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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云南师范大学，中国，昆明

Advanced Hyperspectral Applications Using SNAP and Sentinel-3A OLCI Data

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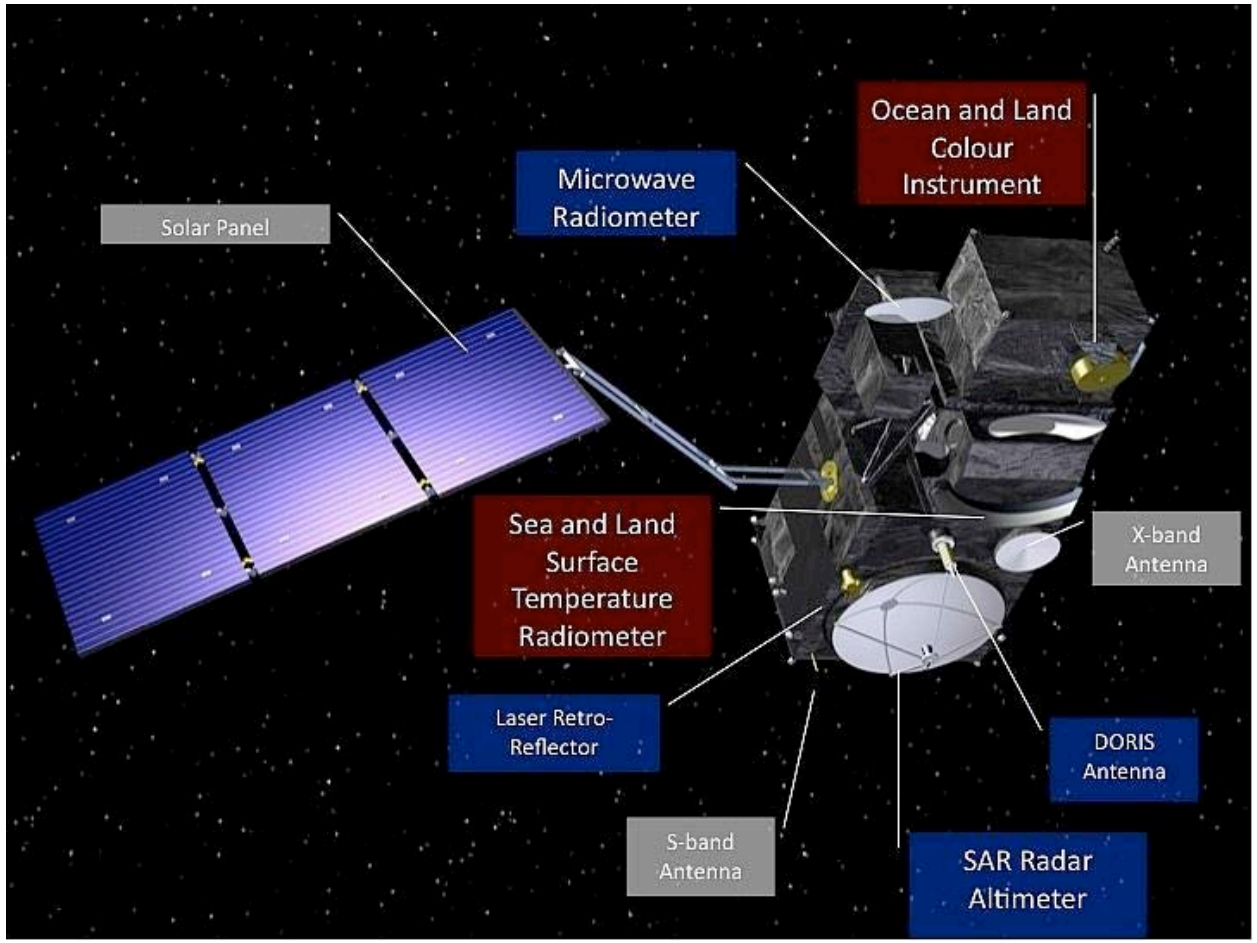
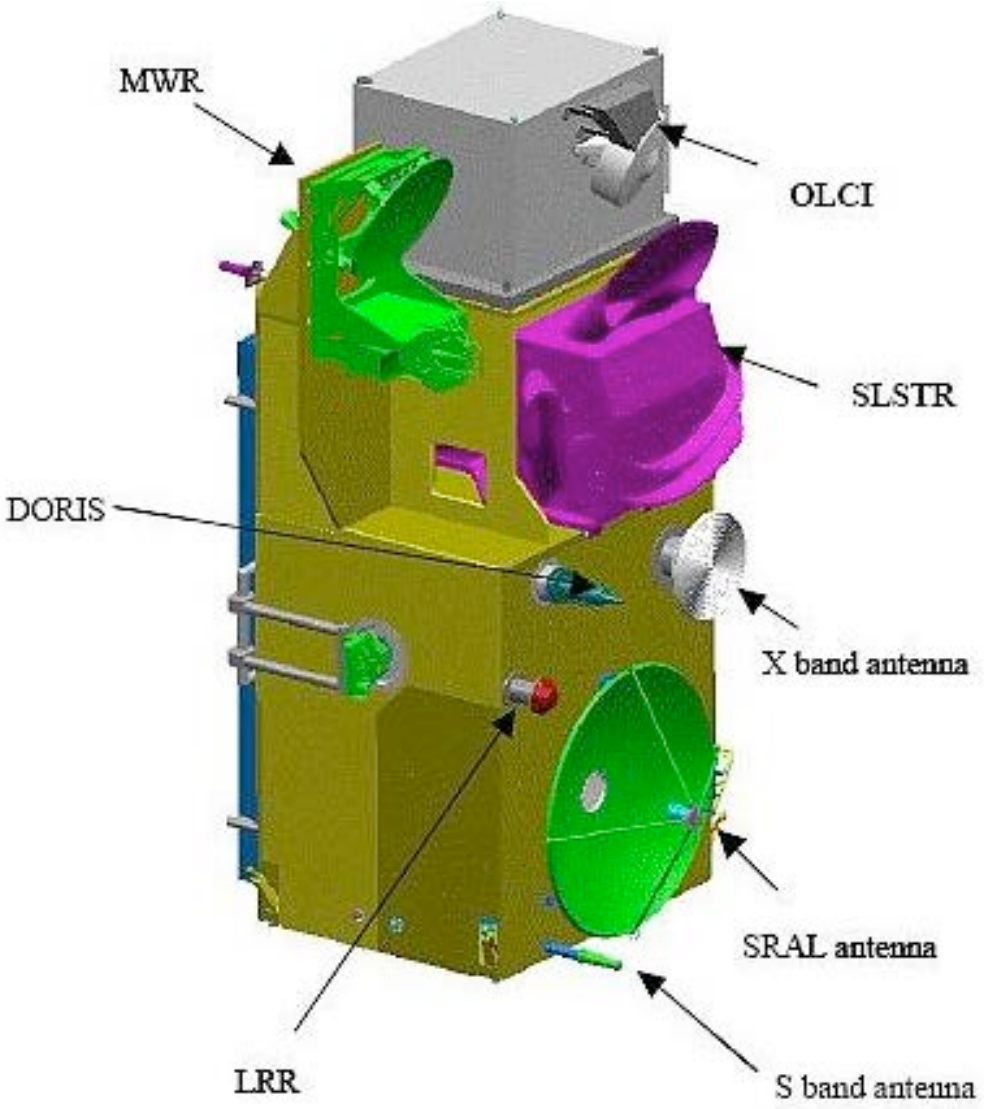
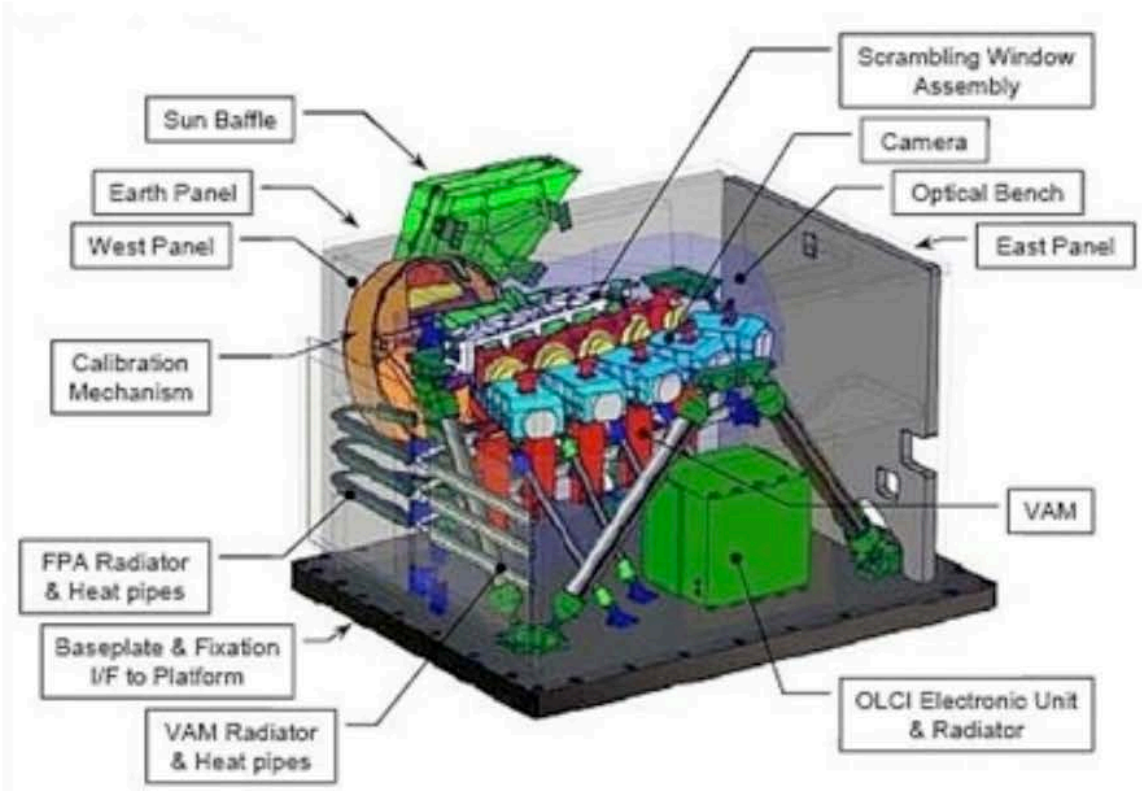
1 Odermatt & Brockmann (Germany) 2 Brockmann Consult (Germany) 3 Image Processing Laboratory (UV, Spain)

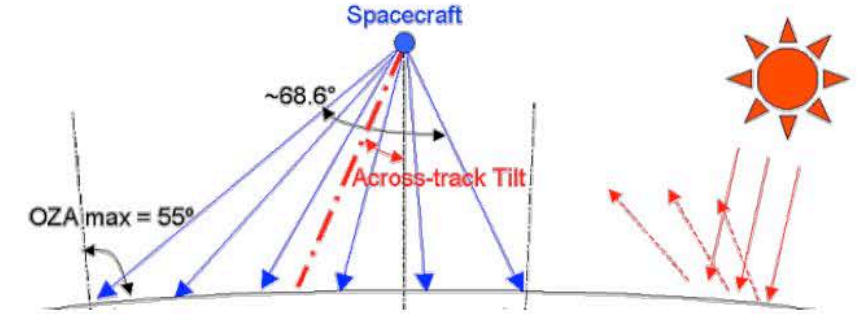
Sentinel-3 Sensors

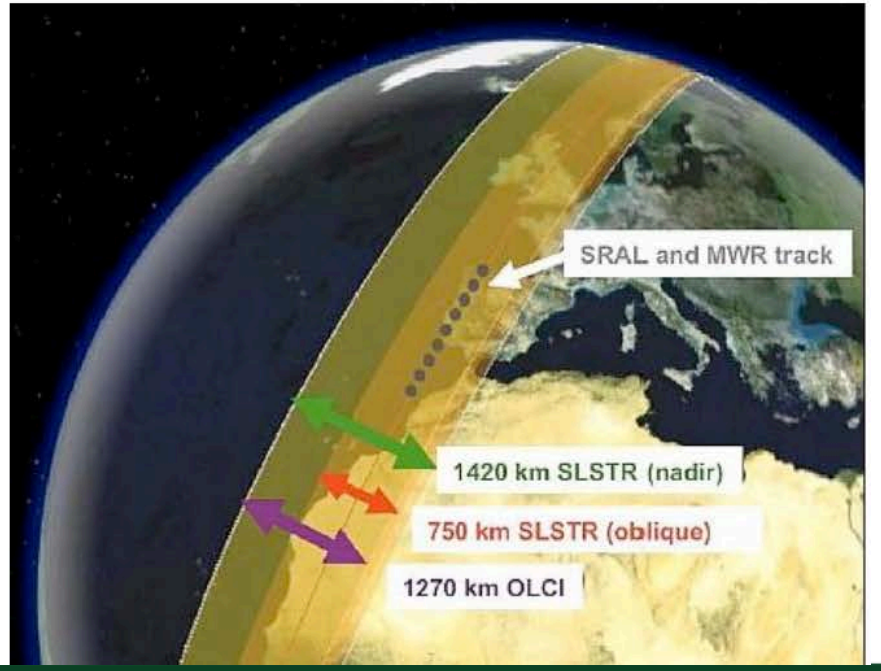




Ocean and Land Colour Instrument: OLCI







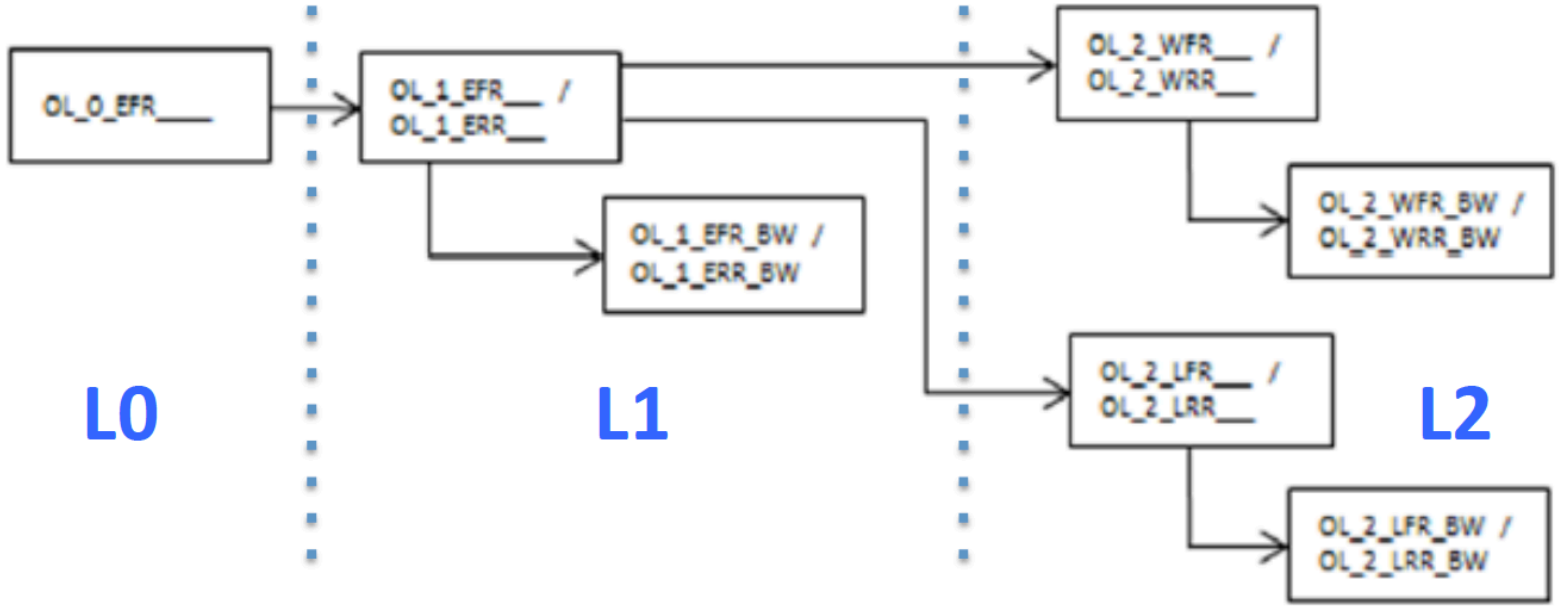
Images credit: ESA

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

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.	

Overview of Sentinel-3 Toolbox in SNAP

- ESA has developed a common architecture for all Sentinel Toolboxes call the **Sentinel Application Platform** (SNAP)
- The SNAP architecture is ideal for Earth Observation processing and analysis due the following technological innovations: Extensibility, Portability, Modular Rich Client Platform, Generic EO Data Abstraction, Tiled Memory Management, and a Graph Processing Framework.

http://step.esa.int/main/toolboxes/snap/

Sentinel Toolboxes Consortia

ARRAY

- Brockmann Consult GmbH
- DLR
- oceandatalab

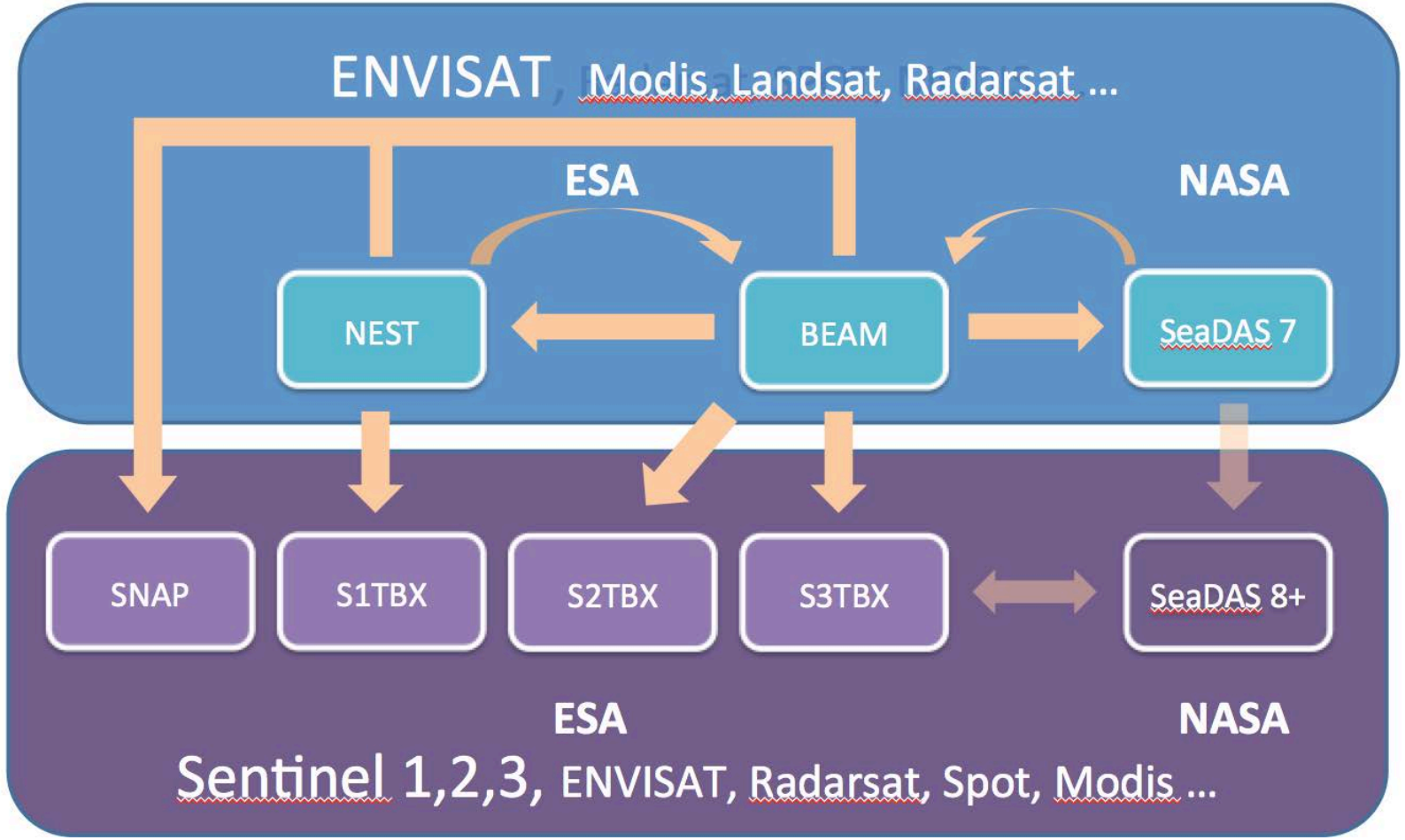
CS

- CS Romania
- Telespazio Vega Deutschland
- INRA
- Brockmann Consult GmbH
- UCL Université catholique de Louvain

Brockmann Consult

- University of Reading
- CS
- ACRI-ST
- ARRAY

S3-TBX Heritage and Evolution



Exercise Overview:

- Goal: To classify land surfaces and assign thermal emissivity factors to each surface type
- 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

1. Radiance to Reflectance

- From the folder *products exercise*, open the scene: *"subset_0_of_S3A_OL_1_EFR____20170729T030116_20170729T030416_20170730T064809_0180_020_246_2519_LN1_O_NT_002.dim"*
- Right click on the product in the *Product Explorer* and select *Open RGB Image Window* with the *OLCI L1 Tristimulus* profile. Stretch the histogram for a better visualization in the *Colour Manipulation* window
- Check the image location in the *World View* window
- Add a pin in the approximate position of Hanoi (21.00°N, 105.85°E)
- In the *Optical* label click on *Preprocessing/Radiance-to-Reflectance Processor*:

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

- Save the output product as: *"subset_0_of_S3A_OL_1_EFR____20170729T030116_20170729T030416_20170730T064809_0180_020_246_2519_LN1_O_NT_002_radrefl.dim"*

[2] Oa08_reflectance - subset_0_of_S3A_OL_1_EFR___20170729T030116_20170729T030416_20170730T064809_0180_020_246_2519_LN1_O_NT_002_radrefl - /Users/Daniel/Dropbox/Upload_20171120_Drag...

Search (⌘+I)

Product Explorer | Pixel Info

Position

Image-X	1845 pixel
Image-Y	2361 pixel
Longitude	106°08'30" E degree
Latitude	19°58'51" N degree

Time

Bands

Oa08_reflectance	0.08219 dl

Tie-Point Grids

Flags

Snap to selected pin

Navigation... | Colour ... | Uncertaint... | World View

Editor: Basic Sliders Table

Name: Oa08_reflectance
Unit: dl
Min: 0.036
Max: 1.299
Rough statistics!

7.47E-2 4.36E-2 0.28

More Options

[1] OLCI L1 – Tristimulus RGB

[1] Oa08_radiance

[2] OLCI L2 W – Tristimulus RGB

[2] Oa08_reflectance

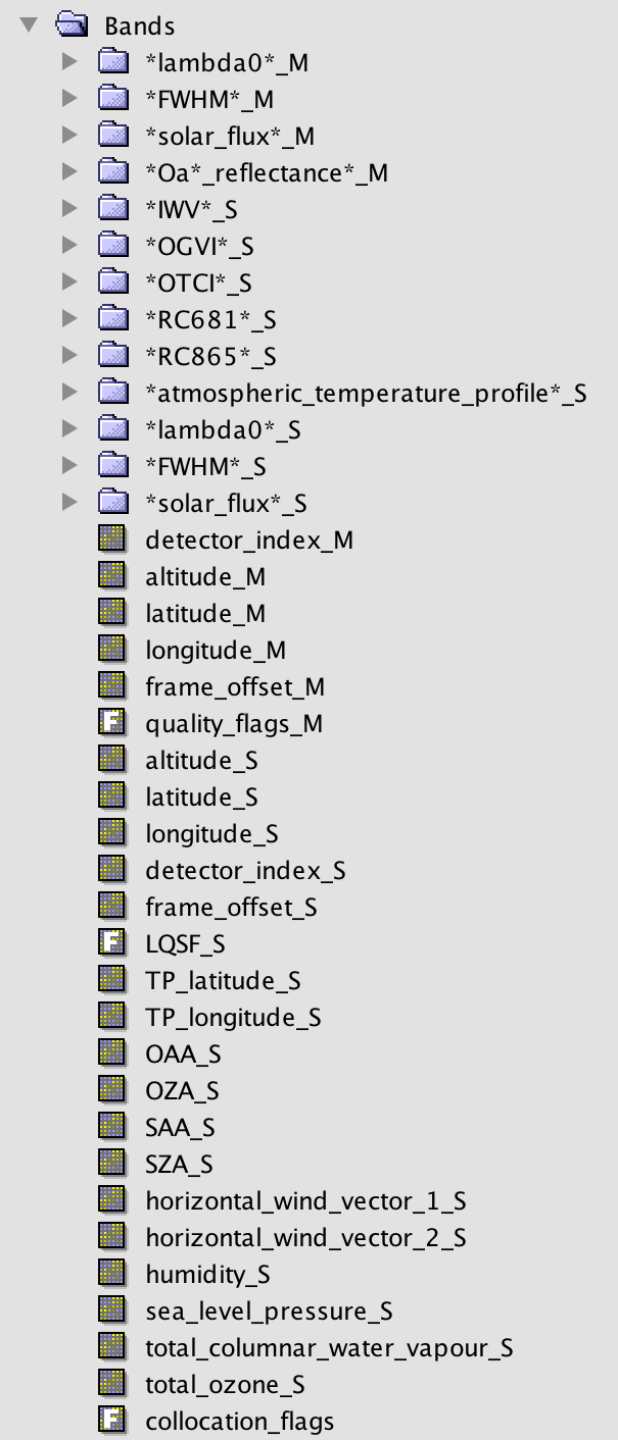
Hanoi

Product Library | Layer Manager | Mask Manager

X -- Y -- Lat -- Lon -- Zoom -- Level --

2. 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_S3A_OL_1_EFR____20170729T030116_20170729T030416_20170730T064809_0180_020_246_2519_LN1_O_NT_002_radrefl.dim
- Slave file:
  subset_0_of_S3A_OL_2_LFR____20170729T030116_20170729T030416_20170730T070654_0180_020_246_2519_LN1_O_NT_002.dim
- Target file:
  collocate_subset_0_of_S3A_OL_1_EFR____20170729T030116_20170729T030416_20170730T064809_0180_020_246_2519_LN1_O_NT_002_radrefl.dim
- Open RGB view using bands 8, 6 and 3



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,

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

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

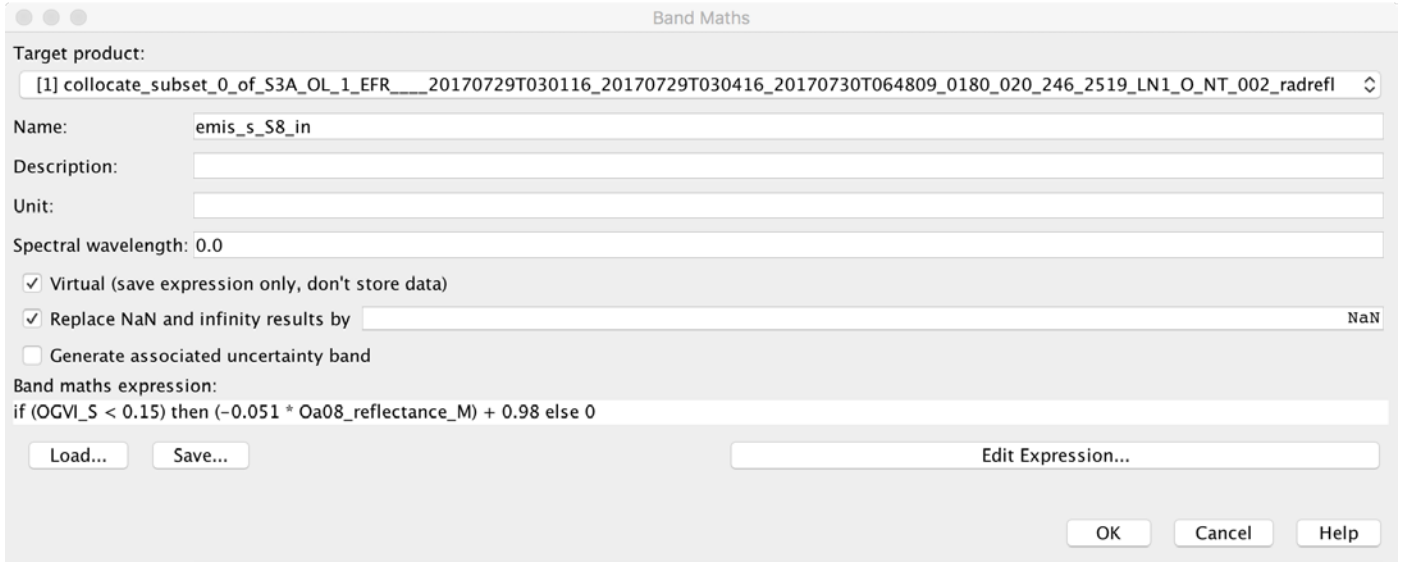
$$B_\lambda(T) = \frac{C_1\lambda^{-5}}{\exp(C_2/\lambda T) - 1}, \qquad (2)\ (2)$$

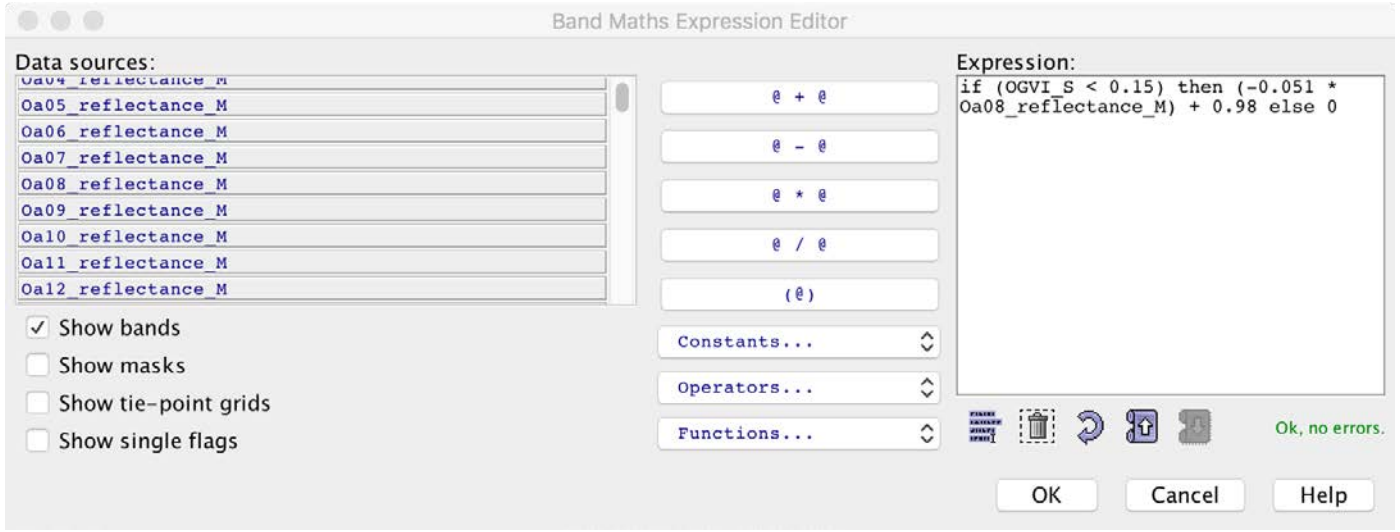
in which C_1 and C_2 are constants ($C_1 = 1.191 \times 10^8$ W μm^4 sr^{-1} m^{-2}, $C_2 = 1.439 \times 10^4$ μm K).

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

3. Emissivity Calculation using Vegetation Indices

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





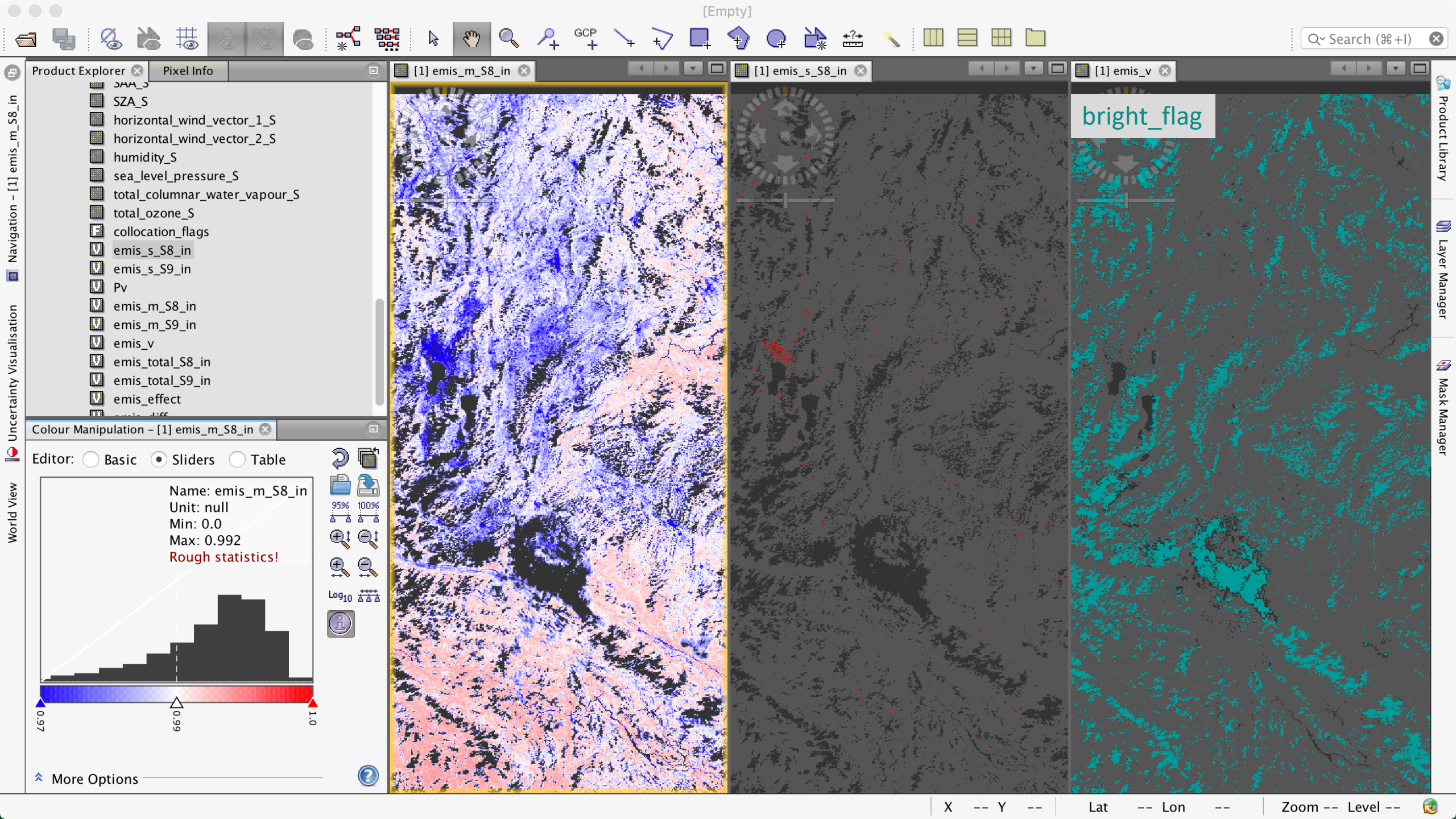
band math expressions.txt

Not registered

~/Dropbox/Upload_20171120_Dragon/Optical/band math expressions.txt

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

Soil emissivity
emis_s_S8_in = if (OGVI_S < 0.15) then (-0.051 * Oa08_reflectance_M) + 0.98 else 0
emis_s_S9_in = if (OGVI_S < 0.15) then (-0.032 * Oa09_reflectance_M) + 0.983 else 0

Mixed vegetation emissivity
emis_m_S8_in = if (OGVI_S > 0.15) and (OGVI_S < 0.99) then 0.969 * (1 - Pv) + (0.99 * Pv) else 0
emis_m_S9_in = if (OGVI_S > 0.15) and (OGVI_S < 0.99) then 0.977 * (1 - Pv) + (0.99 * Pv) else 0

Vegetation emissivity
emis_v = if (OGVI_S > 0.99) then 0.99 else 0

Total emissivity
emis_total_S8_in = if (emis_s_S8_in != 0) or (emis_m_S8_in != 0) then (emis_s_S8_in + emis_m_S8_in) else NaN
emis_total_S9_in = if (emis_s_S9_in != 0) or (emis_m_S9_in != 0) then (emis_s_S9_in + emis_m_S9_in) else NaN

Effective emissivity
emis_effect = emis_total_S8_in + emis_total_S9_in / 2

Differential emissivity
emis_diff = emis_total_S8_in - emis_total_S9_in

Water vapour to g*cm2
water_vapour = IWV_S / 10
```

L: 1 C: 1 Text File Unicode (UTF-8) Unix (LF) Saved: 29.10.17, 08:45:23 942 / 115 / 25 100%


[Empty]
Search (⌘+I)
Product Explorer
Pixel Info
SZA_S
horizontal_wind_vector_1_S
horizontal_wind_vector_2_S
humidity_S
sea_level_pressure_S
total_columnar_water_vapour_S
total_ozone_S
collocation_flags
emis_s_S8_in
emis_s_S9_in
Pv
emis_m_S8_in
emis_m_S9_in
emis_v
emis_total_S8_in
emis_total_S9_in
emis_effect
Colour Manipulation – [1] emis_m_S8_in
Editor: Basic Sliders Table
Name: emis_m_S8_in
Unit: null
Min: 0.0
Max: 0.992
Rough statistics!
0.97
0.99
1.0
More Options
[1] emis_m_S8_in
[1] emis_s_S8_in
[1] emis_v
bright_flag
Navigation – [1] emis_m_S8_in
Uncertainty Visualisation
World View
Product Library
Layer Manager
Mask Manager
X -- Y --
Lat -- Lon --
Zoom -- Level --

4. Batch Processing with the Graph Builder