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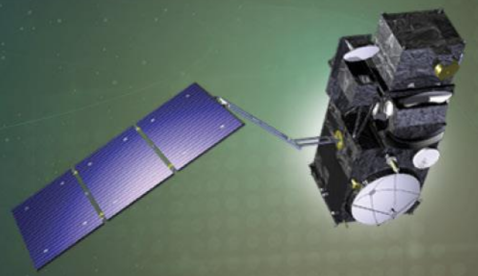

7th Sentinel-3 Validation Team Meeting 2022

18-20 October 2022 | ESA-ESRIN | Frascati (Rm), Italy

Comparison of SLSTR Clear-Sky Infrared Measurements with those of Geo-stationary Imagers, and skin SST Accuracy Assessment Using Ship Radiometers

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Sequence of Presentation

- Motivation
- Data: SLSTR on Sentinel 3a, ABI on GOES-16, SEVIRI on MSG-4
- Procedure
  - Brightness temperature harmonization
  - Test cases
  - Assess accuracies
- Validation of derived SST_{skin} using M-AERIs
- Conclusions

Motivation

- The generation of multi-decadal Climate Data Records of SST requires the combination of measurements from several sensors on different satellites.

- The successful combination requires knowledge of the accuracies and consistency of the on-orbit measurements and of the derived skin SSTs.

- We present results of a comparison of the brightness temperatures (BTs) measured by the Sentinel-3a SLSTR and those by the Geostationary Operational Environmental Satellite (GOES-16) Advanced Baseline Imagers (ABI) and Meteosat Second Generation (MSG-4) Spinning Enhanced Visible and Infrared Imager (SEVIRI).

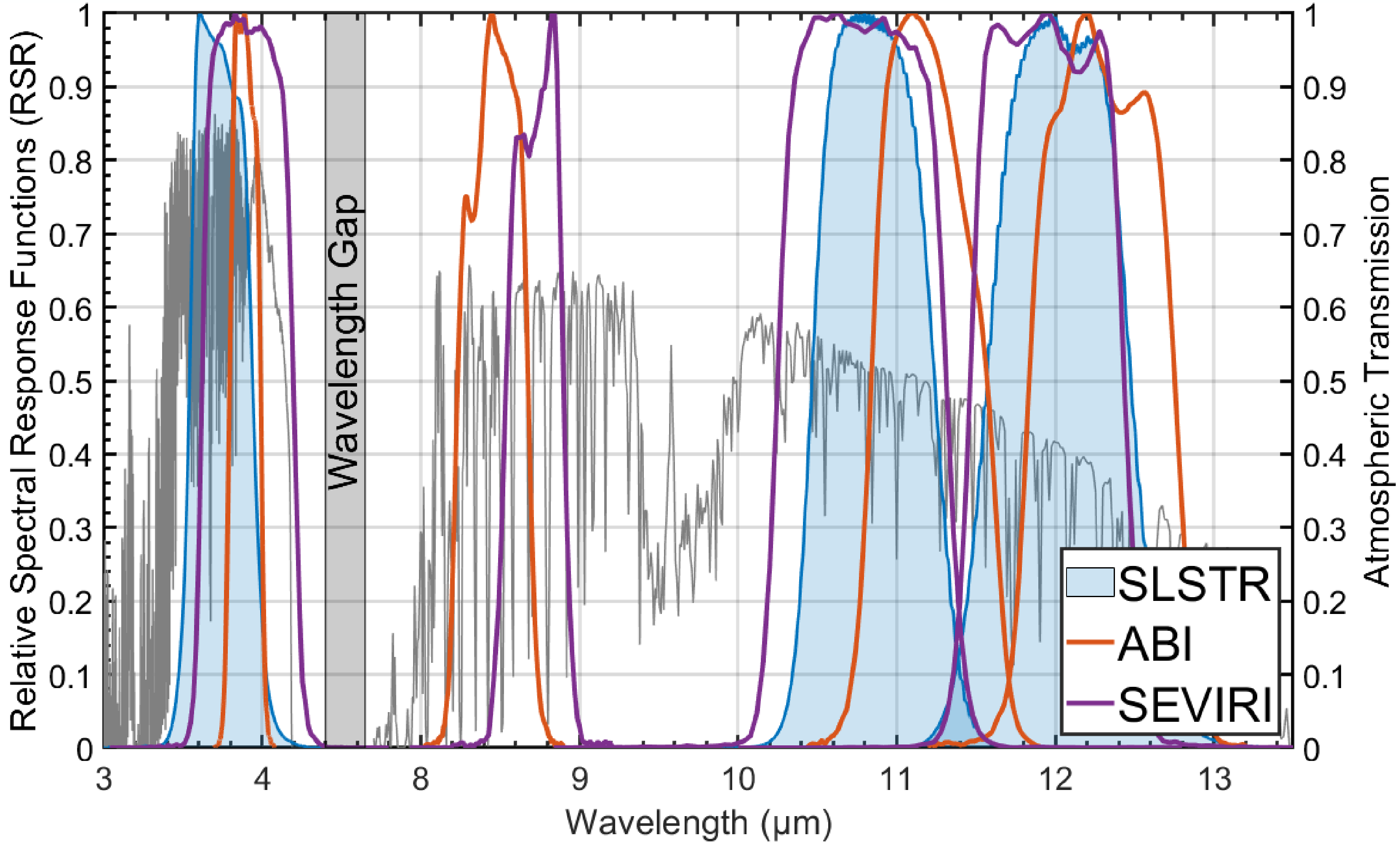
Radiometer Sampling Characteristics.

Satellite radiometer	Source	Temporal resolution	Nadir Spatial resolution
Sentinel-3A SLSTR	EUMETSAT Copernicus Online Data Access (CODA)	3 minutes for L-1B data	1 km
GOES - ABI	NOAA Amazon Web Services (AWS) Data Centre	10 minutes	2 km
MSG-4 SEVIRI	EUMETSAT Data Centre	15 minutes	3 km

Infrared Bands for SST_{skin}

Band	Band	Center Wavelength (µm)	Band	Center Wavelength (µm)	Band	Center Wavelength (µm)
	GOES - ABI		MSG-4 SEVIRI		Sentinel-3A SLSTR	
IR038	7	3.90	4	3.90	S7	3.74
IR087	11	8.50	7	8.70	-	-
IR112	14	11.20	9	10.80	S8	10.95
IR123	15	12.30	10	12.00	S9	12.00

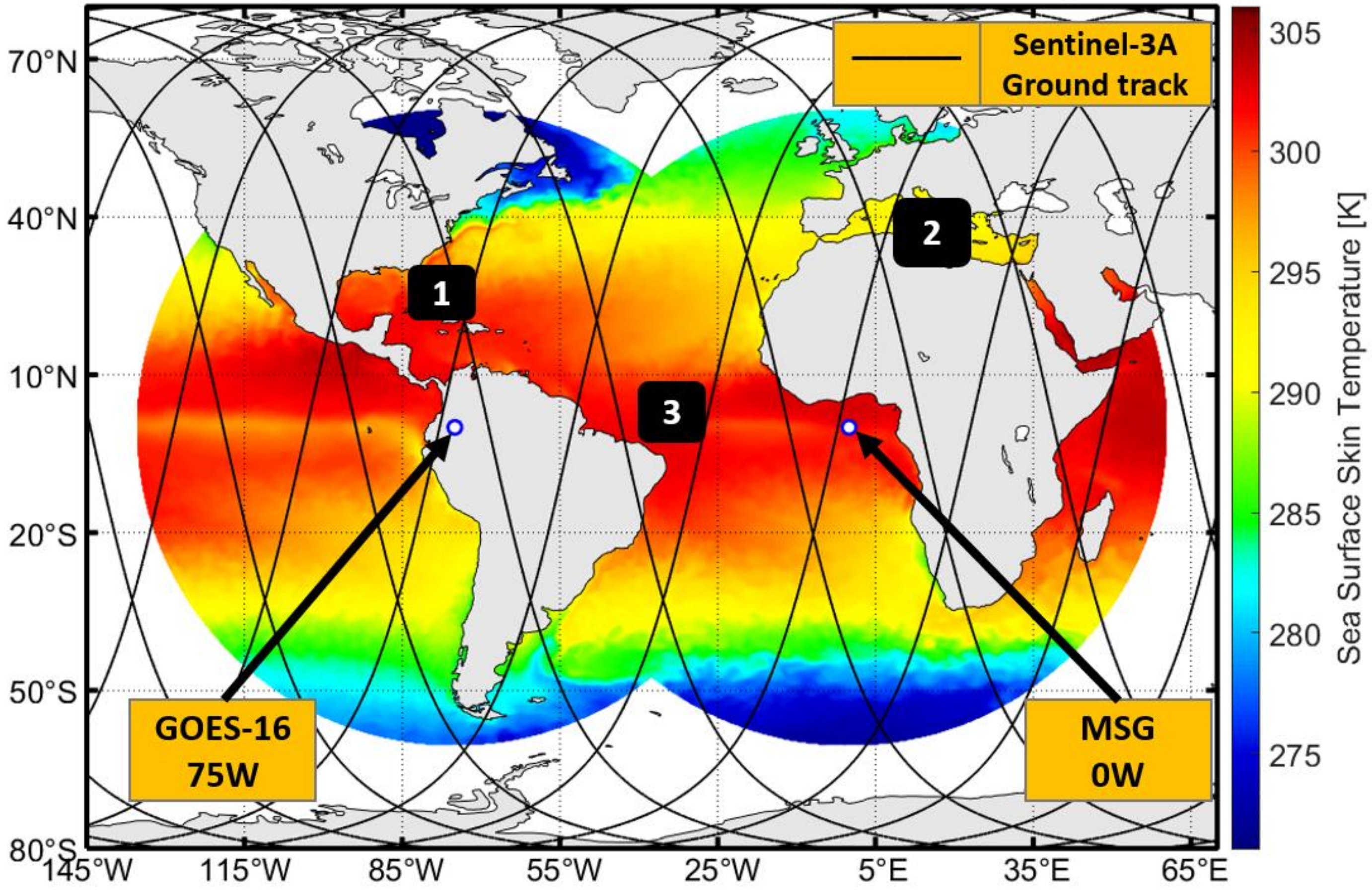
Radiometer Relative Spectral Response Functions.



SLSTR L1-B data used in this study

Areas	Comparisons	Date	UTC Time
1 Eastern tropical North Atlantic Ocean	SLSTR with ABI	Jan 01, 2020	Day: 15:21:14 Night: 02:55:20
2 Mediterranean Sea	SLSTR with SEVIRI	Dec 23, 2019	Day: 09:04:56 Night: 20:21:51
3 Cross-covered region	SLSTR with SEVIRI and ABI	Nov 27, 2019	Day: 12:09:44 Night: 00:36:20

Geostationary satellite coverages. Background: May 2020 SST



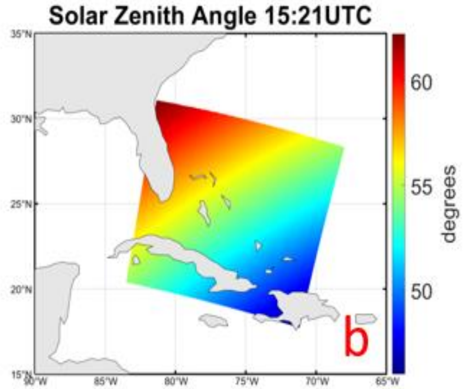
Procedure

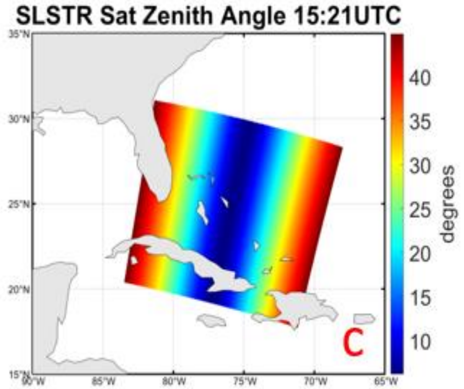
- Select SLSTR granules in mostly cloud-free areas, but some cloud is desirable.
- For each SLSTR pixel find ABI and SEVIRI pixel within 1 km, and usually < 5 minutes
- Use Radiative Transfer modelling (RTTOV) to simulate top-of-atmosphere brightness temperatures (TOA BTs) in all bands.
- Sea surface and vertical atmospheric data for TOA BT simulations from NASA Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA-2).
- Convert BTs of ABI and SEVIRI into equivalent SLSTR brightness temperatures:

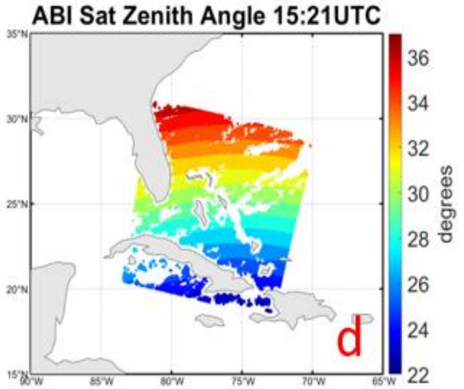
$$BT_{\mathrm{SLSTR\ equivalent}} = a \times BT_{ABI\ or\ SEVIRI} + b \times BT_{SLSTR} \times (\sec(\theta_{SLSTR}) - 1)$$
$$+ c \times BT_{ABI\ or\ SEVIRI} \times (\sec(\theta_{ABI\ or\ SEVIRI}) - 1) + d$$

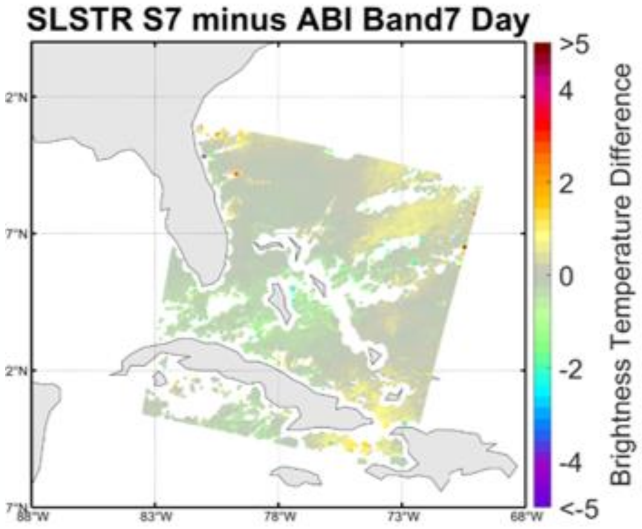
- Coefficients are scene dependent

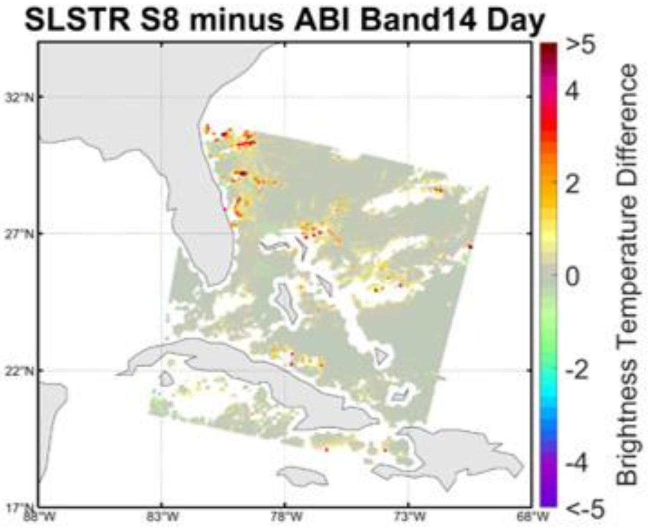
Area 1. SLSTR daytime IR image on Jan 01, 2020, 15:21:14 UTC

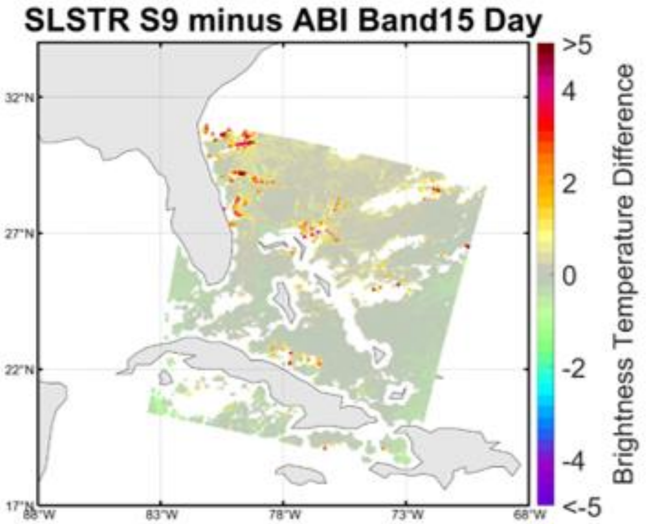




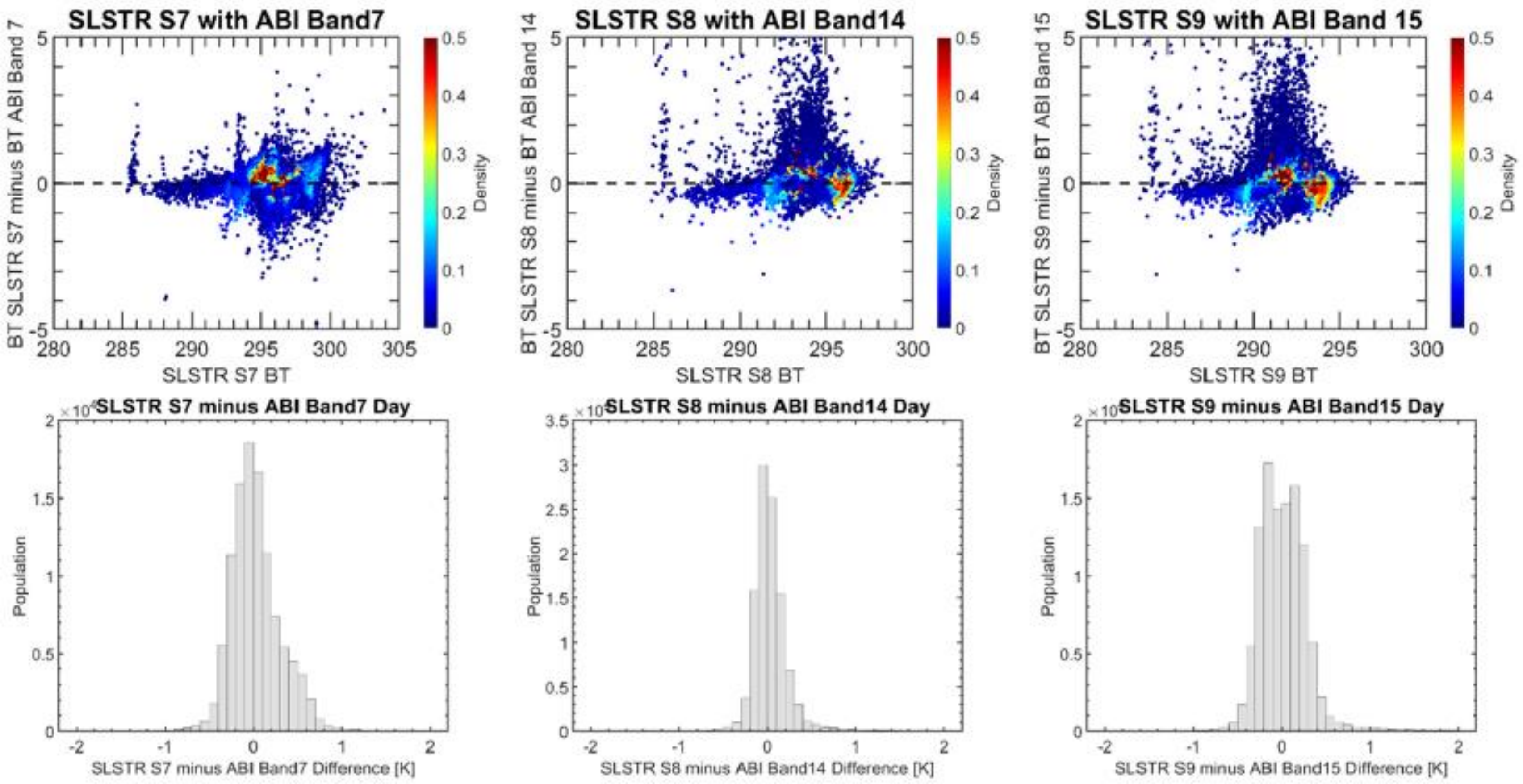




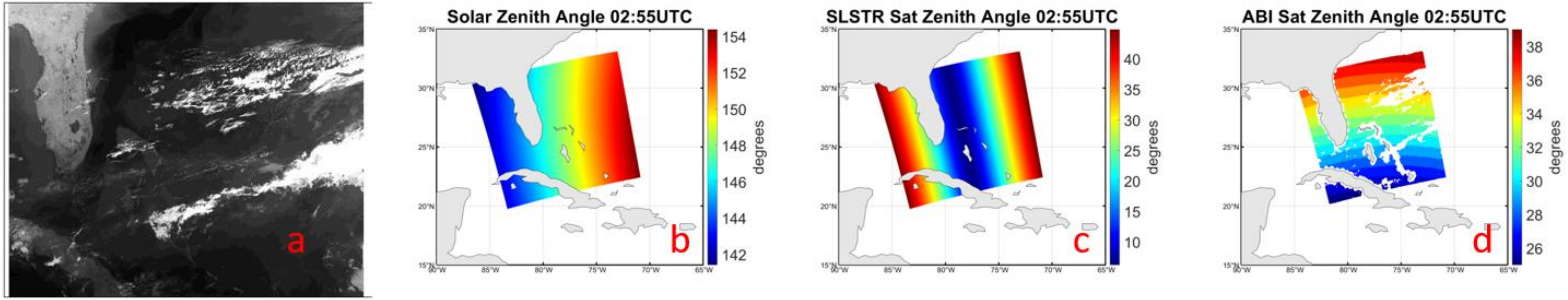


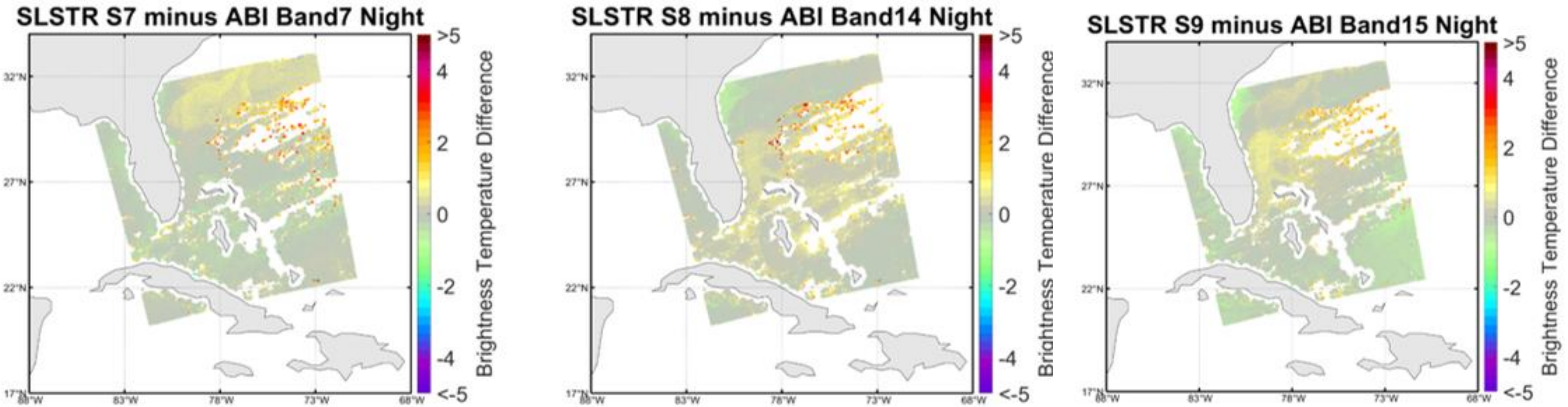


Area 1. SLSTR daytime IR image on Jan 01, 2020, 15:21:14 UTC

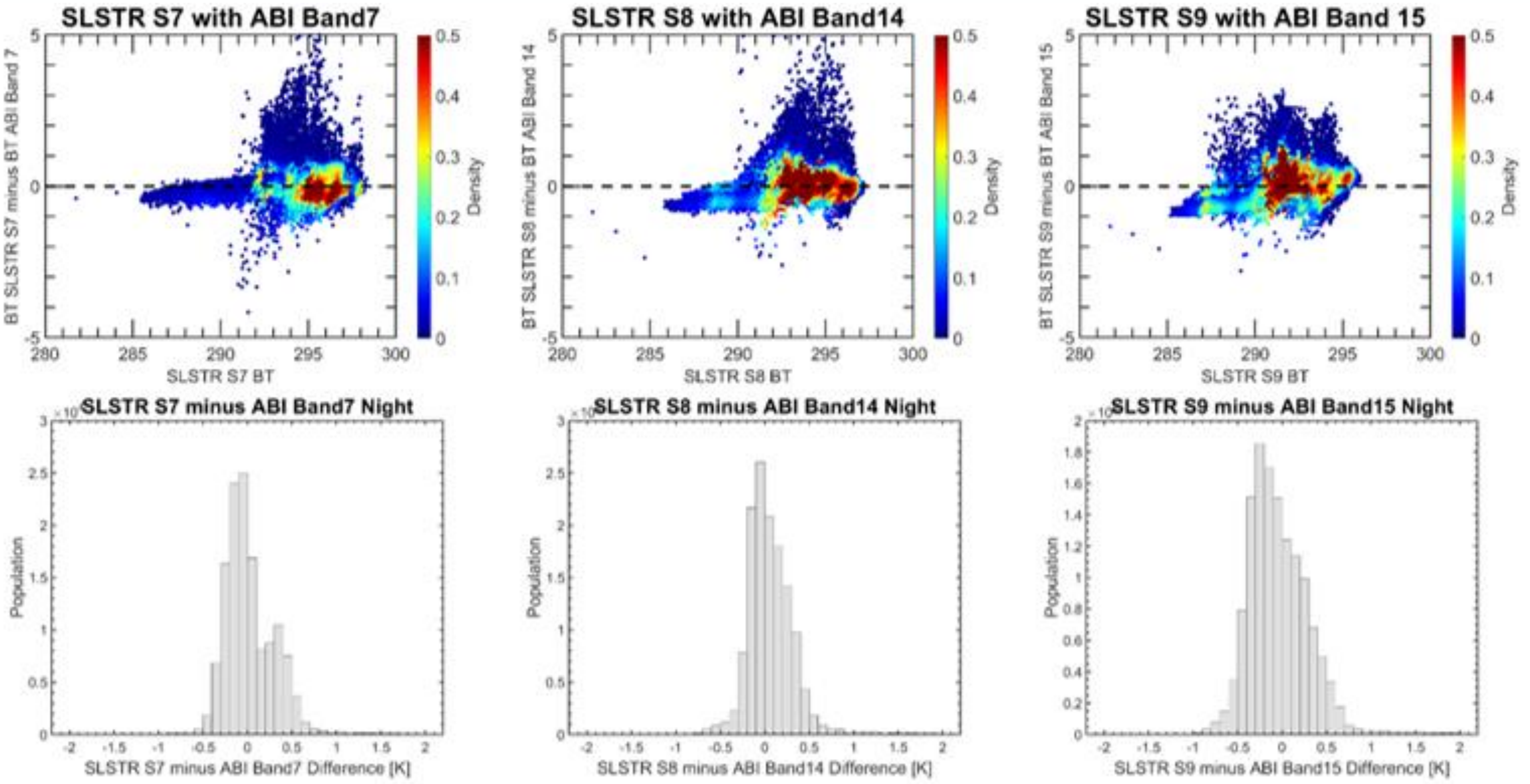


Area 1. SLSTR nighttime IR image on Jan 01, 2020, 02:55:20 UTC.





Area 1. SLSTR nighttime IR image on Jan 01, 2020, 02:55:20 UTC.



Area 1. SLSTR *vs* ABI BTs.

Eastern Tropical North Atlantic Ocean	Day/ night	Band (SLSTR)	Mean (K)	STD (K)	RSD (K)
SLSTR vs ABI	Day	S7 - 3.74 μm	0.028	0.296	0.248
		S8 - 10.95 μm	0.054	0.326	0.145
		S9 - 12.00 μm	0.042	0.401	0.260
	Night	S7 - 3.74 μm	0.039	0.360	0.281
		S8 - 10.95 μm	0.079	0.383	0.230
		S9 - 12.00 μm	-0.035	0.360	0.330

Area 2. SLSTR *vs* SEVERI BTs.

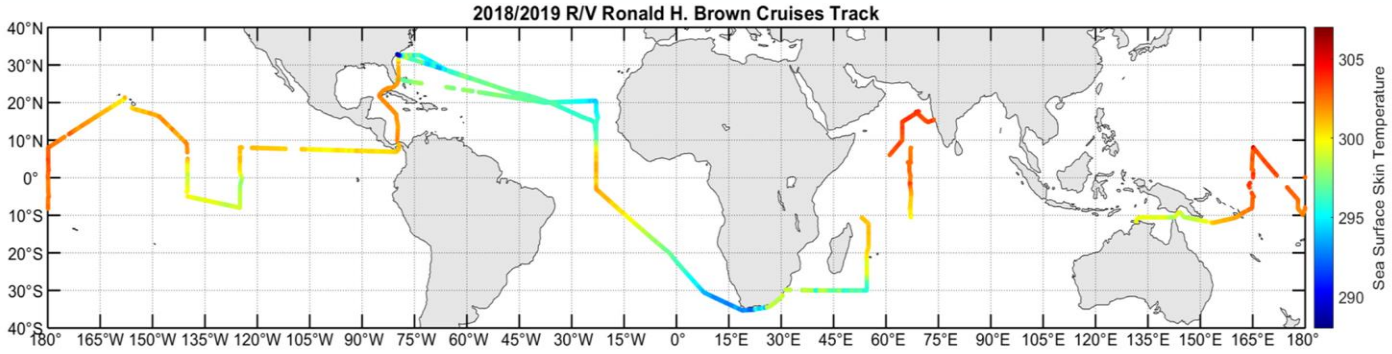
Mediter-ranean Sea	Day/ night	Band (SLSTR)	Mean (K)	STD (K)	RSD (K)
SLSTR vs SEVIRI	Day	S7 - 3.74 μm	0.133	0.544	0.493
		S8 - 10.95 μm	0.067	0.454	0.143
		S9 - 12.00 μm	0.073	0.440	0.198
	Night	S7 - 3.74 μm	0.077	0.480	0.320
		S8 - 10.95 μm	0.143	0.674	0.240
		S9 - 12.00 μm	0.124	0.644	0.328

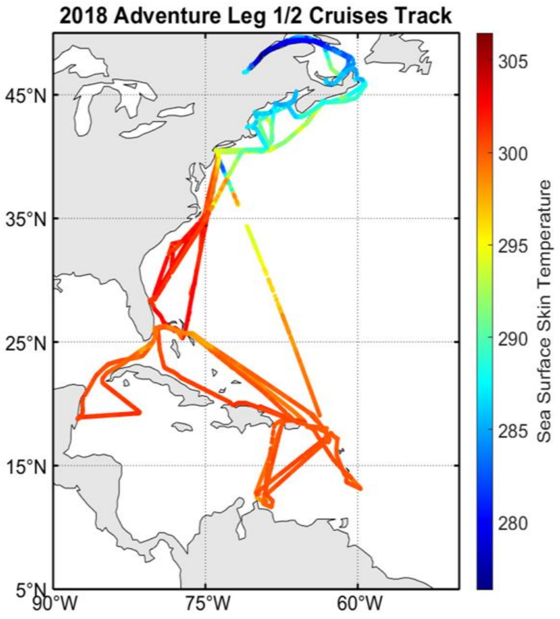
Area 3. SLSTR *vs* ABI and SEVIRI BTs

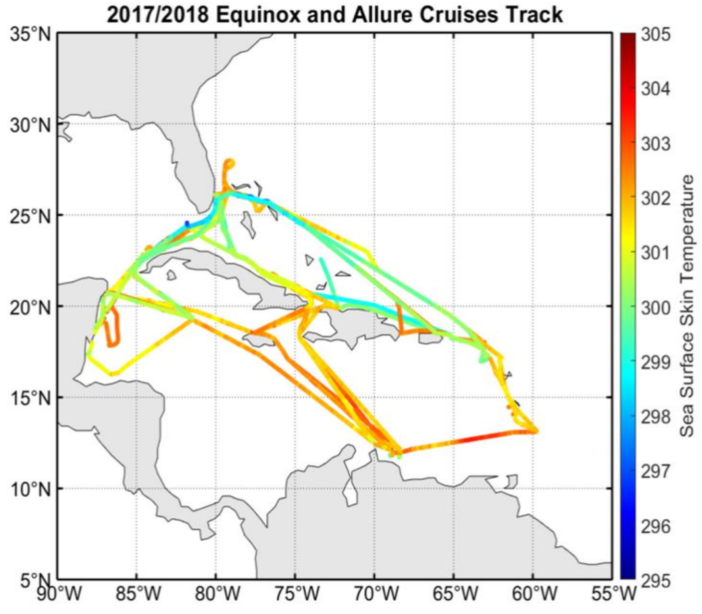
Equatorial Atlantic Ocean	Day/ night	Band (SLSTR)	Mean (K)	STD (K)	RSD (K)
SLSTR vs ABI	Day	S8 - 10.95 µm	0.035	0.452	0.184
		S9 - 12.00 µm	0.056	0.516	0.211
	Night	S8 - 10.95 µm	0.128	0.891	0.186
		S9 - 12.00 µm	0.143	1.084	0.207
SLSTR vs SEVIRI	Day	S8 - 10.95 µm	0.087	0.450	0.202
		S9 - 12.00 µm	0.072	0.467	0.241
	Night	S8 - 10.95 µm	0.084	0.465	0.224
		S9 - 12.00 µm	0.105	0.549	0.265

Validation of Sentinel 3A SLSTR SST_{skin} with M-AERI

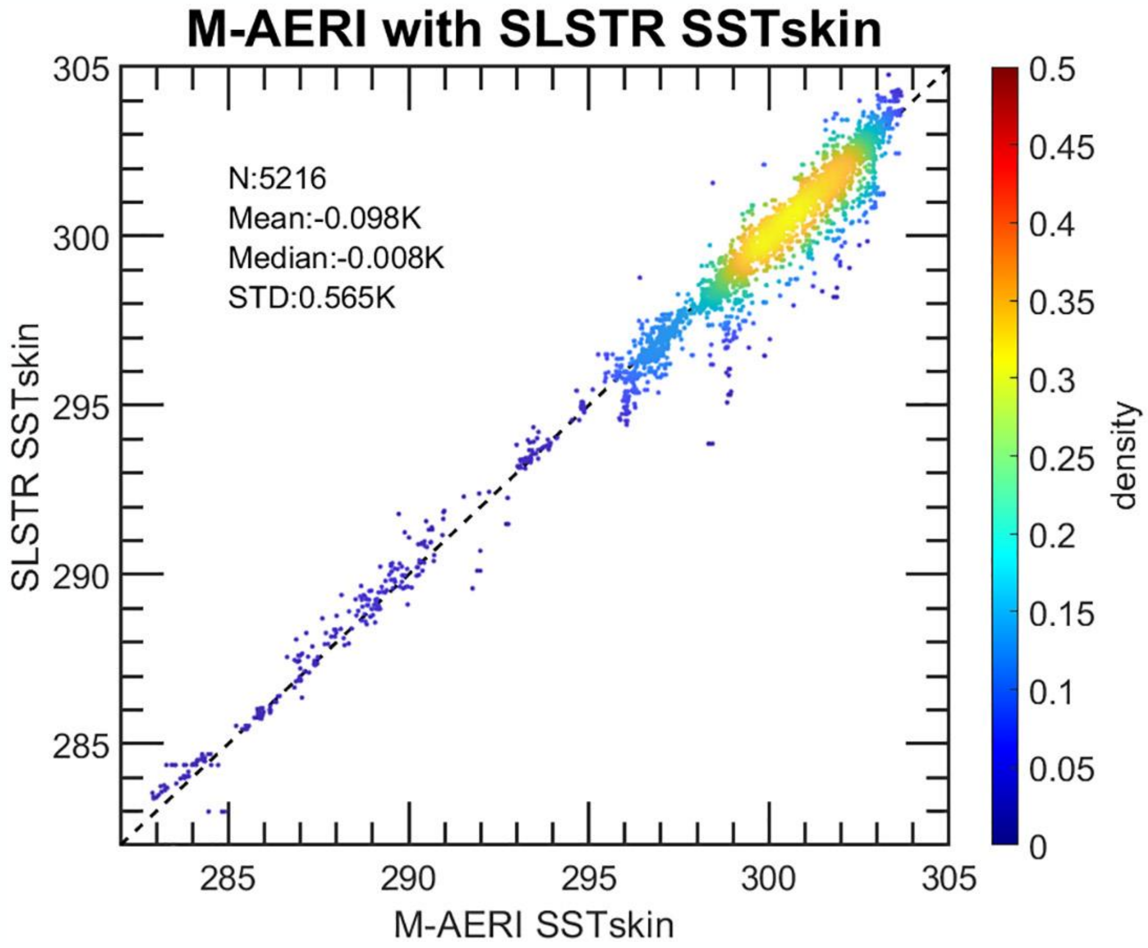
- Matchups within 60 minutes and 10 km.
- Best retrievals from the four possible algorithms used.
- SSESs not applied.
- 5216 Matchups.

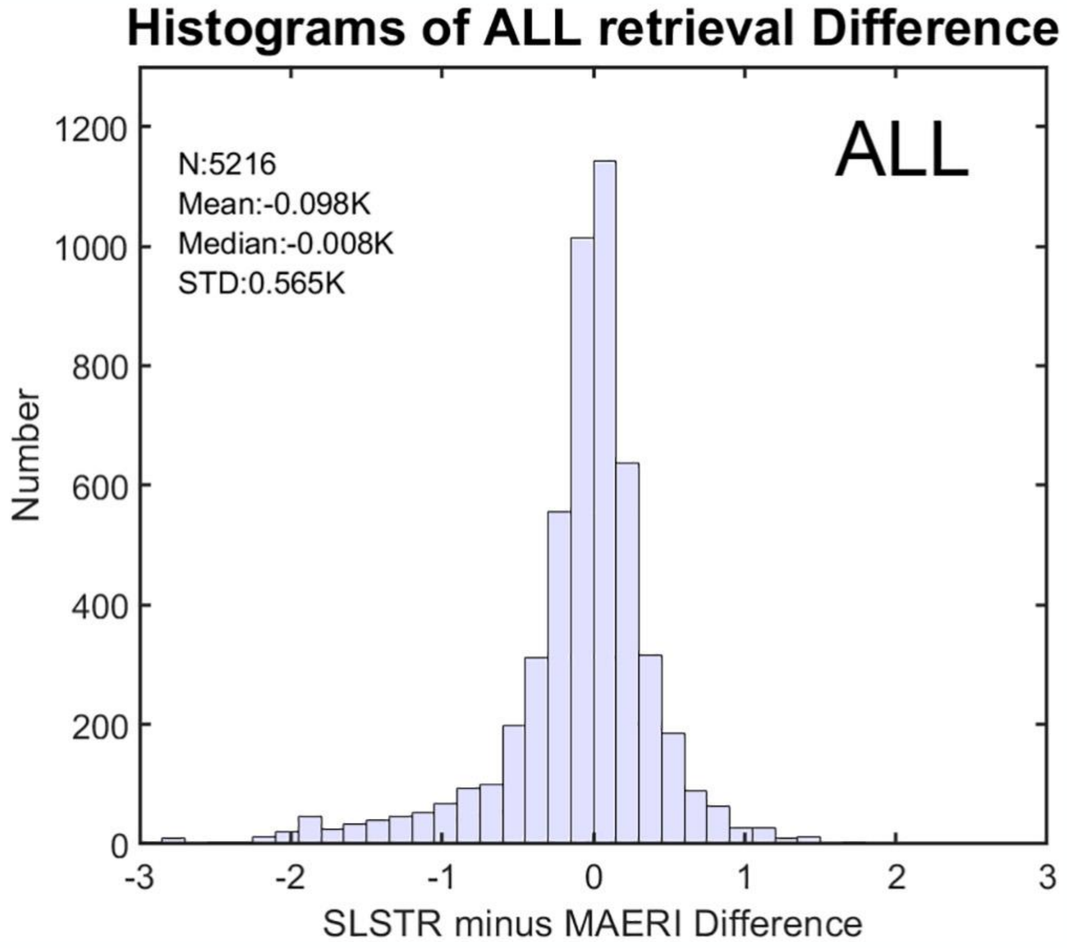






Sentinel-3a SLSTR - M-AERI SST_{skin}



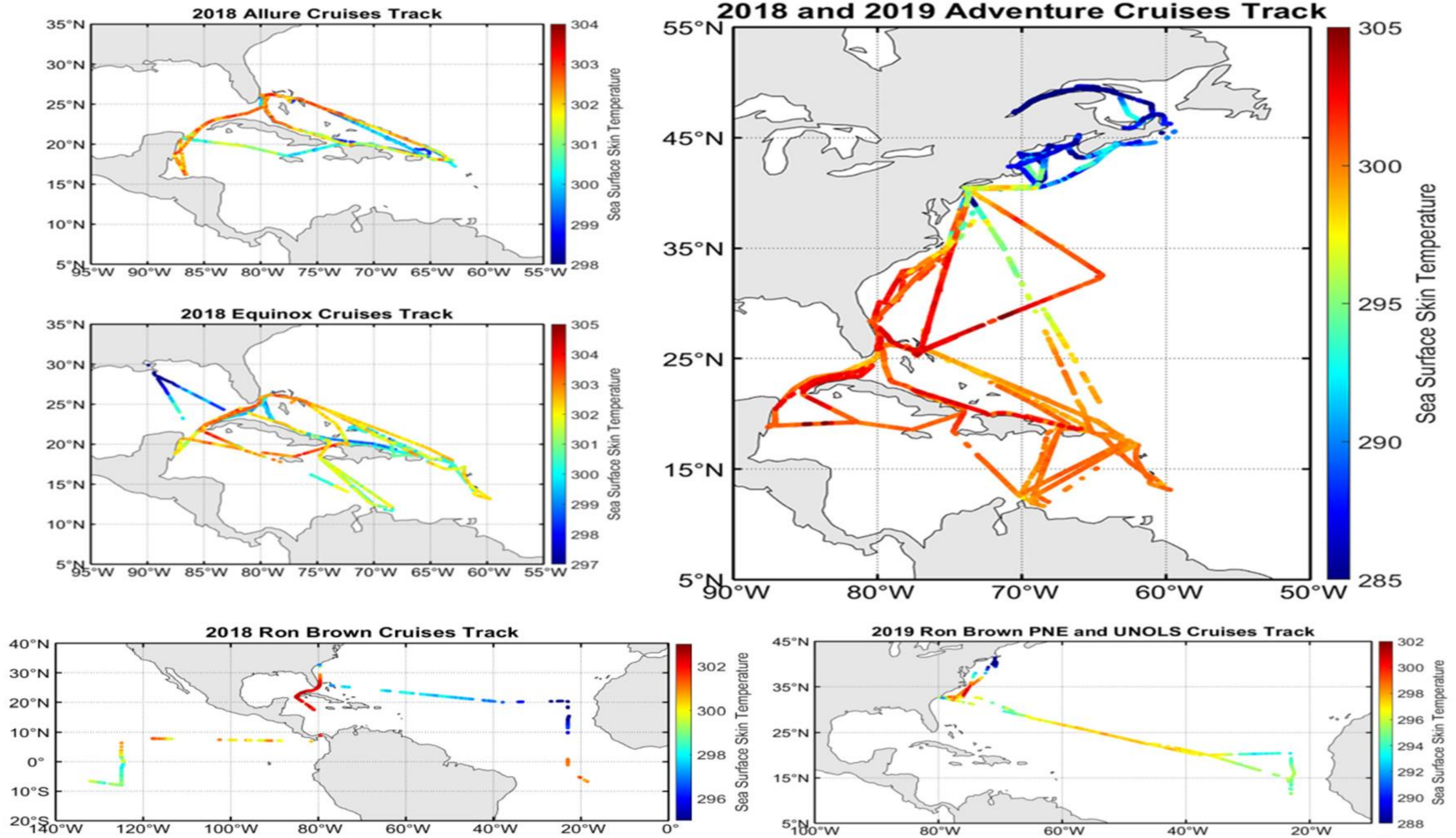


Sentinel-3a SLSTR - M-AERI SST_{skin}

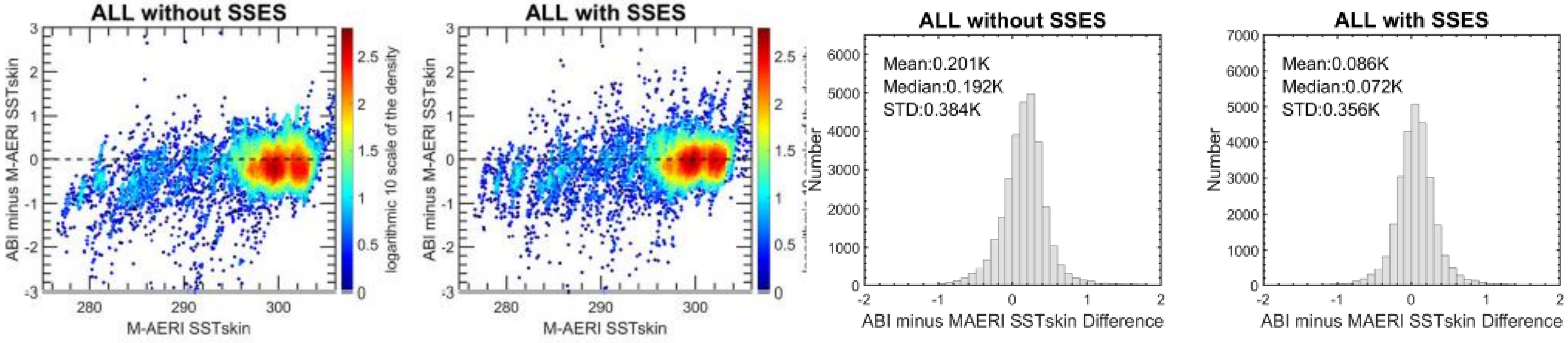
Cruises	START	END	N	Mean	Med	STD	RMS	RSD
2017 Equinox	20170701	20171231	929	-0.274	-0.059	0.742	0.790	0.473
2017 Allure	20171002	20171126	205	-0.179	-0.023	0.780	0.799	0.313
2018 Equinox	20180111	20180415	532	-0.200	-0.106	0.691	0.719	0.326
2018 Adventure, Leg 1	20180212	20180527	451	-0.116	-0.029	0.529	0.541	0.291
2018 Adventure, Leg2	20180601	20181231	1344	0.038	0.033	0.385	0.386	0.242
2018 RHB	20180307	20181023	921	-0.001	0.044	0.415	0.415	0.275
2019 RHB	20190224	20190329	394	-0.143	-0.050	0.471	0.492	0.326
Total	20170701	20190329	5216	-0.098	-0.008	0.565	0.574	0.296

Validation of GOES-16 ABI SST_{skin} with M-AERI

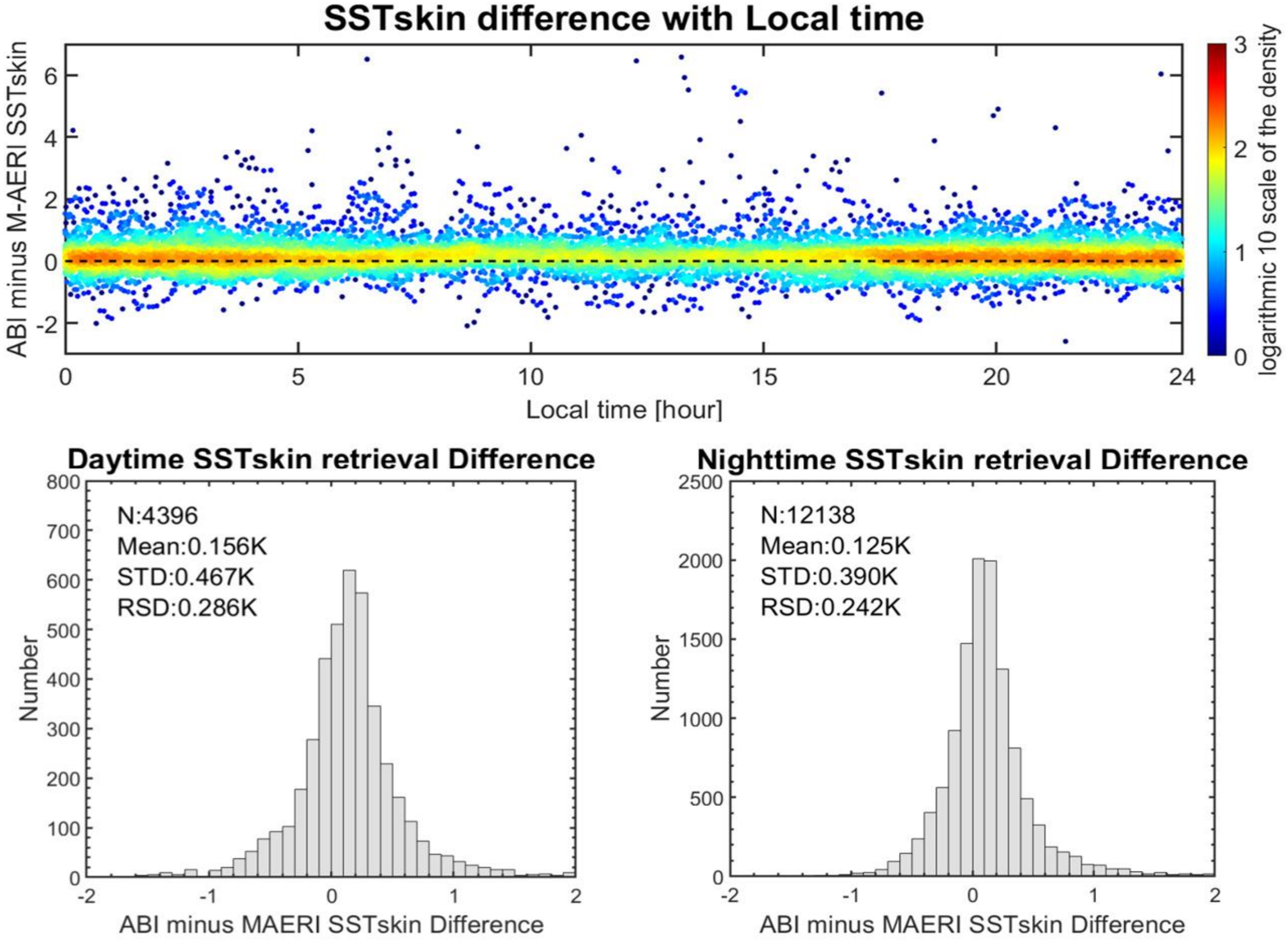
- Matchups within 30 minutes and 5 km.
- ACSPO SST_{skin} retrievals.
- With and without SSESs.
- 44448 Matchups.



GOES-16 ABI - M-AERI SST_{skin}



GOES-16 ABI - M-AERI SST_{skin}



GOES-16 ABI - M-AERI SST_{skin}

CRUISES	N	MEAN	MED	STD	RMS	RSD
2018 Equinox	10869	0.036	0.035	0.302	0.304	0.19
2018 Allure	8948	0.035	0.031	0.231	0.233	0.20
2018 Adventure	11840	0.171	0.136	0.394	0.430	0.24
2019 Adventure	10081	0.089	0.081	0.420	0.430	0.26
2018 RHB	1188	0.060	0.069	0.234	0.242	0.19
2019 RHB PNE	1003	0.069	0.101	0.291	0.299	0.16
2019 RHB UNOLS	519	0.174	0.259	0.744	0.764	0.49
Total	**44448**	**0.086**	**0.072**	**0.356**	**0.367**	**0.22**

SLSTR	**5216**	**-0.098**	**-0.008**	**0.565**	**0.574**	**0.296**

Conclusions

- This study demonstrates the feasibility of combining BTs from SLSTR with those of ABI and SEVIRI.
- Generation of SLSTR effective BTs from radiometers on geostationary satellites requires scene dependent coefficients.
- Test cases indicate SLSTR BTs compare better with those of ABI than those of SEVIRI.
- Conversion equations applicable to larger areas with greater atmospheric variability will likely require extra terms, possibly including additional variables, such as water vapor amount, aerosols…
- Larger discrepancies in the BTs from different sensors are related to cloud edges.
- Basic statistics of SST_{skin} retrievals from SLSTR and ABI are comparable when compared to M-AERI data, with SLSTR having a smaller Median but larger Robust Standard Deviation.

Further details

- Luo, B., & Minnett, P.J. (2020). Comparison of SLSTR Thermal Emissive Bands Clear-Sky Measurements with Those of Geostationary Imagers. *Remote Sensing 12*, 3279. doi:10.3390/rs12203279

- Luo, B., Minnett, P.J., Szczodrak, M., Kilpatrick, K., & Izaguirre, M. (2020). Validation of Sentinel-3A SLSTR derived Sea-Surface Skin Temperatures with those of the shipborne M-AERI. *Remote Sensing of Environment 244*, 111826. doi:10.1016/j.rse.2020.111826

- Luo, B., & Minnett, P.J. (2021). Skin Sea Surface Temperatures From the GOES-16 ABI Validated With Those of the Shipborne M-AERI. *IEEE Transactions on Geoscience and Remote Sensing 59*, 9902-9913. doi: 10.1109/TGRS.2021.3054895

Acknowledgements

- NASA Physical Oceanography Program.
- NASA Participating Investigators Program.
- NASA Senior Review Support.
- NASA Future Investigators in NASA Earth and Space Science and Technology (FINESST) Program – Bingkun Luo.
- Royal Caribbean Group.
- Officers and crew of the NOAA Ship *Ronald H. Brown*.

Thank you for your attention