Comparison (of shipborne radiometers) with other in situ measurements

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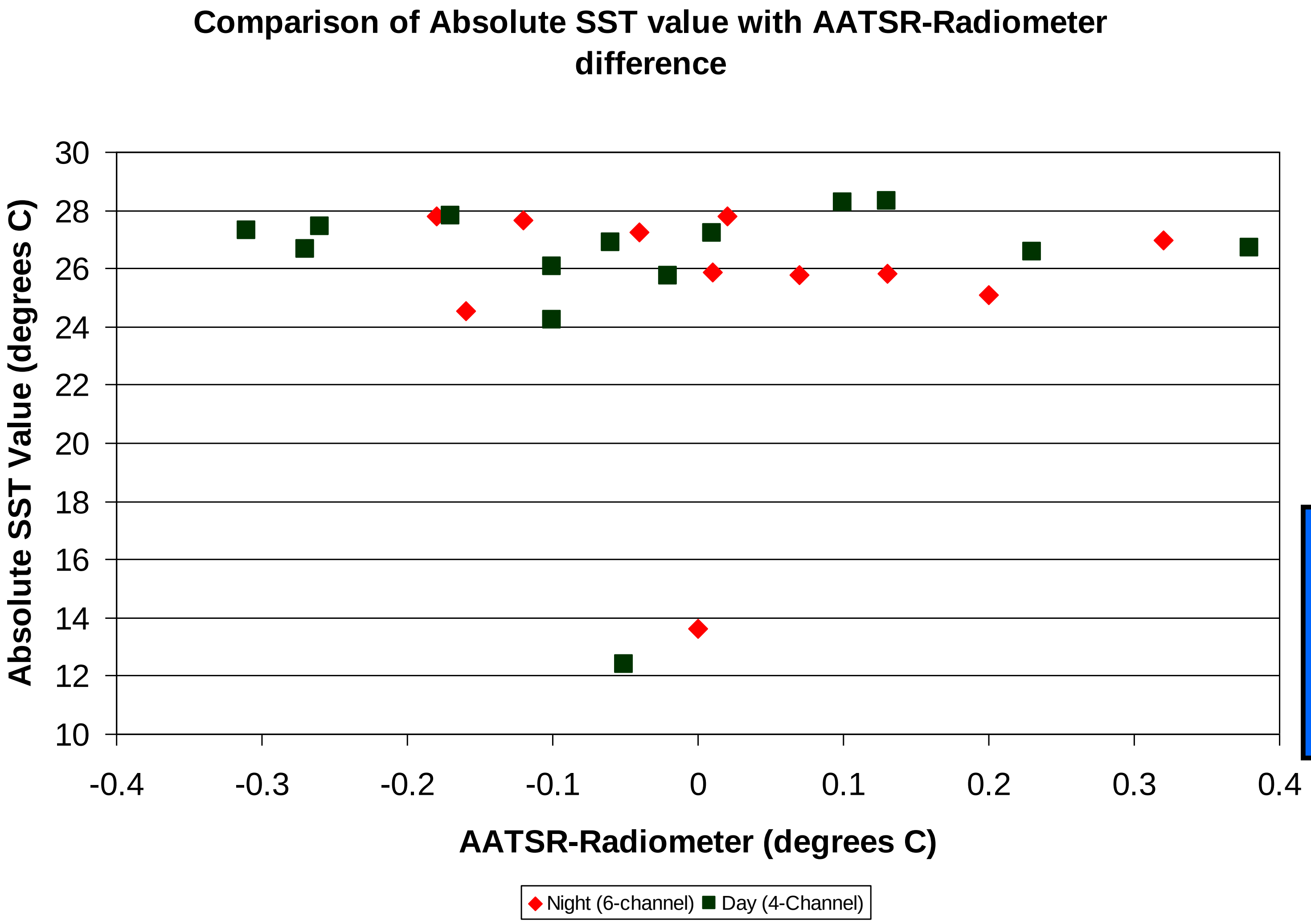
SST Validation – All Radiometers



83.33% data used
(Within 1 sigma)
14 Day
11 Night

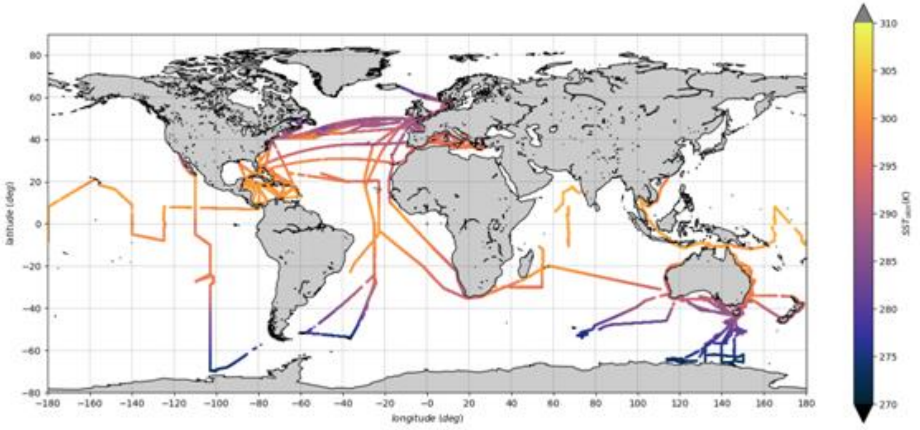
Summary:

	Day	Night
Bias	-0.04	0.02
Stdev	0.19	0.15

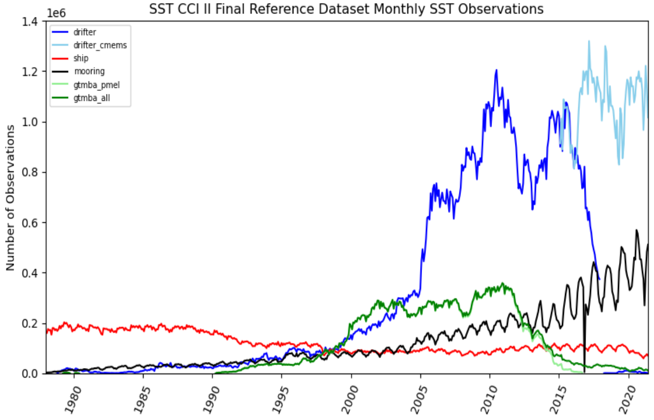
(Fiducial) Reference Measurements for satellite SST validation

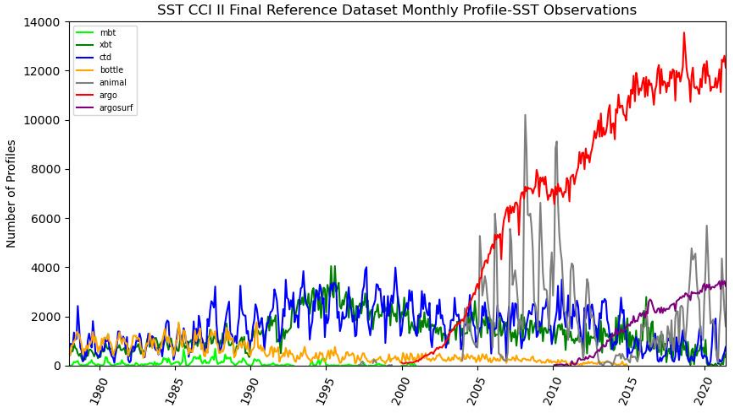
copernicus.eumetsat.int

- Ship-borne radiometers (FRM)
  - Traceable to SI; SST-skin; very-high accuracy; very-poor coverage
  - ISFRN – International Sea Surface Temperature (SST) Fiducial Reference Measurement (FRM) Radiometer Network
- Drifting buoys
  - Variable calibration; global data; SST-depth; good coverage in recent decade(s)
  - GHRSST/DBCP HRSST initiative
  - Copernicus TRUSTED buoys (FRM)
- Argo near-surface (FRM-tbc)
  - Global; acceptable sampling; very-low uncertainty (calibration method to be analysed)
- GTMBA
  - Better calibration; SST-1m; acceptable coverage (influenced by data collection);
- Everything else…



https://ships4sst.org/

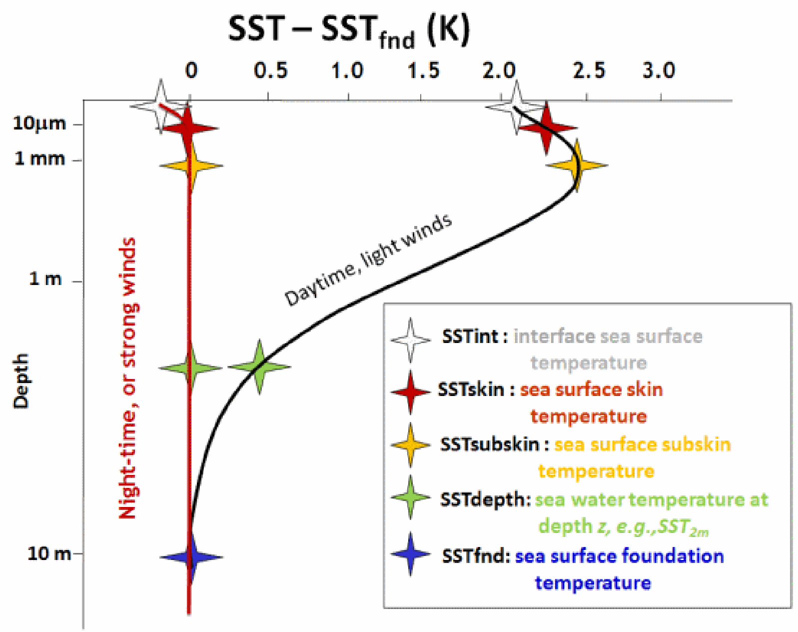




https://www.metoffice.gov.uk/hadobs/hadiod/sirds.html

Use both traceable and non-traceable reference data – "degree of equivalence" - > **Minnett and Corlett 2012**

Understanding the problem

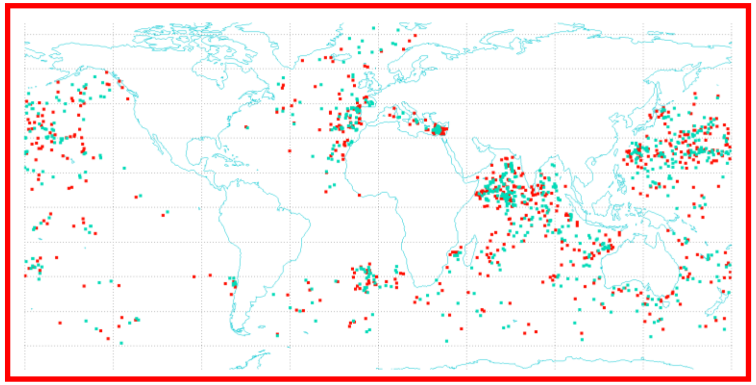


https://www.ghrsst.org/

- Assessment of uncertainty of satellite measurements involves comparison to a reference dataset
  - Create a dataset of match-up coincidences within predefined spatial and temporal limits
- The bias and standard deviation calculated from such a comparison do not provide the uncertainty of each dataset individually but are the mean bias and combined uncertainty of a two-dataset comparison.
- Consequently, the resulting statistics are often dominated by real changes in the SST that can occur within the predefined spatial and temporal limits.
  - <u>And outliers!</u>
- <u>Defines an upper limit for the uncertainty budget</u>

The geophysical limit

- Argo 4 m depth SST and drifter 20 cm depth SST
- Matched with AATSR
- Only matches with wind speed > 6 ms-1 used



Chris Merchant, University of Reading

- Nearest (in time and space) match with drifting buoy also found
  - Argo vs. AATSR: σ = 0.15 K
  - DB vs. AATSR: σ = 0.25 K

AATSR N3 (D3) uncertainty = 0.15 (0.27) K
DB uncertainty = 0.2 K
Argo uncertainty = 0.005 K
Geophysical uncertainty = 0.1 K (1-km; +/- 2 hours)

- Geophysical (point to pixel) variability is 0.1 K (upper limit)

- Implied DB uncertainty (at the time) excluding geophysical effects is 0.20 K (lower limit)

Minnett (1991) determined that limits of 10 km and 2 hours would introduce an error of up to 0.2 K, but this was for a very specific area of the Atlantic Ocean with relatively high temperature variability.

Accounting for geophysical inter-relationships

- To use all available in situ data we need to estimate in situ SST-skin at time of satellite overpass

- Example for drifters
  - Take raw drifter measurement at depth (currently assume 20 cm)
    - *"Skin-raw"*
  - Adjust SST-depth to SST-skin at drifter measurement time using model of skin effect and diurnal stratification
  - Adjust to SST-skin at satellite measurement time using same model of skin effect and diurnal stratification
    - *"Skin-skin"*

- So, we not only need to validate SSTs, but also skin-to-depth models

- Current model used is combination of Fairall et al. (1996) for skin effect, and Kantha and Clayson (1994) for diurnal stratification (referred to as FKC)

Validation uncertainty budget →

$$\sigma_{Total} = \sqrt{\sigma_1^2 + \sigma_2^2 + \sigma_3^2 + \sigma_4^2 + \sigma_5^2} \quad + \text{ clouds}$$

Copernicus Sentinel 3 SST

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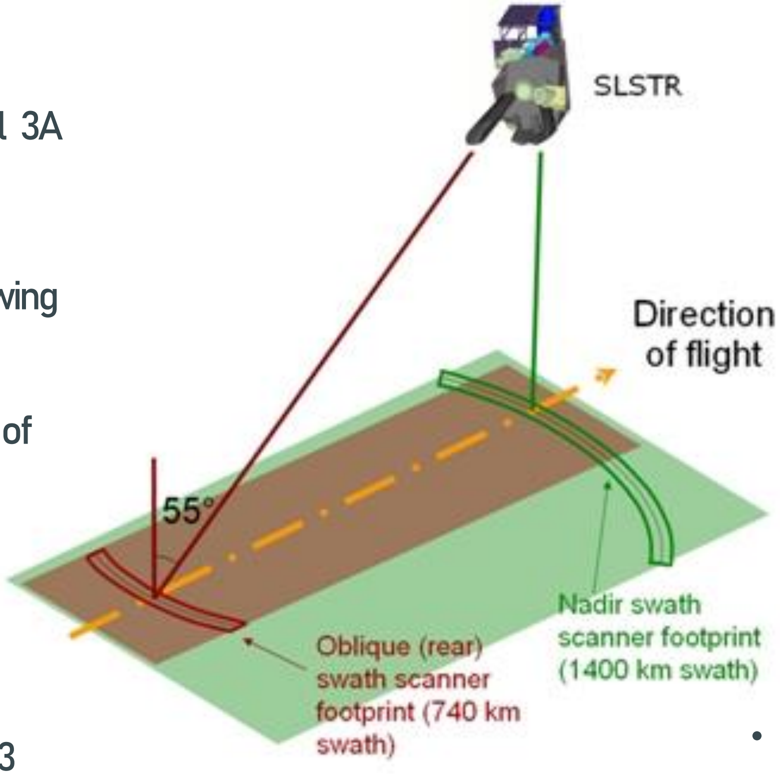
- The first Sea and Land Surface Temperature Radiometer (SLSTR) was launched on Sentinel 3A on 16th February 2016.
  - Sentinel 3B launched on 26 the April 2018
- Dual-view self-calibrating IR radiometer following the ATSR class of sensors
- SST Retrievals by radiative transfer modelling of the form:

$$a_0 + \sum_{1}^{n} a_n BT_n$$

where n is the number of channels

- For SLSTR we use 2 channels during day and 3 during night
  - 3.7 µm not used during day owing to solar contamination
  - We have two views, so we have four SST retrievals in total

SLSTR provides SST_{skin}



SLSTR-A
Operational since 05/07/2017

SLSTR-B
Harmonized to SLSTR-A using SSES
Operational since 12/03/2019

Nominal Channel Centre	Primary Application
S7: 3.7 µm	SST Retrieval
S8: 11 µm	SST/LST Retrieval
S9: 12 µm	SST/LST Retrieval

Four Possible Retrievals:

Nadir 2-channel N2
Nadir 3-channel N3
Dual 2-channel D2
Dual 3-channel D3

- WCT
  - This product provides sea surface temperature for all offered retrieval algorithms.
- **WST**
  - **This product provides the best SST at each SLSTR location in GHRSST L2P format.**

http://slstr.eumetsat.int

SLSTR MDBs

- Main component in SLSTR SST validation
  - Matchups between satellite and in situ data (felyx)
  - Satellite: SLSTR-A/B, AVHRR-B, IASI-B, VIIRS-NPP
  - In situ: drifters, Argo, moored, trusted, **radiometers**
  - Contains core file (L2:WST) plus aux (L2:WCT and L1:MET/RBT)
- MDB access: sftp://s3calval.eumetsat.int
  - Available to Sentinel-3 Validation Team (S3VT)
    - To become S3VT member please submit proposal (s3vt.org) and request access to SLSTR MDB
- Revised radiometer dataset (ship4sstr1i1)
  - Repro MDB: 2016/04-2018/04 (S3A full)
  - NRT MDB:
    - 2018/04 – 2018/12 (S3A; aux: no RBT)
    - 2019/01 to 2022/12 (S3A plus S3B from March 2019; aux: no RBT)

The Validation Space – dependence – drifters

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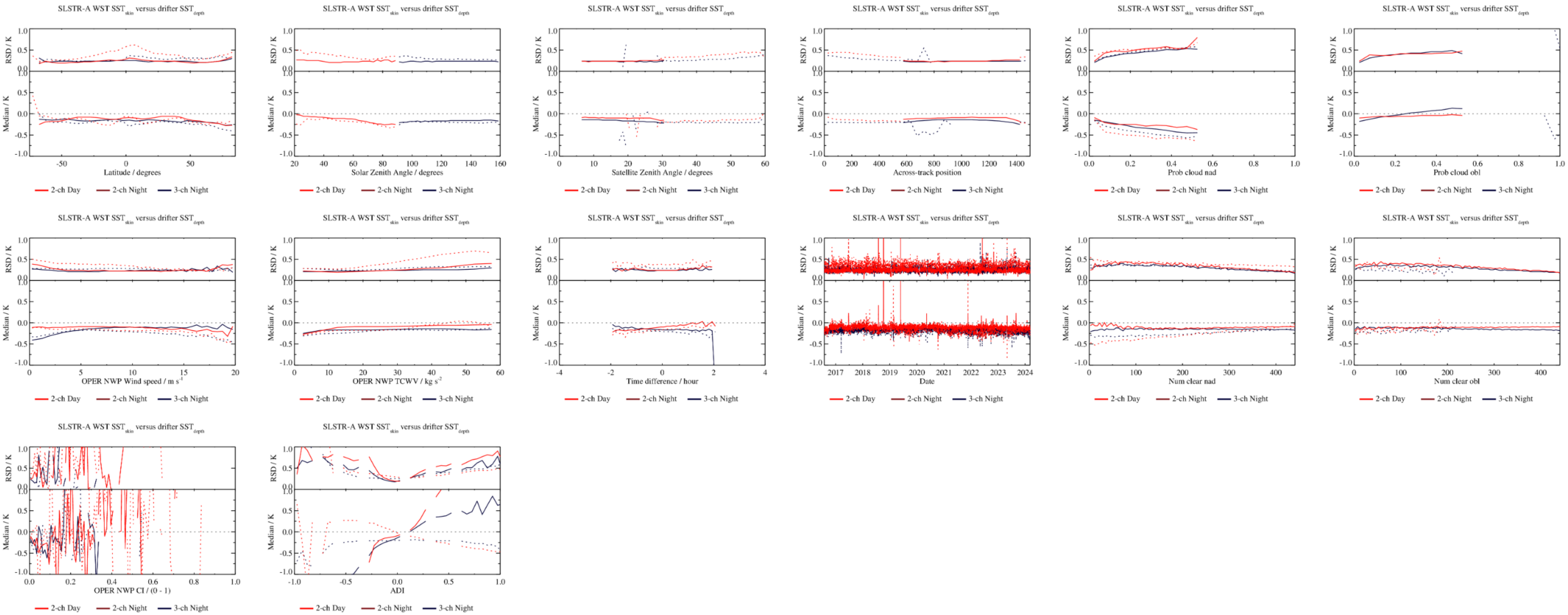
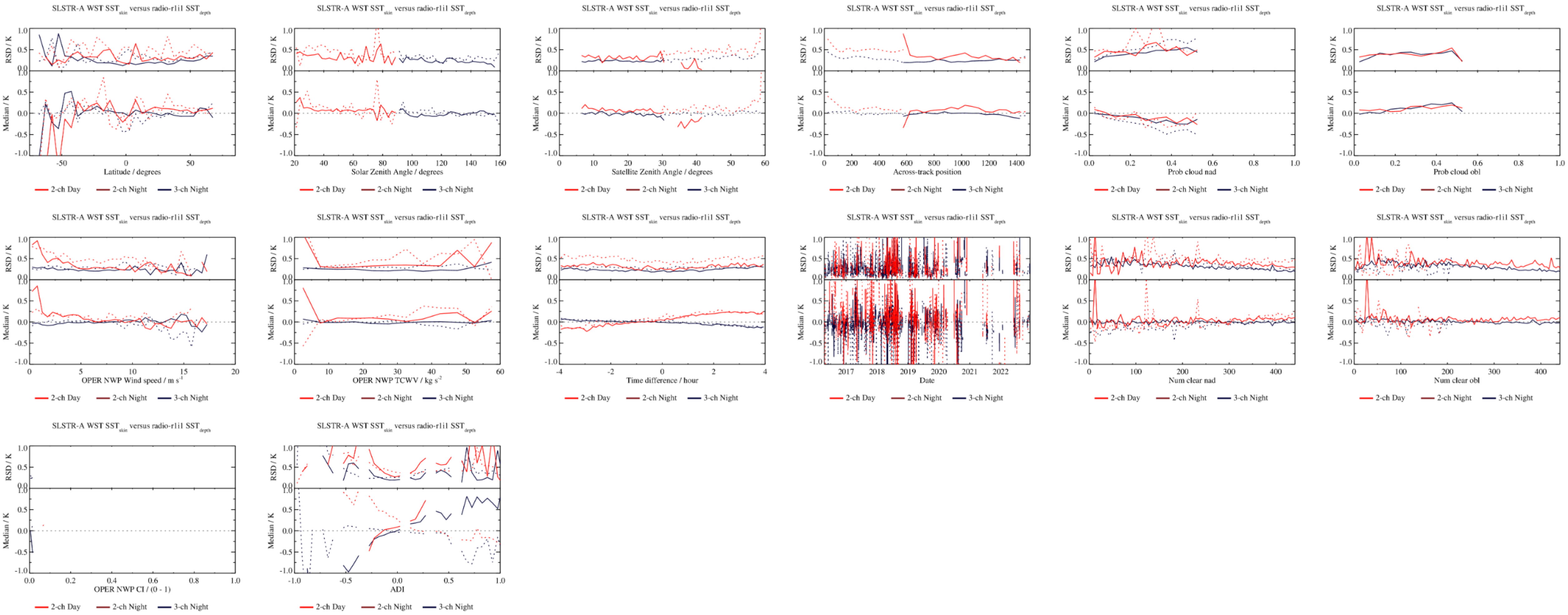


No FKC adjustments applied



No FKC adjustments applied

The Validation Space – spatial

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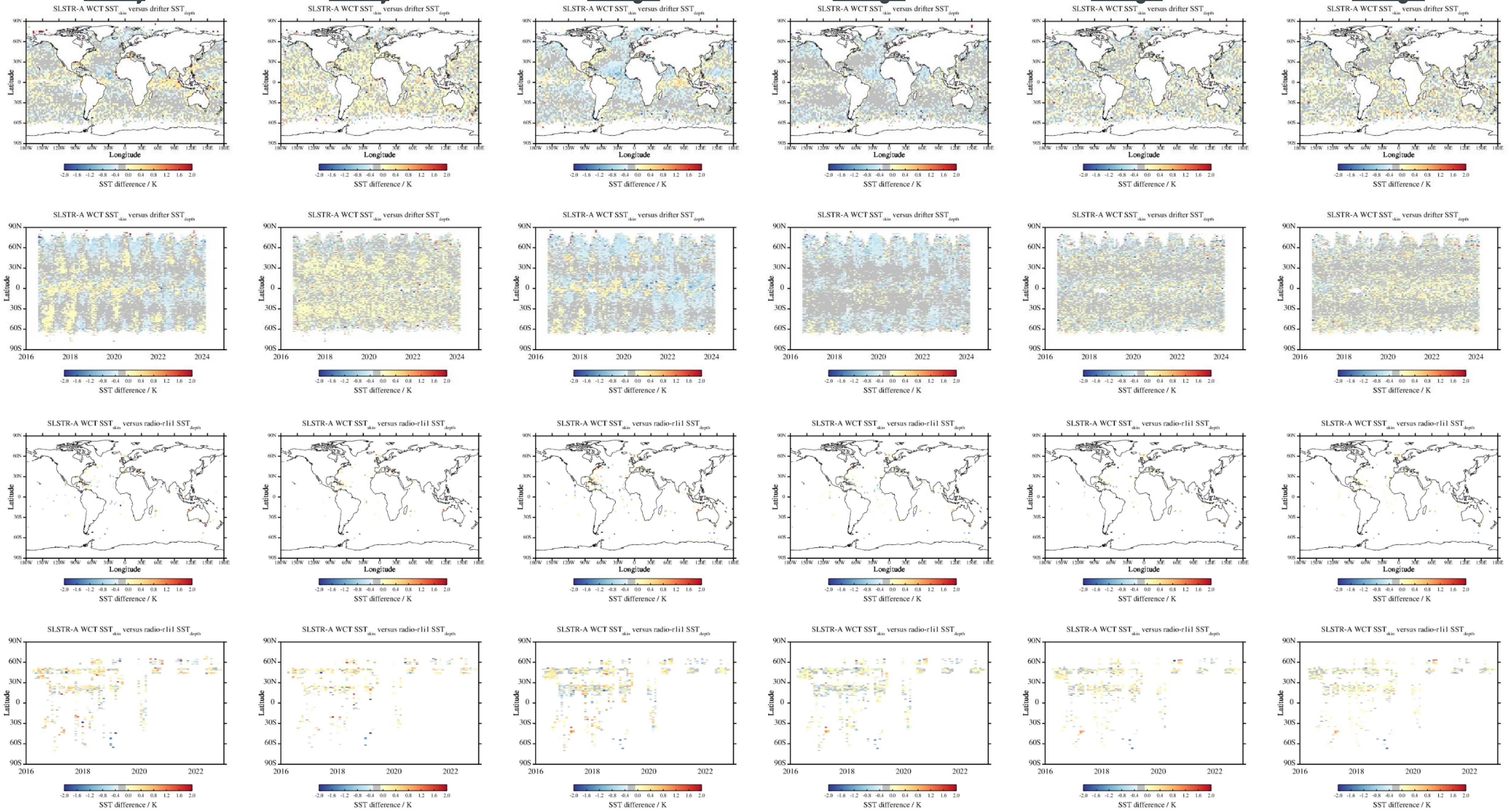
N2 day | D2 day | N2 night | N3 night | D2 night | D3 night

drifters

radiometers



No FKC adjustments applied

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IMPLEMENTED BY EUMETSAT

Summary

- Satellite radiometers such as SLSTR can provide SSTskin within an uncertainty less than 0.1 K
- SLSTR does provide a measure of SSTskin
  - **Confirmed through independent validation using data from multiple in situ sources / depths**
- Demonstrating this requires a thorough understanding of the physics of the atmosphere and the upper ocean
  - Multiple measurement sources, models and methods are needed
- New generation in situ (FRM) are required to support SSTskin validation
  - To identify geophysical effects from retrieval effects
- Continuity of SSTskin FRM is essential to maintain long-term SST records
  - As is continuity of drifter, Argo and mooring records as well – we need an integrated observing system
- Optimal sampling of the validation space is essential
  - Apparent decline of 'global' shipborne radiometer data since COVID-19 is concerning
  - **Do we have all available radiometer data in the SLSTR MDB?**
    - **What can EUMETSAT do to help?**
- Stability of long-term radiometer deployments to be assessed

Acknowledgments:

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Thank you!

Questions are welcome.