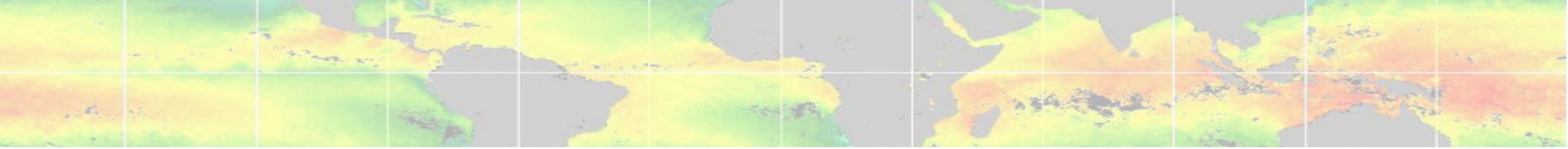

The Marine-Atmospheric Emitted Radiance Interferometer (M-AERI) & Heitronics Radiometers on Saildrones

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ISFRN International Workshop
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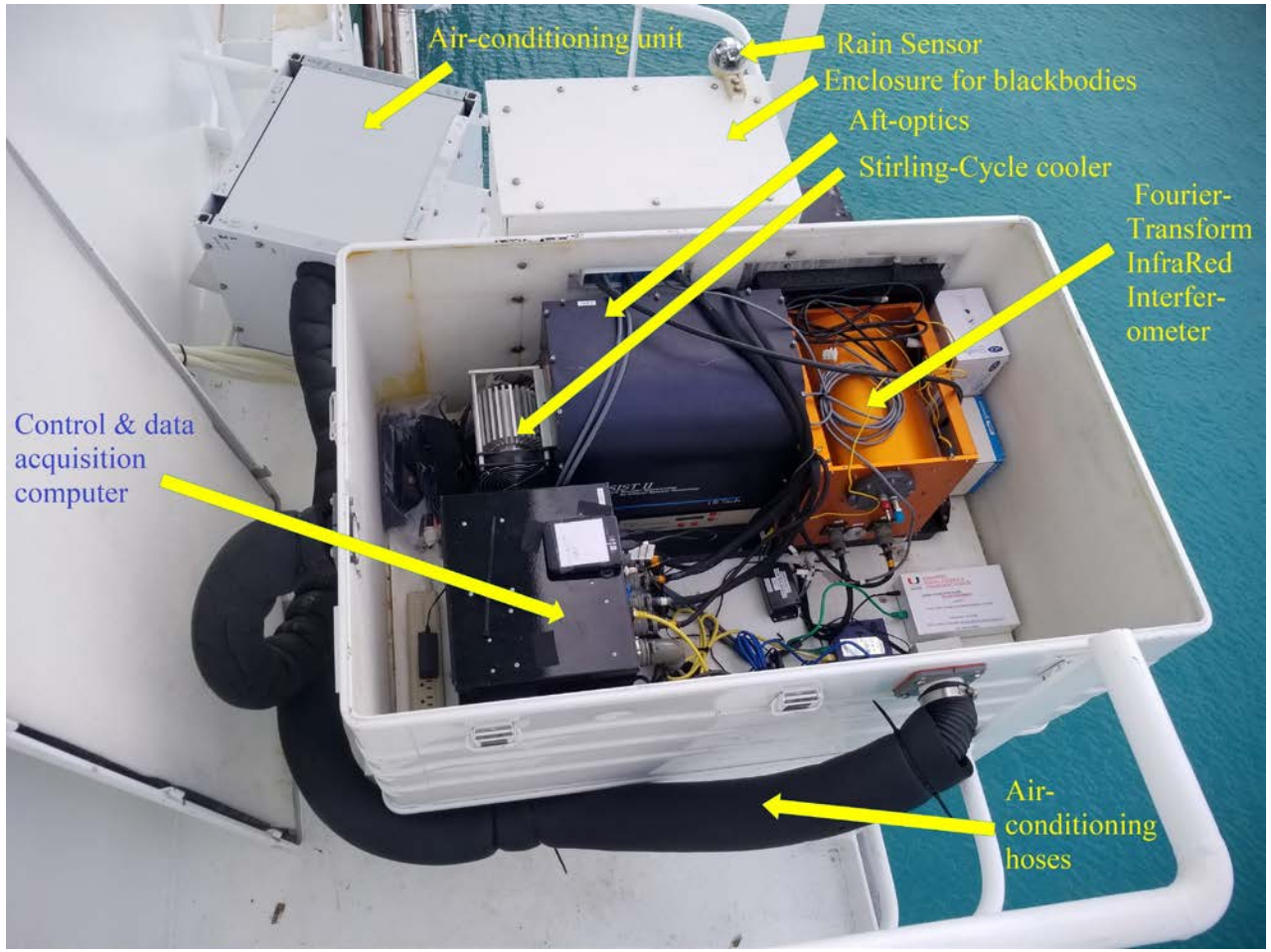
M-AERI

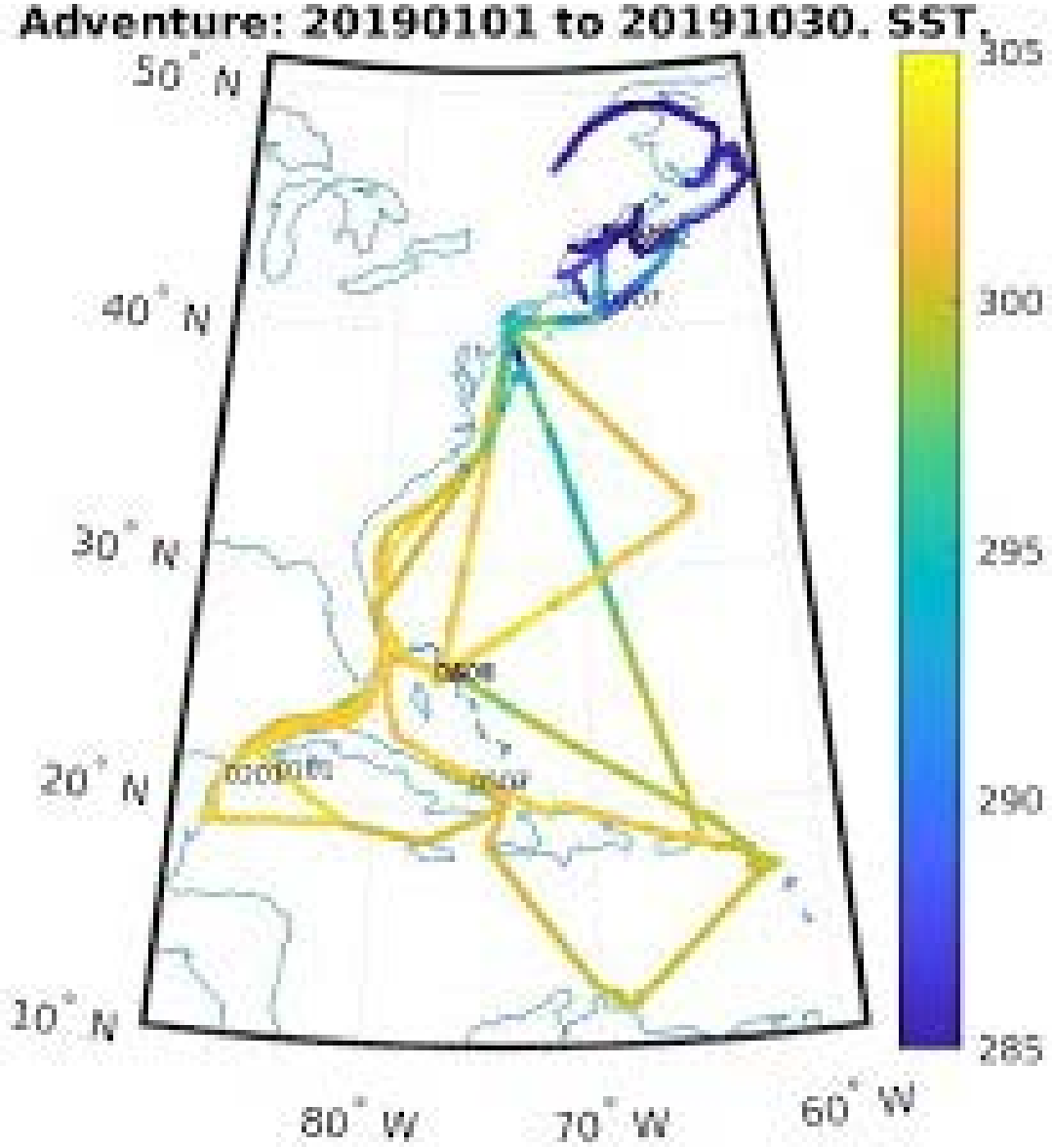
- M-AERI is a very well-calibrated and stable sea-going Fourier Transform Infrared Interferometer.
- At sea calibration by two internal blackbody cavities with thermometers with NIST-traceable calibration.
- Calibration sequence before and after each cycle of measurements.
- Calibration before and after deployments using NIST-designed water-bath blackbody calibration target at RSMAS. Uses SI-traceable thermometers at mK accuracy.
- Periodic radiometric characterization of RSMAS water-bath blackbody calibration target by NIST TXR and NPL AMBER (but not in 2022).

M-AERI deployments

- M-AERI deployments began in 1996; on Royal Caribbean Group (RCG) ships in 2000.
- M-AERIs now operate autonomously over satellite internet link.
- Three Mk2 M-AERI's have been deployed on RCG ships; but in the wake of COVID-19 restrictions, they have not yet been reinstalled. Currently a Mk 2 is on the NOAA Ship *Ronald H Brown*.
- One Mk3 usually deployed on research ships. The Mk 3 has been involved in laboratory measurements in the SUSTAIN (SUrge-STructure-Atmosphere INteraction) at RSMAS – see https://sustain.earth.miami.edu/.

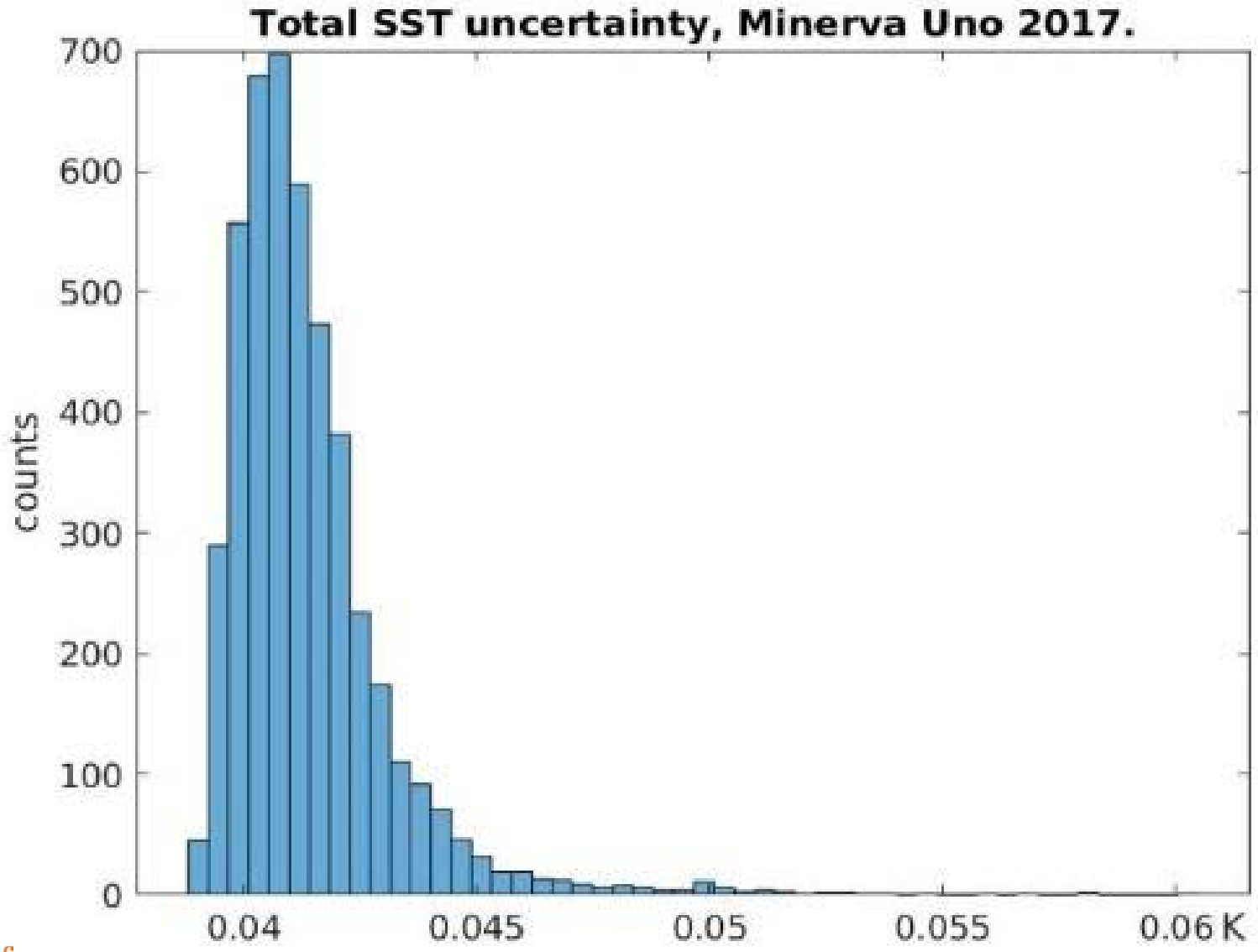
M-AERI Mk2 installed on the *Adventure of the Seas*.



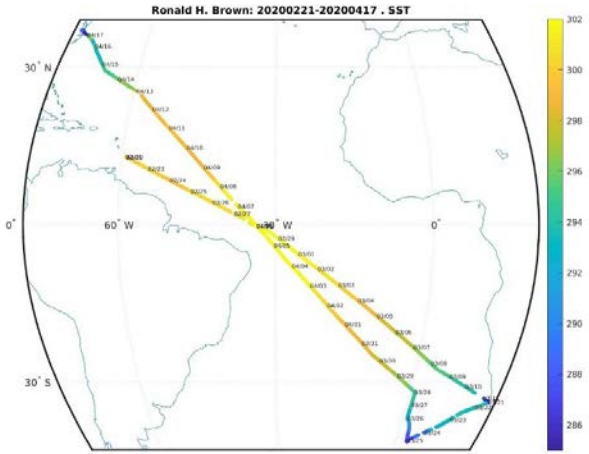


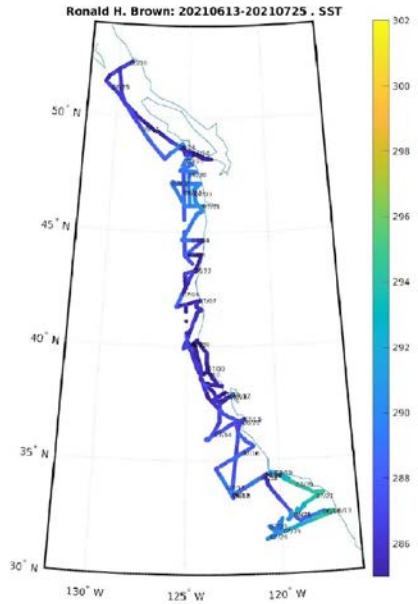
From Minnett, P.J., Knuteson, R.O., & Gero, J. (2022). Surface-based thermal infrared spectrometers. In N.R. Nalli (Ed.), *Field Measurements for Passive Environmental Remote Sensing*. To be published October 2022: Elsevier.

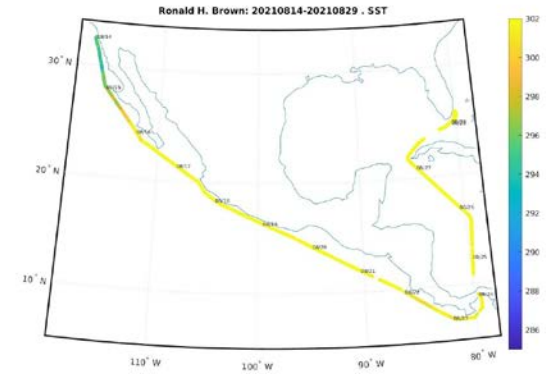
M-AERI Mk2 SST_{skin} accuracies

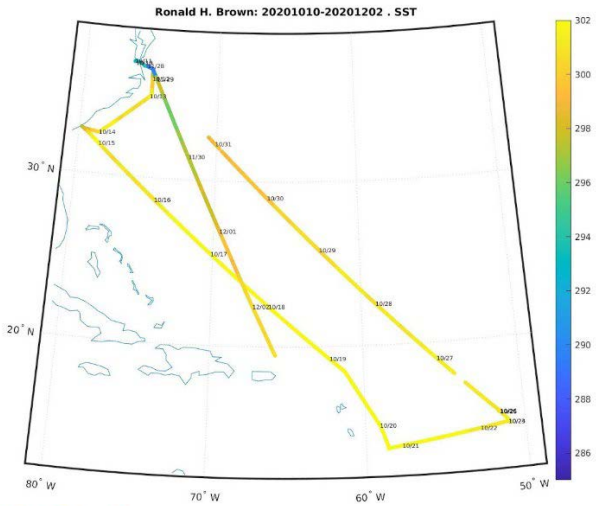


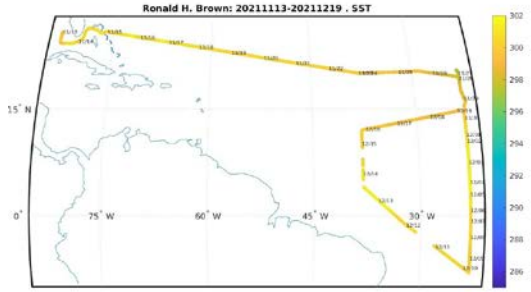
Post-COVID deployments, *Ronald H Brown*

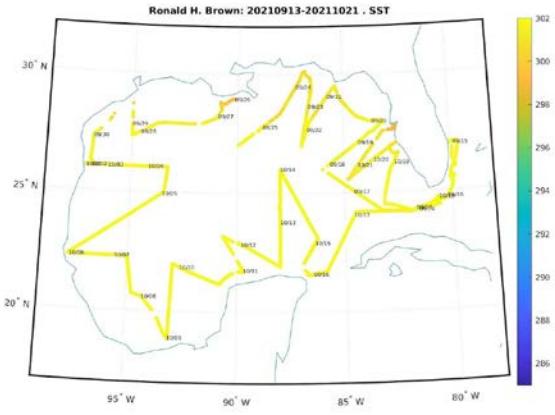


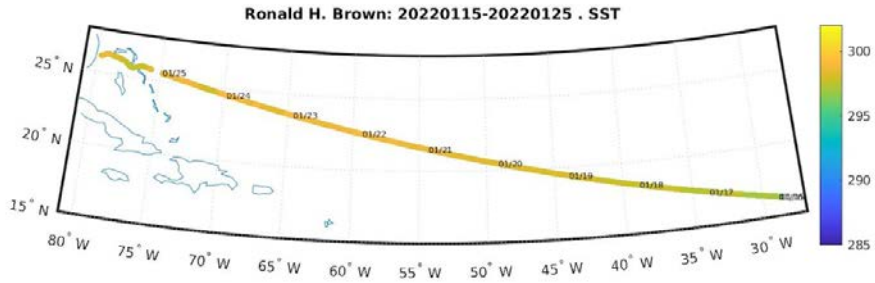












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Accessing M-AERI data

Ship-based high resolution sea surface skin temperature from the Marine-Atmospheric Emitted Radiance Interferometer (M-AERI) deployed between 2013 and 2020

Peter J Minnett, Malgorzata D Szczodrak, Miguel Angel Izaguirre and Bingkun Luo

Show details for 4 authors

University of Miami;
2020-05;
DOI: https://doi.org/10.17604/bswq-0119

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Abstract

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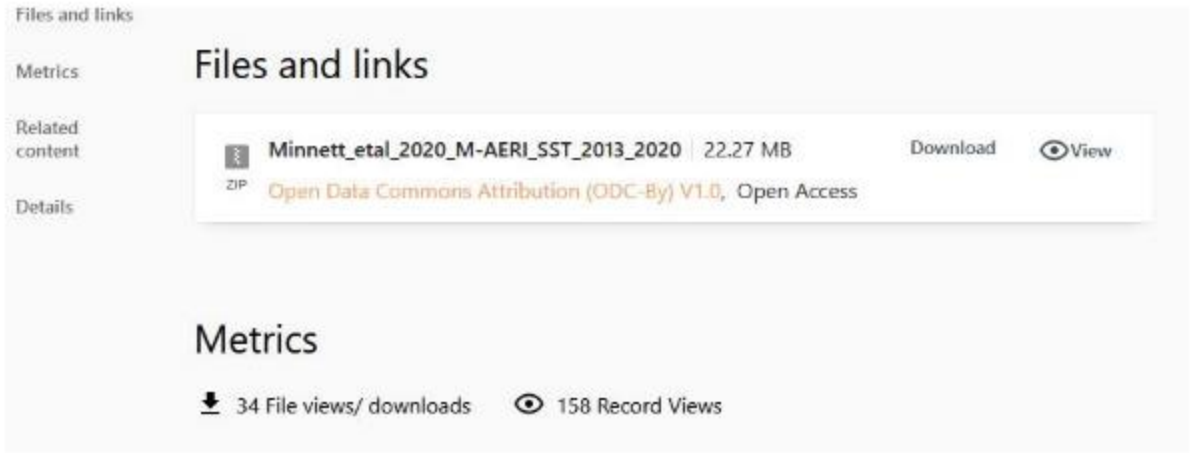
Abstract

M-AERI / SSTskin / Sea Surface Temperature / in situ / Meteorology / Physical Oceanography

<p>This dataset is a part of that taken with sea-going instruments described by "Minnett, P.J., Knuteson, R.O., Best, F.A., Osborne, B.J., Hanafin, J.A., & Brown, O.B. (2001). The Marine-Atmospheric Emitted Radiance Interferometer (M-AERI), a high-accuracy, sea-going infrared spectroradiometer. Journal of Atmospheric and Oceanic Technology, 18, 994-1013". Specifically, this dataset comprises measurements of M-AERIs, ship-based Fourier Transform Infrared (FTIR) interfer...

Expand abstract



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M-AERI data in doi.org/10.17604/bswq-0119

CRUISES	AREA	START	END	DAYS OF DATA
2013 Knorr	Atlantic Ocean	2013-02-13	2013-02-28	16
2013 RHB	North Atlantic Ocean	2013-11-11	2013-12-08	27
2014 Equinox	Caribbean Sea	2014-05-09	2014-06-20	42
2014 Allure	Caribbean Sea	2014-08-24	2014-12-31	130
2014 Equinox	Caribbean Sea	2014-11-16	2014-12-31	46
2015 Allure	Caribbean Sea, North Atlantic Ocean, and Mediterranean Sea	2015-01-01	2015-11-29	360
2015 Equinox	Caribbean Sea	2015-01-01	2015-12-26	360
2015 Minerva Uno	Mediterranean Sea	2015-03-27	2015-04-13	17
2015 Alliance	North Atlantic Ocean	2015-11-17	2015-12-14	28
2016 Equinox	Caribbean Sea, North Atlantic Ocean, and Mediterranean Sea	2016-01-02	2016-12-31	365
2016 RHB	Pacific	2016-11-07	2017-03-19	132

M-AERI data in doi.org/10.17604/bswq-0119 (cont)

CRUISES	AREA	START	END	DAYS OF DATA
2017 Equinox	Caribbean Sea	2017-01-01	2017-12-31	365
2017 Allure	Caribbean Sea	2017-10-02	2017-11-26	56
2017 Minerva Uno	Mediterranean Sea	2017-05-25	2017-06-11	17
2018 Equinox	Caribbean Sea	2018-01-11	2018-09-23	255
2018 Adventure	Caribbean Sea and US East Coast	2018-02-12	2018-12-31	322
2018 Allure	Caribbean Sea	2018-02-18	2018-10-14	238
2018 RHB	Global	2018-03-07	2018-10-23	231
2019 Adventure	Caribbean Sea and US East Coast	2019-01-01	2019-10-30	302
2019 RHB PNE	North Atlantic Ocean	2019-02-24	2019-03-29	34
2019 RHB UNOLS	US East Coast	2019-05-07	2019-05-31	24
2019 RHB JASON	US East Coast	2019-04-08	2019-04-30	22
2020 RHB	Caribbean Sea	2020-01-06	2020-02-13	38
Total	--	2013-02-13	2020-02-13	3427

Skin SST from Saildrones

Skin SST from Saildrones

Saildrones are long-endurance Autonomous Surface Vehicles (ASVs) that carry a suite of meteorological and oceanographic sensors. They use wind for propulsion and solar panels for power. They sail between way-points sent via satellite link. The waypoints are adaptive, being set to achieve scientific measurement objectives and can be updated as required.

Two Saildrones have been deployed in the Pacific Sector of the Arctic in 2019, 2021, and 2019 as part of the NASA/NOPP 3rd Multi-Sensor Improved Sea Surface Temperature Project (MISST-3).

For the 150-day 2019 cruises, both Saildrones were equipped with up- and down-looking Heitronics radiometers (blue), which can be used to derive SST_{skin}. A single down-looking radiometer (green) is standard equipment.

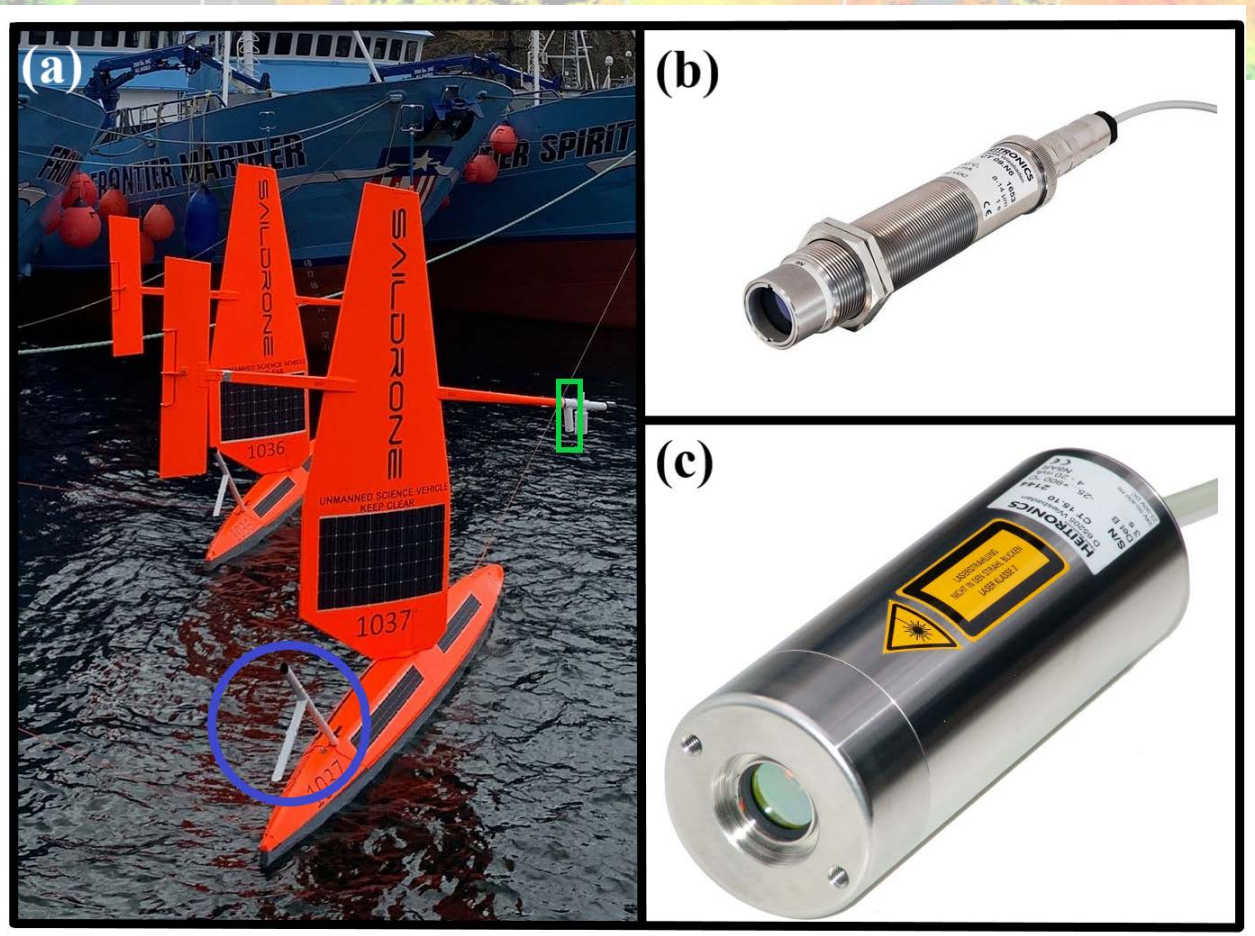
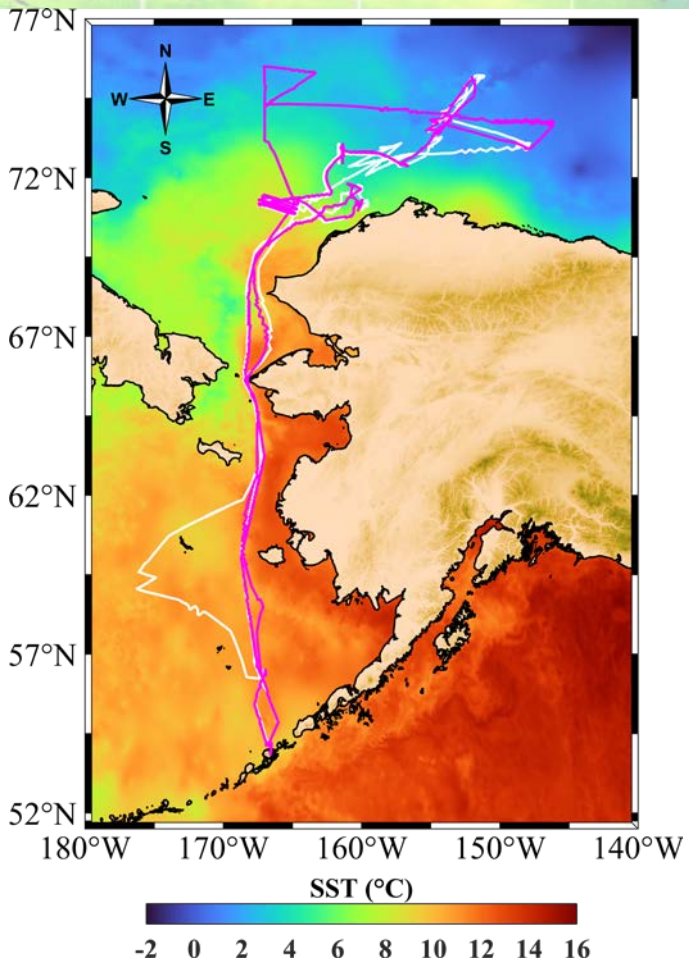
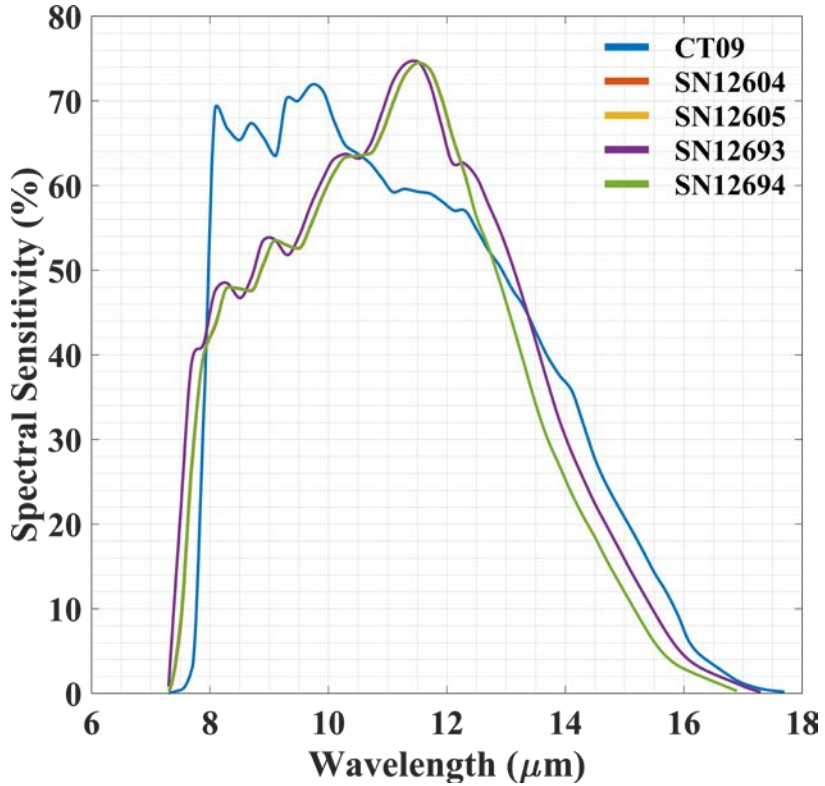


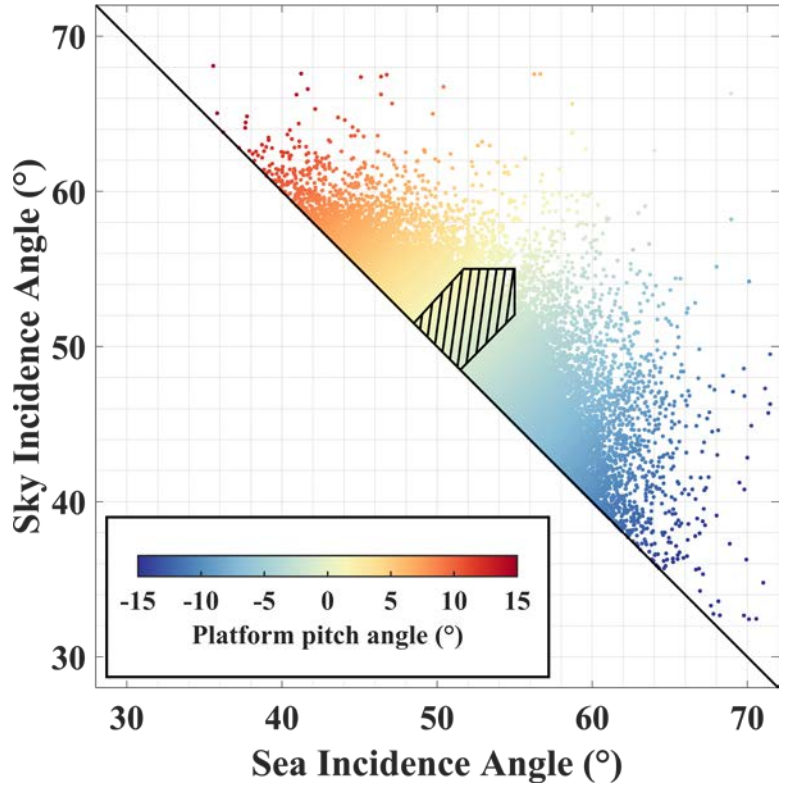
Photo © Saildrone Inc. Used with express permission.
From Jia, C., Minnett, P.J.. Szczodrak, M. and Izaguirre, M.A. (2022), High Latitude Sea Surface Skin Temperatures Derived from Saildrone Infrared Measurements. IEEE Transactions in Geophysics and Remote Sensing. In Review.

MISST-3 2019 deployment





Normalized spectral sensitivity of Heitronics CT09 (sky) and four specific CT15 (sea) IR radiation thermometers



SSTskin can be derived to useful accuracy for angles in the shaded area.

From Jia, C., Minnett, P.J.. Szczodrak, M. and Izaguirre, M.A. (2022), High Latitude Sea Surface Skin Temperatures Derived from Saildrone Infrared Measurements. IEEE Transactions in Geophysics and Remote Sensing. In Review.

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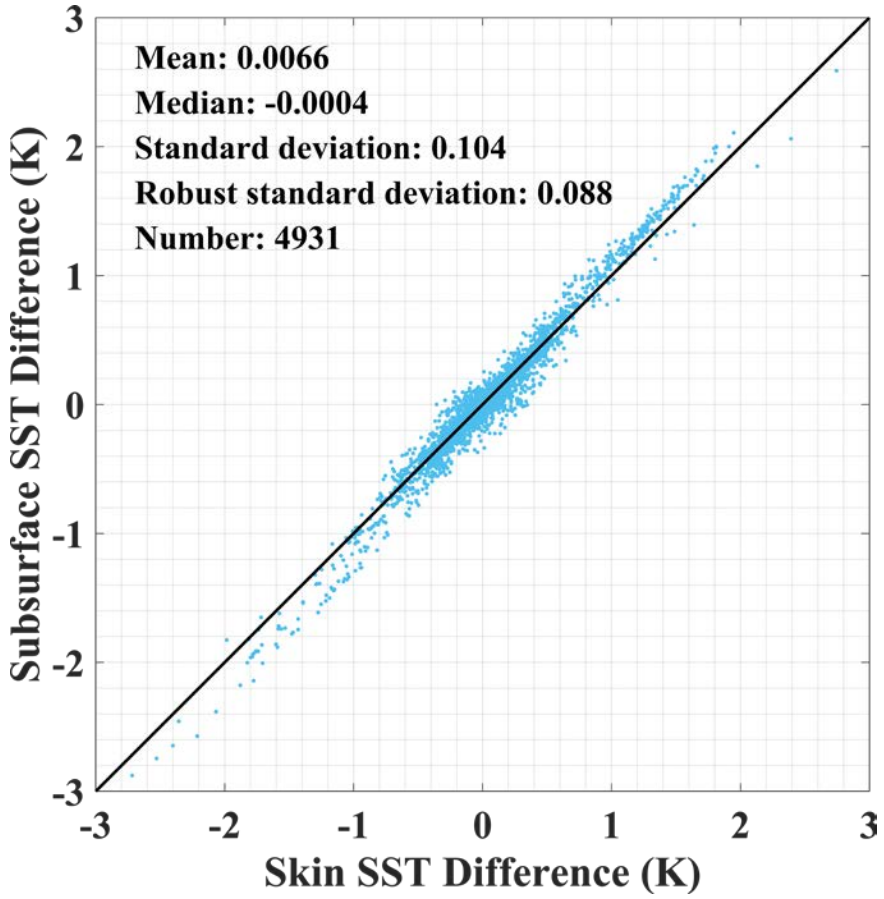
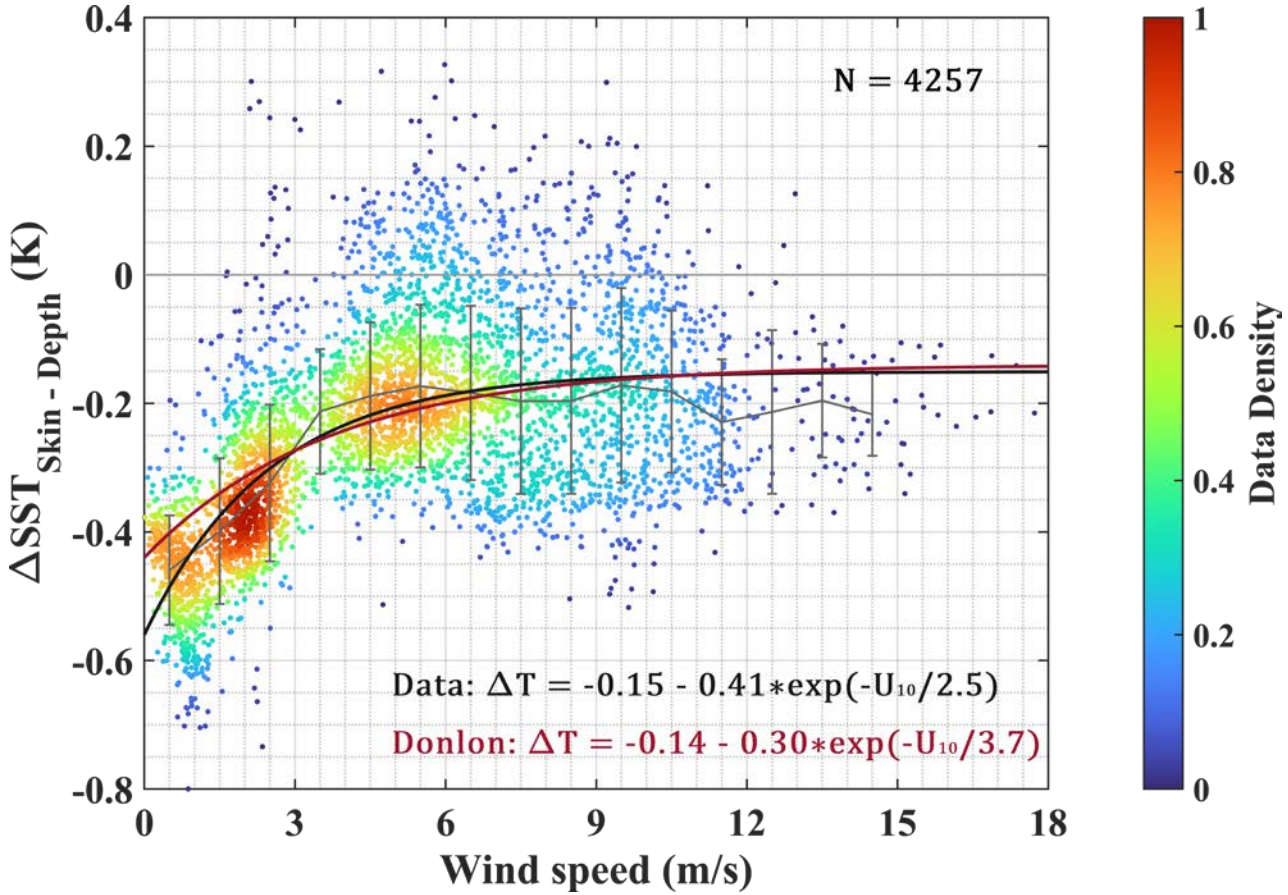
Saildrone SST_{skin} accuracies



- Comparisons of SST_{skin} from two Saildrones separated by < 10 km are comparable to measurements of $SST_{0.3m}$ measured by SBE 56 thermometers (σ = 0.002 K). Periods of diurnal heating have been removed.
- Uncertainty budget gives rms accuracies of 0.122 K

From Jia, C., Minnett, P.J.. Szczodrak, M. and Izaguirre, M.A. (2022), High Latitude Sea Surface Skin Temperatures Derived from Saildrone Infrared Measurements. IEEE Transactions in Geophysics and Remote Sensing. In Review.

Saildrone Measured Skin Effect



Nighttime Saildrone SST_{skin} minus $SST_{-1.71\ m}$ (SBE 56, σ ± 0.002 K) as a function of 10 m wind speed. Fitted curve is shown in black, and the formula from *Donlon et al.* (2002) is in red. The mean and standard deviation of temperature differences, calculated at 1 m $s^{=1}$ intervals, are in gray.

Asymptotic values at high winds differ by 0.01 K.

From Jia, C., Minnett, P.J.. and Luo B. (2022), Significant Diurnal Warming Events Observed by Saildrone at High Latitudes. In preparation.

Summary

- The M-AERIs are robust and maintain their calibration during at-sea deployment over many months.
- The M-AERIs run autonomously, with ~daily checks on their wellbeing over ships' satellite internet.
- Routine operations suspended when a rain sensor indicates rain or spray near the M-AERI aperture.
- M-AERI data submitted to Felyx and to UM repository.
- Post-COVID deployments on the *Ronald H Brown* have resumed.
- We anticipate deployments on RCG ships will resume eventually.

Summary (continued)

- SST_{skin} can be derived to useful accuracy from pairs of Heitronics radiometers on hull of Saildrones in “unicorn” configuration, if measurements from a limited range of accurately measured attitude angles are used, and periods of spray and precipitation are rejected.
- RMS inaccuracies are ~0.122 K
- Matchups between Saildrone SST_{skin} and retrievals from MODIS and VIIRS are underway.

M-AERI Poppins