M-AERI and Saildrone validation of SLSTR, MODIS, VIIRS, ABI, and Reanalysis SST_{skin}

Peter J Minnett, Miguel Angel Izaguirre, Goshka Szczodrak,
Bingkun Luo[#] and Chong Jia*

Dept. Ocean Sciences, Rosenstiel School of Marine, Atmospheric and Earth Science, University of Miami, Miami, USA

[#] Harvard–Smithsonian Center for Astrophysics, 60 Garden St. Cambridge, MA, USA

*Graduate Program of Meteorology and Physical Oceanography, Rosenstiel School of Marine, Atmospheric, and Earth Science, University of Miami, Miami, FL, USA

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FRM4SST: ISFRN Workshop
22-23 April 2024

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

- No new results for Sentinel 3a SLSTR, no comparisons with Sentinel 3b SLSTR.

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

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. https://doi.org/10.1016/j.rse.2020.111826

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MODIS SST_{skin} Comparison with M-AERI

R2019 Residuals MODIS TERRA night LWIR SST_{skin} minus radiometer SST_{skin}.					
Quality	Mean	Median	SD	RSD	N
0	-0.102	-0.061	0.591	0.426	21725
1	-0.276	-0.295	0.658	0.475	7353

R2019 Residuals MODIS TERRA night MWIR SST_{skin} (SST4) minus radiometer SST_{skin}.					
Quality	Mean	Median	SD	RSD	N
0	-0.098	-0.047	0.449	0.324	22254
1	-0.165	-0.129	0.460	0.332	7133

LWIR retrievals use a modified NLSST algorithm applied to clear-sky measurements at λ= 11 and 12 µm.
MWIR retrievals use a modified NLSST algorithm applied to clear-sky measurements at λ = 3.96 and 4.05 µm

Quality = 0 is best, = 1 is good. $\Delta t \leq 30$ min. $\Delta r \leq 10$ km.

S-NPP VIIRS SST_{skin} vs M-AERI SST_{skin}

R2022.0

Period:
2 Jan 2012 –
7 Sept 2021

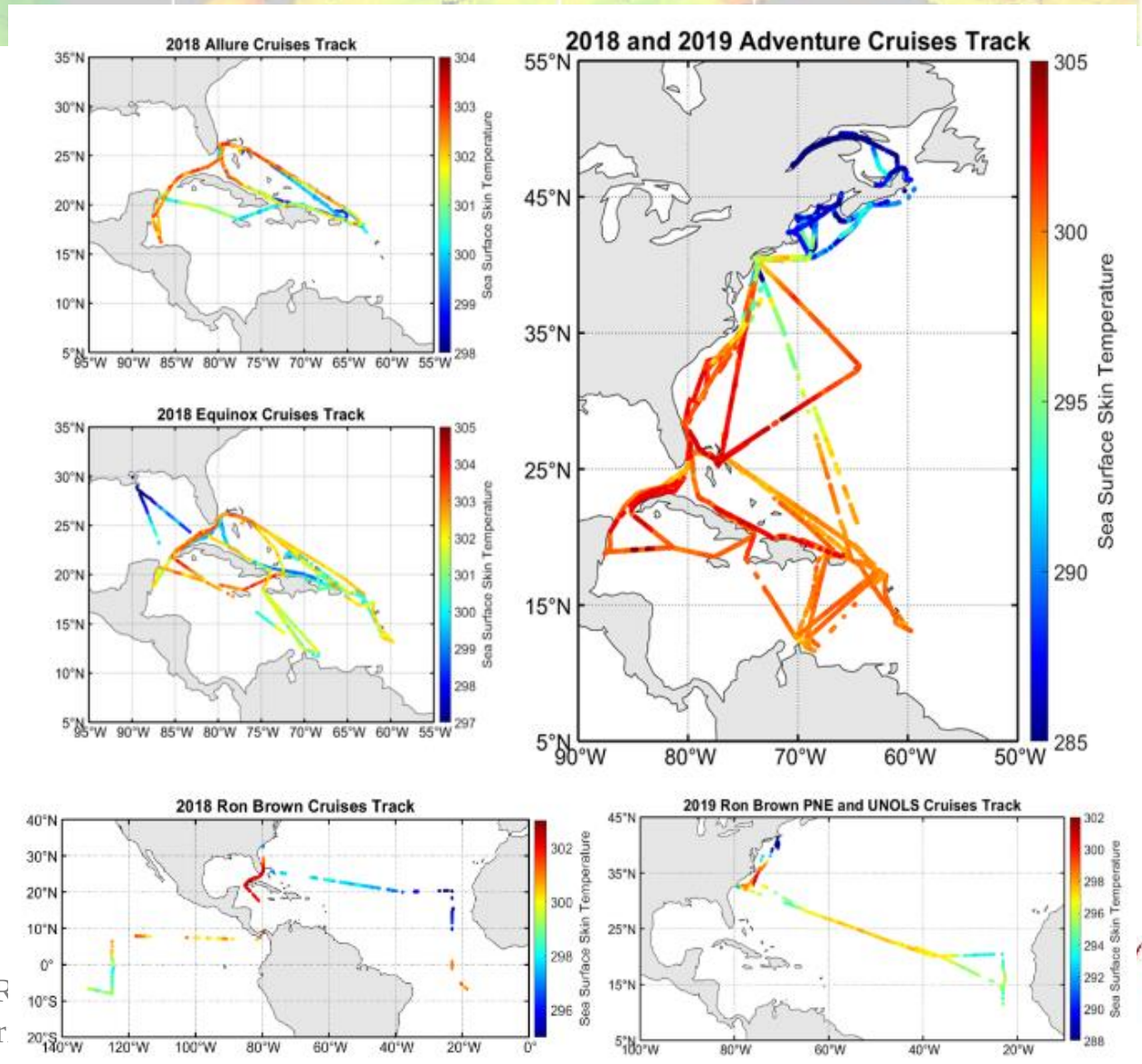
$\Delta t \leq 30$ min.
$\Delta r \leq 10$ km.

Quality	Mean	Median	SD	RSD	N
SST_{skin} day					
0	0.043	0.062	0.453	0.327	6959
1	-0.180	-0.131	0.604	0.436	5600
SST_{skin} night					
0	-0.002	0.013	0.428	0.309	16928
1	-0.251	-0.211	0.662	0.448	7909
SST_{triple} night					
0	0.008	0.020	0.316	0.228	12713
1	-0.125	-0.097	0.432	0.311	9526

Global statistics for VIIRS SST_{skin} retrievals compared to SST_{skin} derived from M-AERI

Advanced Baseline Imager (ABI) on GOES-16

- GOES-16 is above 75.2°W; became operational on 16th December 2017.
- SST_{skin} derived using NOAA ACSPO algorithm, using measurements at λ = 8.4 μm, 10.3 μm, 11.2 μm, and 12.3 μm.
- Hourly SST_{skin} data from https://podaac-tools.jpl.nasa.gov /drive/files/allData/ghrsst/dataGDS2/L2P/GOES16/STAR/ v2.70.
- Matchups with M-AERI within 30 minutes and 5 km.



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. 10.1109/TGRS.2021.3054895

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ABI – M-AERI SST_{skin} Statistics

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	519	0.174	0.259	0.744	0.764	0.49
Total	**44448**	**0.086**	**0.072**	**0.356**	**0.367**	**0.22**

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. 10.1109/TGRS.2021.3054895

ERA5 Numbers: Big & Small

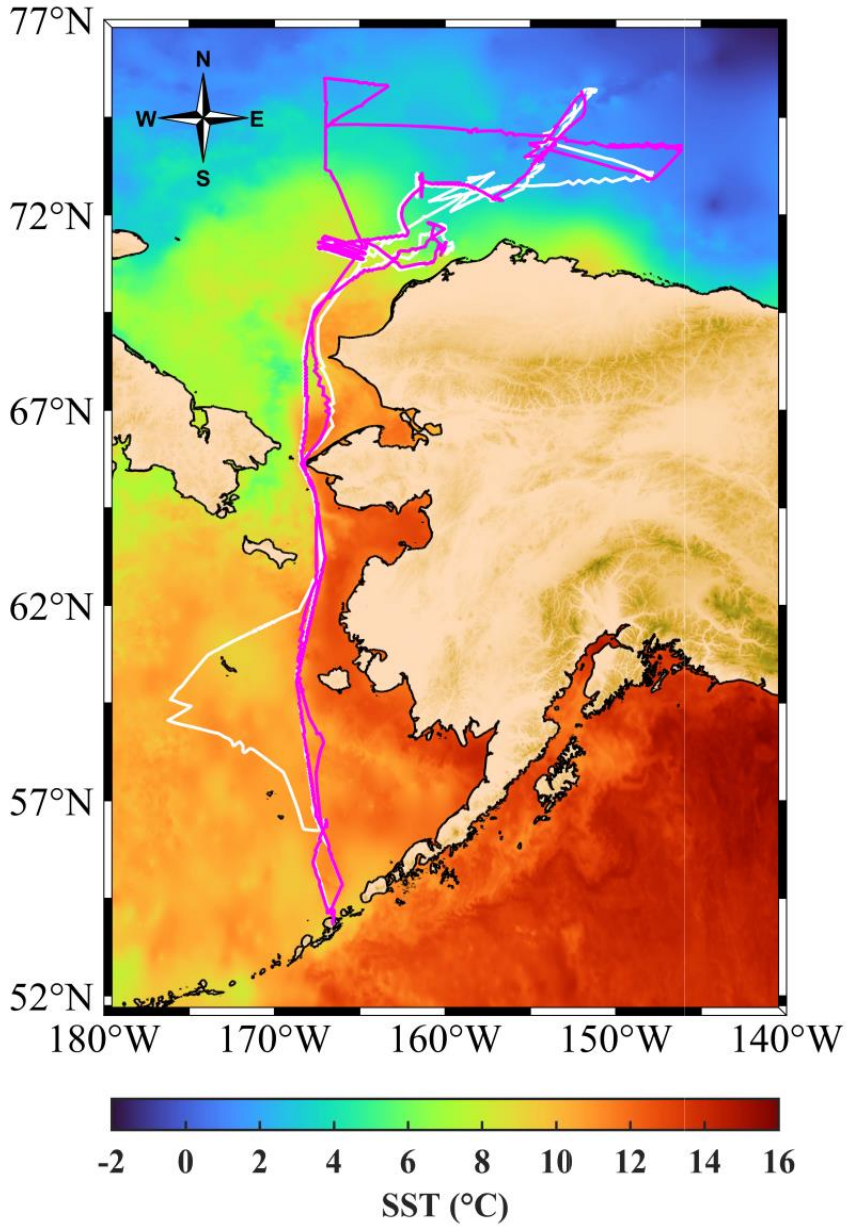
RCG CRUISES	N	MEAN	MED	STD	RMS	RSD
2014 ALLURE	9811	-0.196	-0.199	0.262	0.327	0.233
2014 EQUINOX	5421	-0.293	-0.288	0.247	0.383	0.219
2015 ALLURE	34,658	-0.208	-0.231	0.367	0.422	0.265
2016 EQUINOX	28,673	-0.188	-0.205	0.371	0.416	0.272
2017 EQUINOX	41,945	-0.244	-0.238	0.270	0.364	0.211
2017 ALLURE	5031	-0.145	-0.133	0.218	0.262	0.206
2018 EQUINOX	29,779	-0.266	-0.240	0.291	0.395	0.213
2018 ADVENTURE	7266	-0.170	-0.182	0.480	0.509	0.213
2018 ALLURE	27,215	-0.257	-0.252	0.274	0.376	0.238
2019 ADVENTURE	28,229	-0.169	-0.218	0.548	0.574	0.272
TOTAL	**218,028**	**-0.220**	**-0.228**	**0.358**	**0.420**	**0.239**

R/V CRUISES	N	MEAN	MED	STD	RMS	RSD
2004 RHB	5805	-0.212	-0.165	0.460	0.507	0.342
2006 RHB	3908	-0.152	-0.124	0.383	0.413	0.357
2007 RHB	1257	0.024	-0.029	0.441	0.442	0.415
2008 RHB	1592	0.020	-0.012	0.482	0.483	0.366
2011 RHB	2264	-0.038	-0.005	0.327	0.329	0.308
2013 RHB	7099	-0.201	-0.193	0.230	0.305	0.180
2015 ALLIANCE	5547	-0.299	-0.318	0.242	0.385	0.228
2018 RHB	38,108	-0.167	-0.148	0.282	0.328	0.206
2019 RHB	8378	-0.329	-0.299	0.502	0.601	0.380
TOTAL	**73,958**	**-0.190**	**-0.170**	**0.348**	**0.396**	**0.247**

CRUISES	N	MEAN	MED	STD	RMS	RSD
R/V	73,958	-0.190	-0.170	0.348	0.396	0.247
RCG	218,028	-0.220	-0.228	0.358	0.420	0.239
TOTAL	**291,986**	**-0.213**	**-0.214**	**0.356**	**0.415**	**0.243**

SST_{skin} from Saildrones.

- Saildrones are autonomous surface vehicles that carry a range of oceanographic and meteorological instruments.
- Two Saildrones, SD-1036 & SD-1037, were deployed for 150-day cruises in the Pacific Sector of the Arctic in 2019. Each carried a pair of Heitronics radiometers for the derivation of SST_{skin}.
- After stringent qc, SST_{skin} accuracy is 0.12 K.



MODIS – Saildrone SST_{skin}

	Aqua MODIS			Terra MODIS		
	SD-1036	SD-1037	Total	SD-1036	SD-1037	Total
Mean	-0.073	-0.468	-0.263	-0.076	-0.490	-0.291
Median	-0.036	-0.352	-0.214	-0.021	-0.379	-0.207
STD	0.727	0.701	0.741	0.649	0.752	0.734
RSD	0.656	0.588	0.669	0.551	0.565	0.559
R	0.943	0.947	0.948	0.956	0.945	0.947
Num	411	380	791	409	444	853

	Aqua MODIS			Terra MODIS		
	QL = 0	QL = 1	Total	QL = 0	QL = 1	Total
Mean	-0.173	-0.505	-0.263	-0.198	-0.559	-0.291
Median	-0.138	-0.496	-0.214	-0.132	-0.492	-0.207
STD	0.674	0.855	0.741	0.690	0.788	0.734
RSD	0.561	0.762	0.669	0.500	0.670	0.559
R	0.956	0.908	0.948	0.954	0.933	0.947
Num (1036;1037)	577 (291;286)	214 (120;94)	791 (411;380)	631 (304;327)	222 (105;117)	853 (409;444)

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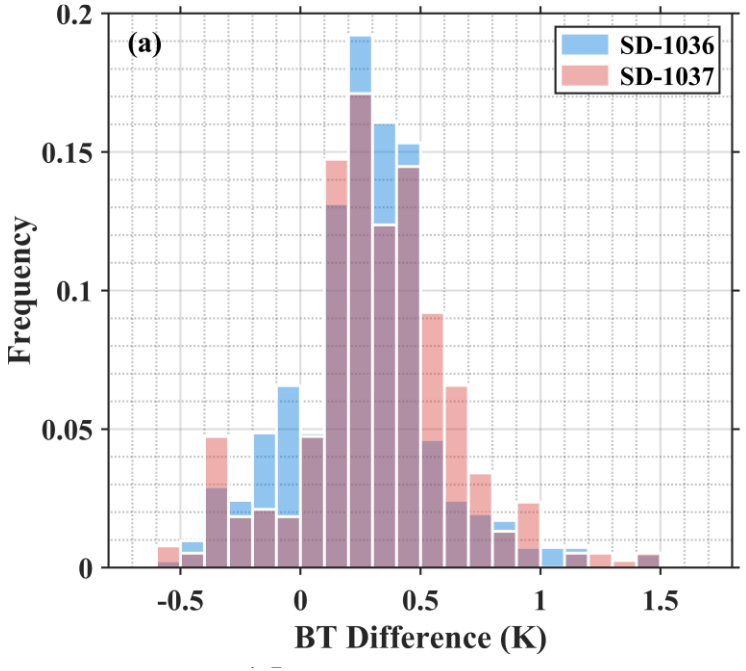
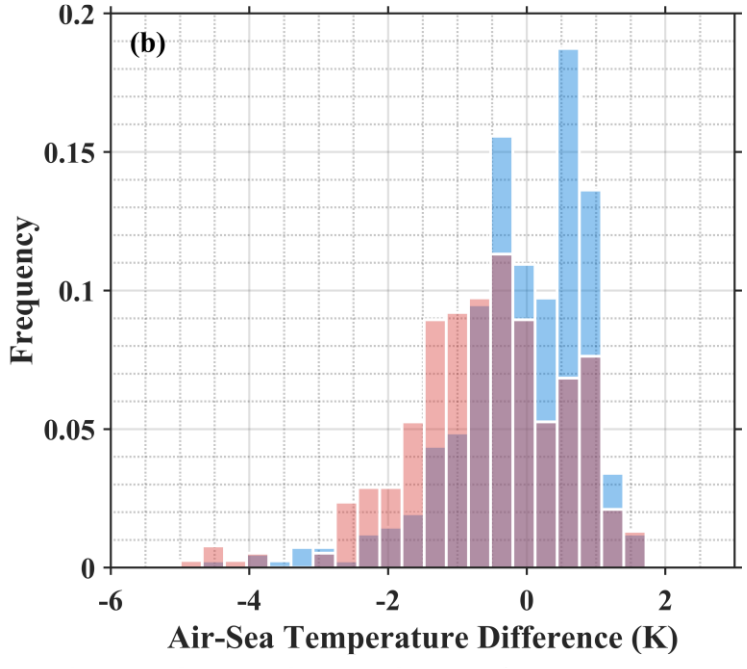
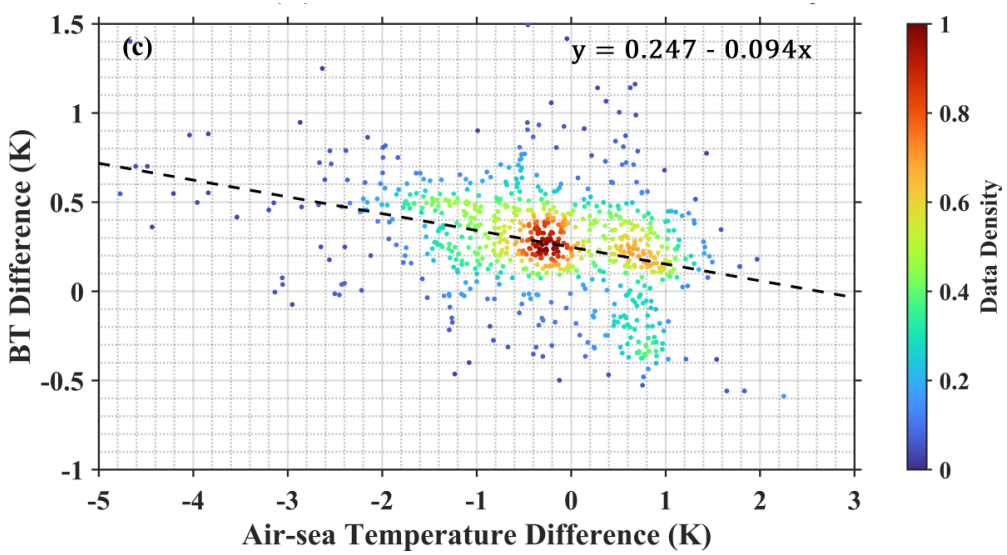
SD-1036 SD-1037 differences







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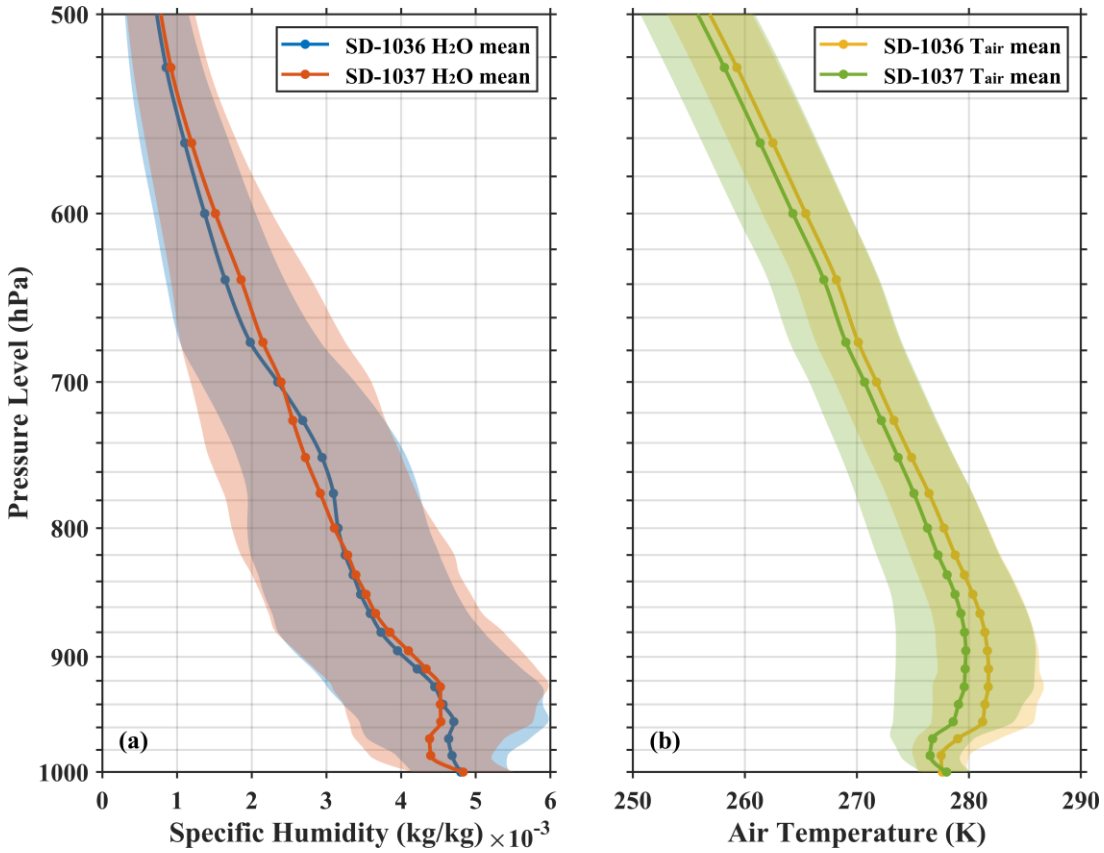
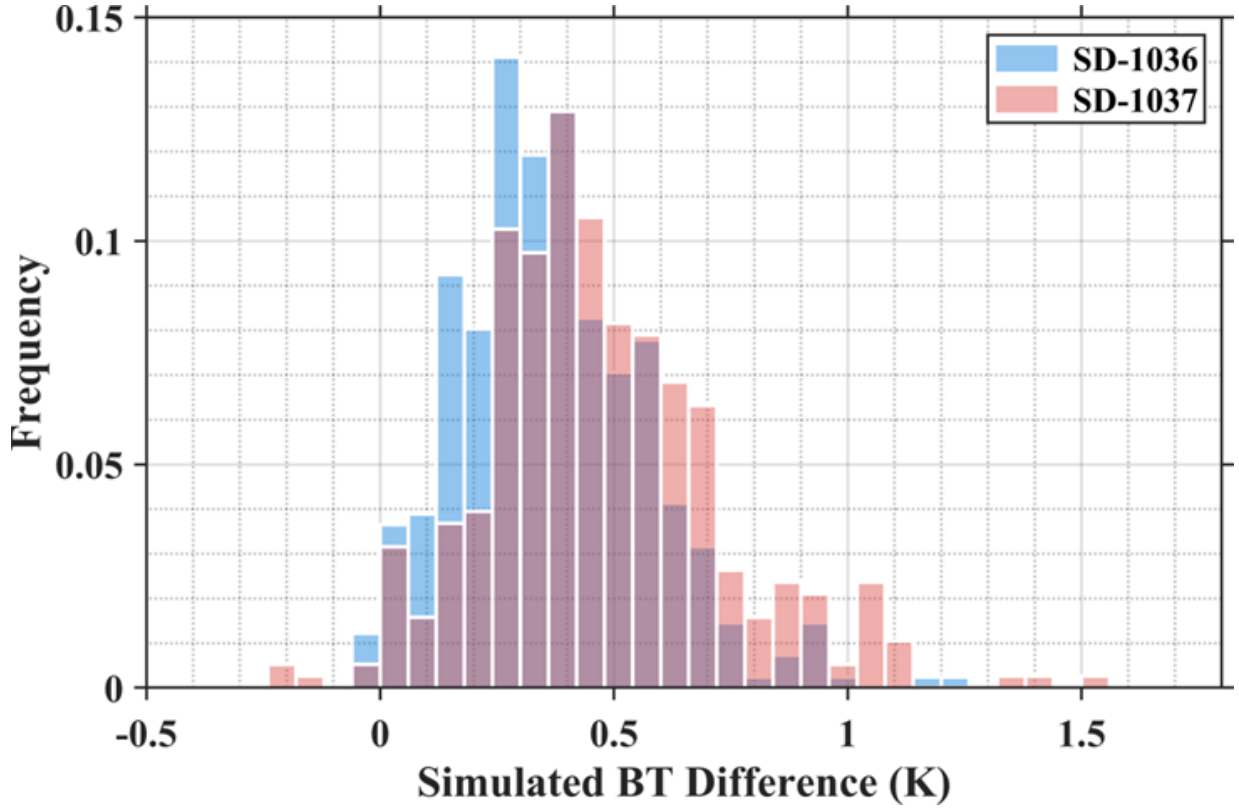
Atmospheric conditions.





BT difference is determined by both the sea surface boundary conditions and intervening atmosphere between surface and the satellite.

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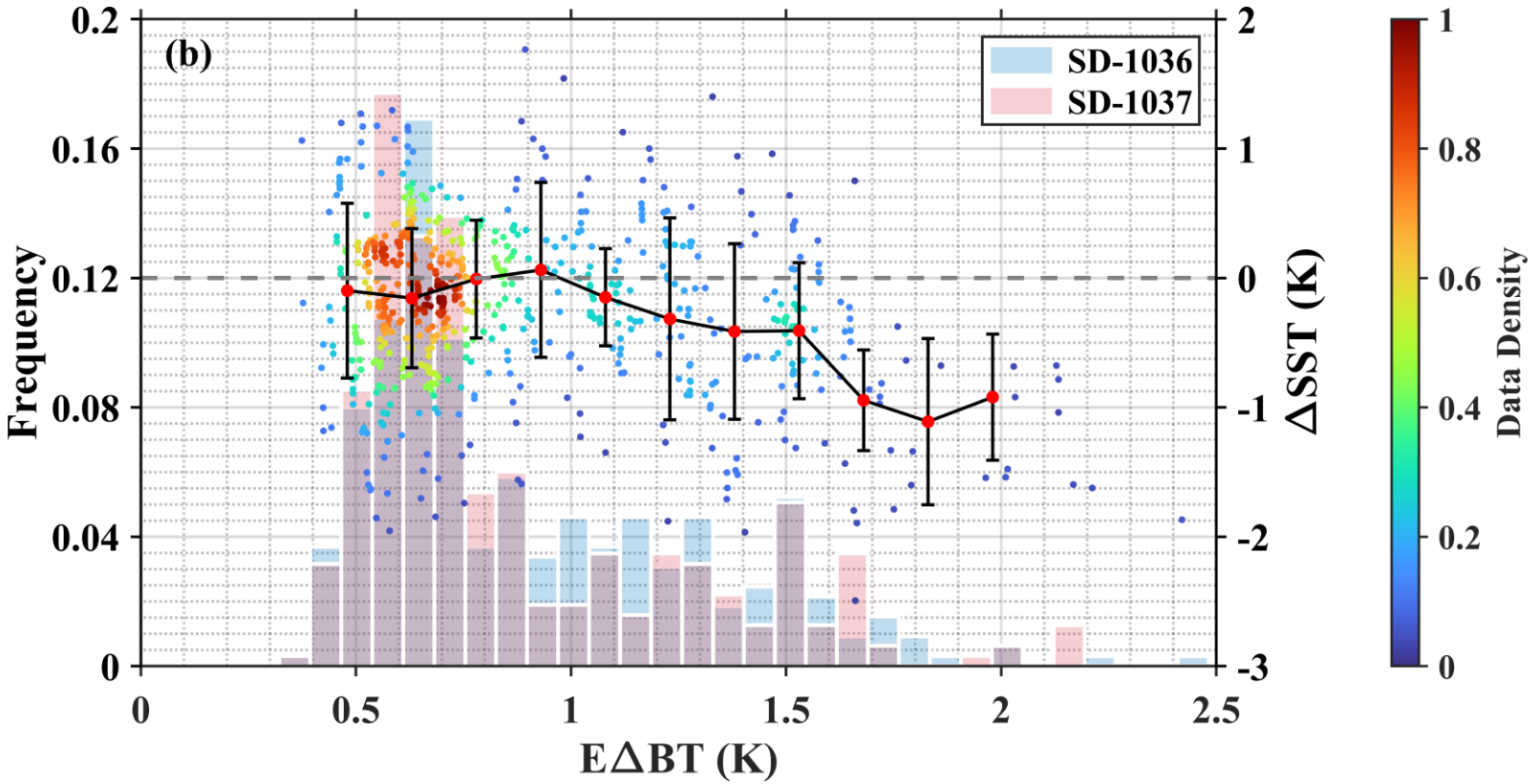
Emissivity difference effects.



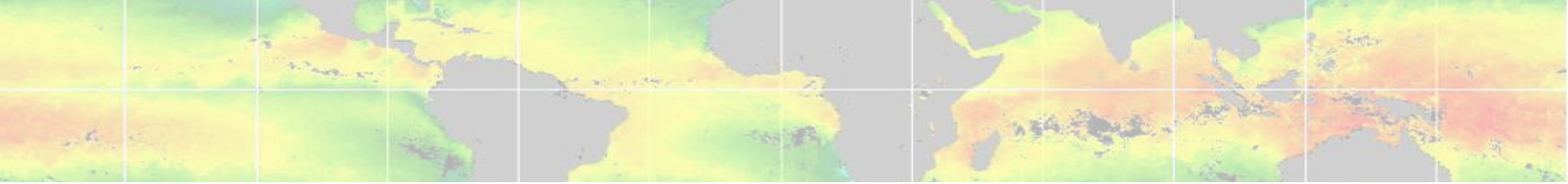
$$E\Delta BT = (\varepsilon_{11} - \varepsilon_{12}) * (T_s - \overline{T_a})$$

Summary

- Well-calibrated shipboard radiometers are capable of assessment of accuracy of satellite SST_{skin} retrievals, and also SST_{skin} from analysis fields.
- Stable, simple radiometers on Saildrones can provide accurate SST_{skin} in sparsely sampled regions in harsh conditions with long deployments.
- Saildrone SST_{skin} comparisons with MODIS SST_{skin} have revealed:
  - Effects of air-sea temperature differences and inversions in the Arctic troposphere.
  - Brightness temperature differences (11µm, 12µm) are influenced by surface emissivity when the atmosphere is very dry.

Acknowledgments

- Funding from NASA.
- Support from Royal Caribbean Group.
- Support from NOAA S *Ronald H Brown*.
- Support from Saildrone Inc.



Thank you.

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