Sentinel-3 SLSTR Cal/Val activities for sea surface temperature measurements

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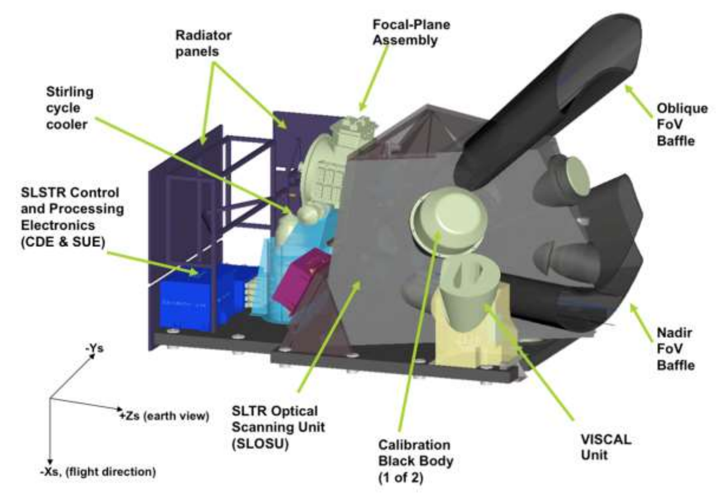
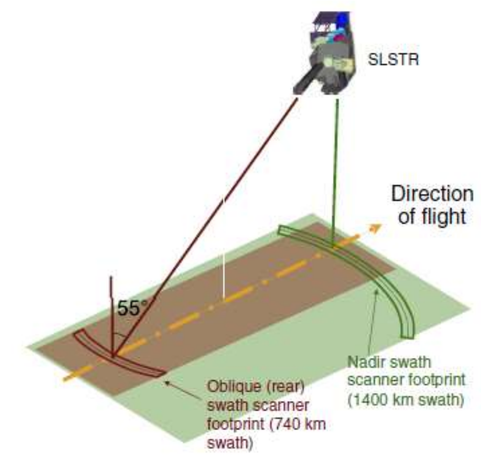
Introduction

Copernicus Sentinel-3 (S-3) satellite carries the Sea and Land Surface Temperature Radiometer (SLSTR) and is a follow on of AATSR instrument. It is employing along track dual view scanning and two on-board calibration targets to obtain improved Sea Surface Temperature (SST) measurement. The first satellite in the series (S-3A) was successfully launched in February 2016 and the next one (S-3B) was launched in April 2018 to complete the first operational Sentinel-3 mission constellation. The next S-3 mission constellation (consisting from S-3C and S-3D) will ensure SLSTR data continuation for Copernicus program at least up to 2030.





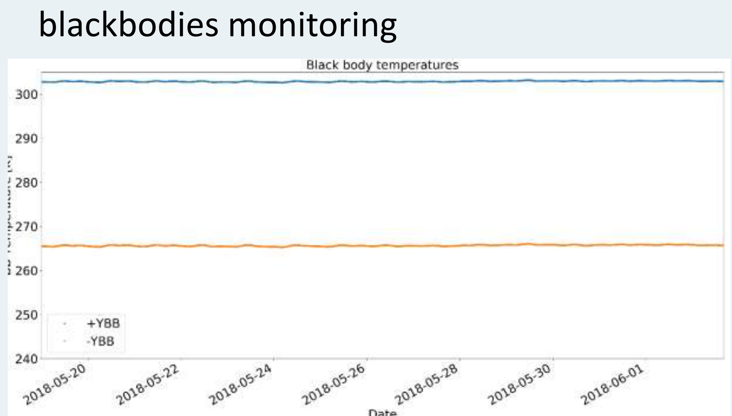
Band	λ center [μm]	Δλ [μm]	SNR/ NeΔT [mK]	Pixel size [km]
S1	0.555	0.02	10.4-14.3	0.5
S2	0.659	0.02	10.0-13.1	0.5
S3	0.865	0.02	9.7-11.5	0.5
S4	1.375	0.015	5.1-6.5	0.5
S5	1.610	0.06	3.2-3.9	0.5
S6	2.250	0.05	5.7-7.1	0.5
S7	3.74	0.38	60-67 mK	1.0
F1	3.74	0.38	225-259 mK	1.0
S8	10.85	0.9	26-37 mK	1.0
F2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

SST is the main parameter obtained from SLSTR instrument and one of the key parameters in global climate monitoring. Therefore, there is a very stringent requirement on producing SST retrievals from SLSTR. Absolute accuracy should be better than 0.3 K and with a temporal stability of 0.1 K/decade. To enable and confirm such a stringent requirements, set of Cal/Val activities are implemented for Sentinel-3/SLSTR mission both on Level-1 and Level-2 products.

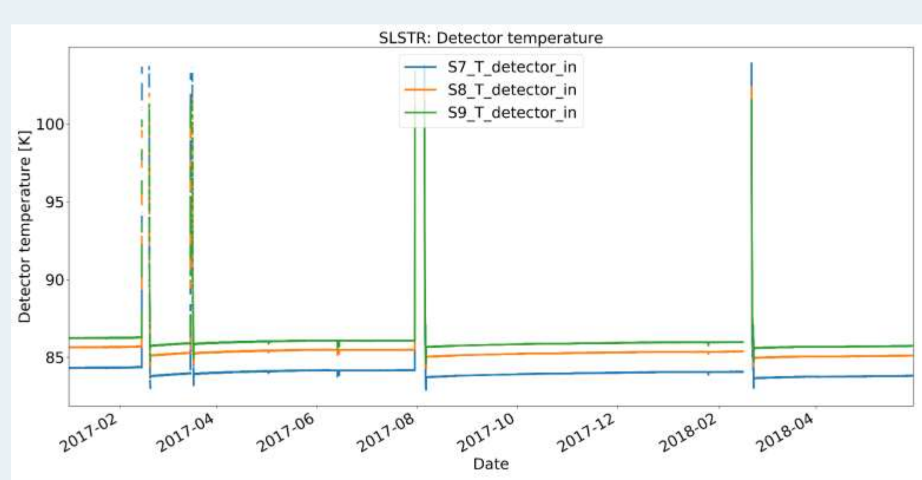
The main one on Level-1 encompasses monitoring of geolocation accuracy and radiometric inter-comparisons of SLSTR infrared channels with Infrared Atmospheric Sounding Interferometer (IASI), while on Level-2 it covers SST bias characterisation by comparison with in situ measurements and inter-satellite and inter-algorithm comparisons against Level-4 SST analysis.

Instrument monitoring

- Example of detector temperature and blackbodies monitoring



Example of nominal behavior of black bodies during the last two weeks of May 2018. The heated blackbody (+YBB) is maintained ~37°C above cold blackbody (-YBB).



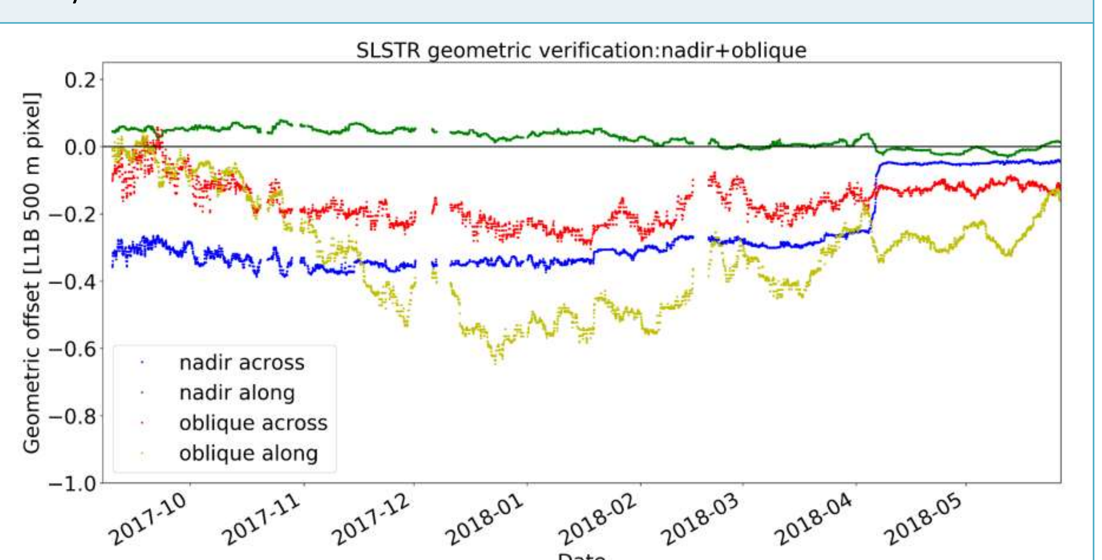
Detector temperatures for IR channels from Jan 2017 to May 2018. Small discontinuities occur due to the scheduled decontamination or following an anomaly. The vertical lines indicate the start and end of each decontamination cycle.

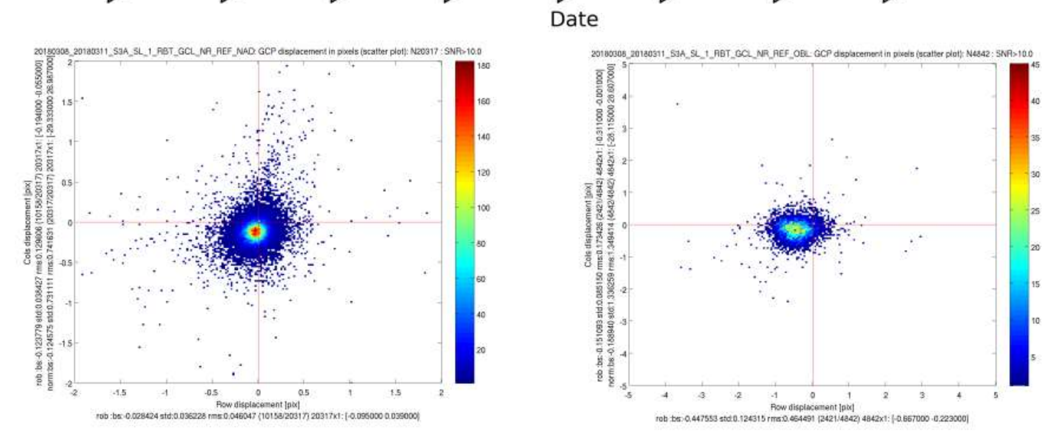
Geolocation verification

- Geolocation performance is monitored by performing cross correlation between imagettes (image subsets) and ground control points (GCPs)
- Difference between predicted and found position defines offset (in L1 500 m pixels)
- Each Level-1 product (3 min) contains several hundred GCPs - only GCPs with high signal-to-noise ratio (larger then 10) are used in analysis
- Both nadir and oblique view within requirements (0.5 SSD)

Upcoming work

- Further improvements for the oblique view
- Seasonality assessment using reprocessed data





Upper figure show offsets per product for nadir and oblique view in along and across direction:
- nadir along track (AL) is nominal
- nadir across track (AC) and oblique (both AL and AC) has been improved with the new PB 2.19 (4[th] April 2018)

Lower figures shows scatter plots (AL vs. AC track offsets) for nadir (left) and oblique (right) view:
- nadir – very good performance
- oblique – small AL offset (~0.4 pix)

Radiometric intercomparison: SLSTR vs IASI

AIM

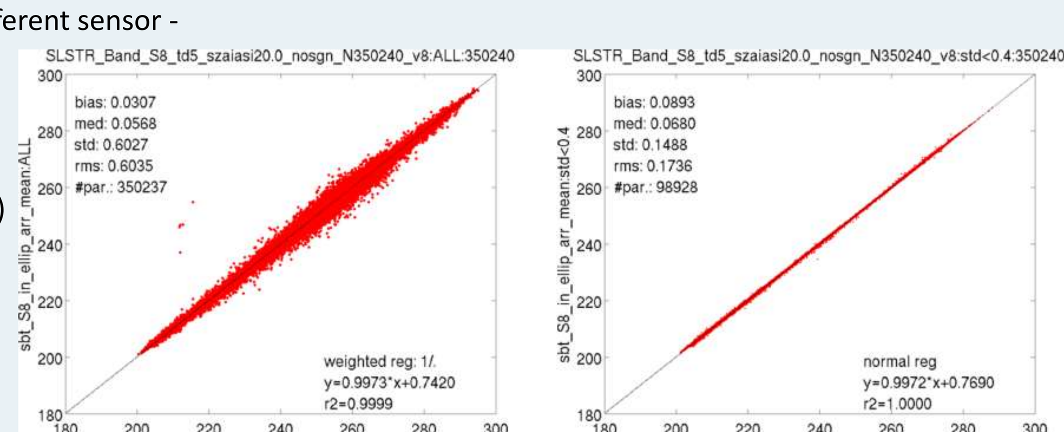
To verify if SLSTR IR is meeting performance requirements:
- The absolute radiometric accuracy of the data acquired in the IR channels shall be smaller than 0.2 K (0.1 K goal) traceable to the ITS-90.
- As a minimum, this requirement shall be met in the blackbody temperature range (~250 K - ~300 K), provided that the on-ground characterization covers the complete temperature range specified.

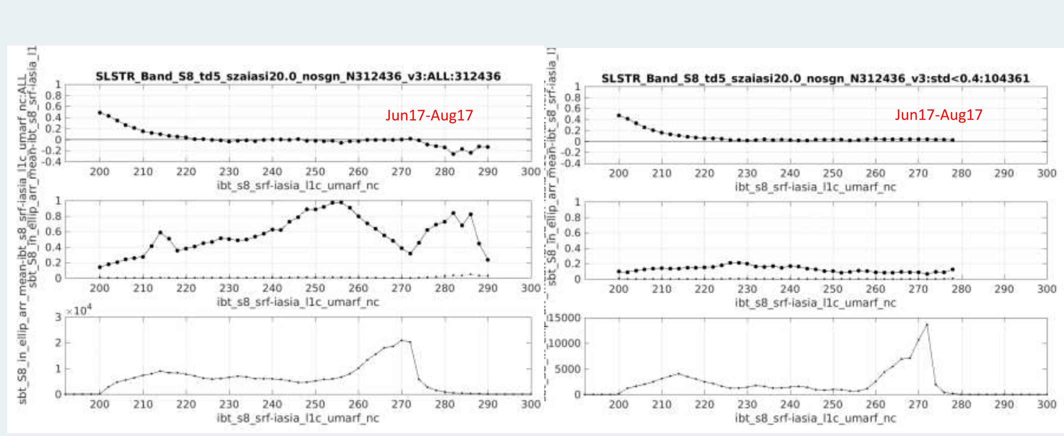
Objectives
- To compare against stable and characterized referent sensor: IASI – Global Space-based Inter-Calibration System (GSICS) referent sensor - due to the stability and characterisation

	All/det0/ det1	homo	ALL
S8	all	0.05+-0.11 (72863)	0.00+-0.64 (291396)
	det0	0.04+-0.12 (73128)	-0.01+-0.66 (291155)
	det1	0.05+-0.12 (73291)	0.00+-0.65 (291488)
S9	all	0.08+-0.11 (73606)	0.03+-0.66 (287830)
	det0	0.07+-0.12 (73963)	0.02+-0.67 (287570)
	det1	0.09+-0.11 (74056)	0.04+-0.67 (287900)

Methodology
- Crossovers (SNO), Collocations (matchups: time, space, viewing angle), Spectral convolutions; Aggregation (avg)

Summary
- Stable calibration within requirements (220-280 K): Near zero nadir view bias (<0.1 K) in S8 and S9 (220 K – 280 K)
- Cold temperature bias (~>0.2 K) (nonlinearity?)
- Small negative bias for >280 K (for QSNO)
- Different detectors response for S9 (~0.08 K)
- IASIA/IASIB double differences

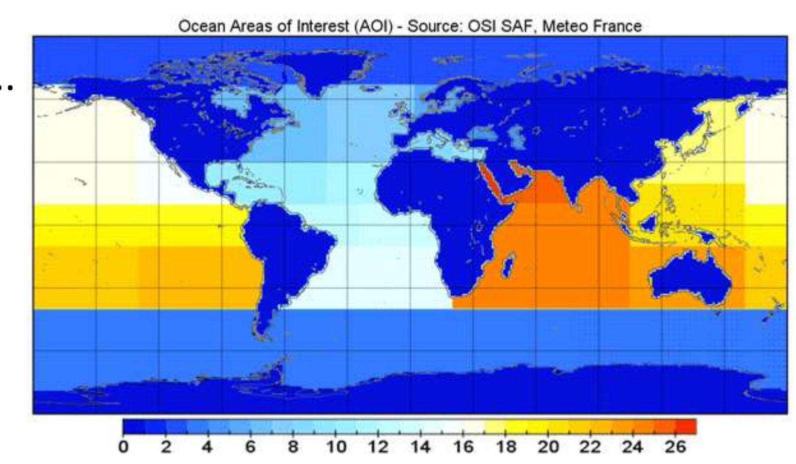


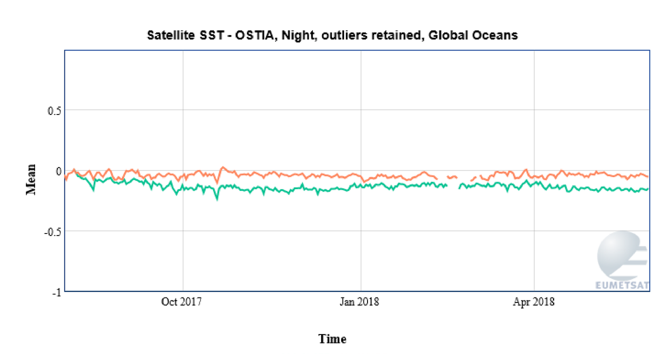


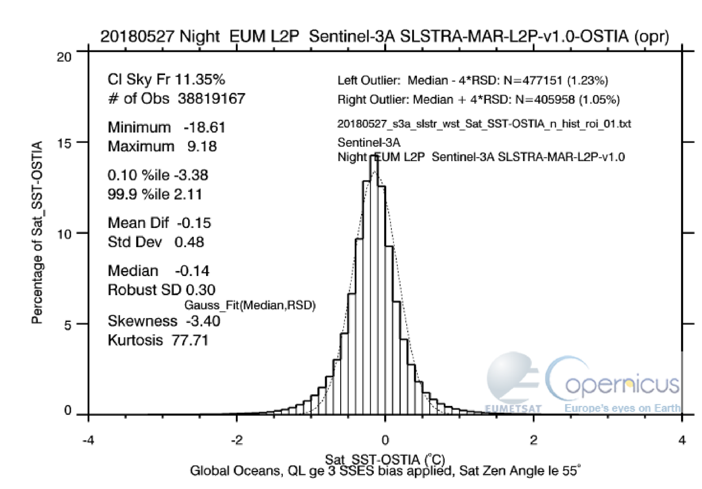
Upcoming work
- SLSTR-B vs IASI-A/B (tandem phase)
- QSNO (Quasi SNOs)
- Reprocessing

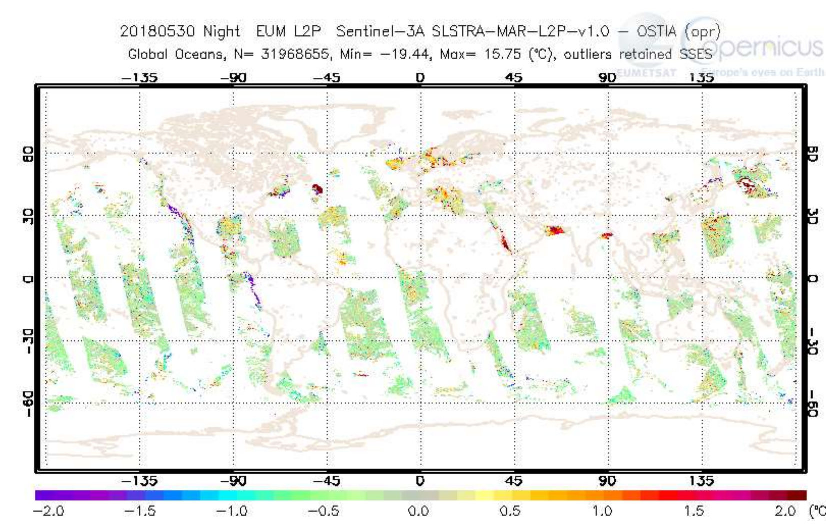
SST Bias Characterisation: Inter-satellite and inter-algorithm comparisons

- Satellite comparison with OSI-SAF and CMEMS products
- Analysing individual algorithms and instrument characteristics
- Global and regional routine analysis
- Daily, monthly plots, maps, time-series, histograms, ...
- **METIS**: http://metis.eumetsat.int/sst/



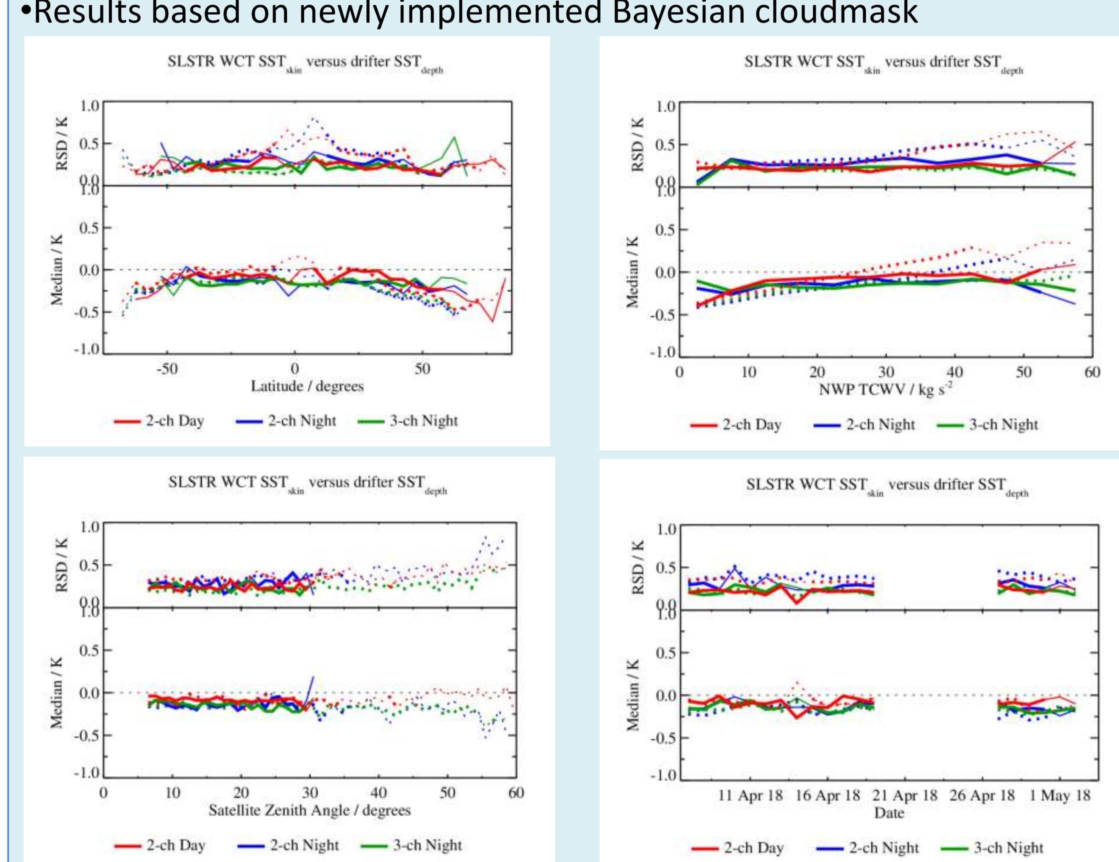




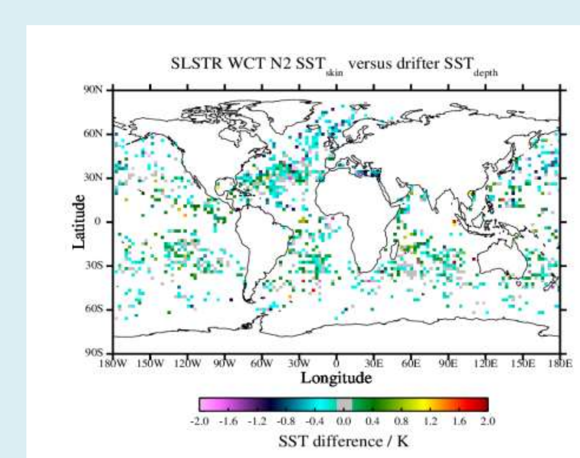


SST Bias Characterisation: Comparisons with in-situ measurements

- Copernicus Coriolis in situ service: drifters on GTS, OceanSITES (Pirata, GTMBA, ...) , Argo GDAC, GTSPP
- Routine and automatic collocations (**felyx**) of SLSTR L1/L2 over in situ measurements and ship mounted radiometers
- OSI-SAF Federated Activity SLSTR MDB: drifters, Argos, moored, radiometers
- Current status: NRT@OPE and NTC@REPRO with SL L1 IR channels
- Upcoming changes: NTC@OPE and NTC@REPRO with SL L1 all channels
- Results presented for cycle 30: 07.04.2018-04.05.2018
- Results based on newly implemented Bayesian cloudmask



- The dependence of the difference between SLSTR-A SST_{skin} and drifting buoy SST_{depth} for Cycle 30
- Latitude dependance (upper left), total column water vapor (upper right), satellite zenith angle (lower left) and time (lower right)
- Daytime 2-channels results are shown in red; night time 2-channels results are shown in blue and nighttime 3-channels are shown in green. Solid lines indicate dual-view retrieval and dashed lines indicate nadir-only retrievals.
- No adjustments added for difference in depth or time between the satellite and in situ measurements



Spatial distribution of match-ups between SLSTR-A SST_{skin} and drifting buoy SST_{depth} for Cycle 30

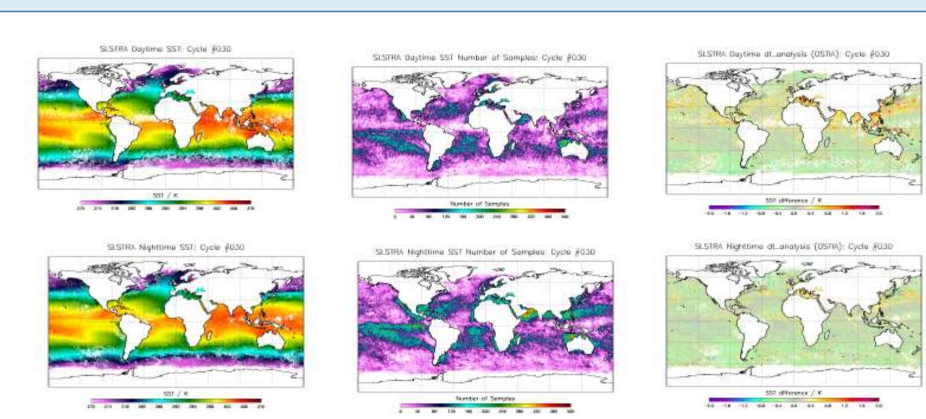
Retrieval	Number	Median (K)	RSD (K)
N2 day	3549	-0.08	0.35
D2 day	1473	-0.08	0.22
N2 night	3880	-0.18	0.37
N3 night	3880	-0.17	0.23
D2 night	1513	-0.14	0.30
D3 night	1513	-0.15	0.24

Match-ups statistics (median and robust standard deviation, RSD) of SLSTR-A/drifter match-ups for Cycle 30 per algorithm. No adjustments have been made for difference in depth or time between the satellite and in situ measurements, therefore at night time (in the absence of diurnal warming) an offset of around -0.17 K is expected.

Very good performance (RSD ≤ 0.3 K) for D2/D3 and N3. Small degradation for N2.

SST L3 analysis

- SST Level 3 routine production. Day, week, cycle, …
- Example of Level 3 spatially average SST for Cycle 30 at a resolution of 0.05 degree for daytime (upper left) and nighttime (lower left)
- Number of 1-km samples in each average (middle) and mean difference to OSTIA L4 SST analysis (right)



Acknowledgements

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