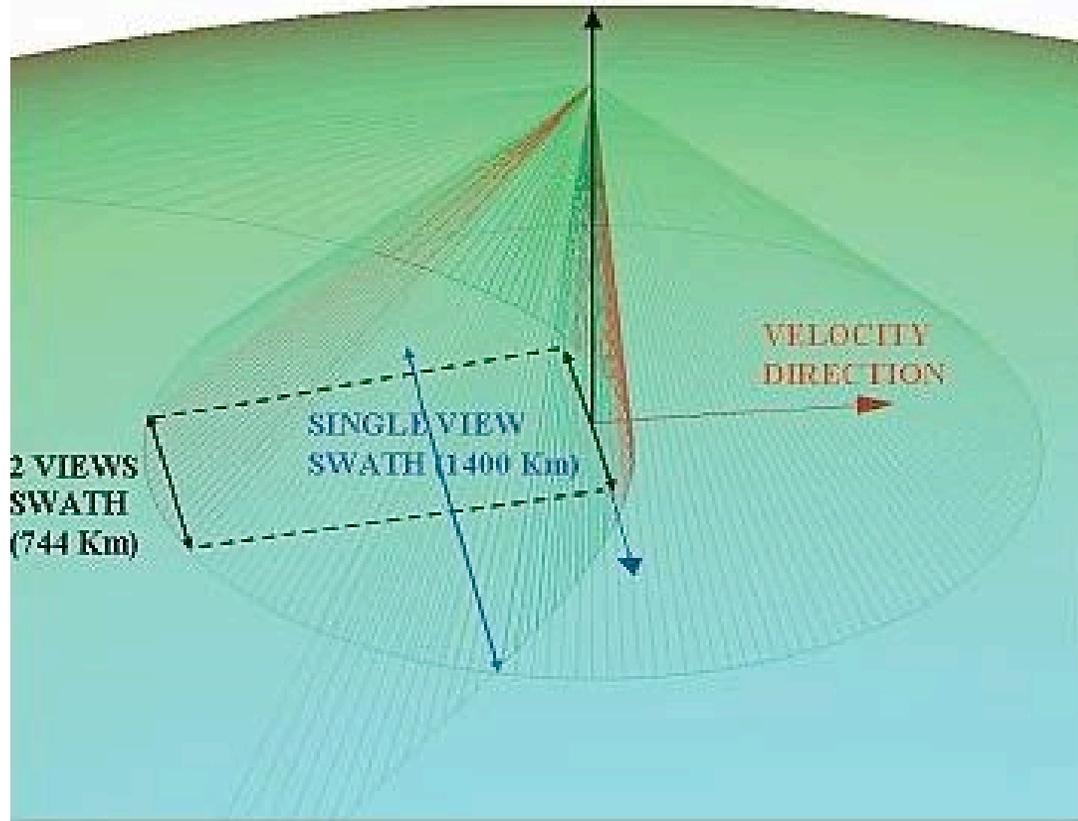
2 Brockmann Consult (Germany)

3 Image Processing Laboratory (UV, Spain)

Sea and Land Surface Temperature Radiometer (SLSTR)



Sea and Land Surface Temperature Radiometer (SLSTR)

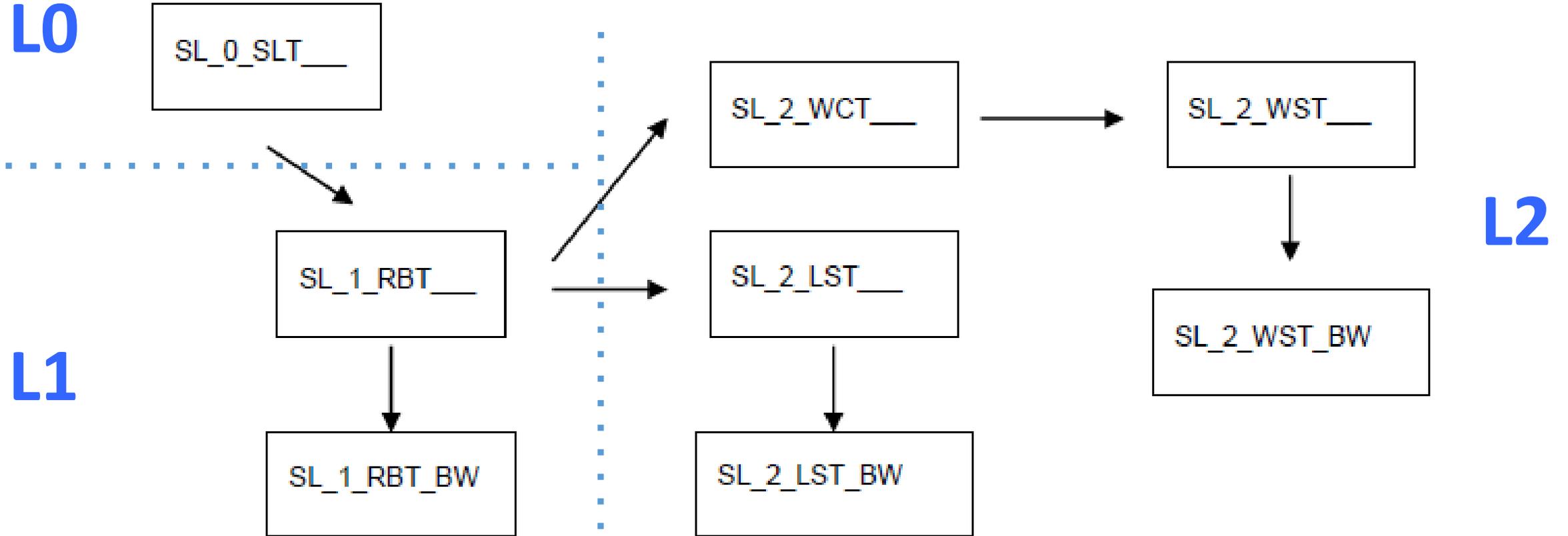


Backward inclined (left) and near nadir (right) views of the scanning mirror geometry

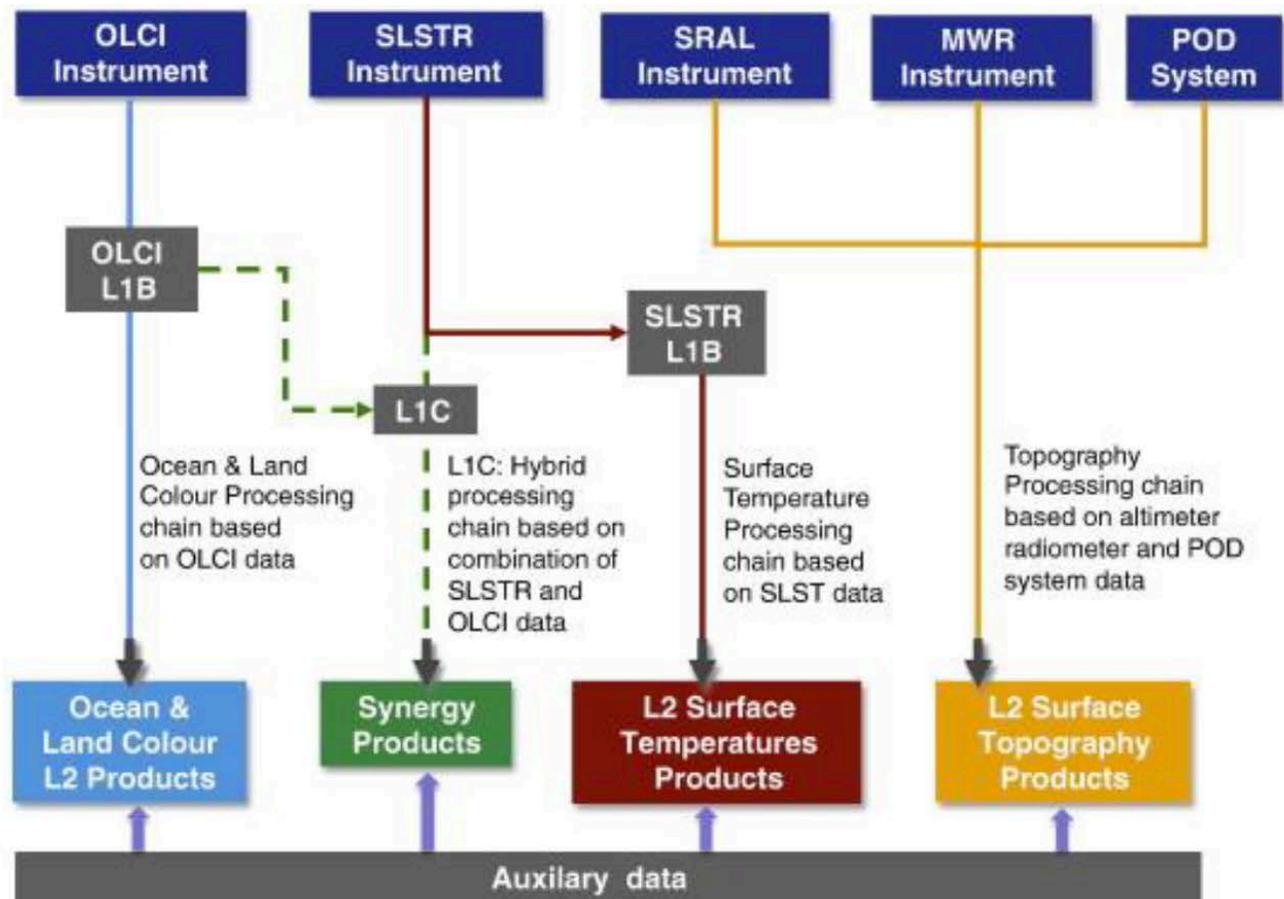
Data and Physical Units in SLSTR Products

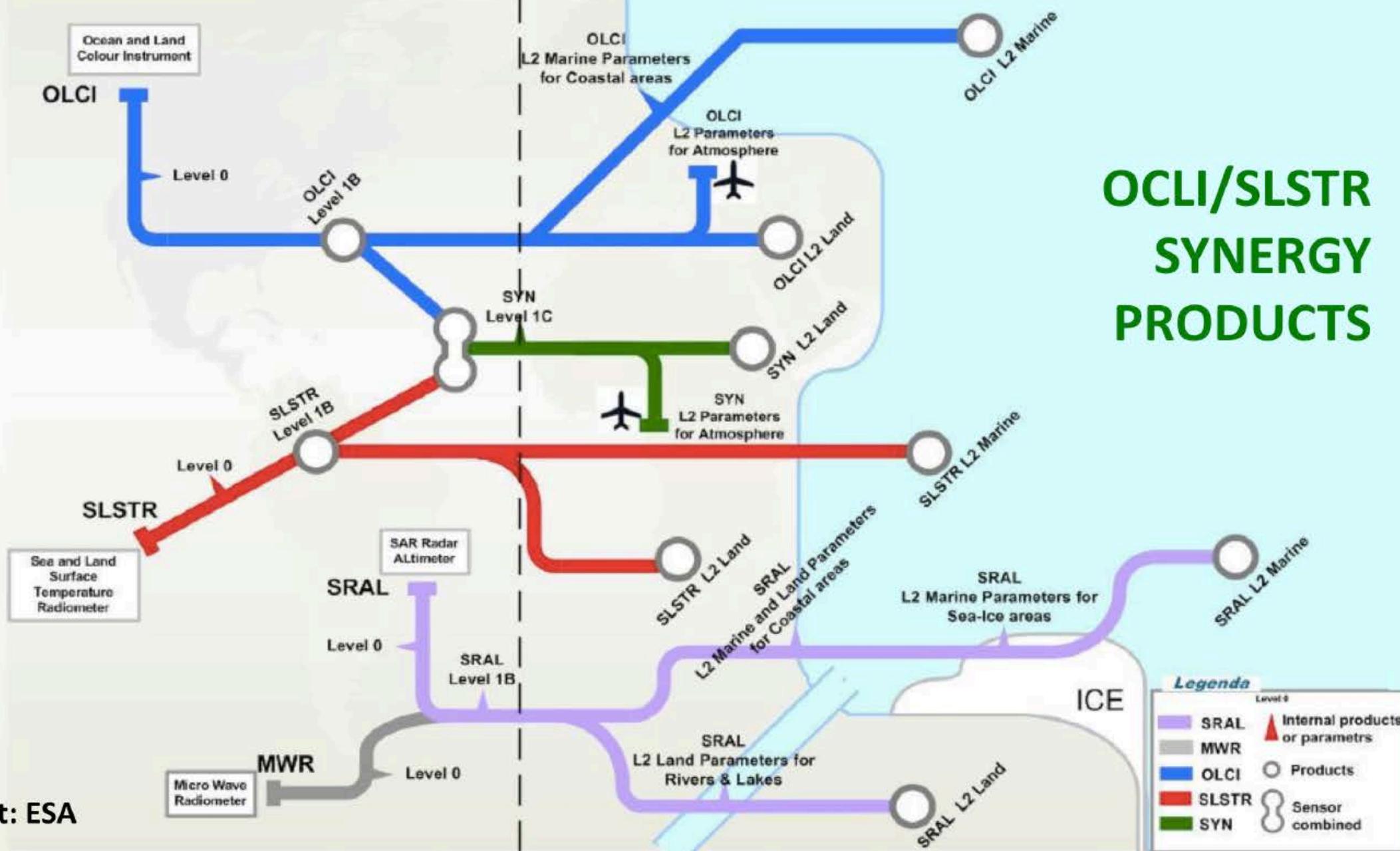
Performance	Parameters	SLSTR	AATSR & ATSR-1/2
Swaths	Nadir view	1 400 km	500 km
	Dual view	740 km	500 km
Global coverage revisit time	1 S/C (dual view)	1.9 days	7-14 days
		0.9 days	-
		1 day	7-14 days
		0.5 days	-
SSI at SSP (km)		0.5 km VIS-SWIR 1 km IR-fire	1 km
Spectral channels centre λ (μm)	VIS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

SLSTR Product Types



Sentinel-3 Data Processing Chains





Exercise Overview:

- Goal: To calculate Land Surface Temperatures using the thermal emissivity factors calculated in D2OT-P1
- 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
 - Band maths operations
 - Graph builder and batch processing
- Sentinel-3 user guide:
<https://sentinels.copernicus.eu/web/sentinel/user-guides/sentinel-3-olci>

Land surface temperature using a split-window algorithm

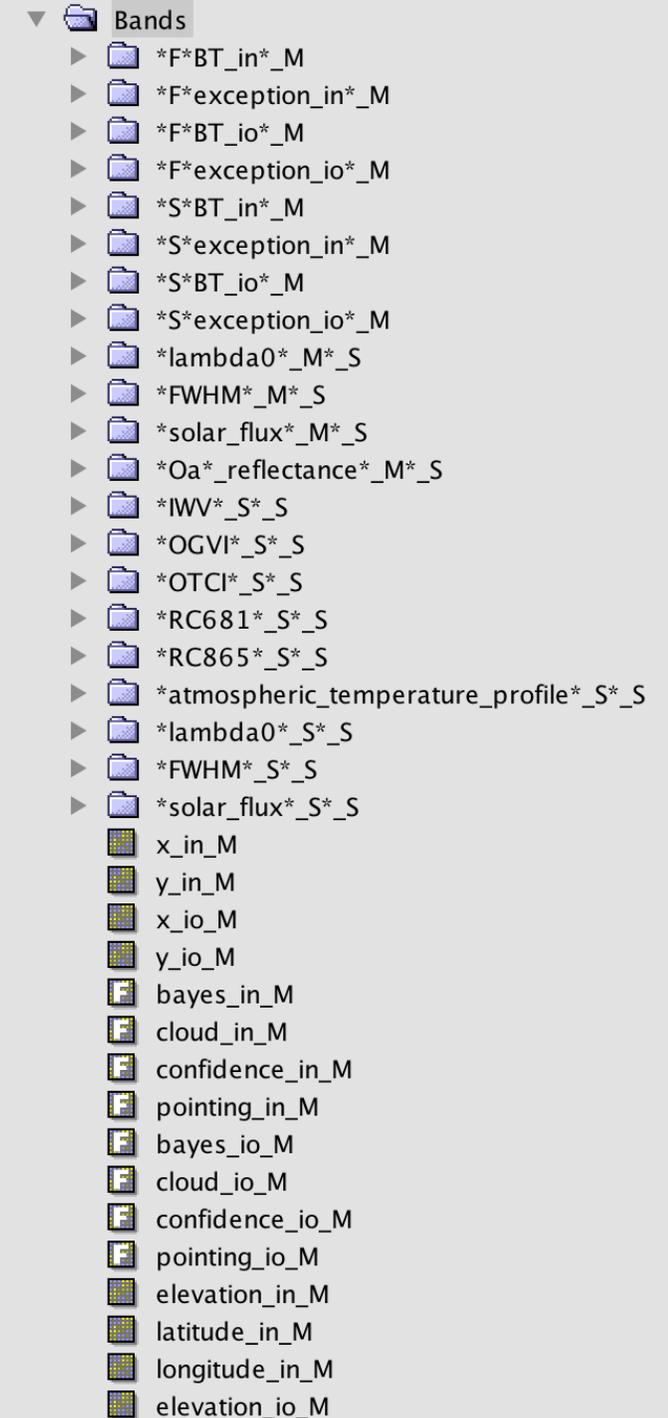
$$T_S = T_i + c_1 (T_i - T_j) + c_2 (T_i - T_j)^2 + c_0 + (c_3 + c_4 W) (1 - \varepsilon) + (c_5 + c_6 W) \Delta\varepsilon \quad (1)$$

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.

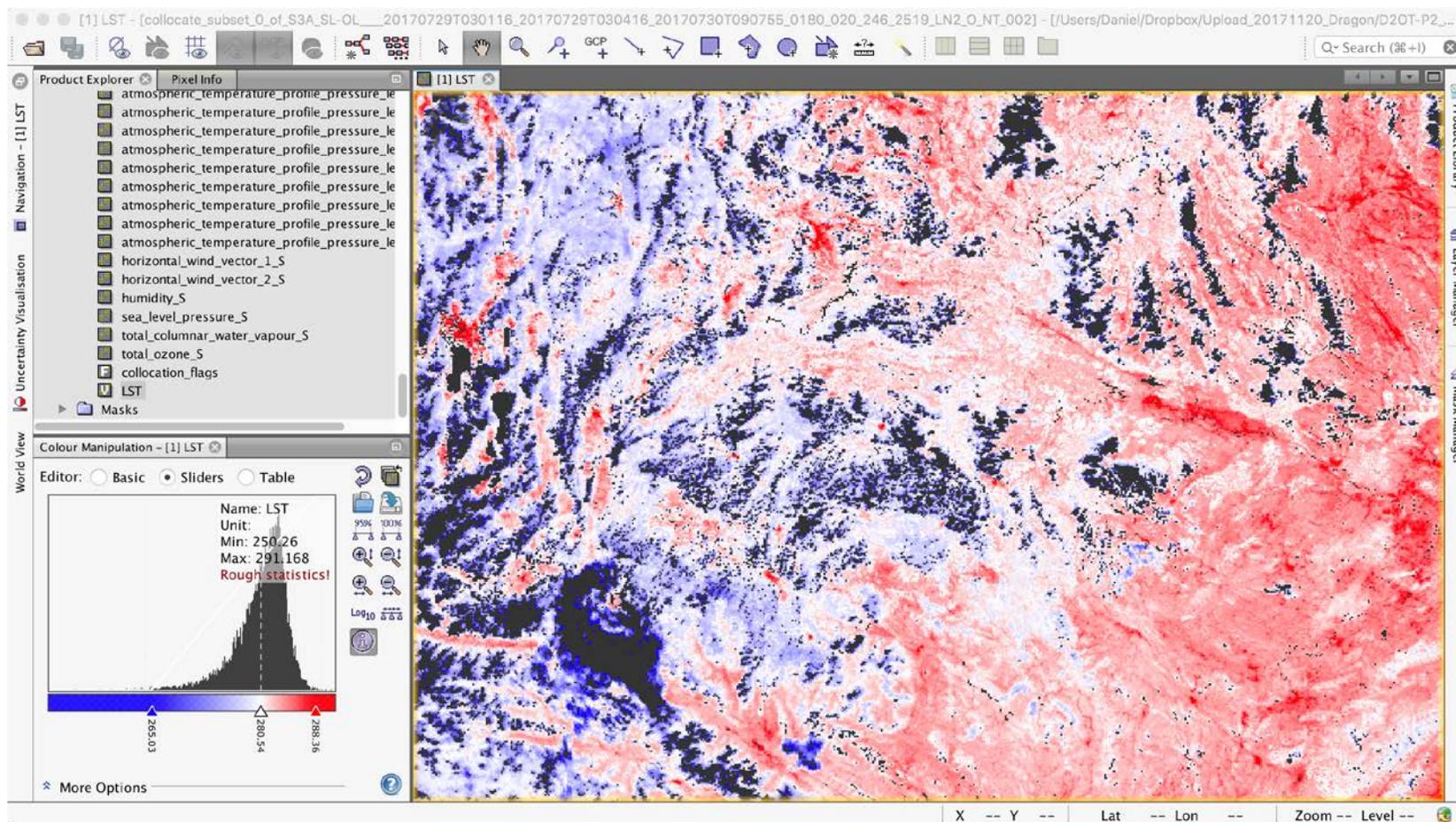
Synergistic use of MERIS and AATSR as a proxy for estimating Land Surface Temperature from Sentinel-3 data; Sobrino et al., 2016, RSE, <http://dx.doi.org/10.1016/j.rse.2016.03.035>

1. SLSTR-OLCI COLLOCATION

- Use the collocation tool to group the SLSTR and OLCI bands in one product with the same spatial resolution (1 km) and geo-location:
- *Raster/Geometric Operations/Collocation*
- Master file:
`subset_0_of_S3A_SL_1_RBT____20170729T030116_20170729T030416_20170730T090755_0180_020_246_2519_LN2_O_NT_002.dim`
- Slave file:
`emissivity_collocate_subset_0_of_S3A_OL_1_EFR____20170729T030116_20170729T030416_20170730T064809_0180_020_246_2519_LN1_O_NT_002_radrefl.dim`



2. LST Algorithm in Band Maths



LST - Properties

Product Node Properties	
Name	LST
Description	
Modified	<input checked="" type="checkbox"/>
Raster Band Properties	
Unit	
Data Type	float32
Raster size	649 x 827
Pixel-Value Expression	S8_BT_in_M + (1.084 * (S8_BT_in_M - ...
Valid-Pixel Expression	(S8_BT_in_M.raw != -32768.0) && (S9...
No-Data Value Used	<input checked="" type="checkbox"/>
No-Data Value	NaN
Spectral Wavelength	0.0
Spectral Bandwidth	0.0
Ancillary Variables	
Ancillary Relations	

LST
649 x 827 pixels, Expr.: S8_BT_in_M + (1.084 * (S8_BT_in_M - S9_BT_in_M)) + (0.2771 * ((S8_BT_in_M - S9_BT_in_M) ^ 2)) + (-0.268) + ((45.1 + (-0.73 * water_vapour_S)) * (1 - emis_effect_S)) + (((-125 + (16.7 * water_vapour_S))) * (emis_diff_S)), 0

Buttons: Help, Close

LST - Pixel-Value Expression

```
S8_BT_in_M + (1.084 * (S8_BT_in_M - S9_BT_in_M)) + (0.2771 * ((S8_BT_in_M - S9_BT_in_M) ^ 2)) + (-0.268) + ((45.1 + (-0.73 * water_vapour_S)) * (1 - emis_effect_S)) + (((-125 + (16.7 * water_vapour_S))) * (emis_diff_S))
```

Buttons: Cancel, OK

3. FLAGS AND MASKS

The screenshot shows the ENVI software interface. The main window displays a satellite image with a mask overlay. The 'Mask Manager' panel on the left lists various flags and masks, with 'clouds' checked. The 'Edit Band Maths Mask' dialog box is open, showing a list of data sources and an expression for creating a mask from cloud-related flags.

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

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
```

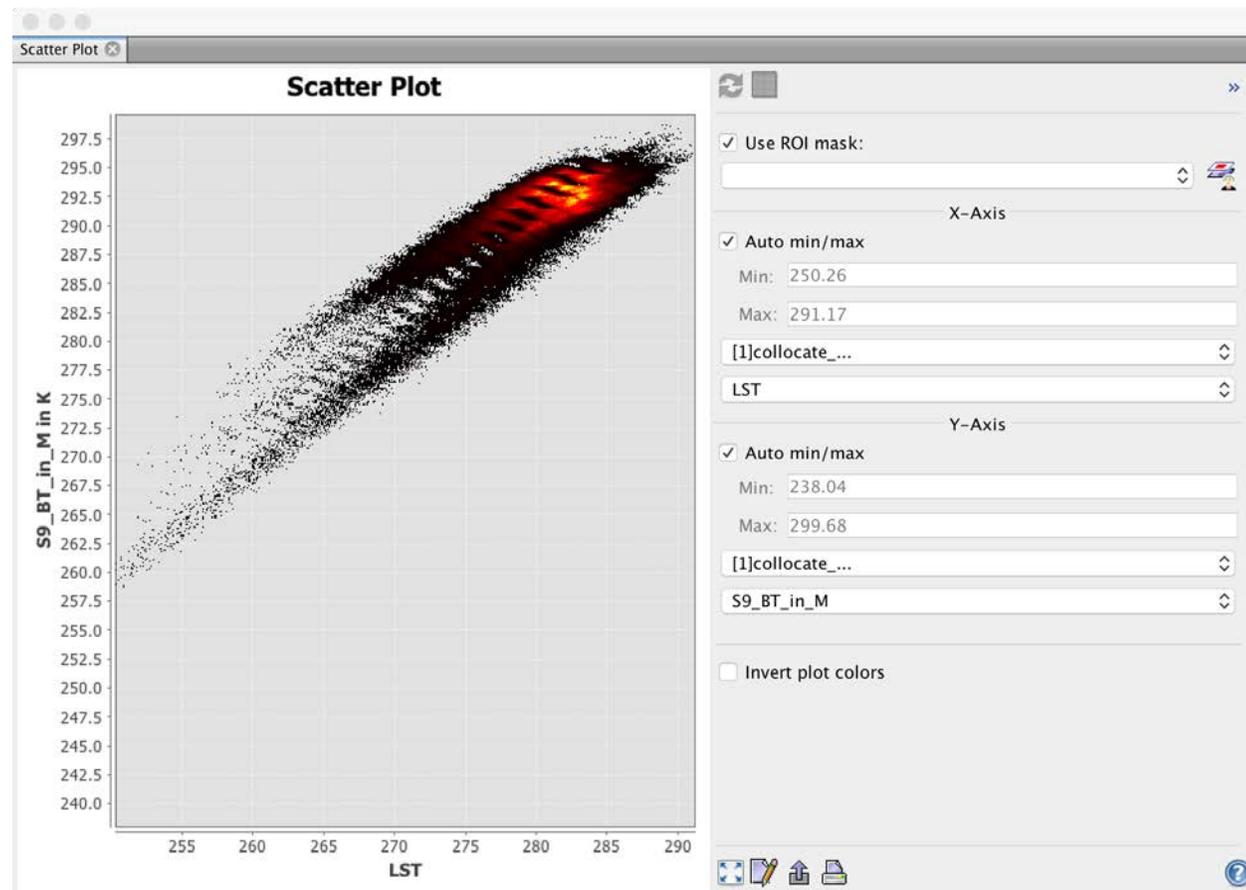
Buttons: @ and @, @ or @, not @, (@), Constants..., Operators..., Functions..., Show bands, Show masks, Show tie-point grids, Show single flags, OK, Cancel, Help.

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

4. Scatter Plot Split Window LST vs. L2

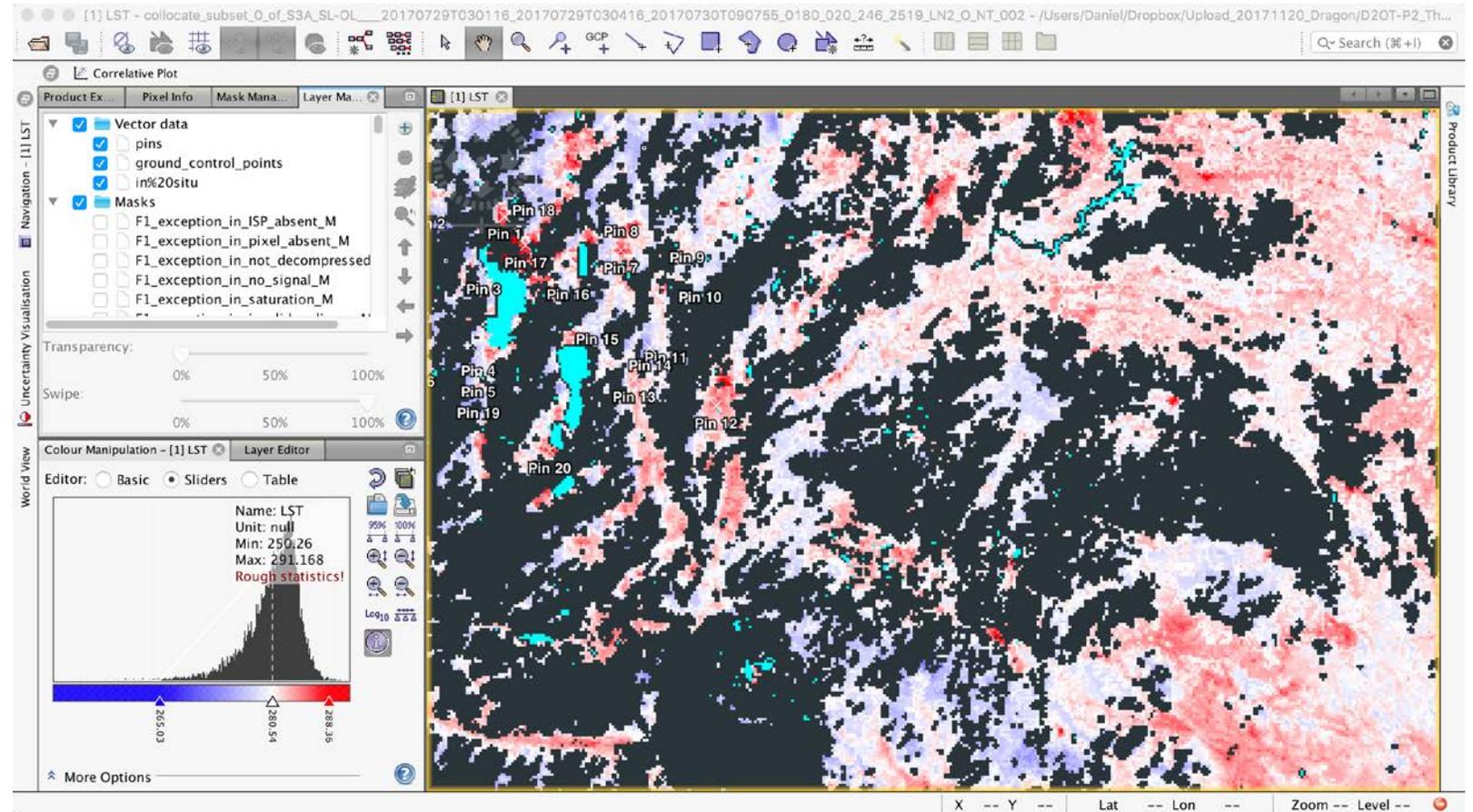
- Compare the split window calculated LST with other thermal bands (Analysis/Scatter Plot)

- [Product error?] Try to collocate the split window calculated LST with the SLSTR L2 product for comparison (S3A_SL_2_LST____20170729T030116_20170729T030416_20170729T050111_0180_020_246_2519_SVL_O_NR_002.SEN3)

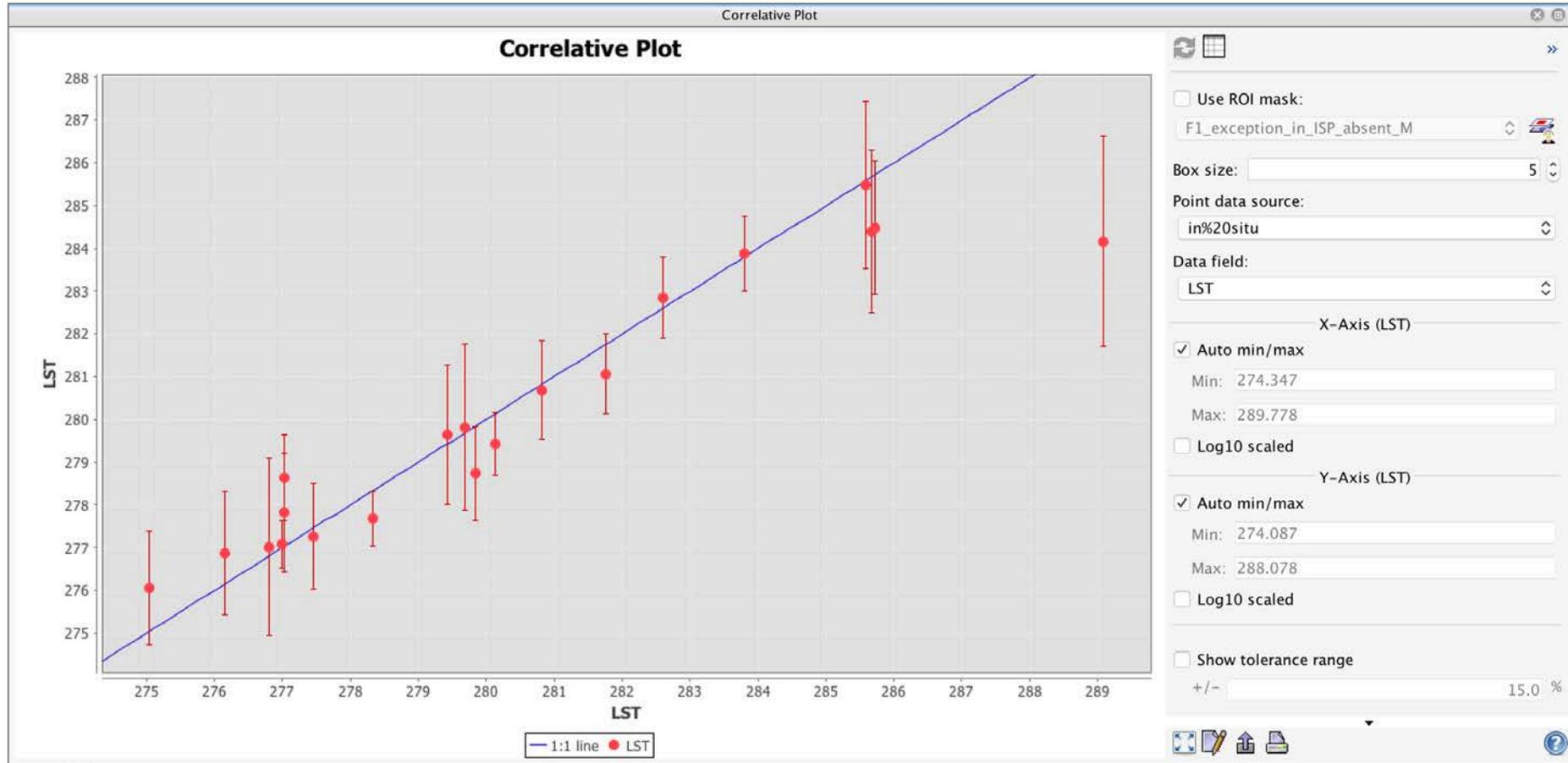


5. Import a Shapefile with in situ data

- Use the dialogue *File/Import/Vector data/ESRI shapefile* to open the shapefile *text/in situ.shp* with in situ data
- Check the Vector Data list in the *Layer Manager*
- Select *Analysis/Correlative Plot*



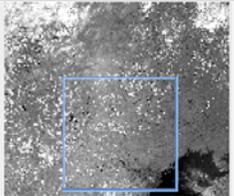
6. Make a Correlation Plot



7. [cont.] Batch Processing

Specify Product Subset

Spatial Subset | Band Subset | Tie-Point Grid Subset | Metadata Subset



Pixel Coordinates | Geo Coordinates

North latitude bound: 27.014

West longitude bound: 102.724

South latitude bound: 19.585

East longitude bound: 107.51

Scene step X: 1

Scene step Y: 1

Subset scene width: 2400.0

Subset scene height: 2400.0

Source scene width: 4865

Source scene height: 4091

Use Preview Fix full width Fix full height

Estimated, raw storage size: 473.0M

OK Cancel Help

Graph Builder : subset.xml

File Graphs



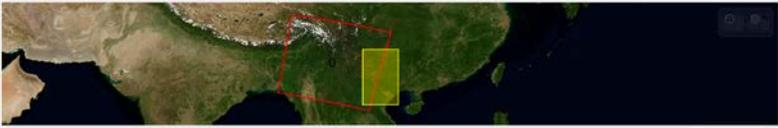
Read Subset Write

Source Bands:

- Oa01_radiance
- Oa02_radiance
- Oa03_radiance
- Oa04_radiance
- Oa05_radiance
- Oa06_radiance
- Oa07_radiance
- Oa08_radiance

Copy Metadata

Pixel Coordinates Geographic Coordinates



27.013999938964844, 102.7239990234375 19.584999084472656, 102.7239990234375 19.584999084472656)) Update

Load Save Clear Note Help Run

Batch Processing : subset.xml

File Graphs

I/O Parameters Subset

File Name	Type	Acquisiti...	Track	Orbit
S3A_OL_1_EFR__20170728T0327...	OL_1_...	28Jul2017	99999	99999
S3A_OL_1_EFR__20170801T0323...	OL_1_...	01Aug2...	99999	99999
S3A_OL_1_EFR__20170802T0257...	OL_1_...	02Aug2...	99999	99999

3 Products

Target Folder

Save as: BEAM-DIMAP

Directory: 20171120_Dragon/D2OT-P1_Optical/products exercise/products exercise

Skip existing target files Keep source product name

Load Graph Run Close Help