MW/IR intercomparison campaign for the establishment of a SST skin-subskin relation

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Introduction

Temperature rise and the immediate effect it has in the Arctic calls for increased monitoring of sea surface temperature (SST), which demands the highest possible synergy between the different sensors orbiting Earth, both on present and future missions (e.g. Sentinel-3 and CIMR). To achieve consistency between the observations from the different missions, there is a need to establish a relation between skin and subskin SSTs, which are measured by infrared and microwave sensors respectively. This would lead to the creation of more homogeneous and higher accuracy datasets that could be used to monitor climate change in greater detail and to be assimilated into climate models.

To address the aforementioned issue, the Danish Meteorological Institute (DMI) and the Technical University of Denmark (DTU) performed, on late May - early June 2021, a week-long intercomparison campaign between Denmark and Iceland, where they collected data by simultaneously deploying a microwave and an infrared radiometer side-by-side onboard M/S Norröna. This campaign was a continuation of the static intercomparison that took place in Copenhagen on January 2021 and is described in [3].

Field campaign setup

The radiometers were installed according to the latest protocols for radiometer deployments [2].

ISAR [4]
- Wavelength: 10.55 μm
- BW: 9.6 - 11.5 μm
- Look angle: 25°

EMIRAD-C [3]
- Frequency: 7.05 GHz
- BW: 7.025 - 7.075 GHz
- Look angle: 55°

EMIRAD-X [3]
- Frequency: 10.69 GHz
- BW: 10.59 - 10.79 GHz
- Look angle: 55°

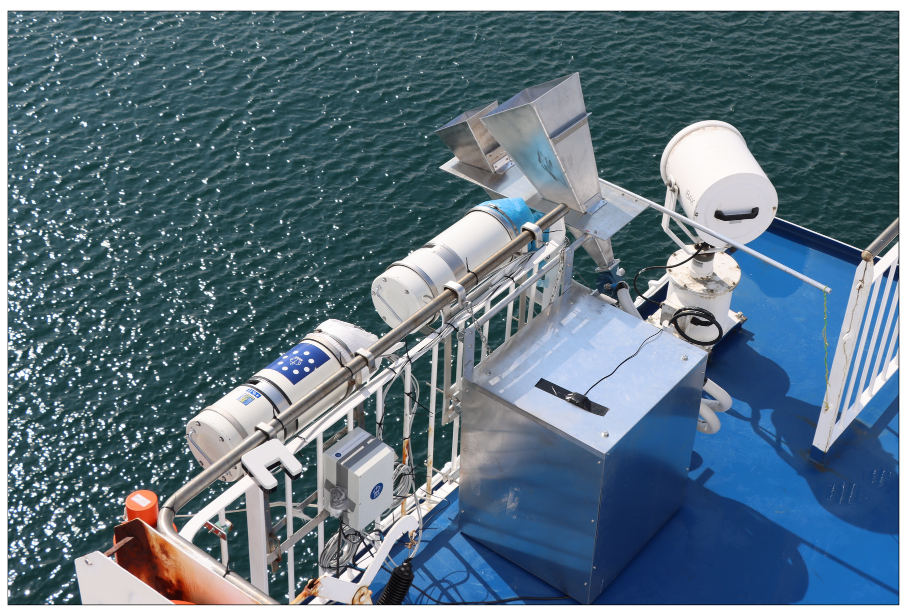

Figure: Radiometer setup with EMIRAD obtaining sky measurements.

Figure: EMIRAD installation.

Sea surface temperature retrievals from microwave TB observations

The conversion of microwave brightness temperature observations to actual sea surface temperature was made by applying a simplified version of the statistical regression method described in [1]. The microwave and infrared observations were merged into a matchup dataset, which was split in two equal parts. One part has been used to calculate the regression coefficients and the other for retrievals. In order to avoid replicating the reference SSTs and due to the limited amount of data, the binning according to wind speed, latitude and daytime/nighttime was not applied.

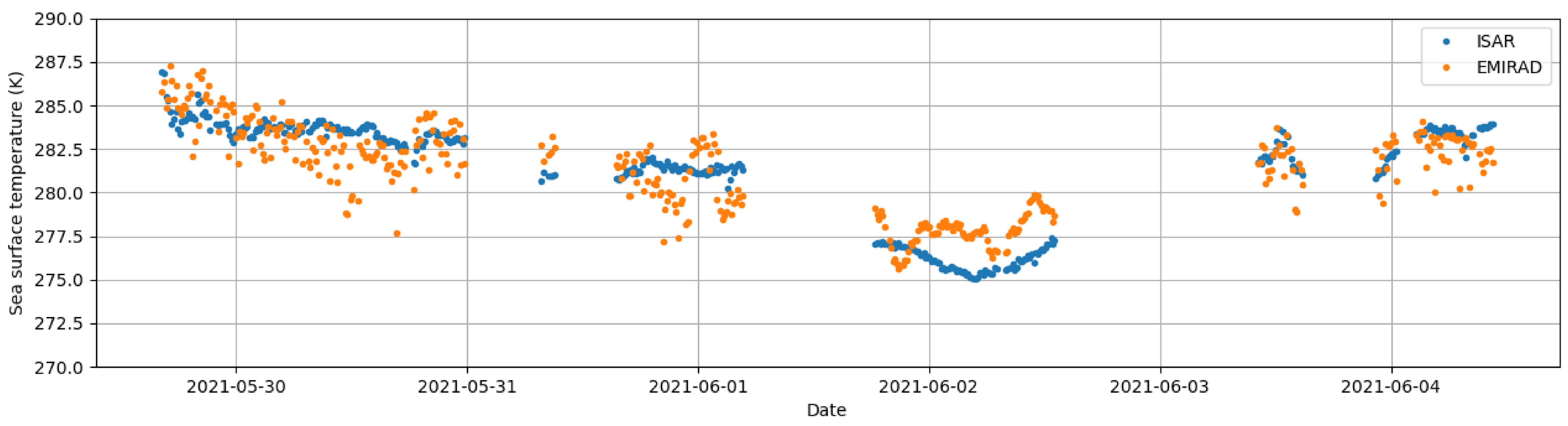

Figure: Comparison of ISAR IR SST measurements and SST retrievals from EMIRAD MW observations.

Findings / remarks

- This is the first time ever that such an intercomparison between microwave and infrared sensors has taken place.
- It is possible to obtain good agreement between microwave and infrared SST retrievals.
- Microwave TB variability is complex and could be driven by several factors.

Future work

- Investigate on the variability of the microwave TB over a footprint-sized area (e.g. 50 km) and compare with the IR-measured SST variability.

References

[1] Emy Alerskans, Jacob L. Høyer, Chelle L. Gentemann, Leif Toudal Pedersen, Pia Nielsen-Englyst, and Craig Donlon. Construction of a climate data record of sea surface temperature from passive microwave measurements. *Remote Sensing of Environment*, 236:111485, 2020.

[2] Jacob L. Høyer, Sotirios Skarpalezos, and Sten S. Søbjærg. Protocols for radiometer deployments. Technical report, Danish Meteorological Institute and Technical University of Denmark, 2021.

[3] Sten S. Søbjærg, Sotirios Skarpalezos, and Jacob L. Høyer. Characterisation report. Technical report, Technical University of Denmark and Danish Meteorological Institute, 2021.

[4] Werenfrid Wimmer. *ISAR User Manual*. University of Southampton, v3.01 edition, 2020.

Acknowledgements

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Weather conditions and data collection

ISARs are designed to stop measuring under rain, to protect the optical mirror from being contaminated. During the campaign minimal rain events were met, and as a result infrared measurements were obtained throughout the biggest part of the route.

The infrared data collected during the campaign have also been added to the FRM database, to which Sentinel-3 data are validated against, and are freely distributed through ships4sst.org.

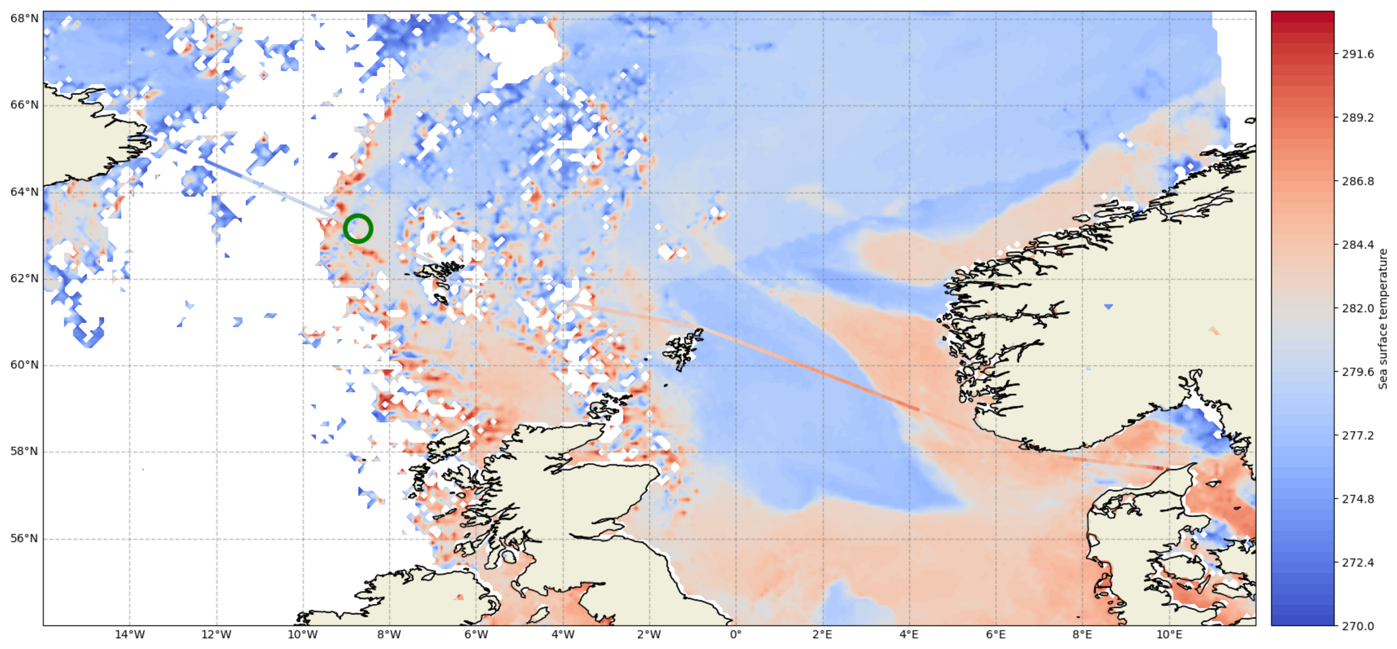

Figure: Sentinel-3B L2 SST with overlayed ISAR SST measurements. Encircled in green is the part of ISAR measurements that temporally corresponds to the Sentinel-3 data.

The microwave data have been matched with ERA-5 reanalysis data and HYCOM salinity, in an effort to understand what is driving the brightness temperature fluctuations along the different EMIRAD channels, as well as to get a quantifiable overview of the conditions under which the campaign took place.

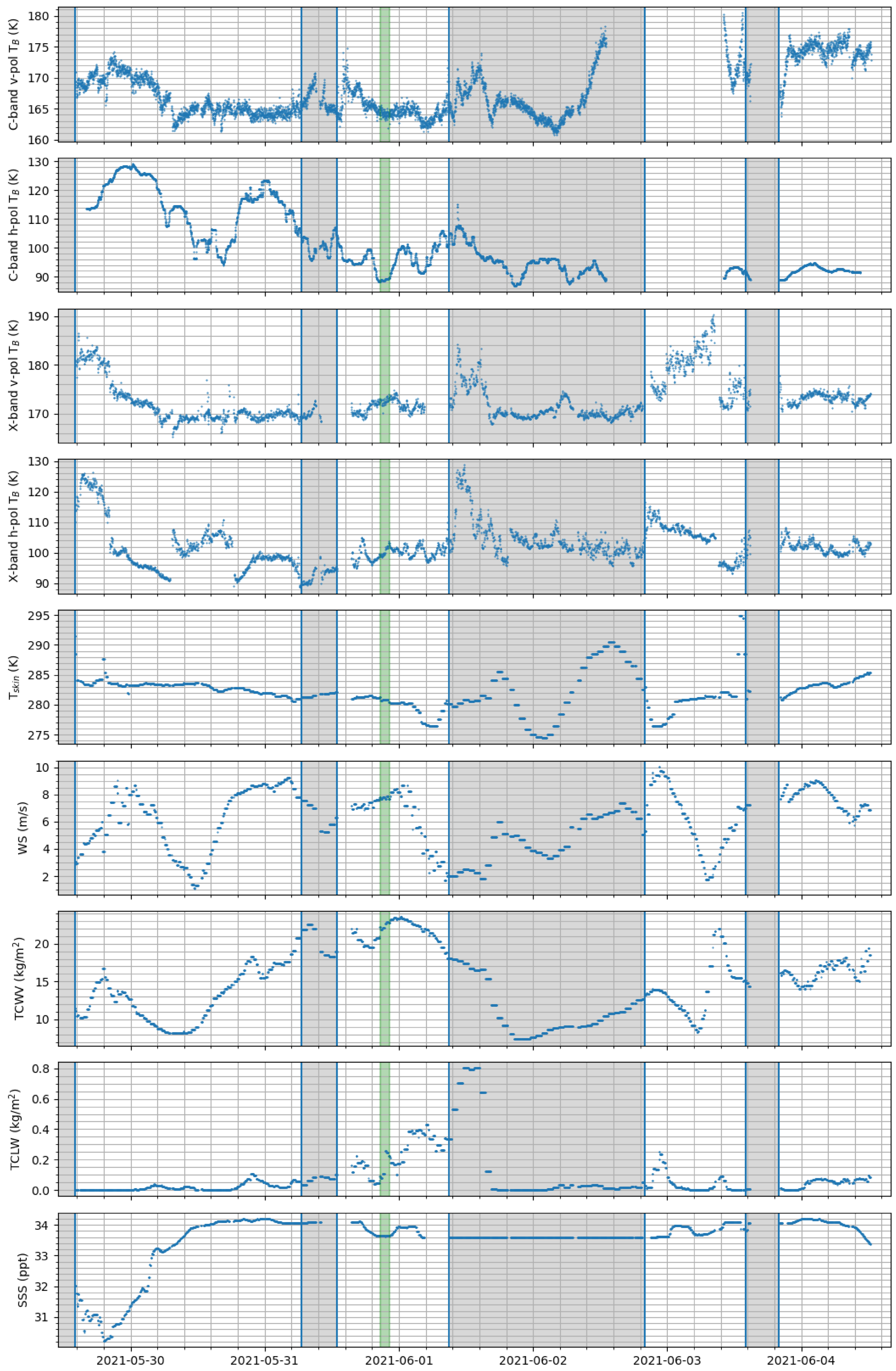

Figure: Microwave measurements matched with ERA-5 reanalysis products and HYCOM salinity. Grey zones indicate periods where the ship was moored in port (from left to right: Denmark, Faroe Islands, Iceland, Faroe Islands). Green zone corresponds to the green circle on the figure with Sentinel-3 data.