OVERVIEW OF SENTINEL-3 SLSTR L1 AND MARINE L2 PRODUCTS

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Introduction

The Sentinel-3 Sea and Land Surface Temperature Radiometer (SLSTR) instrument has nine channels and dual view scanning technique with 500 m resolution in the visible and the shortwave infrared and 1 km in the thermal infrared with the aim to provide highly accurate sea surface temperature (SST) measurements.

The Sentinel-3 SLSTR set of marine products encompasses two user products, SLSTR L1B (SL_1_RBT___) and SLSTR GHRSST L2P (SL_2_WST___) SST and one internal SST product (SL_2_WCT___) aimed for internal analysis and cal/val activities.
To ensure a proper use of the data, understanding the formats, projections and associated information is a pre-requisite for the users. We will give overview of SLSTR instrument, different L1 and L2 grids and views and sea surface temperature (SST) algorithms implemented inside L2 products.

SLSTR L1 & marine L2 SST products

SL_L1_RBT	SL_2_WCT	SL_2_WST
Measurement data files (MDF)		
S[123]_radiance_an/ao S[456]_radiance_an/ao/bn/bo/cn/co S[789]_BT_in/io F[12]_BT_in/io	N2_SST_in N3_SST_in N3R_SST_in D2_SST_io D3_SST_io	GHRSST L2P
Annotation data files (ADF)		
S1/S2/S3_quality_an/ao S4/S5/S6_quality_an/ao/bn/bo/cn/co S7/S8/S9/F1/F2_quality_in/io indices_an/ao/bn/bo/cn/co/in/io cartesian_an/ao/bn/bo/cn/co/in/io/tx	indices_in/io cartesian_in/io/tx	
flags_an/ao/bn/bo/cn/co/in/io	flags_in/io	
geodetics_an/ao/bn/bo/cn/co/in/io/tx	geodetic_in/io/tx	
time_an/bn/cn/in	time_in	
geometry_tn/to	geometry_tn/to	
met_tx Viscal	met_tx	
Total: 78 (111) = 22 (34) MDF + 54 (76) ADF + mfst	Total: 21 = 5 MDF + 15 ADF + mfst	Total: 2= 1 MDF + mfst

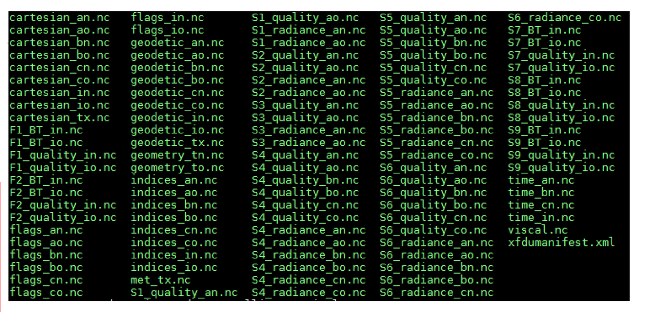
Different grids: <g>
'i'=1 km Thermal IR;
'a'=500 m A stripe grid;
'b'=500 m B stripe grid;
'c'=500 m TDI grid;
't'=tie point grid (16 km)
'f'= F1 grid (1 km) (ongoing)

Different views: <v>
'n'=nadir
'o'=oblique
'x'=agnostic

NRT– near real time (< 3h)
NTC – non-time critical (<30 days)

MDF – measurement data files
ADF – ancillary data files

SL_1_RBT____ SAFE directory content



SL_2_WCT____ SAFE directory content

```
cartesian_in.nc   flags_in.nc      geometry_tn.nc   N2_SST_in.nc
cartesian_io.nc   flags_io.nc      geometry_to.nc   N3R_SST_in.nc
cartesian_tx.nc   geodetic_in.nc   indices_in.nc    N3_SST_in.nc
D2_SST_io.nc      geodetic_io.nc   indices_io.nc    time_in.nc
D3_SST_io.nc      geodetic_tx.nc   met_tx.nc        xfdumanifest.xml
```

SL_2_WST____ (**GHRSST L2P** format):

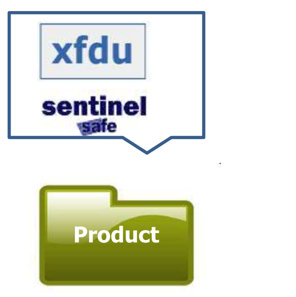
```
20170530000224-MAR-L2P_GHRSST-SSTskin-SLSTRA-20170530024403-v02.0-fv01.0.nc
xfdumanifest.xml
```

Resolution:		Mixed	Image grid (pixels + orphans)	Tie point grid
Format:	XML	NetCDF 4		
Type:	Manifest	Time stamps file (rows) - contains both nadir + oblique and i, a, b, c Quality annotation (detectors, integrators, rows) (band, view, grid) VISCAL (integrators, swir_detectors, visible detectors, views)	Radiances/BTs (band, grid, view) Flags (cloud, pointing, confidence, bayes) Geodetic (lon, lat, elevation) Indices (detector, pixel, scan) Cartesian (x,y)	TP geodetic (lon, lat) TP cartesian (x,y) TP geometry (sataz, satzen, solaz, solzen, satpath, solpath) TP meteo data (cloud, wind, sst, tcwv, ...)

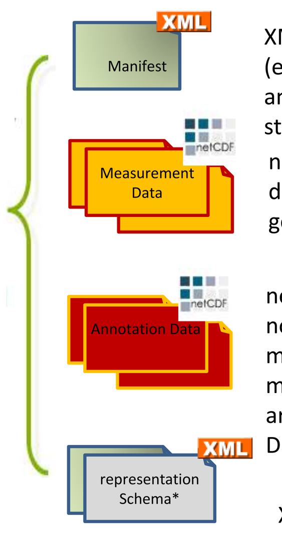
User Product Type	Number of Files	Number of MDFs	Number of ADFs	Number of variables	Estimated size per orbit [GB]	Estimated size per day [GB]	Estimated size per month [TB]	Estimated size per year [TB]
SL_1_RBT	111	34	76	~900	20	290	9	106
SL_2_WCT	20	5	15	~100	3	44	1.3	16
SL_2_WST	2	1	0	20	0.8	12	0.37	4.4

•Sentinel-3 SAFE:

Standard Archive Format for Europe
S3-SAFE: specific to S3 and to SLSTR/OLCI/SRAL



A Sentinel-3 product package is a folder holding a collection of XML and binary files (either NetCDF and/or raw binary based)



XML file containing the package metadata (e.g. sensor name, sensing start/stop, etc.) and providing as well the hierarchic structure of the product.

netCDF4** file(s) containing data derived from measurements (also called geophysical product or scientific data).

netCDF4** file(s) containing data that have not been derived from instrument measurements (e.g. geo-location, meteorological data, etc.); such information are applicable to multiple Measurements Data Files of the same package.

XML file(s) containing the schema of the Measurement/annotation data

Processing baseline

- Number uniquely defining processor (IPF) and auxiliary data (ADF) version (and other system components)
- To be available in the manifest file and global attributes (upcoming changes)

Sentinel-3 filename convention

MMM_SS_L_TTTTTT_ <DATA_START>_<DATA_STOP>_<CREATION_TIME>_<instance_ID>_GGG_<classID>.<ext>

MMM – mission ID: **S3A** = Sentinel- 3A, **S3B** = Sentinel-3B, **S3_** = both Sentinel 3A and 3B

SS - data source: **OL** = OLCI, **SL** = SLSTR, **SR** = SRAL, **DO** = DORIS, **MW** = MWR, **GN** = GNSS, **SY** = Instruments Synergy, **TM** = telemetry data (e.g. HKTM, navigation, attitude, time), AX = for multi instrument auxiliary data

L - Processing level: "**0**" for Level-0, "**1**" for Level-1, "**2**" for Level-2

TTTTTT - Data Type ID: (EFR___, SLT___, RBT___, WST___, WCT___, ...) : suffix "AX": auxiliary data;

Data Start time, stop time and creation time: **YYYYMMDDTHHMMSS**
Instance_ID: 17 chars: STRIPE or FRAME or TILE
STRIPE: **DDDD_CCC_LLL_____**
FRAME: **DDDD_CCC_LLL_FFFF**
TILE:
tile covering the whole globe: "GLOBAL___________"
tile cut according to specific geographical criteria: **ttttttttttttttttt**

GGG - Product Generating Centre: **MAR**, **LN1**, **SVL**, **MR1**...

<ClassID>: **P_XX_NNN** where:

P – platform: **O** for operational, **F** for reference, **D** for development, **R** for reprocessing or underscore "_" if not relevant.

XX - timeliness: **NR** for NRT, **ST** for STC, **NT** for NTC, ...

NNN – baseline collection

<ext>: extension: **SEN3**

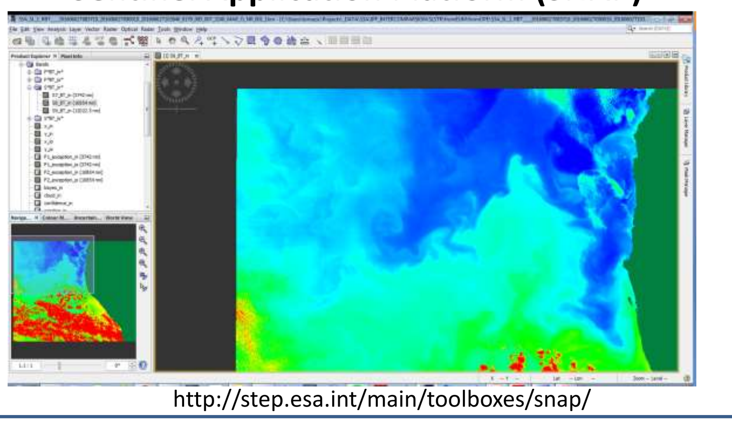
Duration
"***DDDD" = 4 digits; orbit duration:*** Sensing data time interval in seconds.
Cycle
"CCC"= 3 digits; cycle number at the start sensing time of the product
Frame along track coordinate
"**FFFF"= four digits; elapsed time in** seconds from the ascending node indicating the frame start time.
Tile identifier
"ttttttttttttttt"= 17 characters, either letters or digits or underscores "_" or any combination of them. It identifies the geographical area covered by the tile. There are two cases:
1) tile covers a pre-defined area of interest. (e.g. AFRICA___________)
2) tile covers an area according to a regular meshed predefined global grid (e.g. TILE_ID_001)

SLSTR SAFE readers

Cerbere: "free and open source python modules for the reading, interpretation, and writing of (primarly ocean) geophysical data."
•Felyx core component
•**https://git.cersat.fr/cerbere/**

Pytroll: "easy to use, modular, free and open source python framework for the processing of earth observation satellite data."
•http://pytroll.github.io/

Sentinel Application Platform (SNAP)



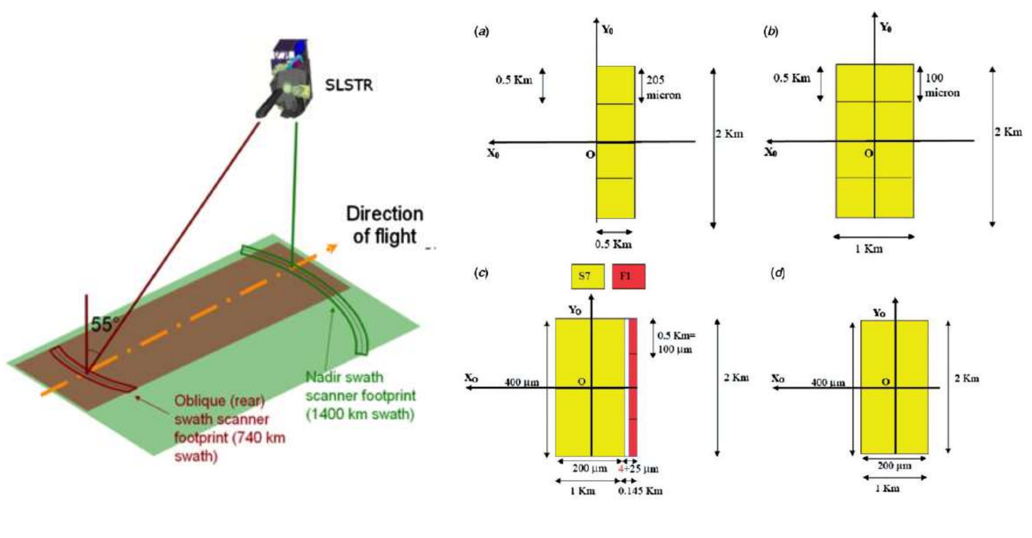
http://step.esa.int/main/toolboxes/snap/

Sentinel-3 data access + resources @ EUMETSAT

- **EUMETCast**: Dissemination of NRT/STC data, Satellite & Terrestrial options available
- Copernicus Online Data Access (**CODA**): https://coda.eumetsat.int
  Rolling archive of **~1 year** of **S3 NTC** data supporting http access + GUI (OpenSearch)
- Copernicus Online Reprocessed Data Access (**CODAREP**): https://codarep.eumetsat.int
  Reprocessed data: **SLSTR-A L1/L2 SST: 04/2016-04/2018;** http access + GUI (OpenSearch)
- **EUMETSAT Data Centre**: Complete historical archive of **all EUMETSAT** data including S3 marine data
- S3 Online Data Access (**ODA**): Rolling archive of ~1 m of **all S3** data supporting ftp access, S3 cal/val users, S3VT only (ftp)
- EUMETSAT **help** desk (ops@eumetsat.int): http://www.eumetsat.int/website/home/ContactUs/index.html
- **SST**: https://www.eumetsat.int/website/home/Data/CopernicusServices/Sentinel3Services/SeaSurfaceTemperature/index.html
- **Visualization** of SLSTR GHRSST L2P SST @EUMETView: https://eumetview.eumetsat.int/mapviewer/

https://eoportal.eumetsat.int

SLSTR instrument



After Coppo et al., 2014

Band	λ center [µm]	Δλ [µm]	SNR/ NeΔT [mK]	Pixel size [km]
S1	0.555	0.02	10.4-14.3	0.5
S2	0.659	0.02	10.0-13.1	0.5
S3	0.865	0.02	9.7-11.5	0.5
S4	1.375	0.015	5.1-6.5	0.5
S5	1.610	0.06	3.2-3.9	0.5
S6	2.250	0.05	5.7-7.1	0.5
S7	3.74	0.38	60-67 mK	1.0
F1	3.74	0.38	225-259 mK	1.0
S8	10.85	0.9	26-37 mK	1.0
F2	10.85	0.9	40-56 mK	1.0
S9	12.0	1.0	28-40 mK	1.0

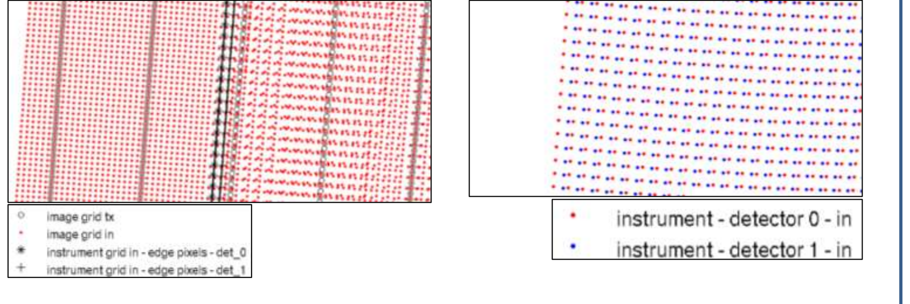
•The SLSTR scan has been optimized to allow a complete observation of the two BBs and the VIS calibration unit every two scans (0.6 sec) and the acquisition of both Earth views (near nadir and oblique) every scan (0.3 s).
•Because of the larger swath widths of the SLSTR, the scan period was increased to 300 msec.
•This choice also reduces the scan speed to 200 rpm allowing heritage mechanism qualifications to cover the 7.5 years operative requirement for the scanner bearing lifetime.
•However it is necessary to instantaneously cover the on ground along-track FOV of 2 Km (satellite speed of 6.7 Km/s) by means of two 1 Km FOV IR detector pixels and four 0.5 Km FOV VIS/SWIR detector pixels.

SLSTR image grids

- **Geolocation**:
- **1km grid for TIR and fire channels**
- **0.5km grid stripe A for Visible/NIR and SWIR channels**
- **0.5km grid stripe B for SWIR channels only**
- all parameters indexed on image grid
- remapping from instrument curved scans to uniform image grid in quasi-Cartesian system done using "first pixel found" method with retaining pixels that are not used (i.e. orphans)
-**remapping keeps original pixel positions** therefore image grid does not look so regular close to swath edge (oblique view and nadir swath edge)
-using image and orphan pixels, and information about scans, pixels, detectors and cosmetic fill pixels → instrument grid
-**Upcoming evolution in regridding scheme:**
- Implementing true nearest neighbour
- Implementing ortho-geolocation

image grid
nadir – swath edge

instrument grid
nadir – swath edge



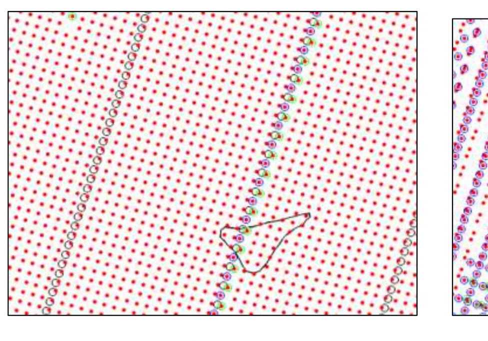


image grid
nadir - SSP

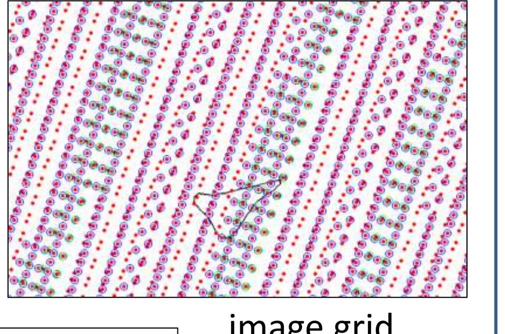
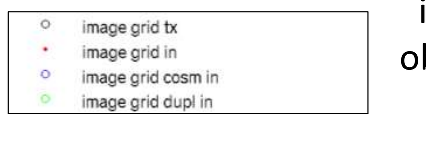
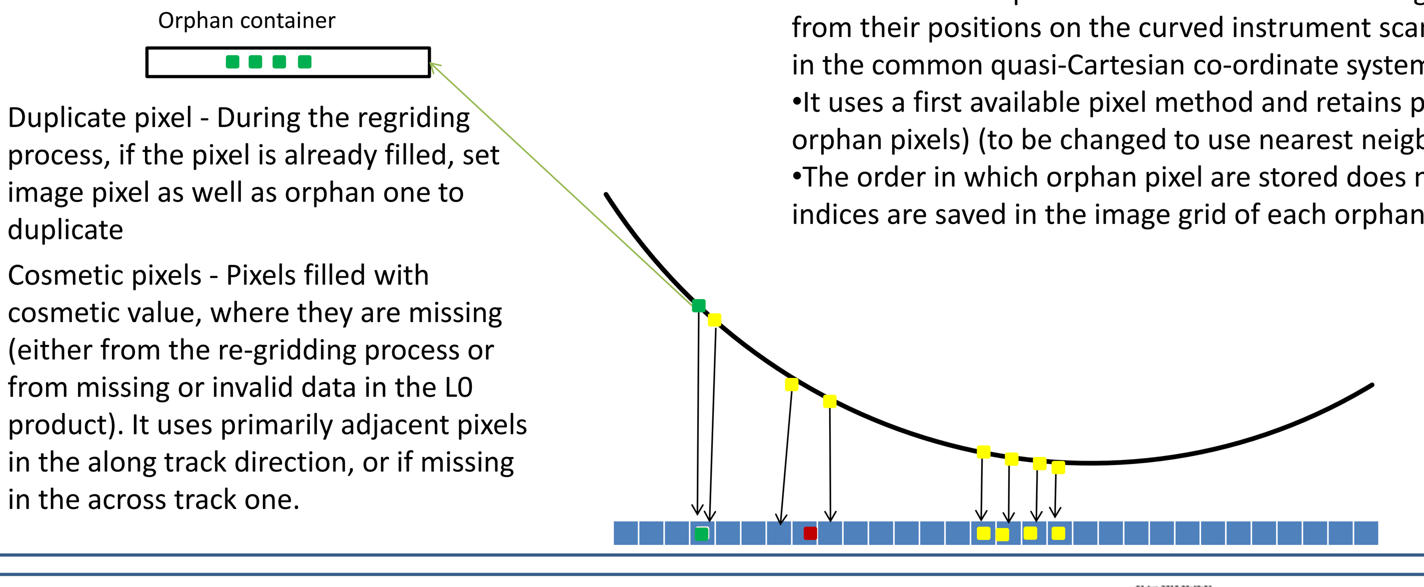


image grid
oblique - SSP



Instrument → image grid



- Duplicate pixel - During the regriding process, if the pixel is already filled, set image pixel as well as orphan one to duplicate
- Cosmetic pixels - Pixels filled with cosmetic value, where they are missing (either from the re-gridding process or from missing or invalid data in the L0 product). It uses primarily adjacent pixels in the along track direction, or if missing in the across track one.

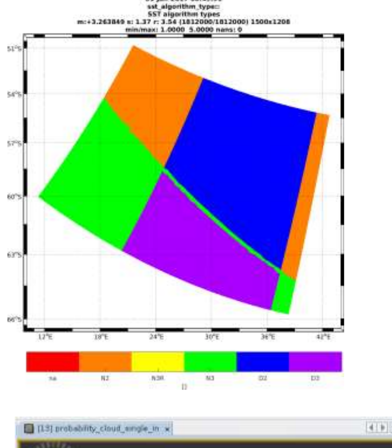
• Procedure remaps the measured nadir and along-track instrument pixels from their positions on the curved instrument scans to a uniform grid of points in the common quasi-Cartesian co-ordinate system.
•It uses a first available pixel method and retains pixels that are not used (i.e. orphan pixels) (to be changed to use nearest neigbour method)
•The order in which orphan pixel are stored does not matter - associated indices are saved in the image grid of each orphan pixel.

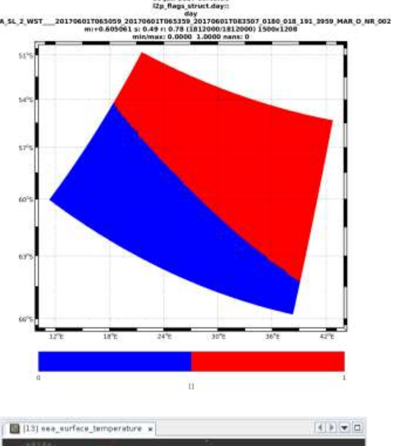
•measurements from the detectors are interleaved in a quasi-random fashion, determined by effect of the satellite orbit and the surface topology on the L1b regridding process.

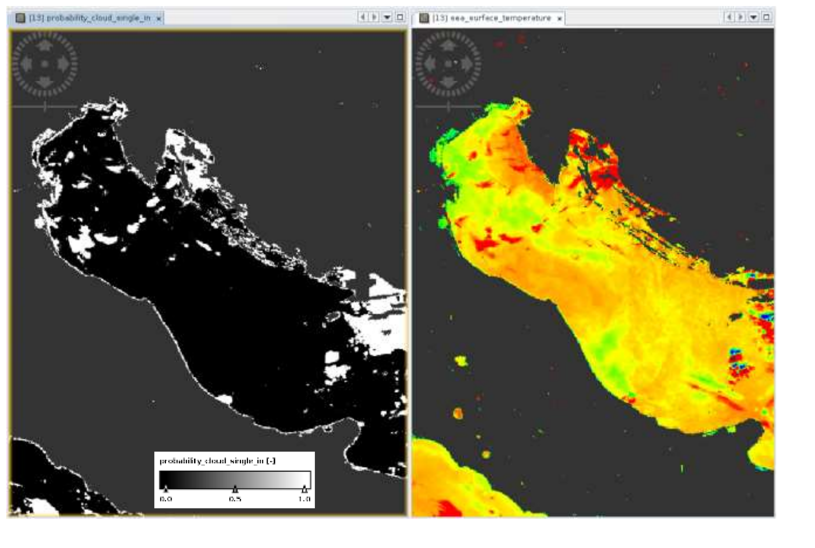
SLSTR L2 SST algorithms

- N2 – nadir only day-time (two channels)
- N3 – nadir only night-time (three channels)
- D2 – dual view day-time (3.7 µm unused)
- D3 – dual view night-time (all channels used)
- *N3R - N3 with SST retrieval coefficients robust to stratospheric aerosol loading events (major volcanic eruptions)*

•**Skin sea surface temperature**
•RTM based: Merchant et al., 1999; Merchant and Le Borgne, 2004; Merchant et al., 2008
•Coefficients based on across-track and along-track angles and total column water vapor
•SL_2_WCT____(internal product): all algorithms
•SL_2_WST___(user product - l2p): N2| N3 | D2 | D3 | N3R (+dual_nadir_sst_difference)







Bayesian cloudmask

- Per pixel probability of clear-sky based on satellite information and prior information (ECMWF) using RTM
- Introduced for SLSTR-A L2 SST on 04/04/2018 as the main cloudmask
- Significant improvement compared to basic cloudmask
- Available in L1 and L2 SST

New variables:
Probability of cloud in pixel (single view) computed on the 1 km nadir and oblique view
•Probability_cloud_single_in
•Probability_cloud_single_io

References

•Sentinel-3 SLSTR Marine User Handbook, v1B, 2017
•SLSTR Level 1 & Level 2 Instrument Products Data Format Specification , S3IPF.PDS.005 , 2018
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•Merchant et al., 1999, Toward the elimination of bias in satellite retrievals of sea surface temperature 1. Theory, modelling and interalgorithm comparison
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