

# Ship-Borne Inter-Comparison of TIR and PMW Instruments for SST Measurements

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## ① Motivation

Fiducial Reference Measurements for SST (FRM4SST)  
CIMR

## ② The TIR-PMW experiment

Instruments  
Setting

## ③ Data analyses

SST retrieval  
SST bias  
Error budget

## ④ Lessons from this experiment

# Instruments characteristics

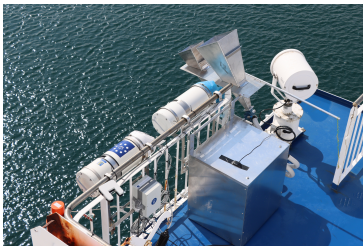
**Table:** Radiometers used during the shipborne inter-comparison campaign.

Num	Type	Name	B	Sea-view angle
2	TIR	ISAR	9.6–11.5 $\mu\text{m}$	25°
1	PMW	EMIRAD-C	7.025–7.075 GHz	55°
1	PMW	EMIRAD-X	10.59–10.79 GHz	55°

# Setup

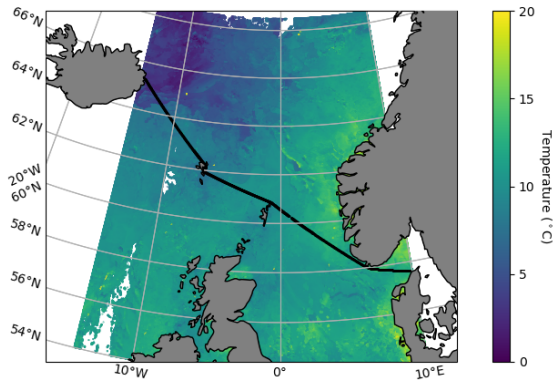


(a) Norröna



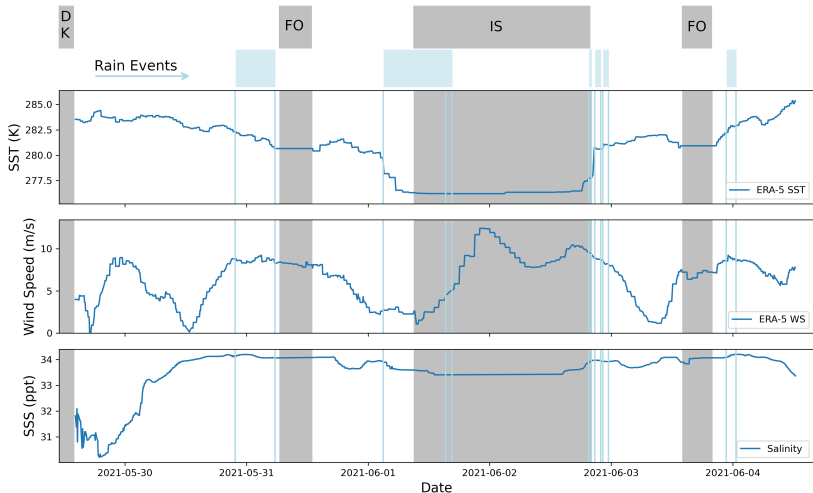
(b) Radiometers setup

# Norröna track (two-way travel)



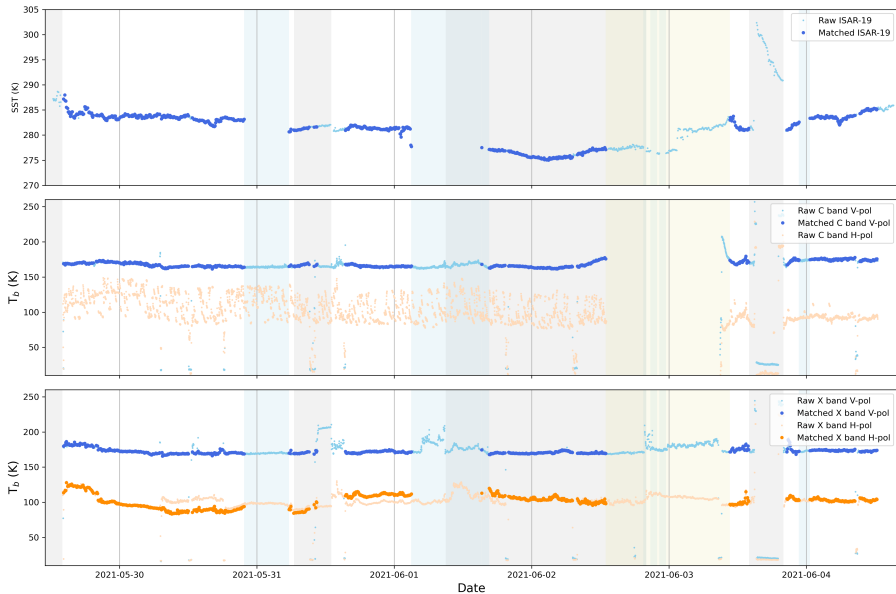
**Figure:** Trajectory of Norröna from May 29 to June 4, 2021. Background image: week-averaged SST, from Sentinel 3 SLSTR.

# Weather and Ocean conditions

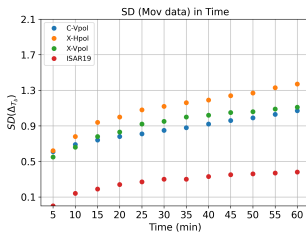


(a) Source: ERA5 and DMI-HYCOM

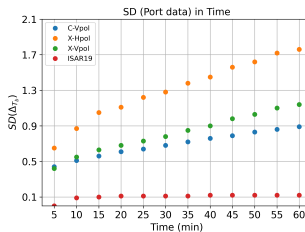
# Data: Raw and Filtered



# Temporal variability



(b) Moving data

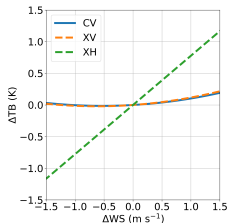


(c) Port data

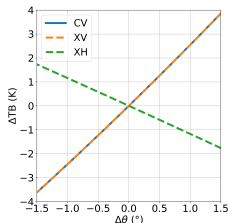


# Brightness Temperature ( $T_b$ ) Sensitivity

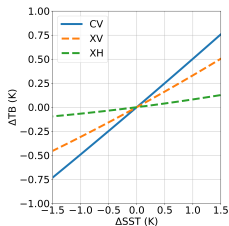
Based on [Wentz, 2002, Nielsen-Englyst, 2021]



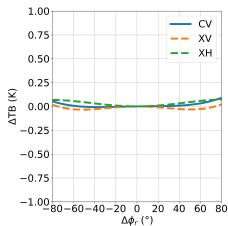
(d) Wind speed



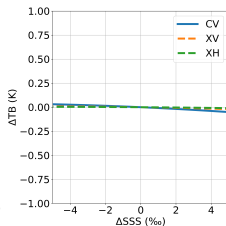
(e) Incidence angle



(f) SST



(g) Angle rel. to wind



(h) SSS

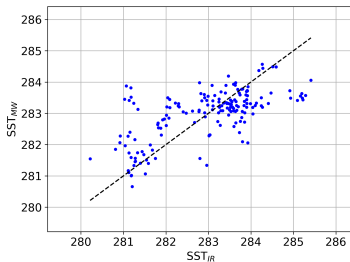
$$SST_{MW} = c_0 + c_1 t_{CV} + c_2 t_{CV}^2 + c_3 t_{XV} + c_4 t_{XV}^2 + c_5 t_{XH} + c_6 t_{XH}^2 + \dots$$

$$c_7 WS + c_8 WS^2 + 1/\epsilon$$

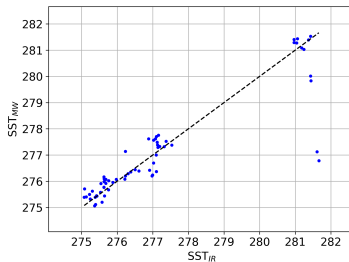
$$t = T_b - 150$$

$$\epsilon = \sqrt{\sum_p \epsilon_p^2}$$

# SST comparison

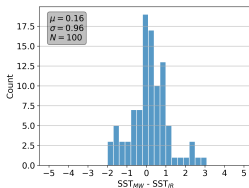


(i) Moving data,  $R^2 = 0.45$ .

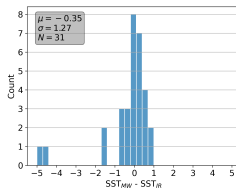


(j) Port data,  $R^2 = 0.83$ .

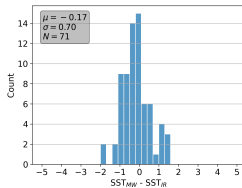
# SST Bias day/night



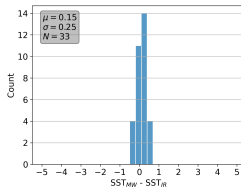
(k) Moving - Day



(l) Port - Day



(m) Moving - Night



(n) Port - Night

# Error estimation

$$\epsilon_{SST}^2 = \epsilon_{EMIRAD}^2 + \epsilon_{WS}^2 + \epsilon_{SSS}^2 + \epsilon_{\theta}^2 + \epsilon_{\phi}^2$$

Contributor	Moving $\epsilon_{SST}$ (K)	Port $\epsilon_{SST}$ (K)
$\epsilon_{inst}$	0.21	0.20
$\epsilon_{WS}$	0.80	-
$\epsilon_{SSS}$	0.00	0.00
$\epsilon_{\theta}$	0.39	-
$\epsilon_{\phi_r}$	0.13	-
Depth Temp. diff.	0.28	0.28
Total	0.97	0.34

# Lessons from this experiment

- Instrument design consideration:
  - Sensitivity to noise
  - Cables losses due to manipulation
  - Improve robustness
- Incorporate complementary instrumentation:
  - PMW incidence angle
  - Local weather conditions
- Ensure a larger matchup dataset

# References



Frank Wentz (2002)

AMSR ocean algorithm

*EORC Bulletin. Technical Report 9, 8 – 28.*



Pia Nielsen-Englyst et al., (2023)

Impact of channel selection on SST retrievals from passive microwave observations

*Remote Sensing of Environment 254.*

# The End

Questions? Comments?