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 L2P (SL_2_WST___) and one internal 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 SLSTR instrument, different L1 and L2 grids and views and sea surface temperature (SST) algorithms implemented inside L2 products.

SLSTR L1 & marine L2 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	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 views: <v>
'n'=nadir
'o'=oblique
'x'=agnostic

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)

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

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____ SAFE directory content

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

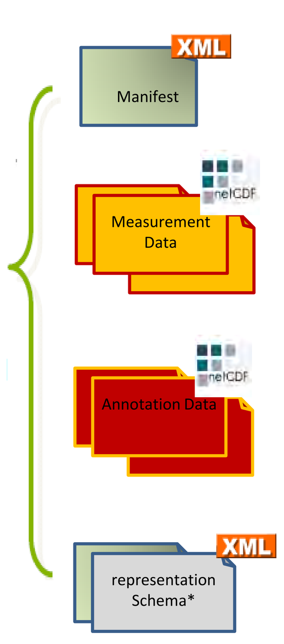
Resolution:		Mixed	Image grid (pixels + orphans)	Tie point grid
Format:	XML	NetCDF 4		
Type:	Manifest	Time stamps file (rows) - contains both nadir + oblique and i, a, b, c Quality annotation (detectors, integrators, rows) (band, view, grid) VISCAL (integrators, swir_detectors, visible detectors, views)	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	17	240	7.4	89
SL_2_WCT	20	5	15	~100	2.6	37	1.1	14
SL_2_WST	2	1	0	20	0.6	8	0.25	3

Sentinel-3 SAFE

- SAFE: Standard Archive Format for Europe;
- S3-SAFE: specific to Sentinel-3 and to SLSTR/OLCI/SRAL
- Designed to act as a common format for archiving and conveying data within Europe EO archiving capabilities
- Designed to be compliant with Open Archival Information System (OAIS)
- Instance of XML Formatted Data Units (XFDU)
- Restricts the XFDU specifications for specific utilization in the EO domain
- Use of XFDU (CCSDS 661.0-B-1, Blue Book, 09/2008)

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

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 " in the last 2 digits indicates an auxiliary data, suffix "BW" indicates a browse product.

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: '**LN1**', '**LN2**', '**MAR**', ...

<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)

S3A_SL_1_RBT____20160523T094210_20160523T094510_20160523T113538_0179_004_250_2340_MAR_O_NR_001.SEN3
S3A_SL_1_RBT____20160531T225635_20160531T225935_20160601T010401_0179_004_372_1980_MAR_F_NR_001.SEN3
S3A_SL_1_RBT____20160523T094210_20160523T094510_20160525T022953_0179_004_250_2340_LN2_O_NT_001.SEN3
S3A_SL_2_WST____20160422T032431_20160422T032931_20160423T141910_0299_003_189______MAR_O_NR_001.SEN3
S3A_SL_2_WCT____20160520T082344_20160520T082644_20160520T100158_0179_004_206______MAR_O_NR_001.SEN3

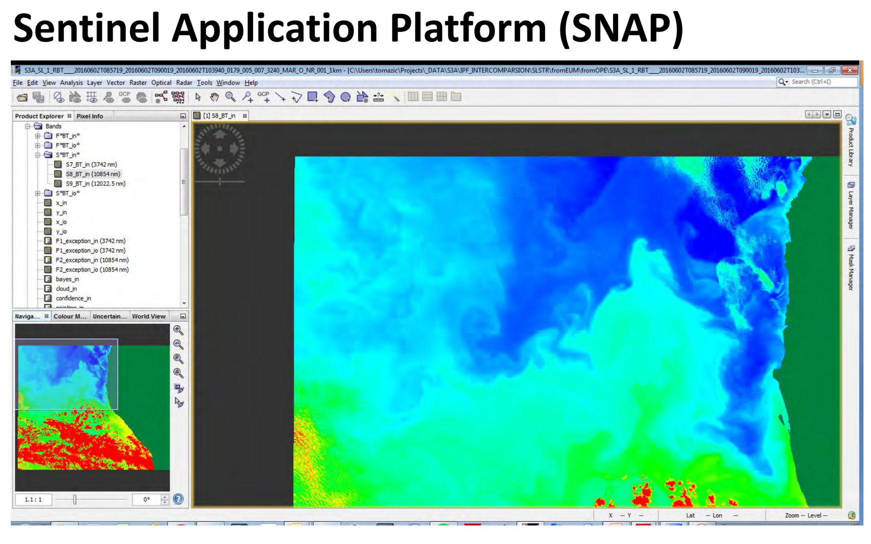
SLSTR SAFE readers

Python

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

```
from cerbere.mapper.safeslfile import SAFESLFile
fname ='S3A_SL_2_WCT___....SEN3'
fd = SAFESLFile(url=fname)
swath.load(fd)
lats = swath.get_lat()
lons = swath.get_lon()
times = swath.get_times()
```

Sentinel Application Platform (SNAP)

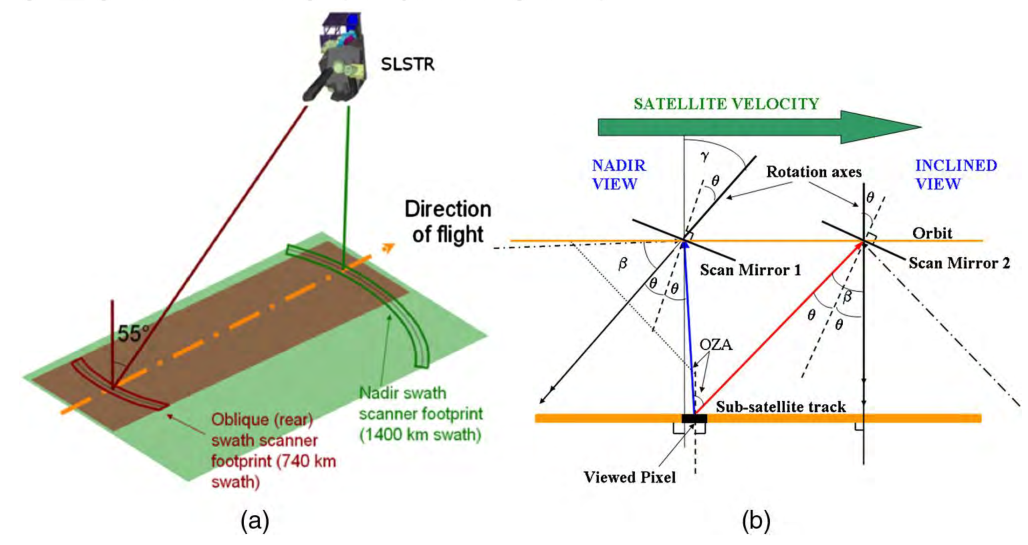


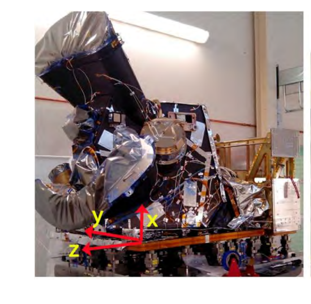
http://step.esa.int/main/toolboxes/snap/

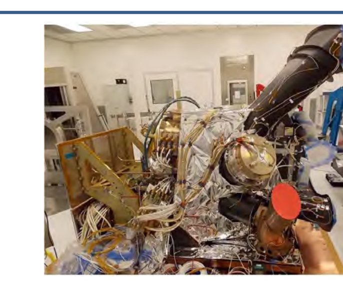
References

- SLSTR Level 1 & Level 2 Instrument Products Data Format Specification , S3IPF.PDS.005 , 1.11, 2015
- Coppo et al., 2014, Sea and Land Surface Temperature Radiometer detection assembly design and performance
- Merchant et al., 1999, Toward the elimination of bias in satellite retrievals of sea surface temperature 1. Theory, modelling and interalgorithm comparison
- Merchant and Le Borgne, 2004, Retrieval of sea surface temperature from space, based on modelling of infrared radiative transfer: Capabilities and Limitations
- Merchant et al., 2008, Deriving a sea surface temperature record suitable for climate change research from the along-track scanning radiometers

SLSTR instrument



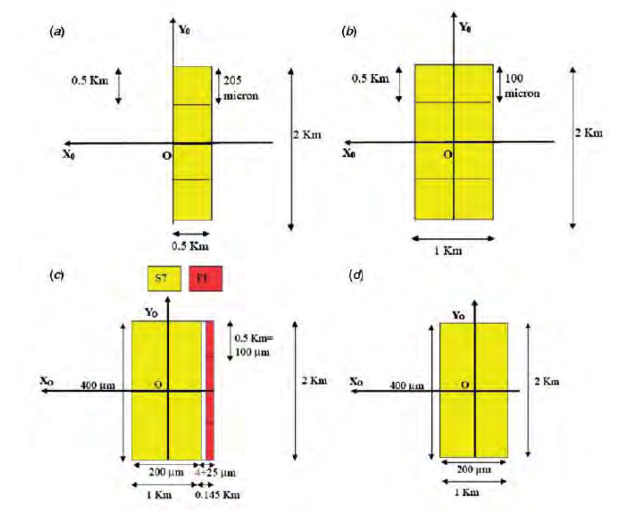




Two separate scans (instead of one for AATSR) have been implemented to increase the swath width with respect to (A)ATSR, by means of two mirrors inclined at θ ≅ 23.5 deg with respect to the rotation axis (Fig. 1) with a half cone angle of β ≅ 47 deg: the inclined view rotation axis is pointed toward the SSP, while the near-nadir view rotation axis is tilted backwards by γ ≅ 41 deg (Fig. 1).

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

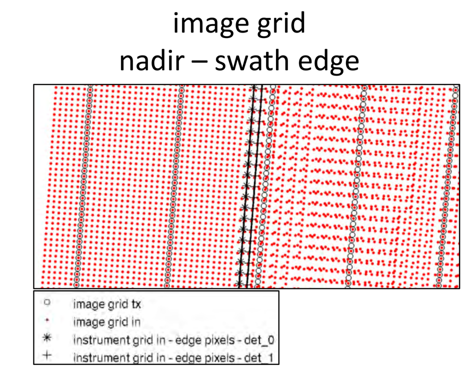


- The SLSTR scan has been optimized to allow a complete observation of the two BBs and the VIS calibration unit every two scans (0.6 sec) and the acquisition of both Earth views (near nadir and oblique) every scan (0.3 s).
- Because of the larger swath widths of the SLSTR, the scan period was increased to 300 msec, compared to 150 msec for AATSR.
- This choice also reduces the scan speed to 200 rpm (instead of 400 rpm of AATSR) 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 (instead of 1 of AATSR).

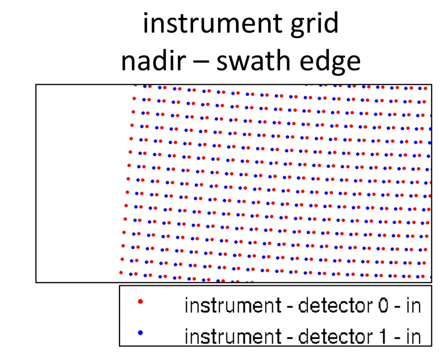
SLSTR image grids

- **Geolocation**: computing the orthogeolocation (i.e. longitude, geodetic latitude both corrected for the Digital Elevation Model (DEM), and altitude wrt the reference ellipsoid WGS84) and corresponding (x,y) quasi-cartesian coordinates of the center of each instrument pixel for each view and three of the four grids defined in SLSTR L1b products:
- **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 – continuity req.
- remapping from instrument curved scans to uniform image grid in quasi-Cartesian system done using nearest neighbor method with retaining pixels that are not used (i.e. orphans)
- **remapping keeps original pixel positions** (nearest method) 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

image grid nadir – swath edge



instrument grid nadir – swath edge



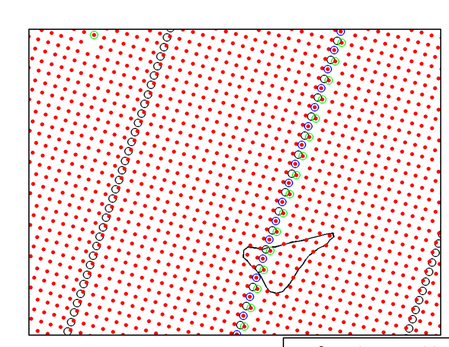


image grid nadir - SSP

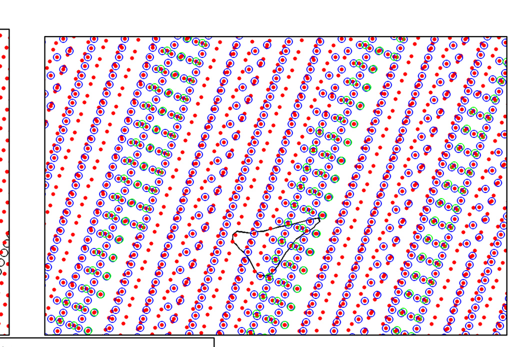
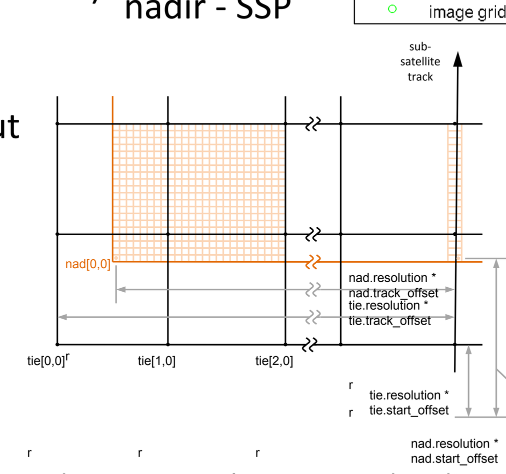


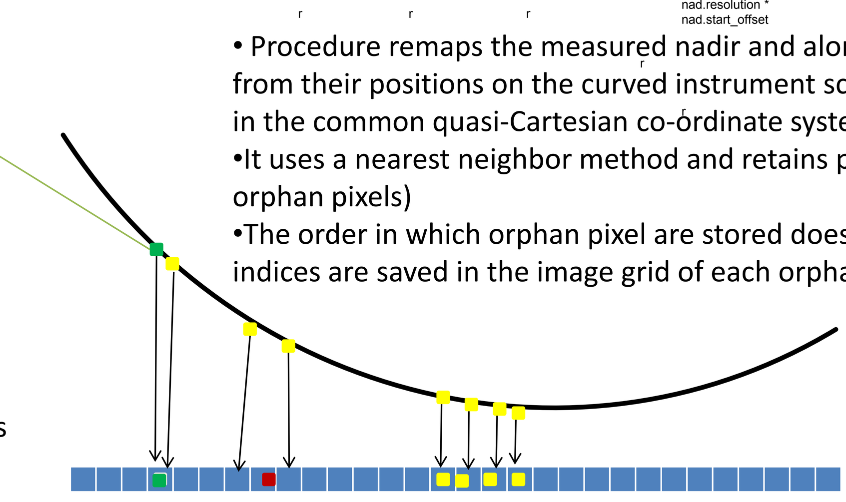
image grid oblique - SSP

Instrument → image grid



Orphan container

- 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.

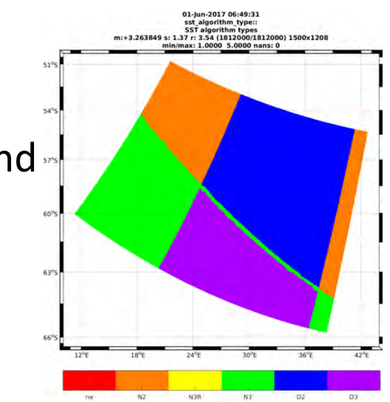


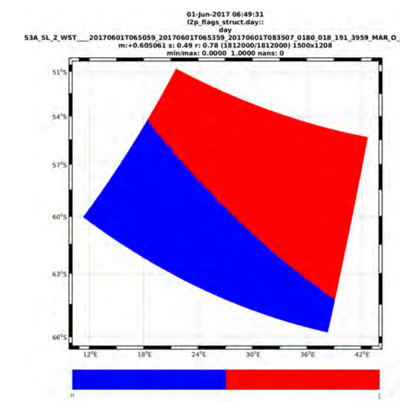
- Procedure remaps the measured nadir and along-track instrument pixels from their positions on the curved instrument scans to a uniform grid of points in the common quasi-Cartesian co-ordinate system.
- It uses a nearest neighbor method and retains pixels that are not used (i.e. orphan pixels)
- The 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.

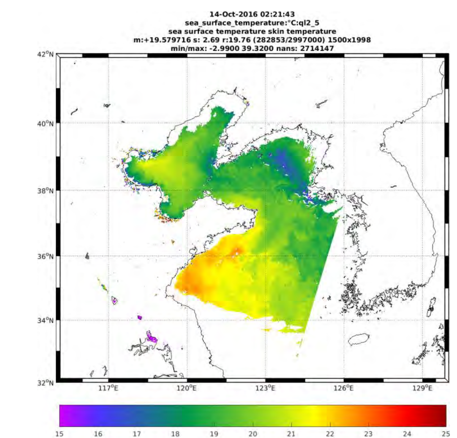
On going investigation to update the regridding algoriithm

SLSTR L2 SST algorithms

- N2 – across-track single-view day-time retrieval (3.7 µm and along-track view are unused)
- N3 – across-track single-view night-time (along-track view unused)
- 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.







desert dust	aerosol	common swath centre	nadir day	oblique day	algorithm
0	0	0	0	0	N3
0	0	0	0	1	N3
0	0	0	1	0	N2
0	0	0	1	1	N2
0	0	1	0	0	D3
0	0	1	0	1	N3
0	0	1	1	0	D2
0	0	1	1	1	D2
0	1	0	0	0	N3R
0	1	0	0	1	N3R
0	1	0	1	0	none
0	1	0	1	1	none
0	1	1	0	0	D3
0	1	1	0	1	N3R
0	1	1	1	0	D2
0	1	1	1	1	D2
1	0	0	0	0	N3
1	0	0	0	1	N3
1	0	0	1	0	N2
1	0	0	1	1	N2
1	0	1	0	0	D3
1	0	1	0	1	D2
1	0	1	1	0	D2
1	0	1	1	1	D2
1	1	0	0	0	N3R
1	1	0	0	1	N3R
1	1	0	1	0	none
1	1	0	1	1	none
1	1	1	0	0	D3
1	1	1	0	1	D2
1	1	1	1	0	D2
1	1	1	1	1	D2

- SL_2_WCT____(internal product): all algorithms
- SL_2_WST___(user product - l2p): either N2| N3 | D2 | D3 | N3R (+dual_nadir_sst_difference)

The dependence of the choice of SST algorithm on the presence of desert dust or stratospheric aerosol, the across-track swath position and the solar geometry in the two instrument views.

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