Integrated Marine Observing System

Australian Government
Bureau of Meteorology

Applications of RV Investigator ISAR data

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OUTLINE

I. Investigating night-time cool skin effect

II. Validation of Himawari-8 skin SST – preliminary results

III. Conclusions

PART 1: Investigating night-time cool skin effect

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  - Helen Beggs (BoM)
  - Sasha Ignatov (NOAA)
  - Alex Babanin (Melb. Uni.)

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Nighttime Cool Skin Effect Observed from Infrared SST Autonomous Radiometer (ISAR) and Depth Temperatures

Haifeng Zhang[1], Helen Beggs[2], Alexander Ignatov[3], and Alexander V. Babanin[4]

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Abstract/Excerpt | Full Text | PDF

Abstract

The nighttime ocean cool skin signal ΔT [defined as skin sea surface temperature (SST_{skin}) minus depth SST (SST_{depth})] is investigated using 103 days of matchups between shipborne Infrared SST Autonomous Radiometer (ISAR) SST_{skin} and water intake SST_{depth} at ~7.1–9.9-m depths, in oceans around Australia. Before data analysis, strict quality control of ISAR SST_{skin} data is conducted and possible diurnal warming contamination is carefully minimized. The statistical distribution of ΔT, and its dependencies on wind speed, heat flux, etc., are consistent with previous findings. The overall average ΔT value is −0.23 K. It is observed that the magnitude of the cool skin signal increases after midnight and a coolest skin offset (with an average value of −0.36 K) is found at around dawn. The dependency of ΔT on SST conditions is observed. Direct warm skin events are discovered when the net heat flux direction is from the atmosphere to the ocean, which is more likely to occur at high latitudes when the air is very humid and warmer than the SST. In addition, several cool skin models are validated: one widely used physical model performs best and can capture most skin-effect trends and details; the empirical models only reflect the basic features of the observed ΔT values. If the user cannot apply the physical model (due to, e.g., the algorithm complexity or missing inputs), then the empirical parameterization in the form proposed in a 2002 study can be used. However, we recommend using a new set of parameters, calculated in this study, based on much more representative dataset, and with more rigorous quality control.

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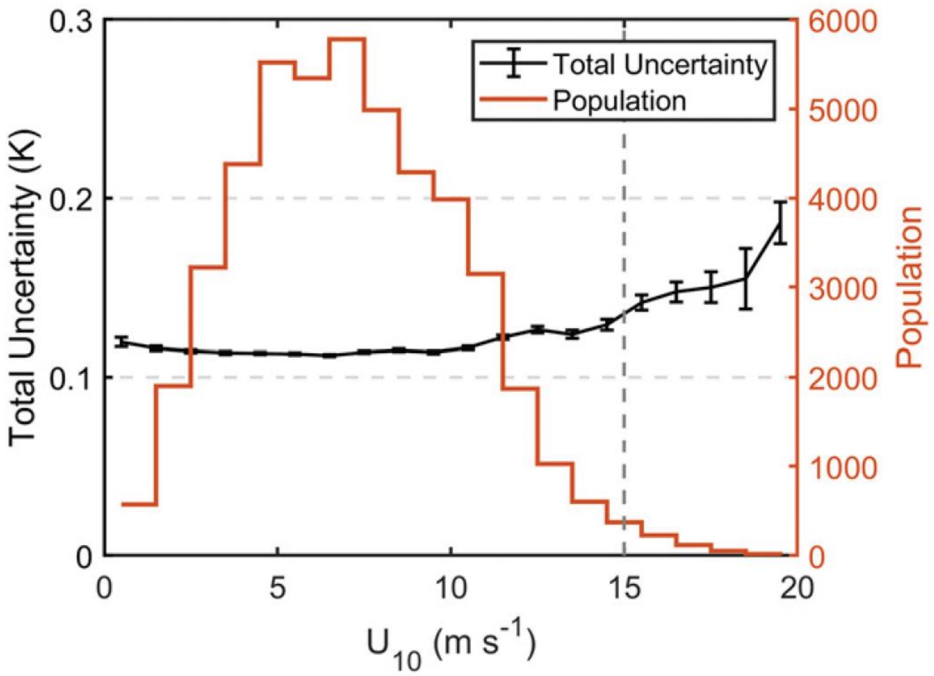
PART 1: Investigating night-time cool skin effect

- SST_{skin} - ISAR onboard R/V Investigator; SST_{depth} - SBE 38 sensor at 7-10 m depth
- Cool skin amplitude: $\Delta T = SST_{skin} – SST_{depth}$ (representing $SST_{subskin}$) under well mixed conditions
- Matchups of 103 days spanning two years from Jan. 2016 - Feb. 2018 along Australian coastal transects with a small portion coming from cruises through the Southern Ocean to Antarctica
- Heat fluxes calculated following version 3.6 of the TOGA COARE bulk parameterizations (positive when into the ocean; Fairall et al., 1996a)
- Physical cool skin model involved: Fairall et al. (1996b; hereafter F96)

PART 1: Investigating night-time cool skin effect

- Quality control of ISAR SST_{skin}
  - Only SST_{skin} values with total uncertainty <= 0.2 K are adopted (uncertainty code v3.1 for 2016–17 data and v3.8 for 2018)
  - $U_{10} < 15\ ms^{-1}$

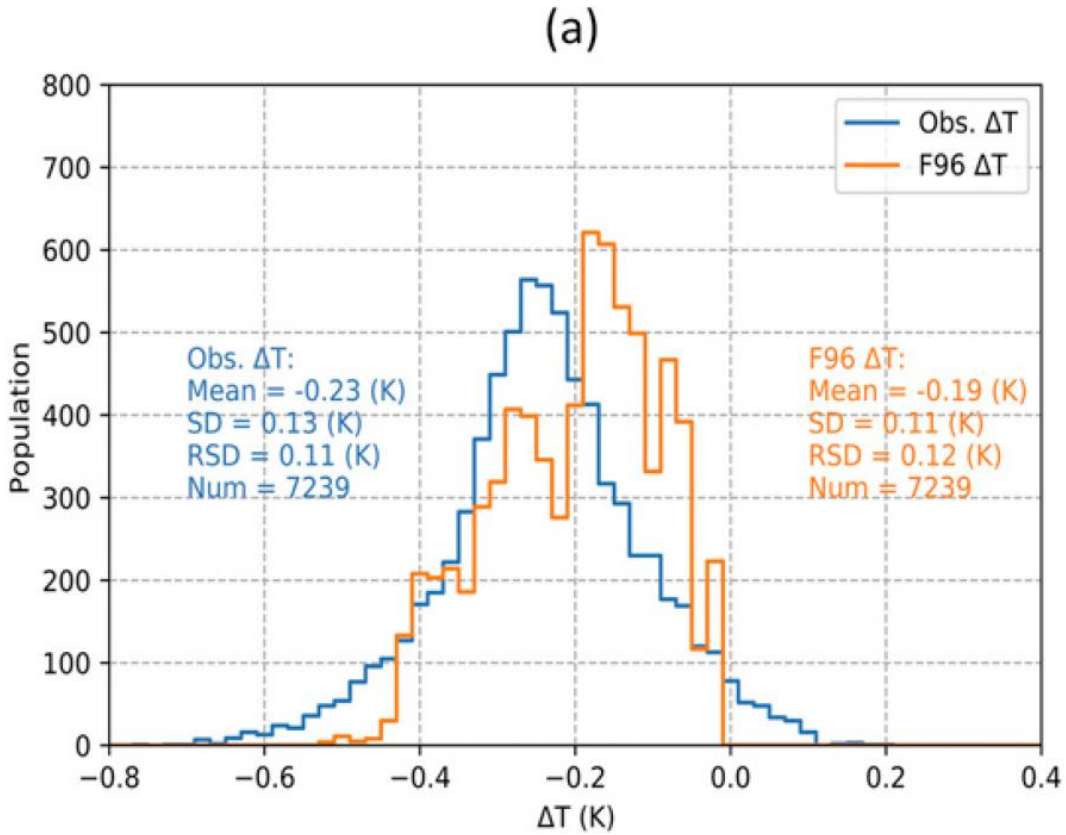


- Minimization of DW signals
  - Nighttime only
  - Well-mixed conditions: instead of applying the $U_{10} > 2$ (6) ms^{-1} filter fo nighttime (daytime), another approach is adopted: $DW_{max} < 0.3$ K

- Final collocations: N = **7239**

PART 1: Investigating night-time cool skin effect

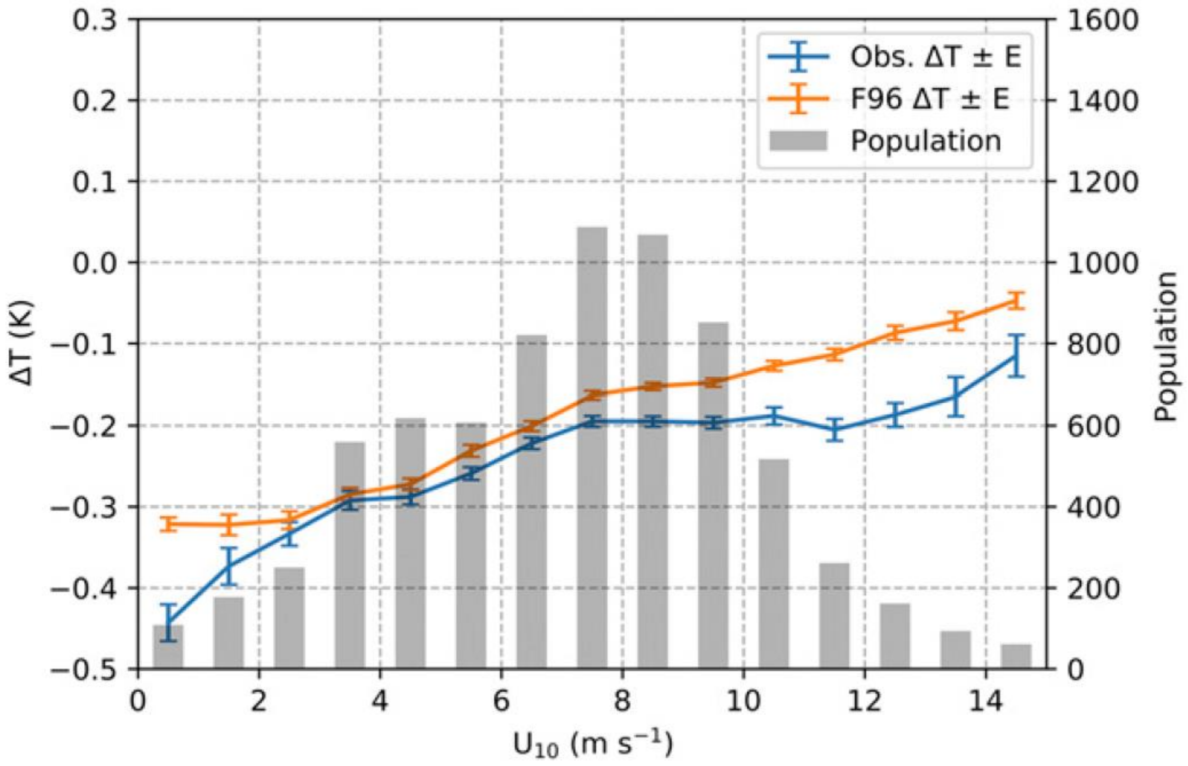
- Distributions and statistics of cool skin amplitudes, ΔT, from observations and F96 model



- Meteorological and marine inputs into F96 are from concurrent observations from the cruises
- F96 is doing well but no positive ΔT values

PART 1: Investigating night-time cool skin effect

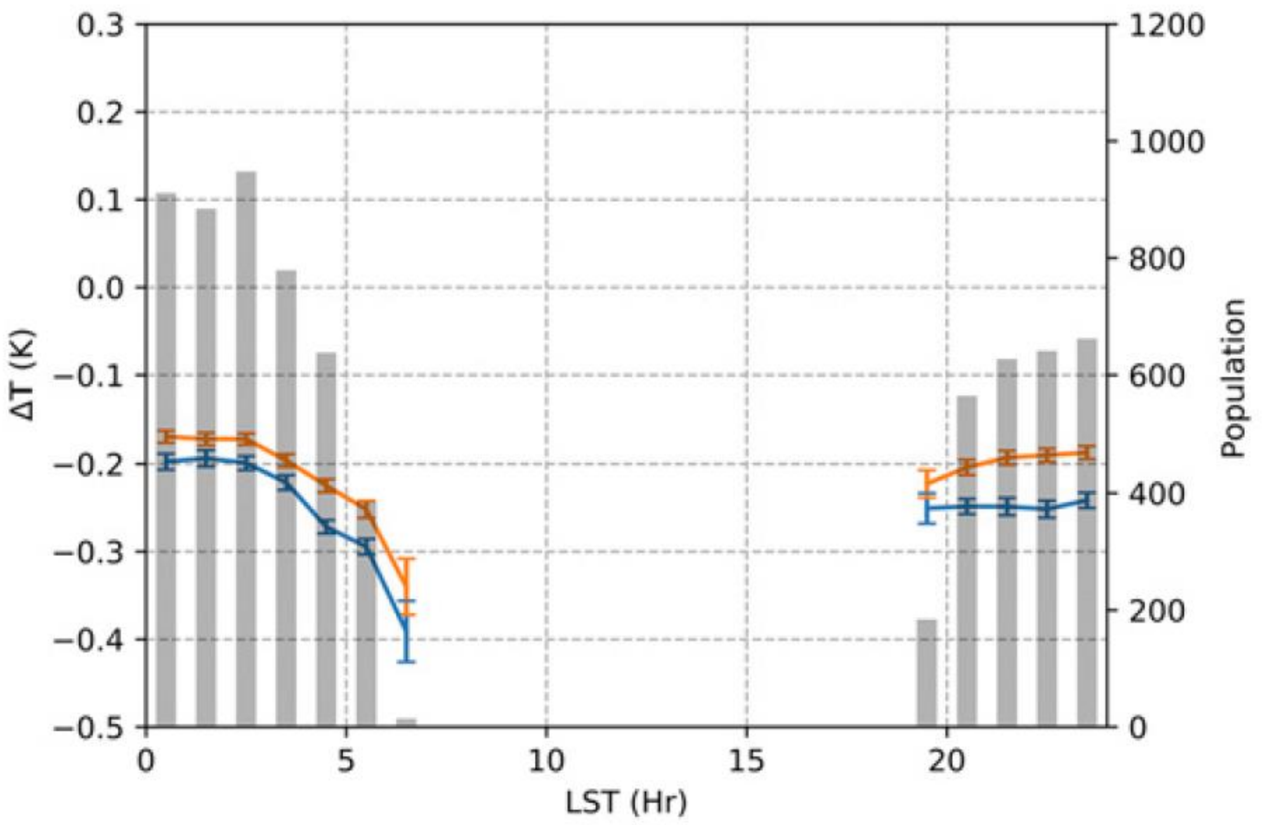
- Dependence of ΔT on U_{10}

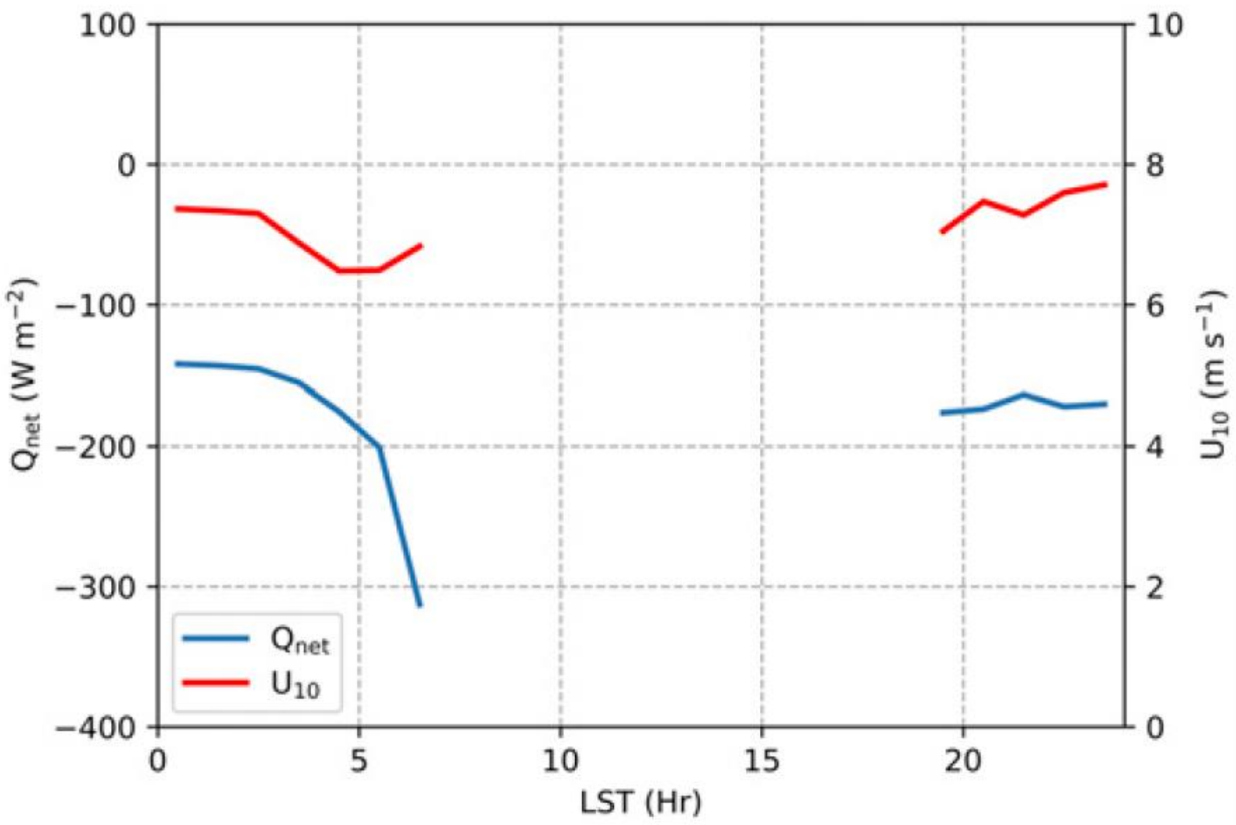


- All negative ΔT values for the whole wind speed range (0-15 ms^{-1})
- Calmer winds typically lead to cooler skins

PART 1: Investigating night-time cool skin effect

- Dependence of ΔT on local hour

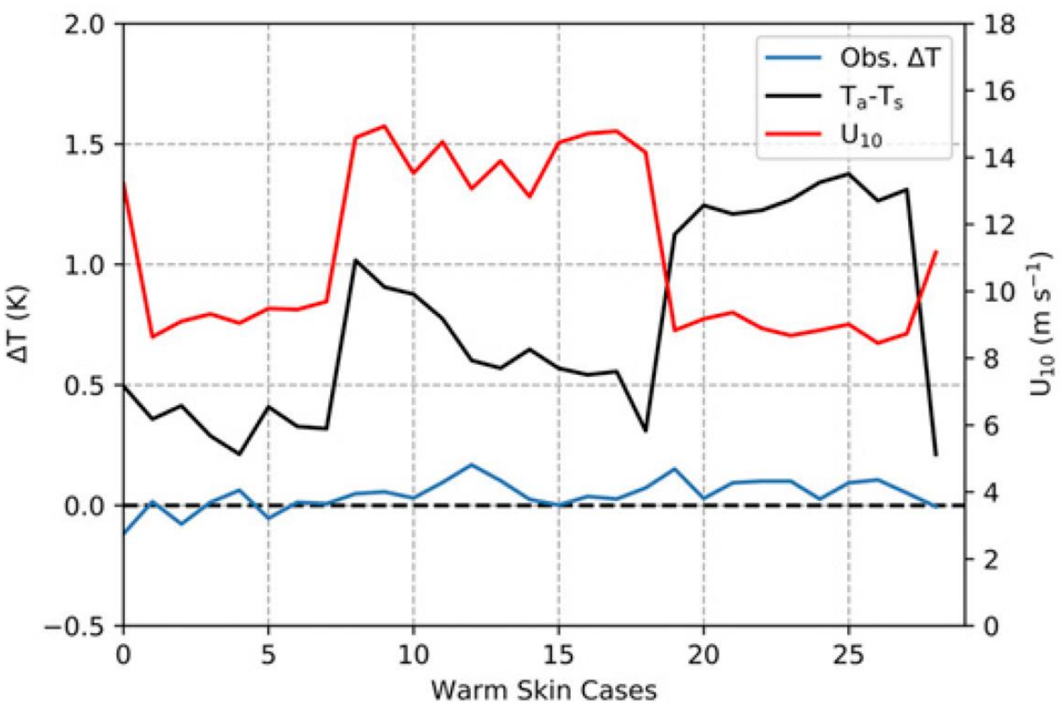




- Dawn times have the largest Q_{net}, hence the coolest skins

PART 1: Investigating night-time cool skin effect

- Warm skin signals



- Only 0.4% (29 out of 7239) of all data were made under positive Q_{net} (heat from air to ocean) conditions
- **25** out of 29 (86.2%) of all ΔT values are positive, indicating warm skin?
- Physically reasonable: (1) all U_{10} being > 8 ms^{-1}: **well-mixed**; (2) average **RH is 97.7%:** positive Q_l; (3) **T_{air} > SST**: positive Q_s; and (4) **SST_{skin} < 10 ºC**: low Q_{lw}.

OUTLINE

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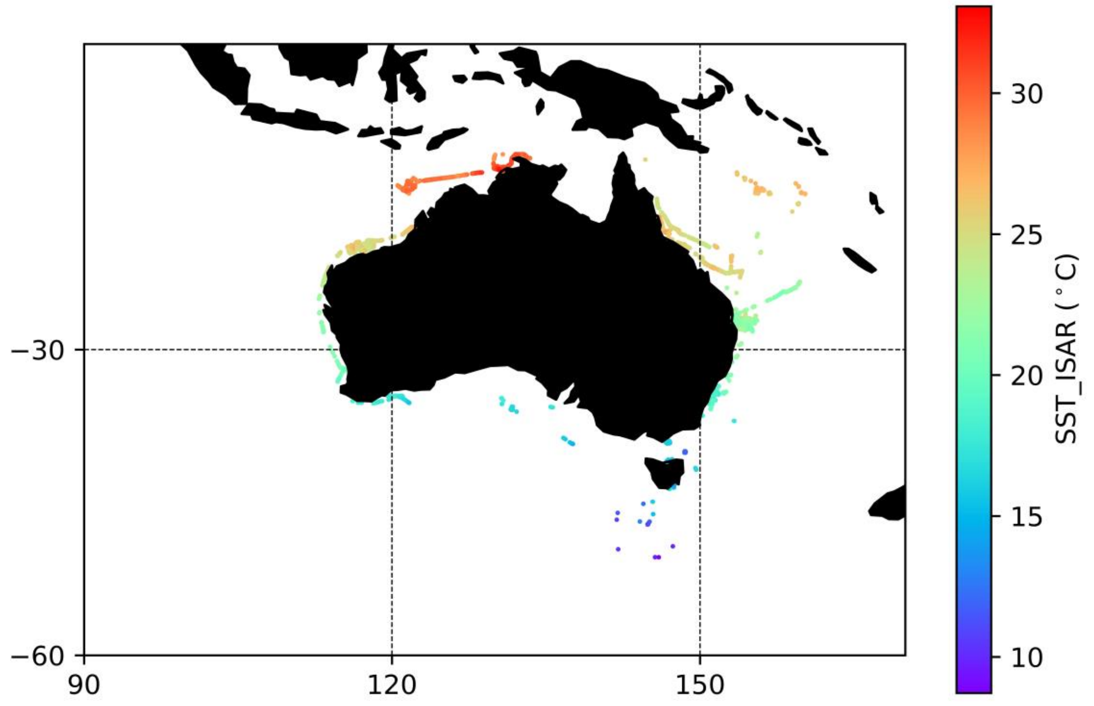
II. Validation of BoM Himawari-8 SST – preliminary results

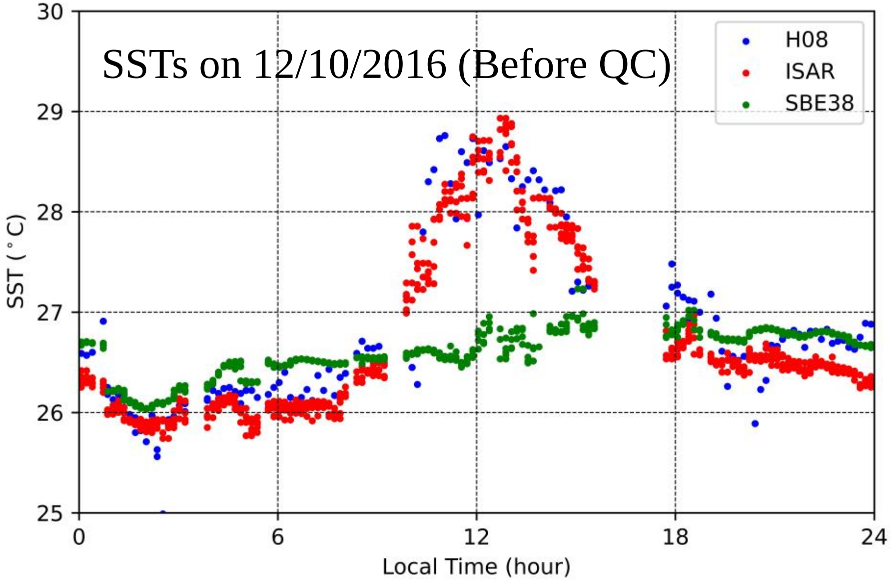
III. Conclusions



- Himawari-8 L2P fv02 (reprocessed) SST products at BoM
- ISAR SST uncertainty code version:
  - V3.1 – 2016-2017 (incl. part of 2018)
  - V3.8 – (part of) 2018-2019
  - V5.6 – 2020
- QC & Collocation method:
  - SSES_bias is subtracted from H08 skin SSTs
  - H08 SST QL = 5
  - H08 SST probability_clear = 1
  - ISAR total uncertainty <= 0.2 K & wind speed (obtained from ship) <= 15 ms^{-1}
  - Both ISAR and SBE38 SST should pass all the IMOS data processing system QC steps
  - Spatial/temporal window: 5 km and ± 5 mins around each H08 pixel. If more than one pair, retain the best pair only.
  - Further manual QC of ISAR SST for each cruise by directly comparing with SBE38 to discard suspicious cruises.
- Final temporal coverage in this study: Jan. 2016 – Dec. 2019

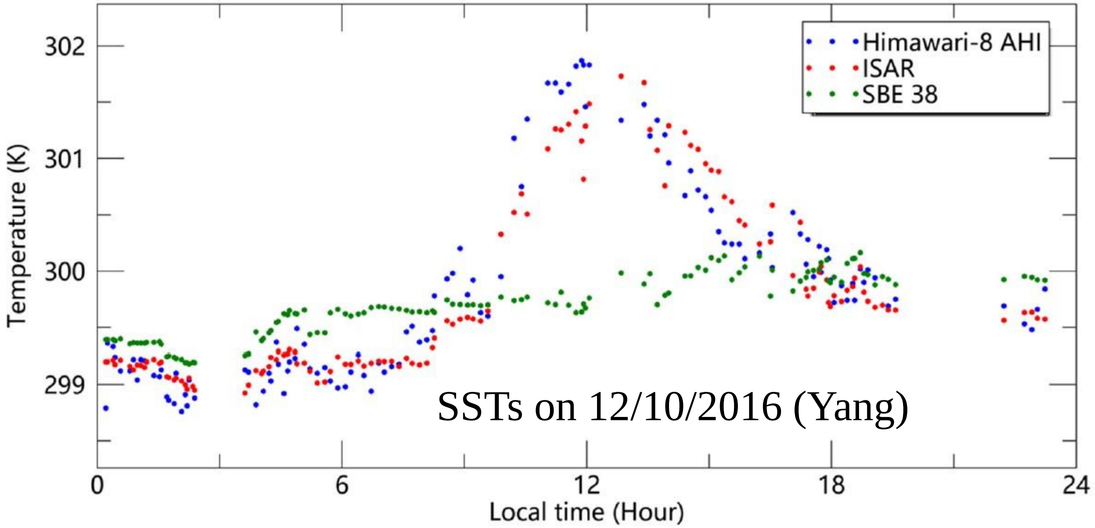
PART 2: Himawari-8 SST Validation Using ISAR Data – preliminary results

- First impression of BoM H08 L2P reprocessed SST data



This study (BoM L2P H08 SST)

Yang et al 2020 (JAXA L2)



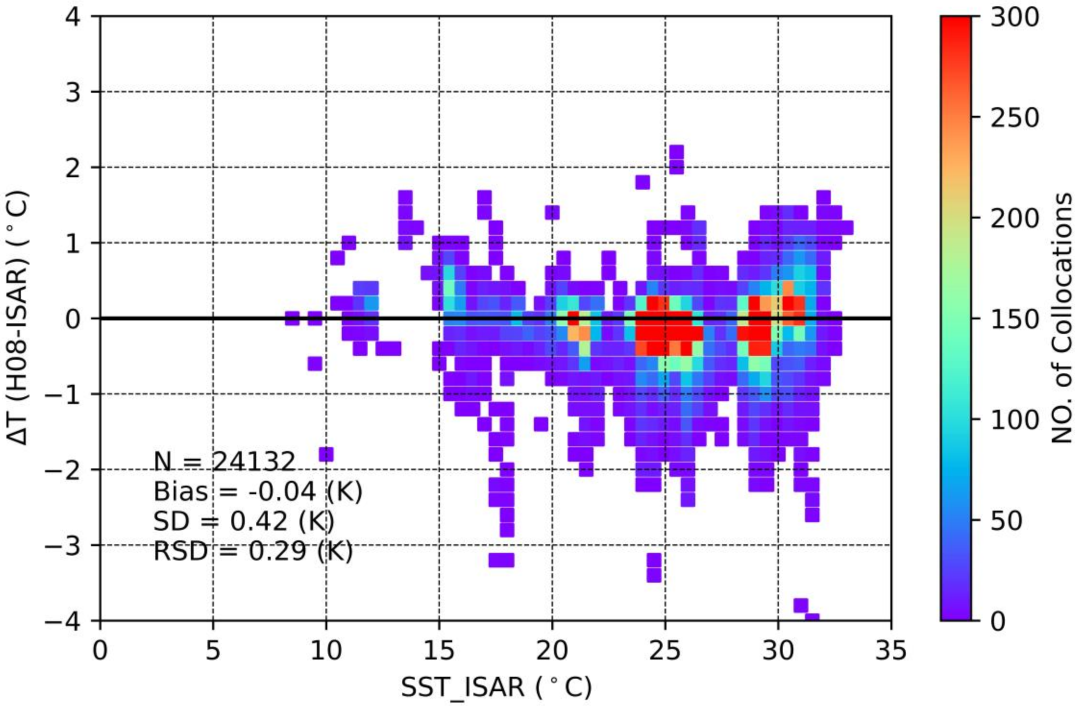
- Case study – H08 has reasonable sensitivity to skin diurnal warming signals; good agreement with Yang et al 2020

- Statistics (SST_{H08} – SST_{ISAR})

Year	N	Bias (K)	SD (K)	RSD (K)
2016	5600	-0.19	0.42	0.27
2017	6503	0.01	0.35	0.26
2018	10	-0.05	0.23	0.20
2019	12019	0.01	0.43	0.30
All	**24132**	**-0.04**	**0.42**	**0.29**

Table 4. Statistics of SST difference of the matchups for different ISAR QLs.

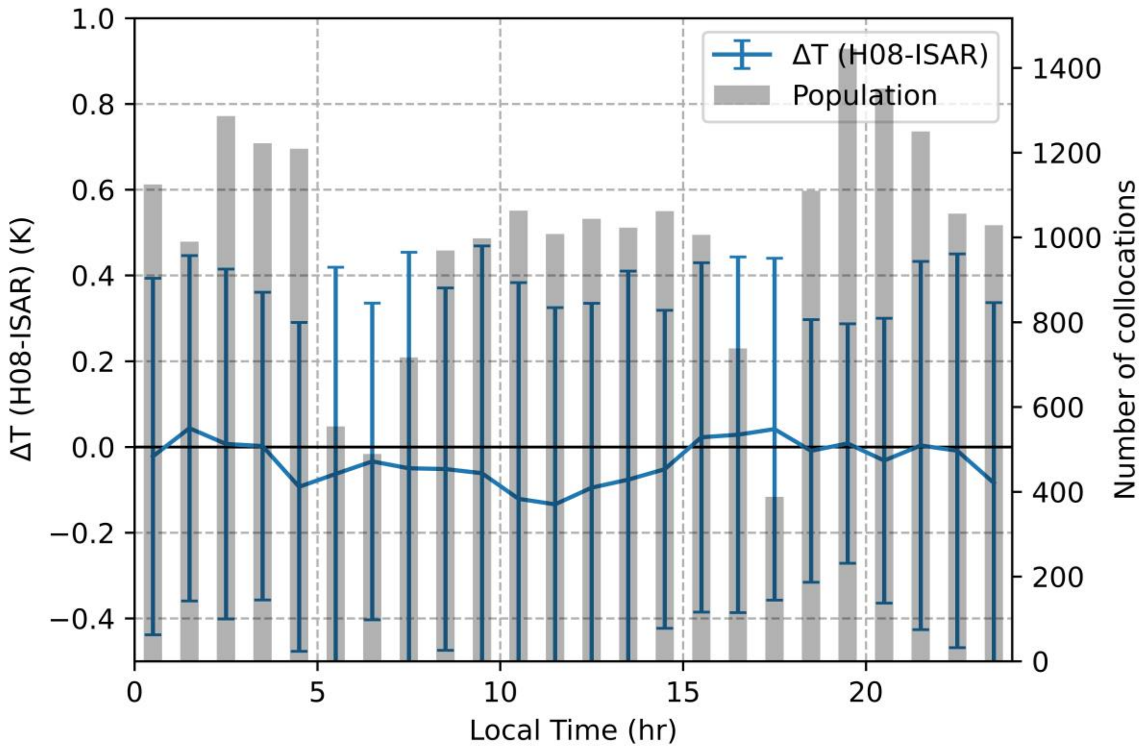
QL	N	Mean (K)	Median (K)	SD (K)	RSD (K)	Max (K)	Min (K)	P (±0.3K)	P (±0.5K)
QL ≤ 3	673	−0.04	−0.02	0.37	0.33	1.45	−1.74	64%	85%
QL = 4	1829	0.09	0.10	0.31	0.28	1.63	−1.52	66%	90%
QL = 5	872	0.10	0.09	0.27	0.24	1.13	−1.32	72%	91%
QL ≥ 4	2701	0.09	0.10	0.30	0.27	1.63	−1.52	68%	90%

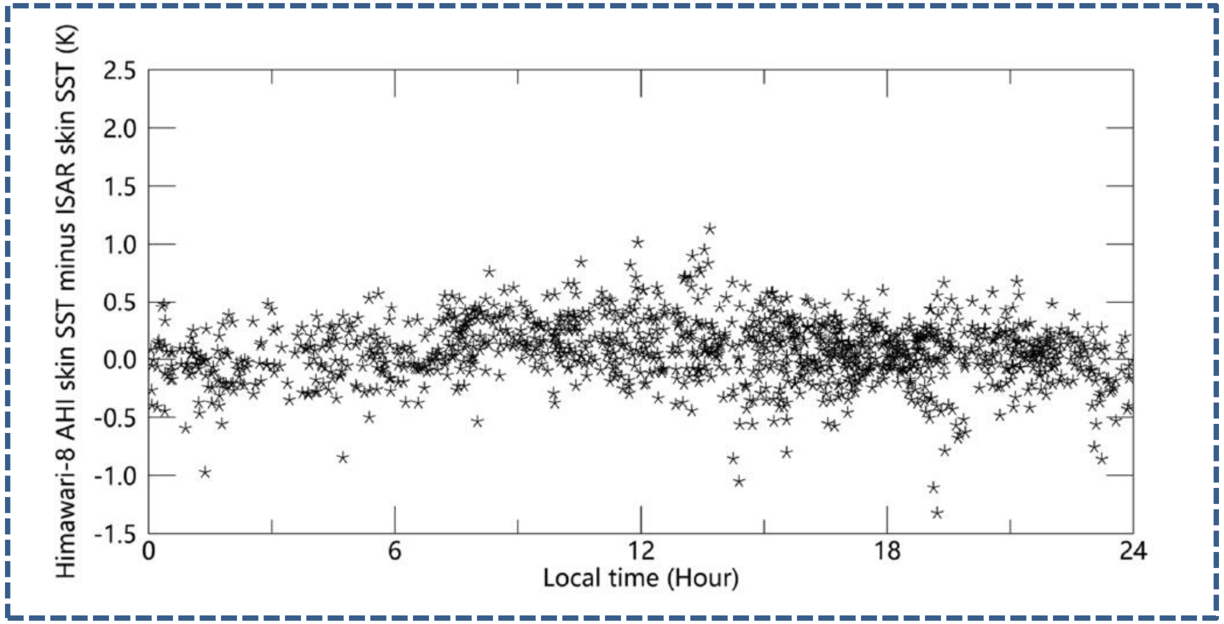


- Statistically, BoM H08 L2P SST data is of good quality when compared with ISAR skin SSTs.
- Compared with Yang et al 2020, slightly colder bias and larger SD

PART 2: Himawari-8 SST Validation Using ISAR Data – preliminary results

➢ Distribution of ΔT (SST_{H08} – SST_{ISAR}) against local time

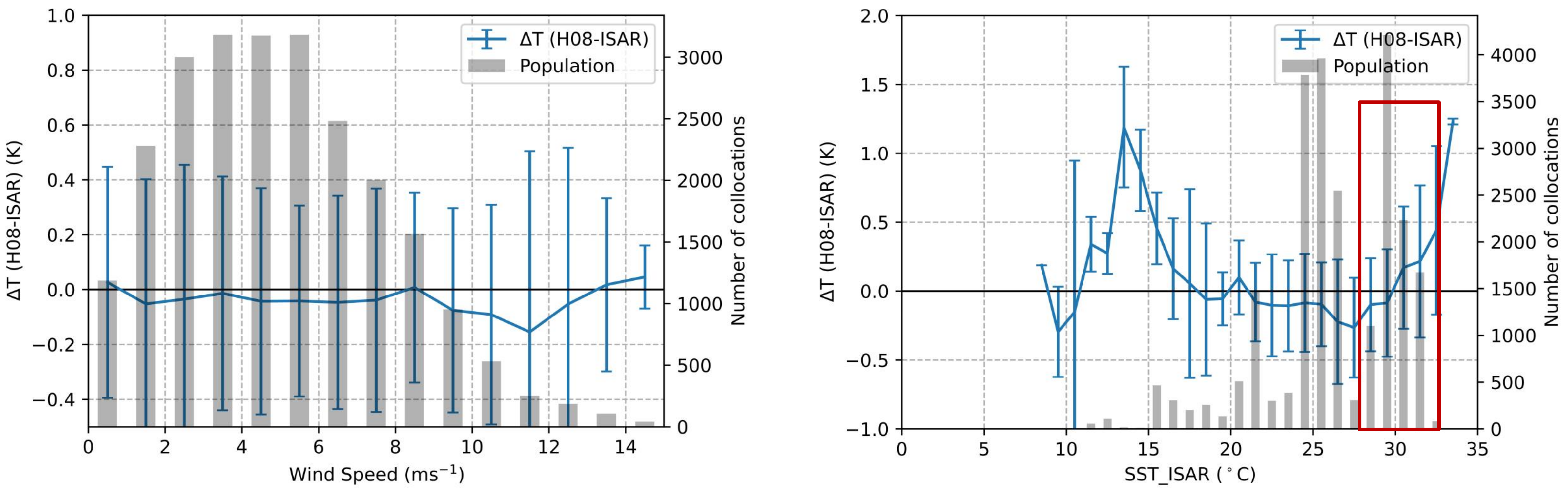




- No obvious dependence of ΔT on local time observed, as also noted in Yang et al 2020.

PART 2: Himawari-8 SST Validation Using ISAR Data – preliminary results

- Distribution of ΔT ($SST_{H08} - SST_{ISAR}$) against wind speed (left) and SST (right)



- No obvious dependence of ΔT on wind speed observed.
- There appears to be a warming trend of H08 under very warm SST conditions (> 27 degC)

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PART 3. Conclusions

- Cool skin effect:
  - **Nighttime** cool skin signals obtained from **concurrent ISAR and SBE38 SSTs** show expected features and statistics.
  - **F96** cool skin model **performs very well**
  - **Real warm skin signals** are directly observed in nature

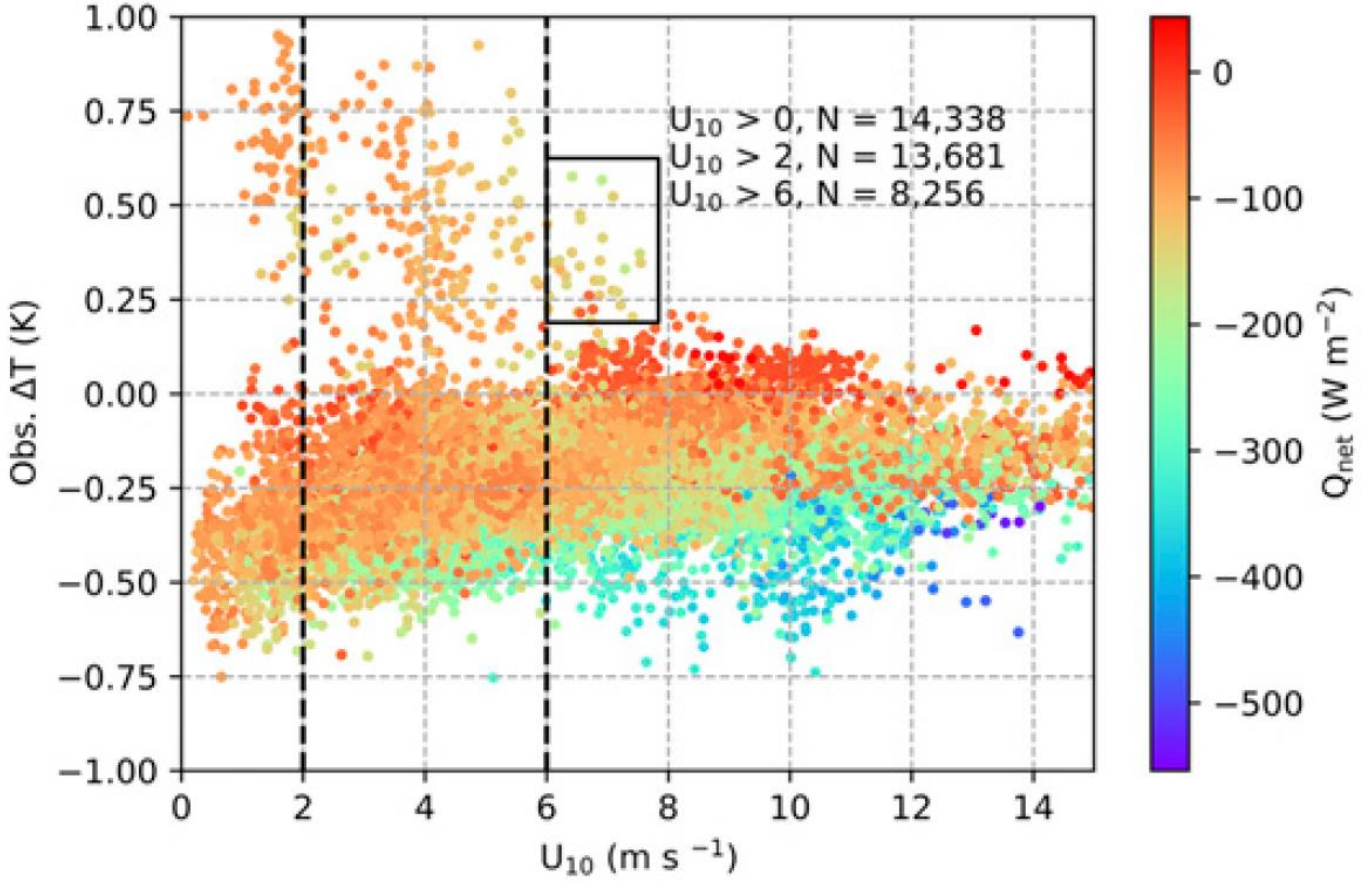
- BoM H08 L2p skin SST validation:
  - After careful **QC** (on both ISAR and satellite SST measurements), BoM H08 L2p skin SST data is found to be of **very good quality** under nearly all available conditions in this study.
  - Himawari-8 AHI skin SST with high temporal resolution (10 mins) are **sensitive to DW signals**.

- RV Investigator ISAR skin SST product:
  - In general, with proper QC, reprocessed ISAR skin SSTs from RV Investigator are of **good quality** and **can be used for scientific research purposes** for this study period.

THANK YOU!

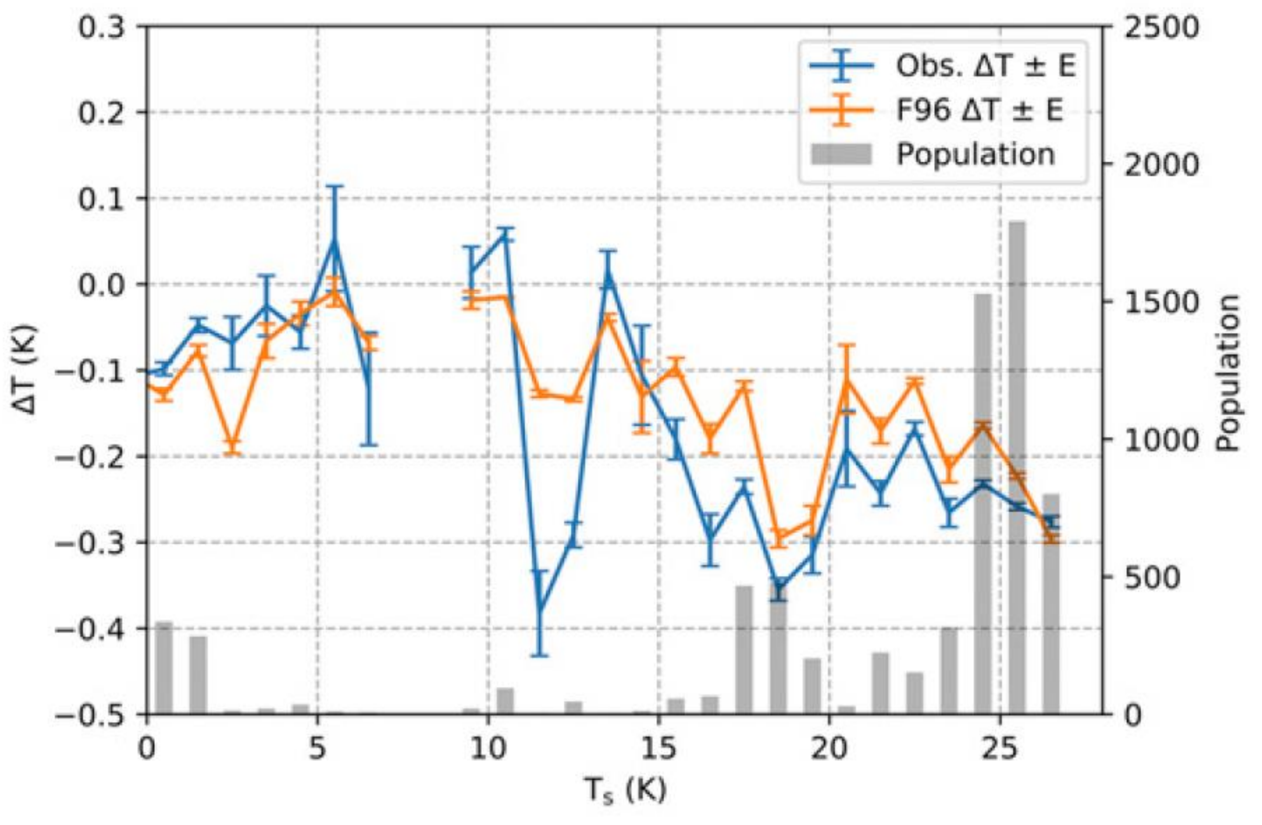
Extra slides for discussion

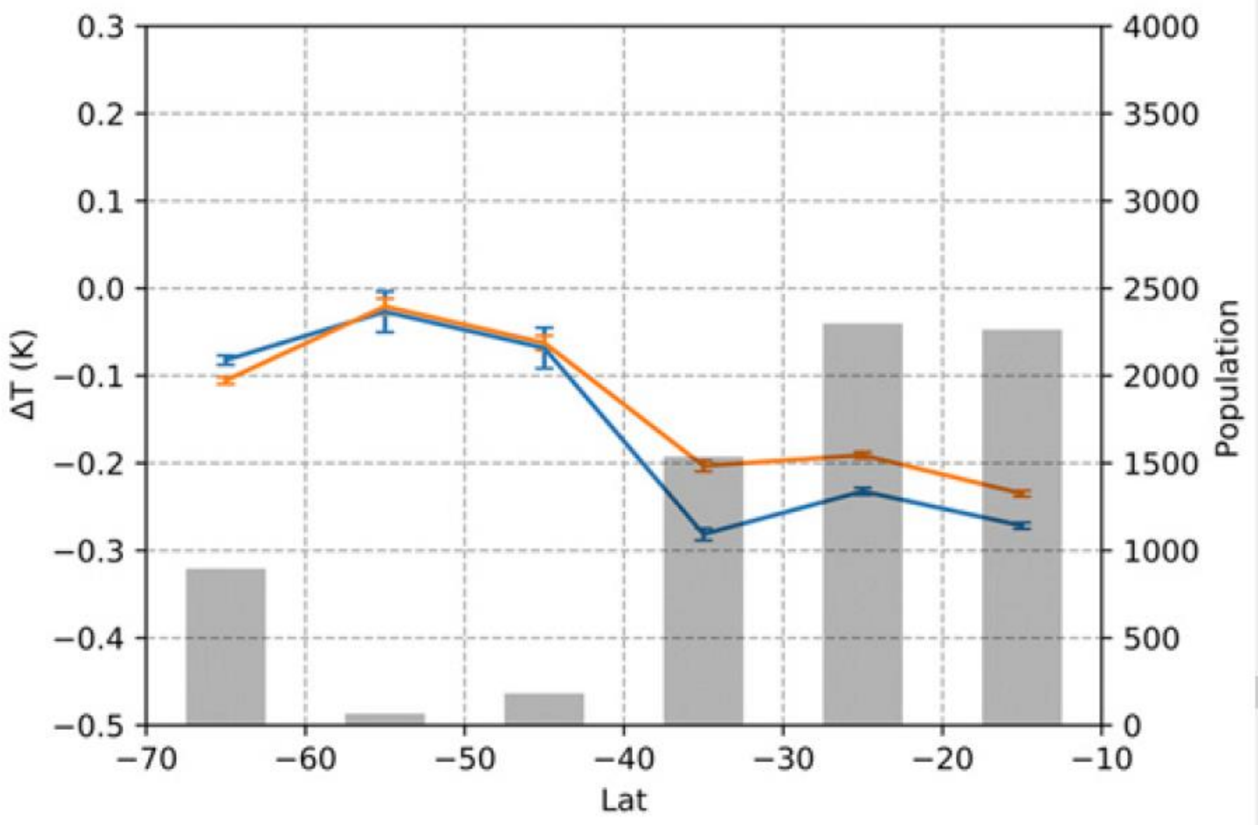
PART 1: Investigating night-time cool skin effect



- The distribution of nighttime ΔT values as a function of U_{10}. Colour indicates the corresponding net heat flux Q_{net}. Populations of Δ T under different U_{10} filters are shown. The two dashed vertical lines mark U10 = 2 and 6 ms^{-1}.

PART 1: Investigating night-time cool skin effect





- Dependence of ΔT on SST_{skin} and latitude.

PART 1: Investigating night-time cool skin effect

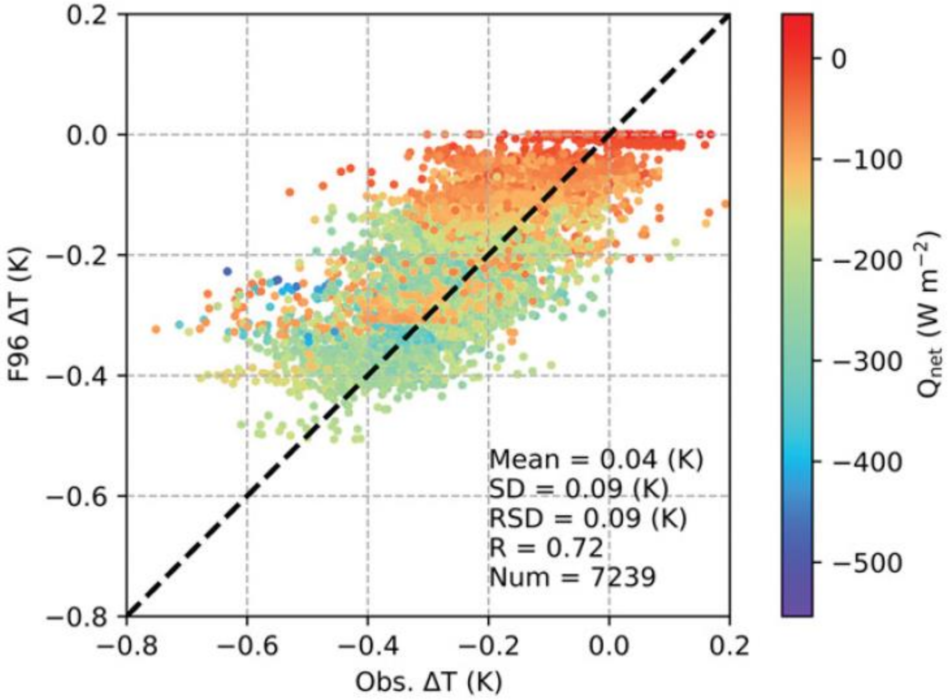


FIG. 10. Scatterplot of the collocated observed and F96 ΔT values. The black dashed line is the 1:1 reference line. The color indicates the corresponding Q_{net}. Statistics of the differences between F96 and observed (F96 − observed) ΔT are shown, including the mean, SD, RSD, and correlation coefficient R.

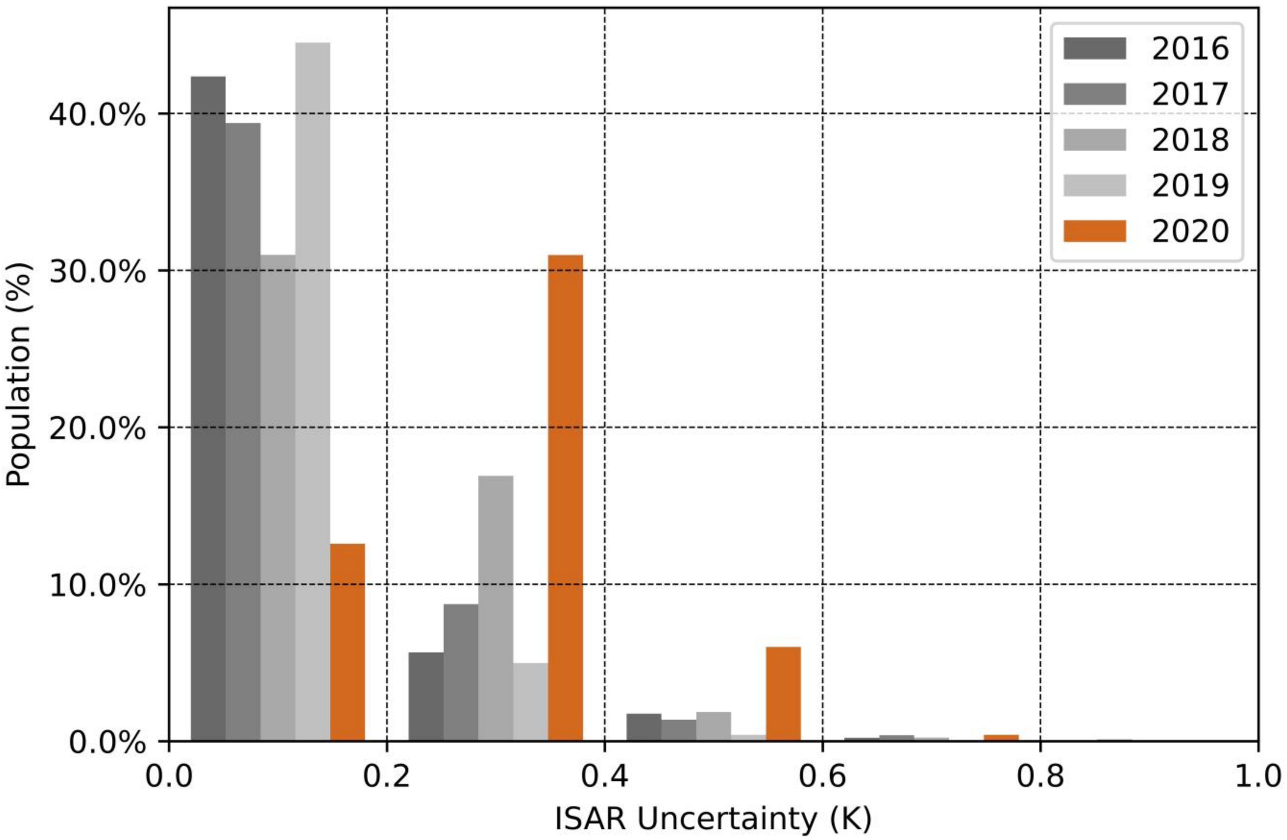
- Comparison between F96 and observations.

PART 2: Himawari-8 SST Validation Using ISAR Data – preliminary results

- Comparison between ISAR and SBE38 for each cruise (after all the above QC) – red cruises are further deleted

Year	Voyage_ID	Voyage Dates	N	Bias (K)	SD (K)
2016	IN2016_V02	01.08-02.26	14	-0.32	0.08
	IN2016_T02	08.25-08.28	190	-0.23	0.22
	IN2016_V04	08.31-09.22	459	0.03	0.12
	IN2016_V05	09.27-10.24	3576	-0.2	0.24
	IN2016_V06	10.28-11.12	1361	-0.24	0.27
2017	IN2017_V01	01.14-03.01	1	-0.32	0
	IN2017_V02	03.16-03.27	8	-0.37	0.09
	IN2017_C01	04.11-04.27	113	-0.25	0.07
	IN2017_C02	05.04-05.14	621	-0.24	0.15
	IN2017_V03	05.15-05.20	35	-0.06	0.06
	IN2017_V05	10.11-11.09	5419	-0.19	0.21
	IN2017_T02	11.14-11.25	306	0.04	0.43
2018	IN2018_V01	01.11-02.21	10	-0.23	0.03
	IN2018_T01	04.05-04.14	385	**0.35**	**0.84**
2019	IN2019_V04	08.09-09.02	506	-0.23	0.22
	IN2019_V05	09.09-09.28	1863	-0.14	0.16
	IN2019_T02	10.06-10.13	524	-0.19	0.1
	IN2019_V06	10.20-12.16	9126	-0.52	0.69
	IN2019_T03	12.22-12.31	588	**-1.13**	0.4
2020	IN2020_V01	01.10-03.05	149	**-0.9**	0.13
	IN2020_V09	08.27-09.12	1	**-0.6**	0

- Distribution of ISAR total uncertainty for different years



- ISAR total uncertainty shows a large increase in 2020