Comparison of Sentinel-3a SLSTR derived Sea Surface Skin Temperature with M-AERI observations

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Introduction

The Skin Sea Surface Temperature (SST_{skin}) derived from satellite measurements and models is one of the key factors for determining ocean-atmosphere interactions in climate prediction and ocean modeling research. SENTINEL-3a is a European Earth Observation satellite mission developed to support ocean, land, atmospheric applications. We compare SST_{skin} from the Sea and Land Surface Temperature Radiometer (SLSTR) on board the Sentinel-3a satellite from July 2017 - March 2019 using the independent Marine-Atmospheric Emitted Radiance Interferometer (M-AERI) deployed on ships during the Aerosols and Ocean Science Expeditions (AEROSE) cruises. The inter-comparison results show that a small average difference of ~0.06K and median difference of 0.005K between SLSTR and M-AERI.

1. Motivation & Data

➢ **Motivation:**

▪The successful application of all SLSTR-derived SST fields depends on confident knowledge of their accuracies.

▪Several sources of error and uncertainties impact the SLSTR measurements and the geophysical variables derived from them.

▪Determine the accuracies by comparing the satellite-derived temperatures with independent surface based measurements of equal or better accuracy.

▪Satellite SST requirements for climate research: Accuracy = 0.1K Stability = 0.04 K/decade. (Ohring, G., et al. 2005).

➢ **Copernicus Sentinel-3A SLSTR**

- Sentinel-3A was launched February 16th 2016.
- Operational L2 SST from 5/7/17.
- Bayesian cloud implementation Jan 2018.
- Dual-view to provide robust & accurate Sea-Surface Temperature (SST) and highly accurate thermal calibration

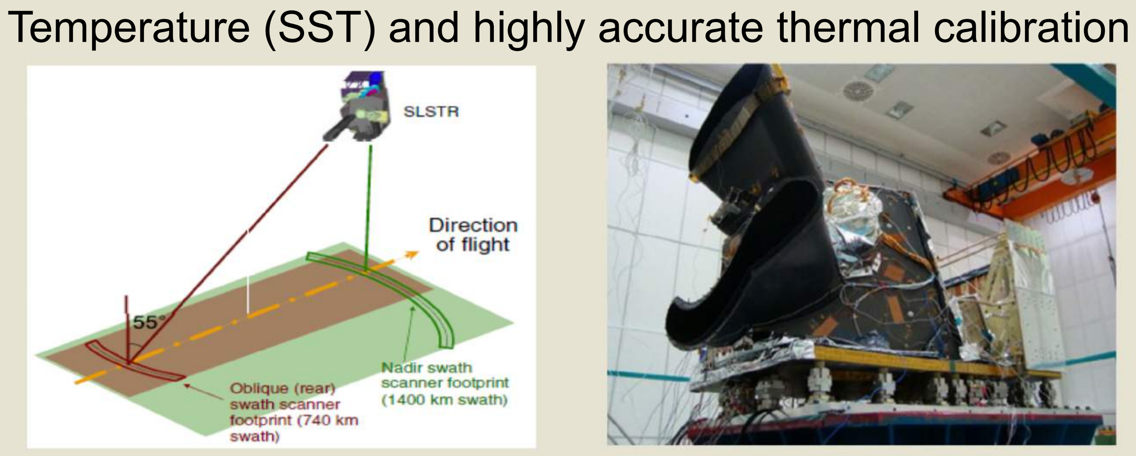


Figure: SENTINEL-3 SLSTR Instrument

➢ **Independent M-AERI in-situ data:**

•The M-AERI is an accurate, self-calibrating, Fourier transform IR spectroradiometer that measures emission spectra from the sea and atmosphere.

•At sea calibration by two internal blackbody cavities with thermometers with SI-traceable calibration. Calibration sequence before and after each cycle of measurements.

•Calibration before and after deployments using NIST-designed water-bath blackbody calibration target.

•Periodic radiometric characterization of RSMAS water-bath blackbody calibration target by NIST TXR and NPL AMBER.

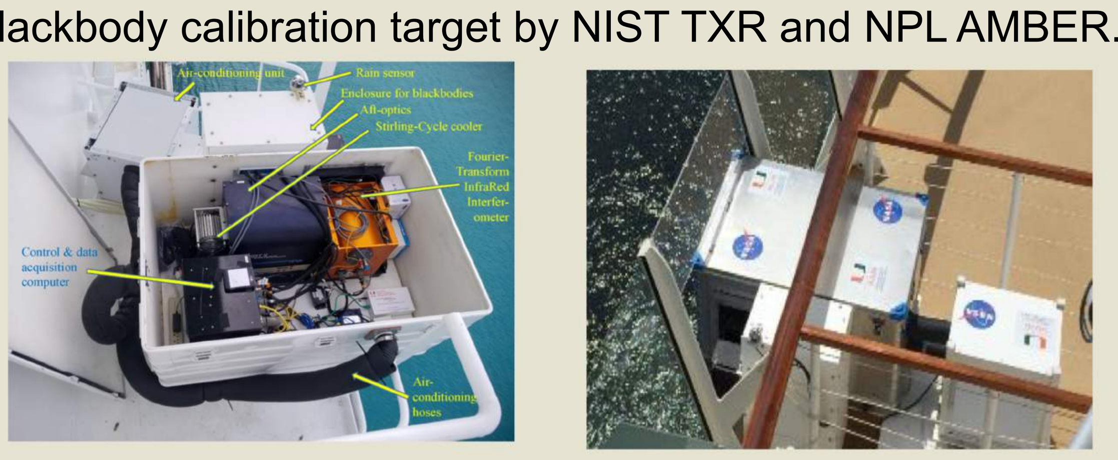
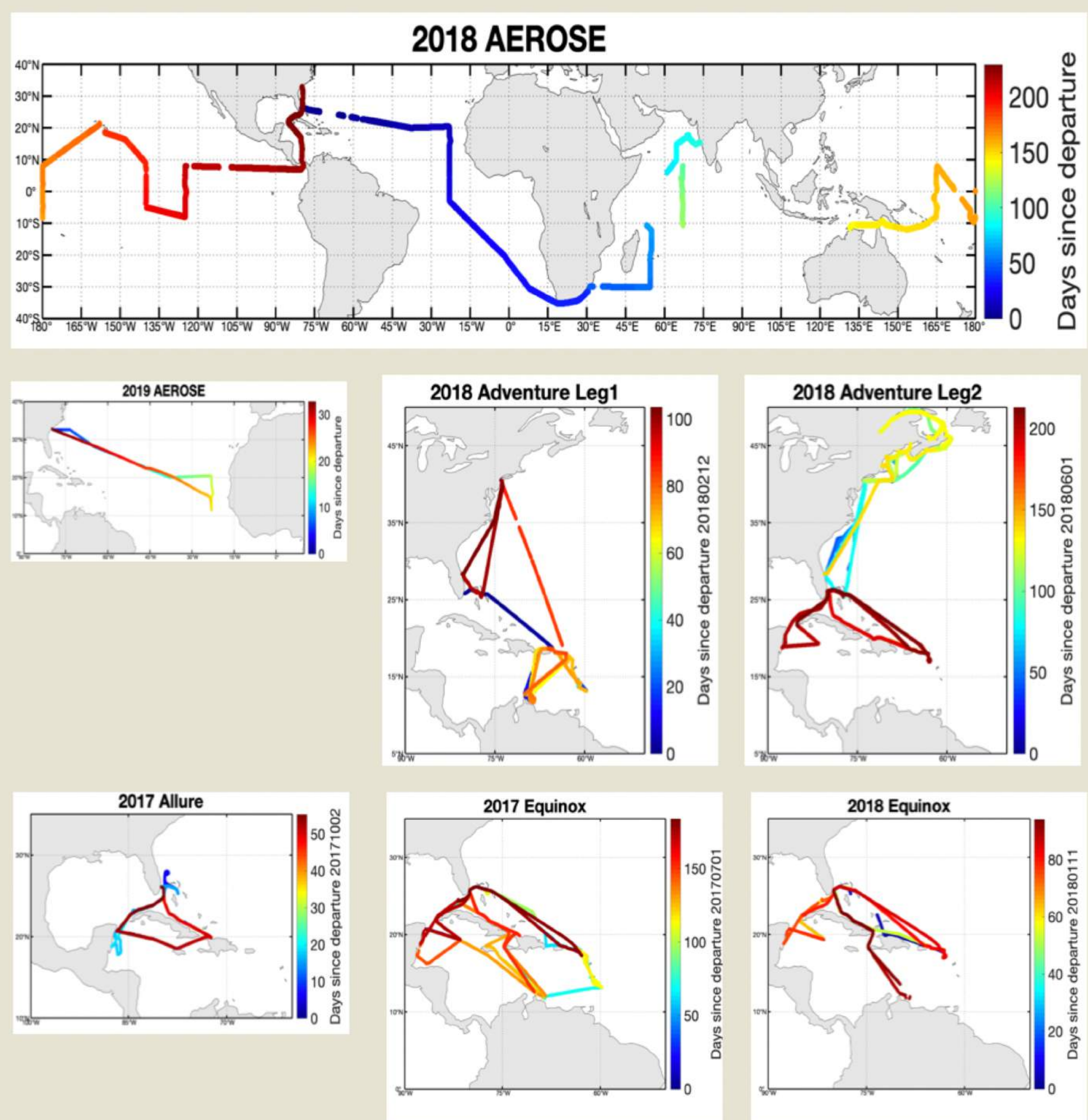


Figure: M-AERI Deployments

	At λ= 10.0 µm (1000 cm^{-1})			At λ= 7.7 µm (1302 cm^{-1})		
Parameter	Type A Uncertainty [K]	Type B Uncertainty [K]	Uncertainty in Brightness temp[K]	Type A Uncertainty [K]	Type B Uncertainty [K]	Uncertainty in Brightness temp [K]
Repeatability of Measurement	0.014		0.014	0.0349		0.0349
Reproducibility of Measurement	0.0058 (0.0035)		0.0058 (0.0035)	0.0178 (0.0089)		0.0178 (0.0089)
Linearity of Radiometer		0.0003	0.0003		0.0003	0.0003
Primary calibration		0.0097	0.0097		0.0086	0.0086
Drift since calibration			0			0
RMS total	0.0152 (0.0144)	0.0102	0.0182 (0.0176)	0.0392 (0.0360)	0.0091	0.0402 (0.0372)

Table: Error Budget of M-AERI measurements

2. M-AERI Cruises



Figures: M-AERI cruise tracks color indicates the days since departure.

3. SST_{skin} Error Statistics

➢ **Match-up Details**

- The SLSTR M-AERI MUDB combines match-ups from multiple cruises.
- Only contains data fields from SLSTR L2 WST but with different WCT algorithms.
- The co-location criteria used are: 5 km distance and 1 hour time
- Only SLSTR Quality level of 5
- Time Period: July 2017 - March 2019
- Operational SLSTR L2 SST_{skin} data are available from EUMETSAT Data Center.

Cruises	START	END	N	N*	Mean	Med	STD	RMS	RSD
2017 Equinox	20170701	20171231	34439	897	0.192	0.044	0.603	0.632	0.412
2017 Allure	20171002	20171126	6713	197	0.063	0.012	0.526	0.528	0.303
2018 Equinox	20180111	20180415	15817	519	0.152	0.103	0.467	0.491	0.311
2018 L1 Adventure	20180212	20180527	11201	451	0.093	0.024	0.484	0.493	0.292
2018 L2 Adventure	20180601	20181231	35826	1341	-0.040	-0.034	0.369	0.371	0.242
2018 AEROSE	20180307	20181023	38354	921	0.001	-0.044	0.415	0.415	0.275
2019 AEROSE	20190224	20190329	8407	392	0.143	0.050	0.443	0.465	0.324
Total	--	--	**150757**	**5169**	**0.068**	**0.005**	**0.476**	**0.481**	**0.289**

Table: Error Statistics of SLSTR minus MAER-I SST_{skin} difference.

- The results of the SST_{skin} comparison reveal that SLSTR are in good agreement with the in-situ measurements.
- SLSTR on Sentinel-3A SST_{skin} has a median difference of ~0.005 K and Robust SD of ~0.28 K with respect to M-AERI. But for 2017, S-3A SLSTR SST_{skin} has a negative bias compared to M-AERI.

4. SST_{skin} Validation

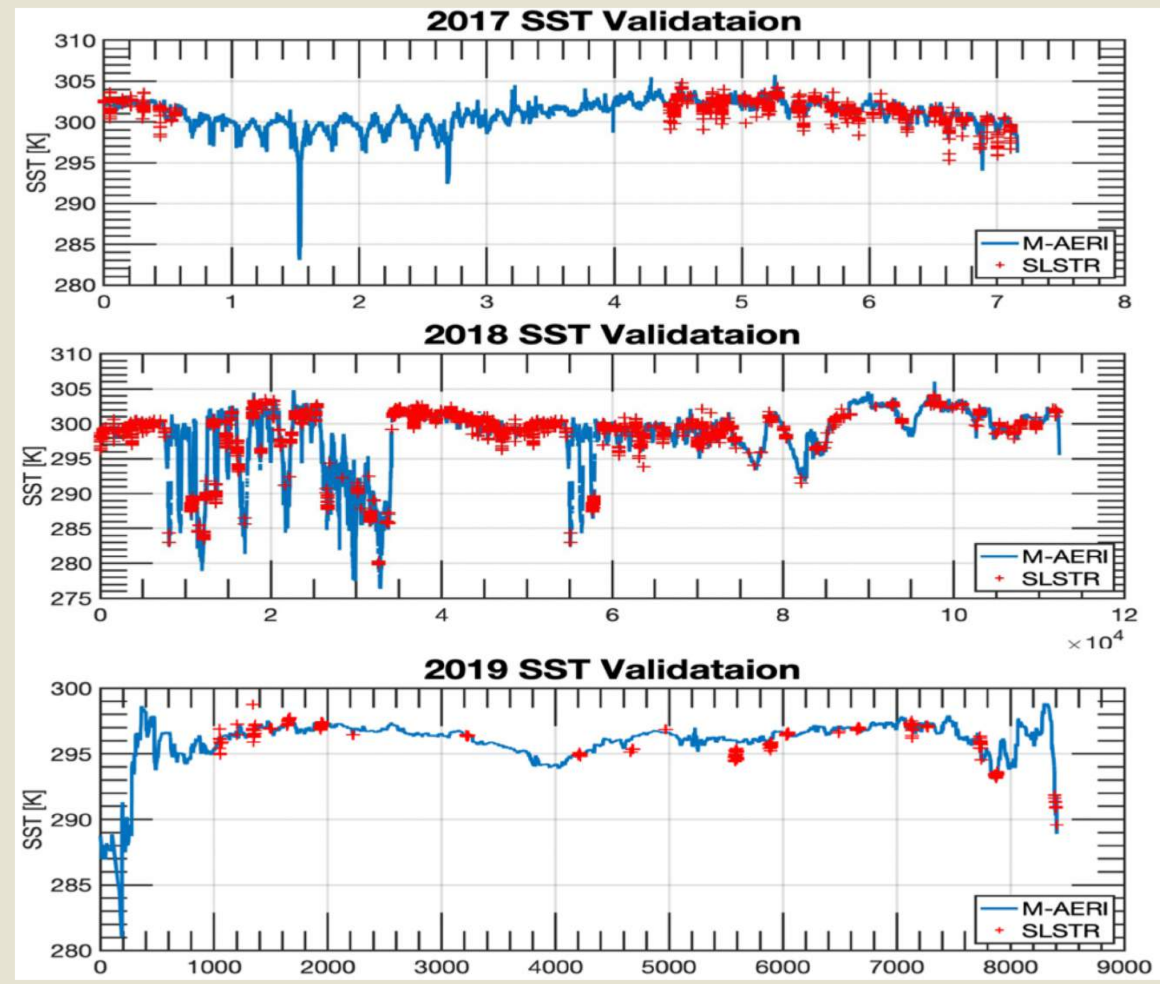


Figure: Blue: Plots of M-AERI SST, X-axis is the Record number of M-AERI measurements of each year. Red: Scatter plots of the SLSTR SST_{skin} in matchup database.

Products	For the SLSTR SST vs Drifters SST								
	2017			2018			2019		
	N*	Mean	RSD	N*	Mean	RSD	N*	Mean	RSD
N2	0	**	**	347	0.023	0.451	138	-0.027	0.147
N3	563	0.375	0.660	1062	0.134	0.327	112	0.512	0.605
D2	0	**	**	481	-0.025	0.344	83	-0.002	0.572
D3	529	-0.050	0.253	1723	-0.017	0.231	59	0.046	0.346
Total	1092	0.169	0.387	3613	0.029	0.275	392	0.143	0.324

Table: Error Statistics of SLSTR minus M-AERI SST_{skin} according to N2, N3, D2 and D3 algorithms.

5. Error Distribution

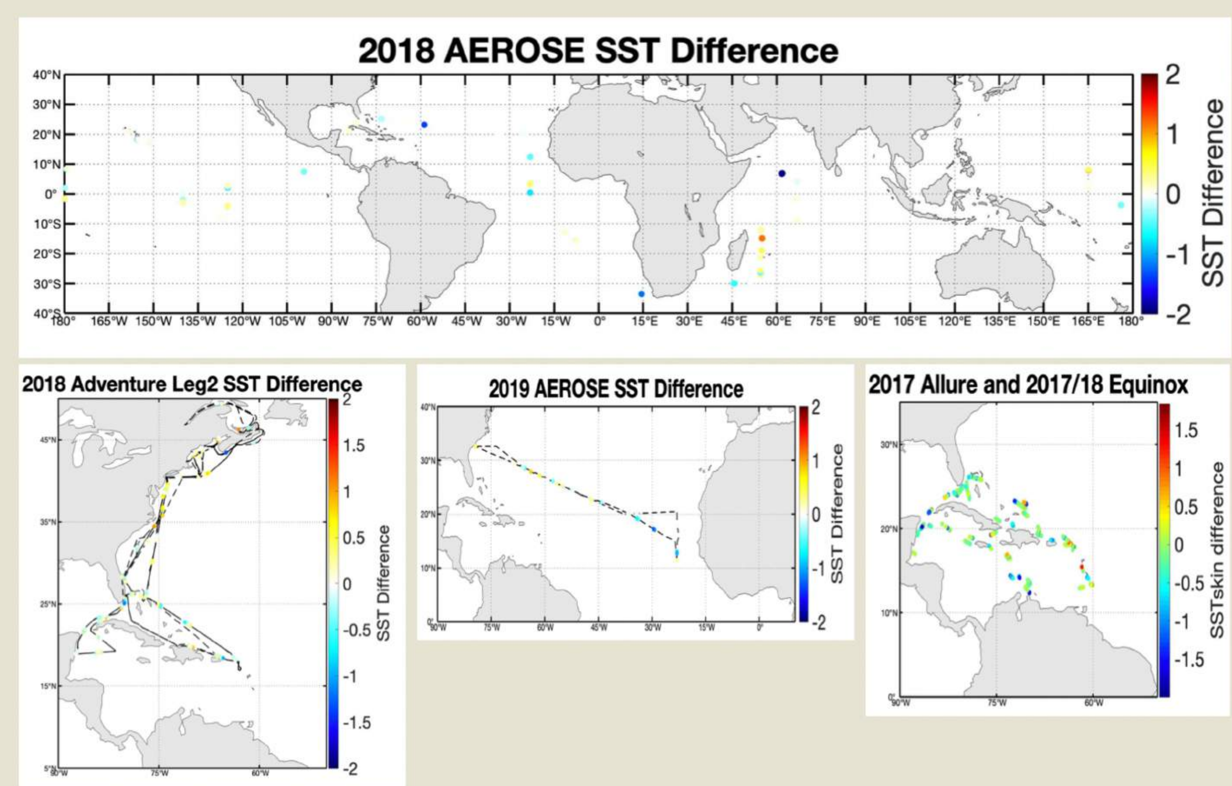


Figure: Locations of SLSTR minus M-AERI SST_{skin} differences.

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7. References

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