

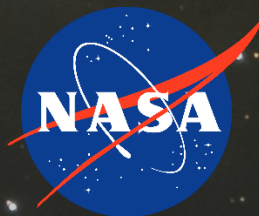
# Towards SSS Fiducial Reference Measurements: An Overview of Sub-Footprint Variability, Stratification, and Calibration-Validation Methods

Julian J Schanze<sup>1</sup>, Jesse Anderson<sup>1</sup> & Oleg Melnichenko<sup>1</sup>

<sup>1</sup> Earth & Space Research



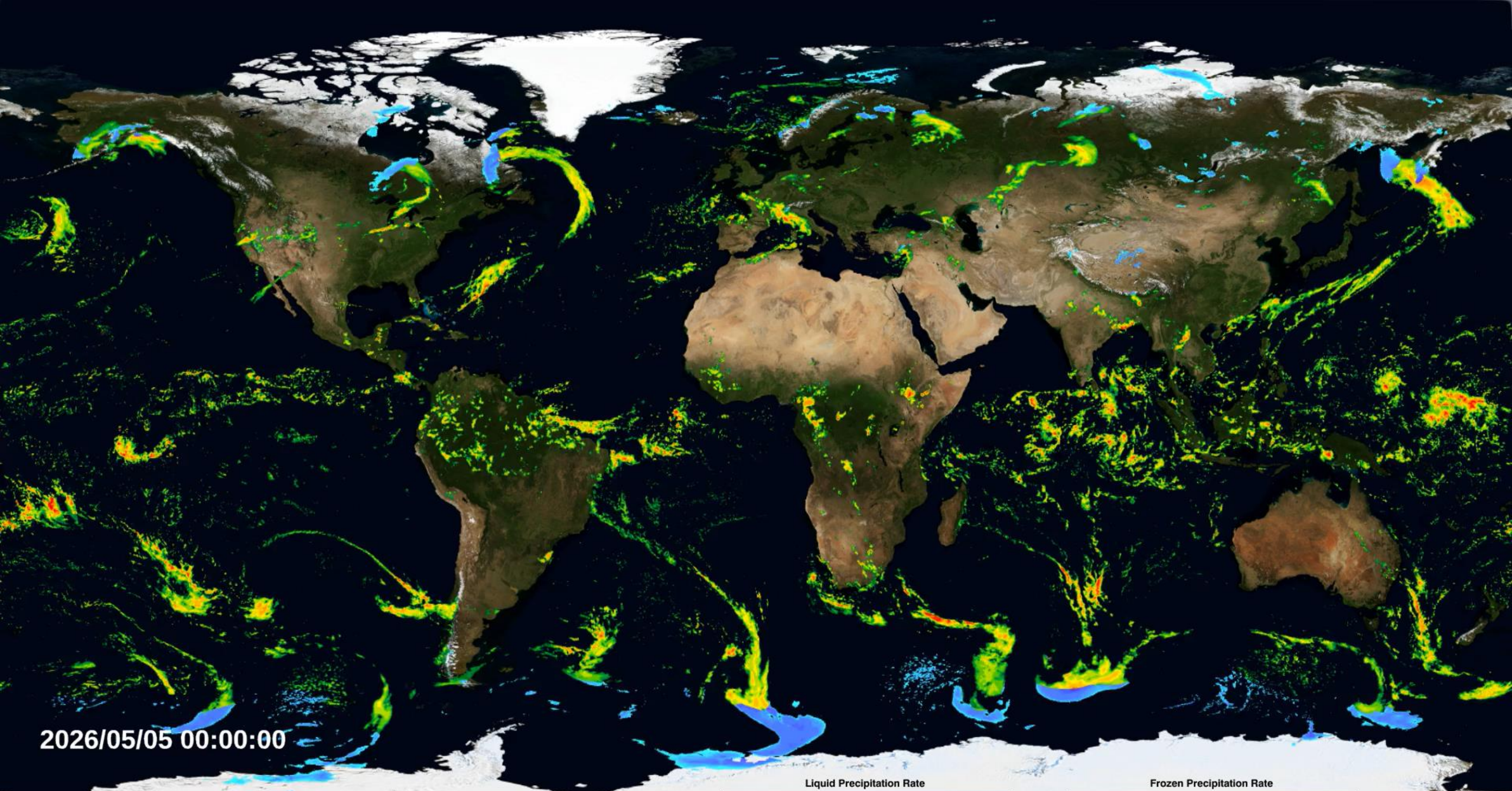
2026 Salinity Science & Technology Conference, Seattle, WA



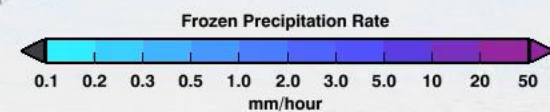
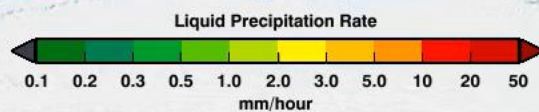
# Measurement Challenges

Evaporation and Precipitation do not occur on the same space- or time-scales.



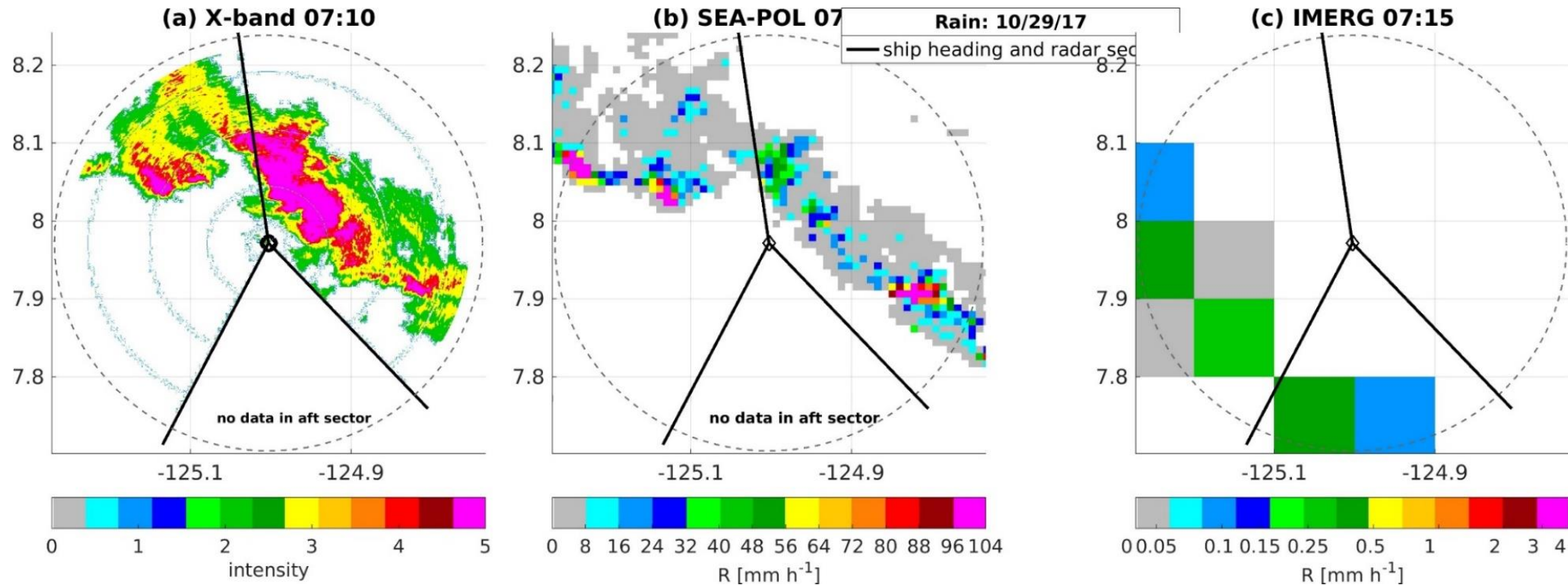


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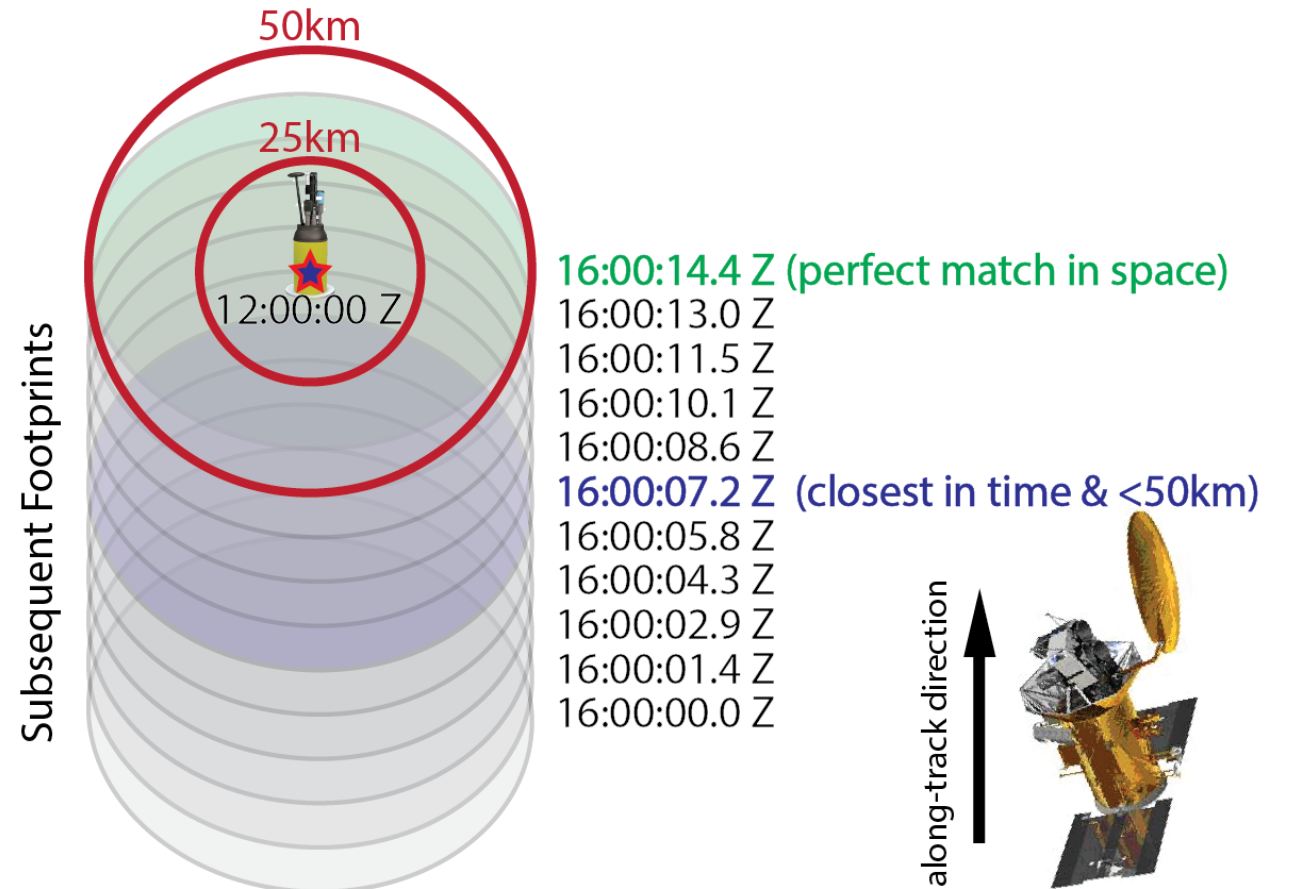
# Precipitation



- Evaporation is much smoother than Precipitation
- Huge density variance input at different space- and time-scales
- No air-sea feedback like T → 'Fossil' [sorry, EJL] puddles and MIZ
- Scales as small as hundreds of meters

# Matchups

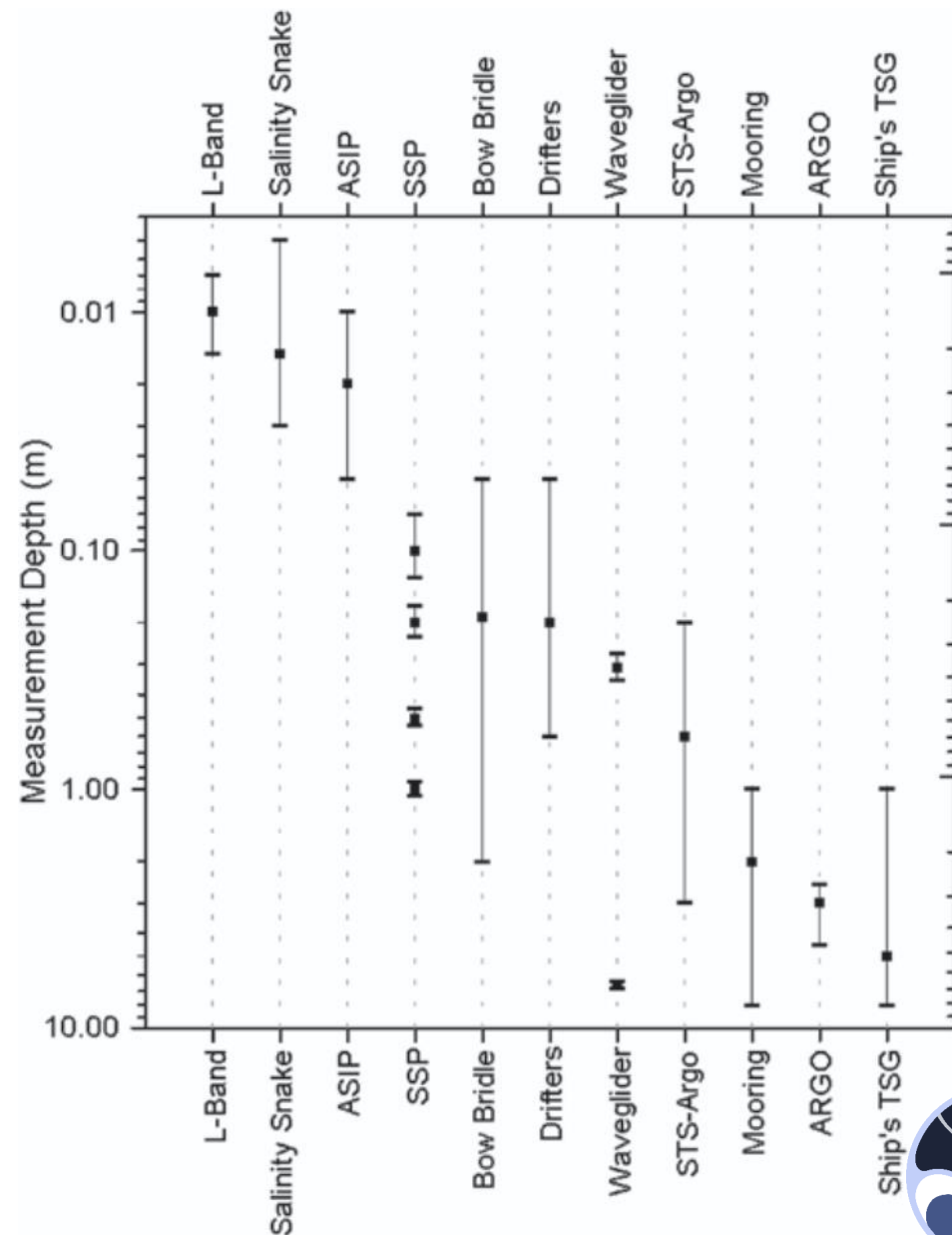
- The most common way of assessing the quality of a satellite SSS product is to use matchups
- To average or not to average in time or space?
- Matchup criteria whitepaper: [doi://10.5281/zenodo.4769713](https://doi.org/10.5281/zenodo.4769713)
- **Both horizontal and vertical mismatches contribute significantly and are frequently unaccounted for in error estimates**



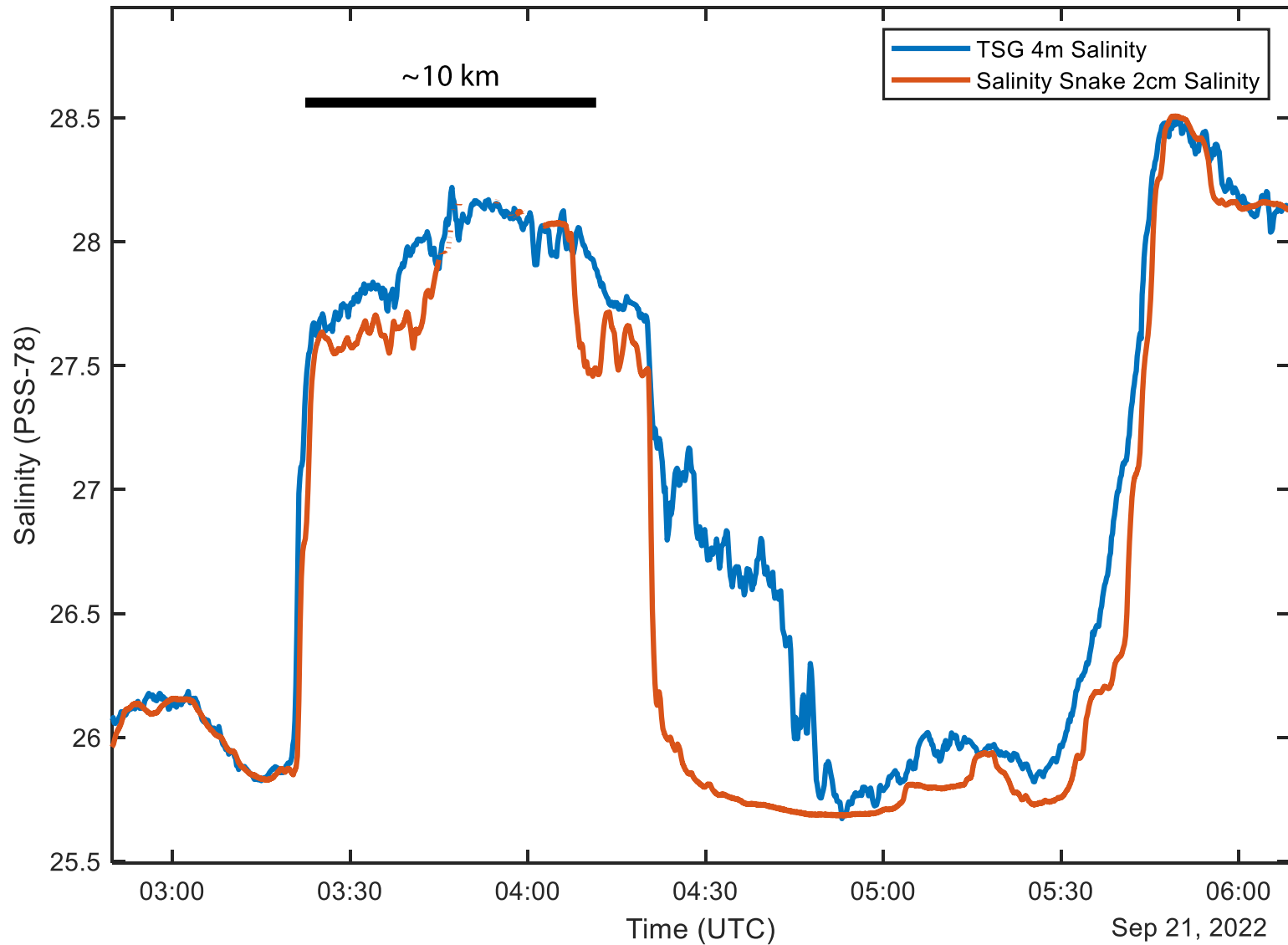
# SATELLITE AND IN SITU SALINITY

## Understanding Near-Surface Stratification and Subfootprint Variability

BY J. BOUTIN, Y. CHAO, W. E. ASHER, T. DELCROIX,  
R. DRUCKER, K. DRUSHKA, N. KOLODZIEJCZYK, T. LEE, N. REUL,  
G. REVERDIN, J. SCHANZE, A. SOLOVIEV, L. YU, J. ANDERSON,  
L. BRUCKER, E. DINNAT, A. SANTOS-GARCIA, W. L. JONES,  
C. MAES, T. MEISSNER, W. TANG, N. VINOGRADOVA, AND  
B. WARD

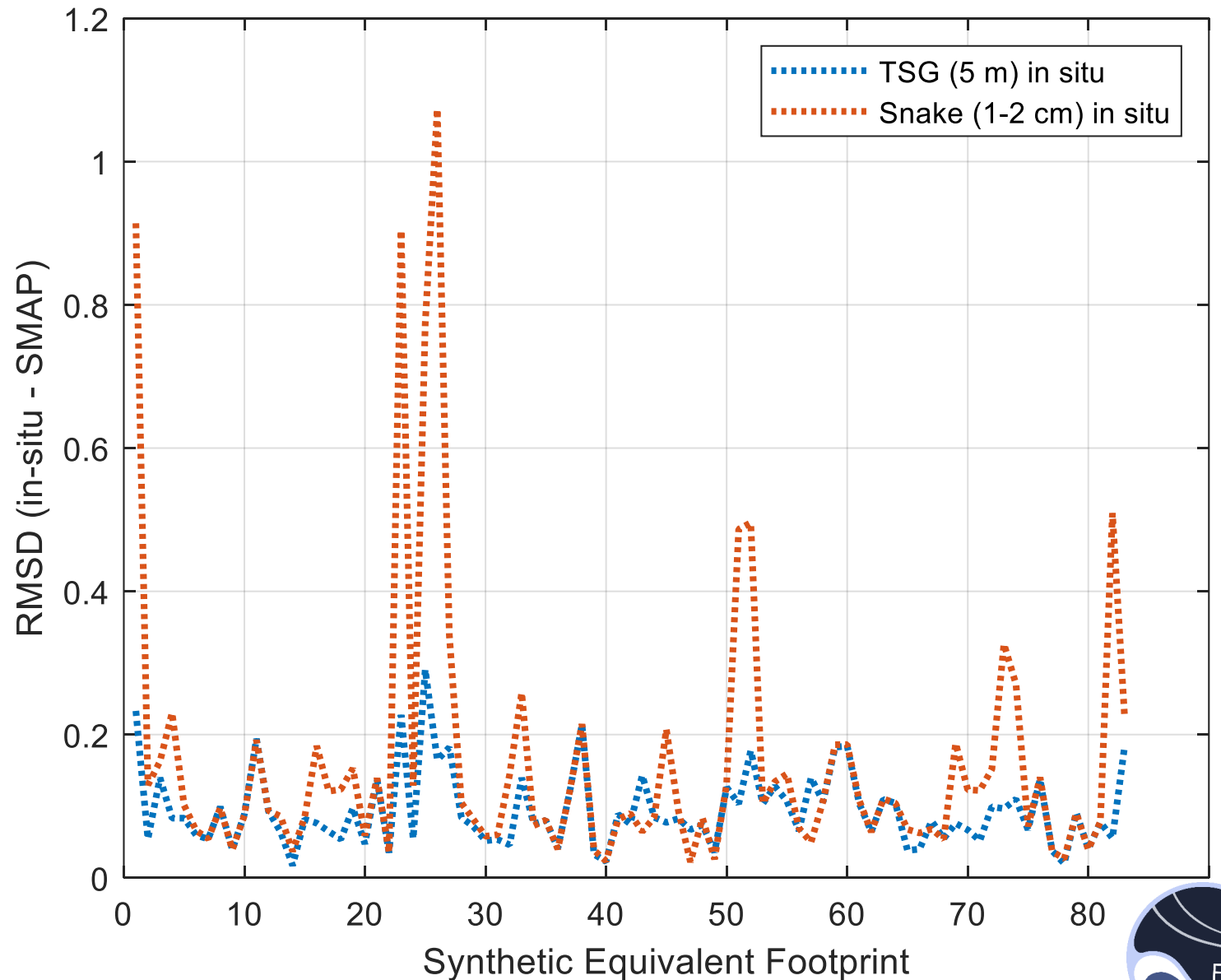


# SASSIE: Gradients in the Upper 5m



- Strong gradients with typical frontal processes
- Unresolvable with SMOS, SMAP, or CIMR

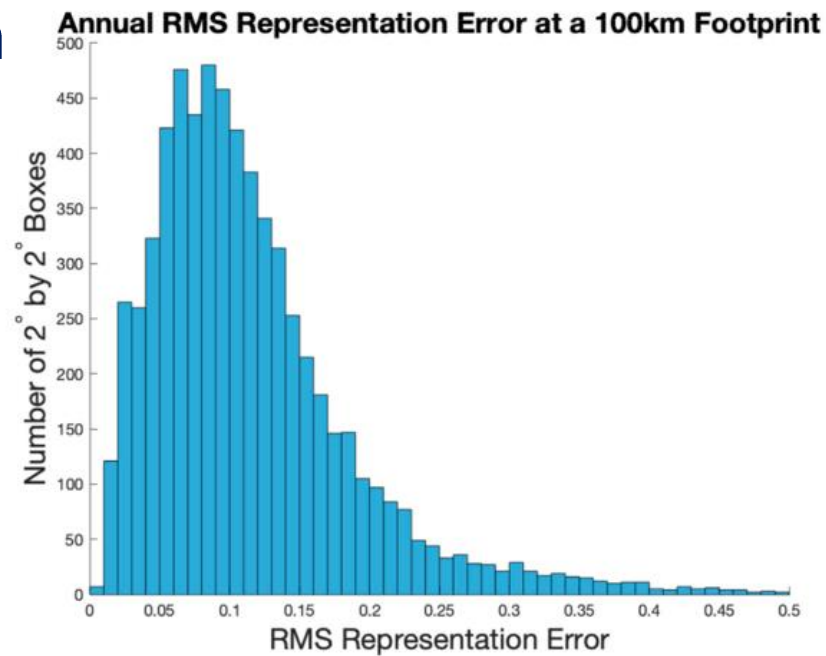
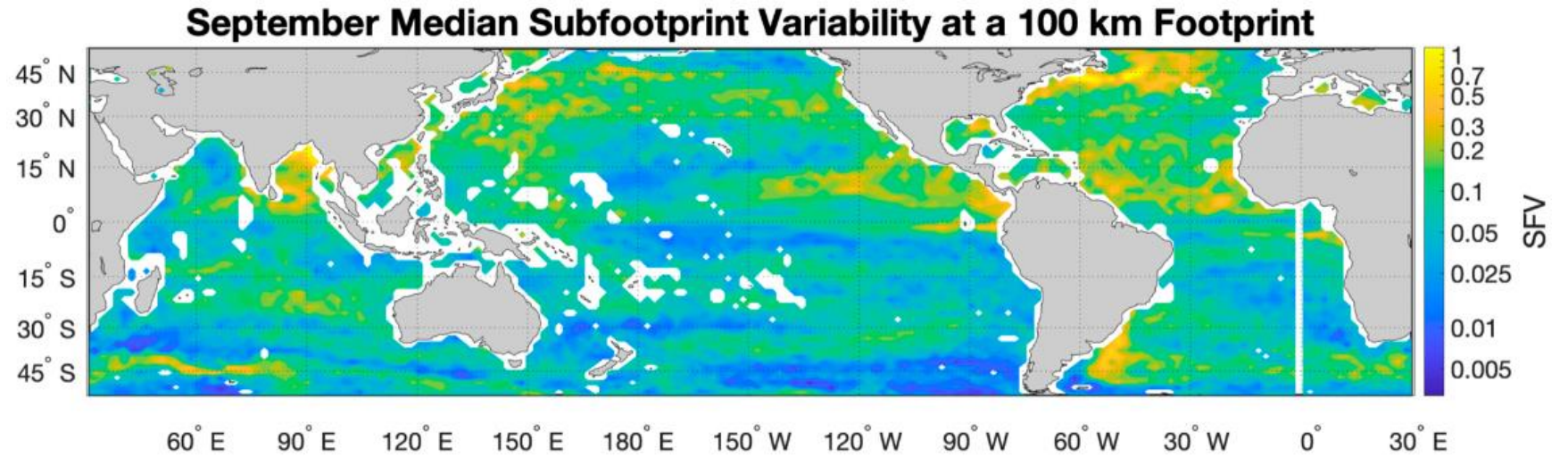
- Mean synthetic RMSD for SMAP footprint based on salinity snake
- Same for 5m depth TSG intake (blue)
- Significantly higher RMSD for snake than 5m TSG
- Mean RMSDs:
  - **0.08 (TSG)**
  - **0.16 (Snake)**



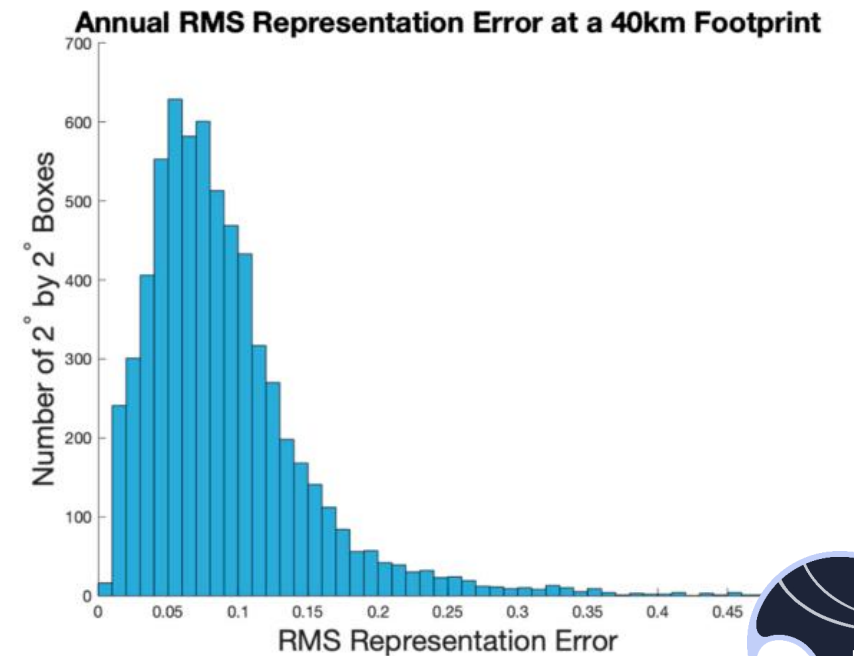
# Sub-Footprint Variability

➤ Bingham et al. 2021 - global high-resolution model

➤ Higher resolution still has a relatively high representation error



(a)



(b)



# Fiducial Reference Measurements

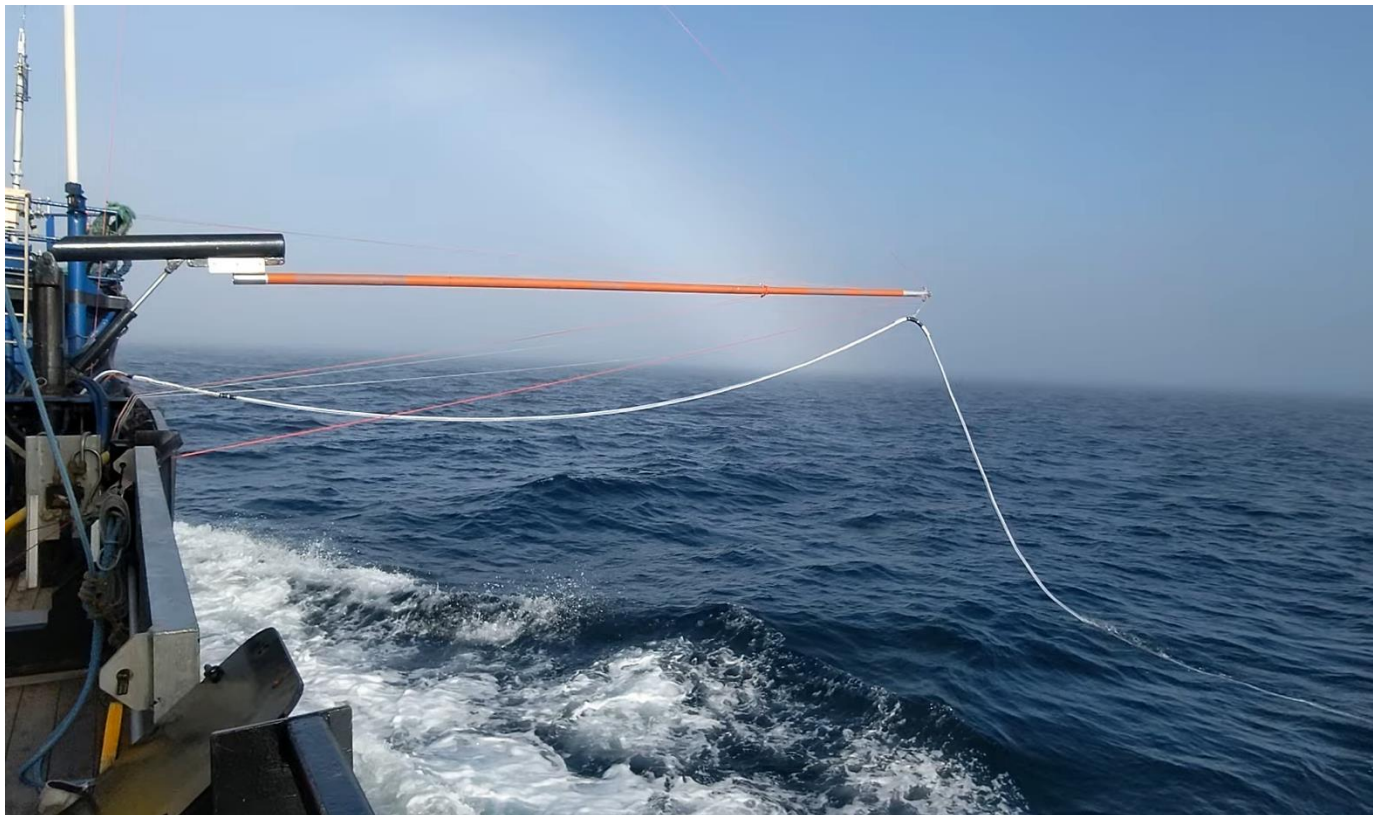
- What is an FRM?
- Do we need FRMs?



Charlton T. Lewis, Charles Short, *A Latin Dictionary*

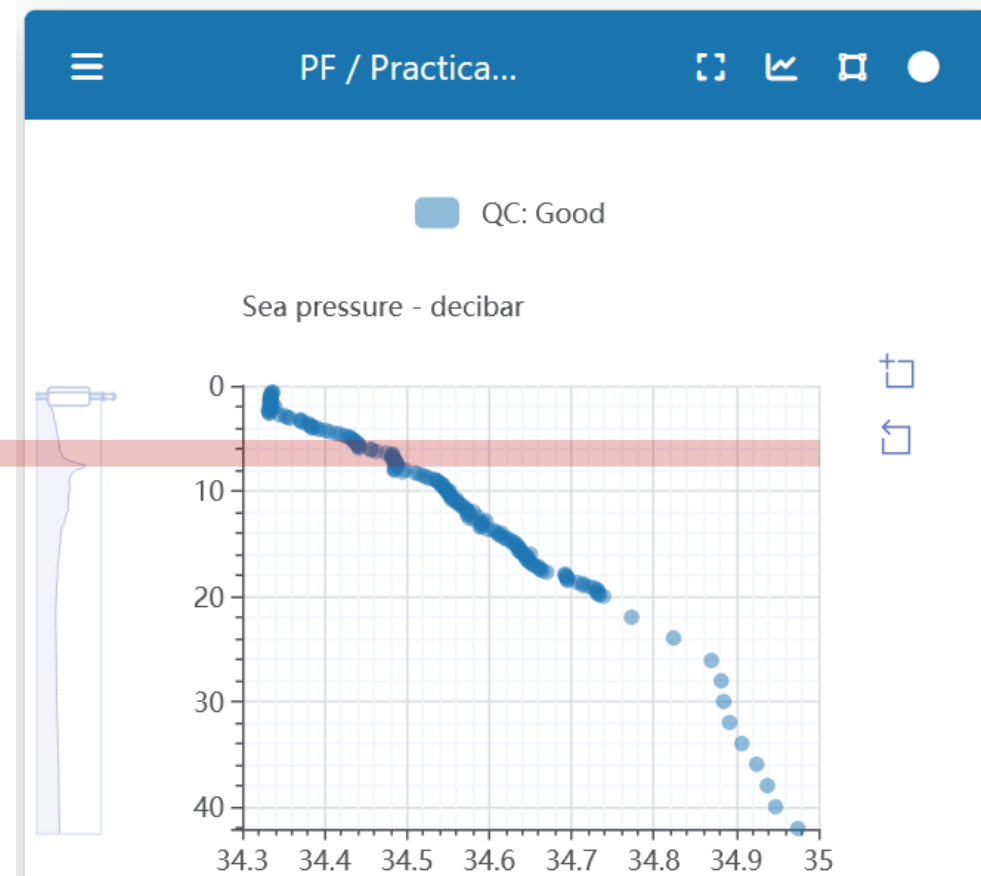
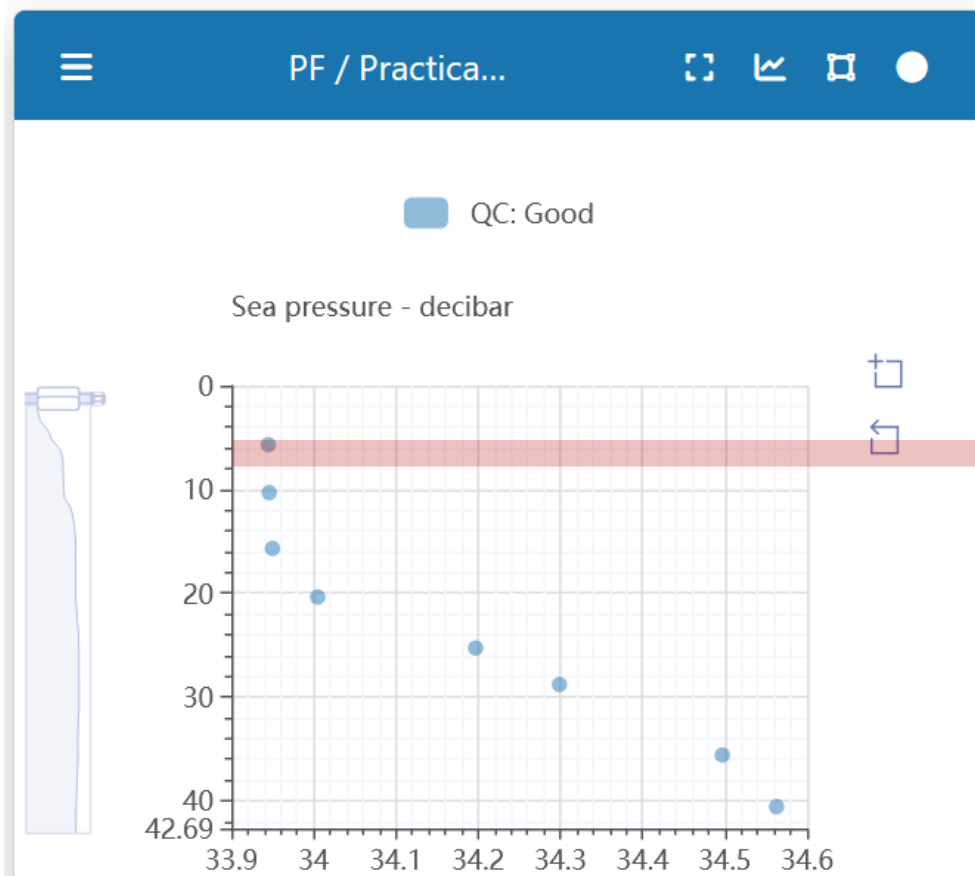
**fidūcia**, ae, f. fido,

*I. trust, confidence, reliance, assurance (class.).*

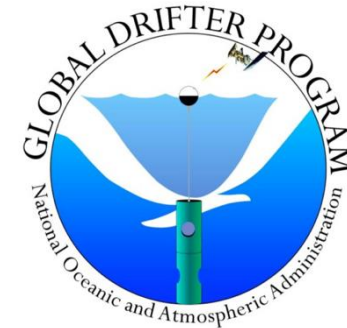


# Changes in Surface Salinity Measurements

- Floats have changed in the last decade
- Higher sampling rates
- Better pressure sensors
- More aggressive programming

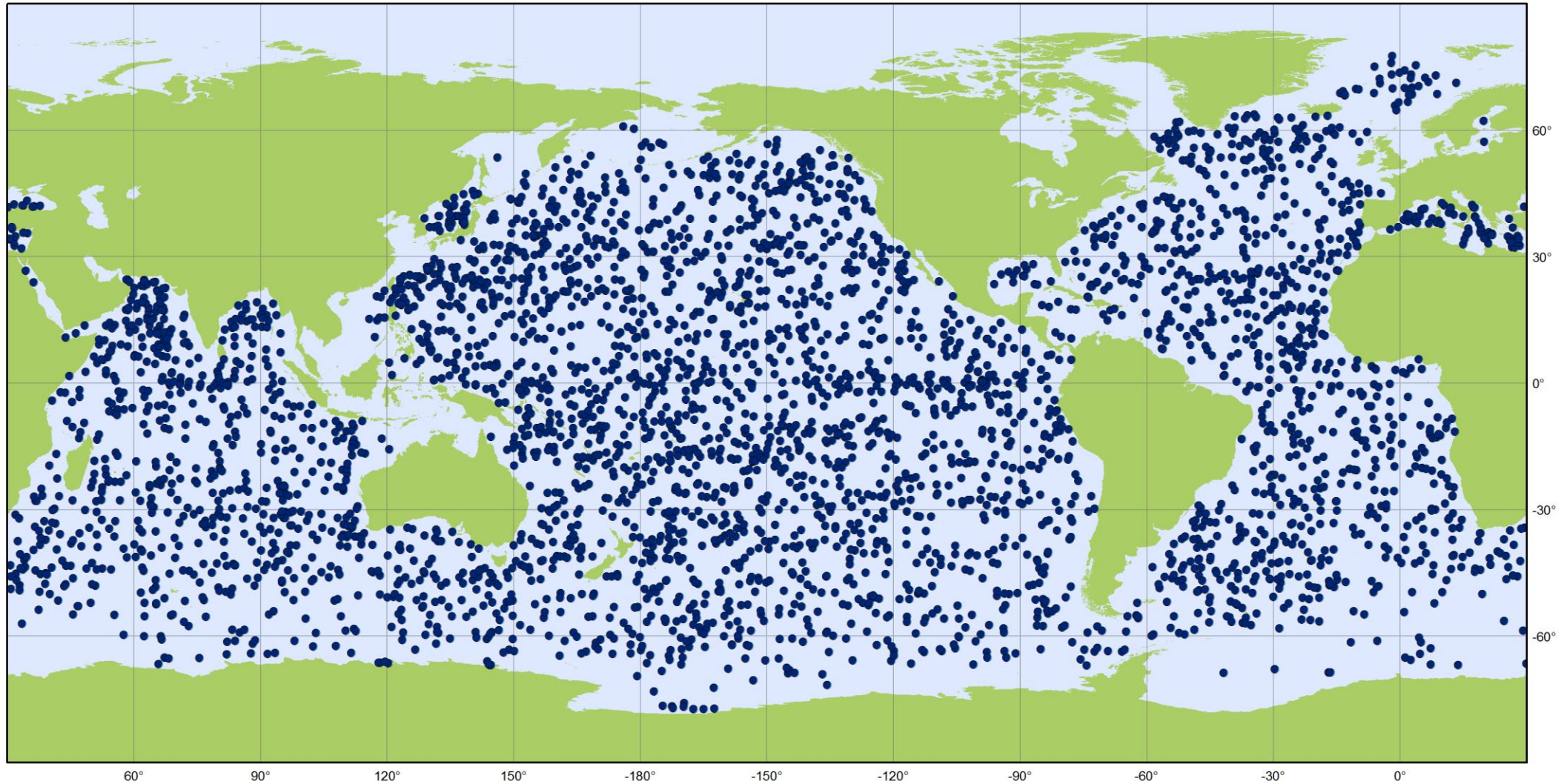


- Drifter Program
- Ships of Opportunity





# 10 years ago...



Argo

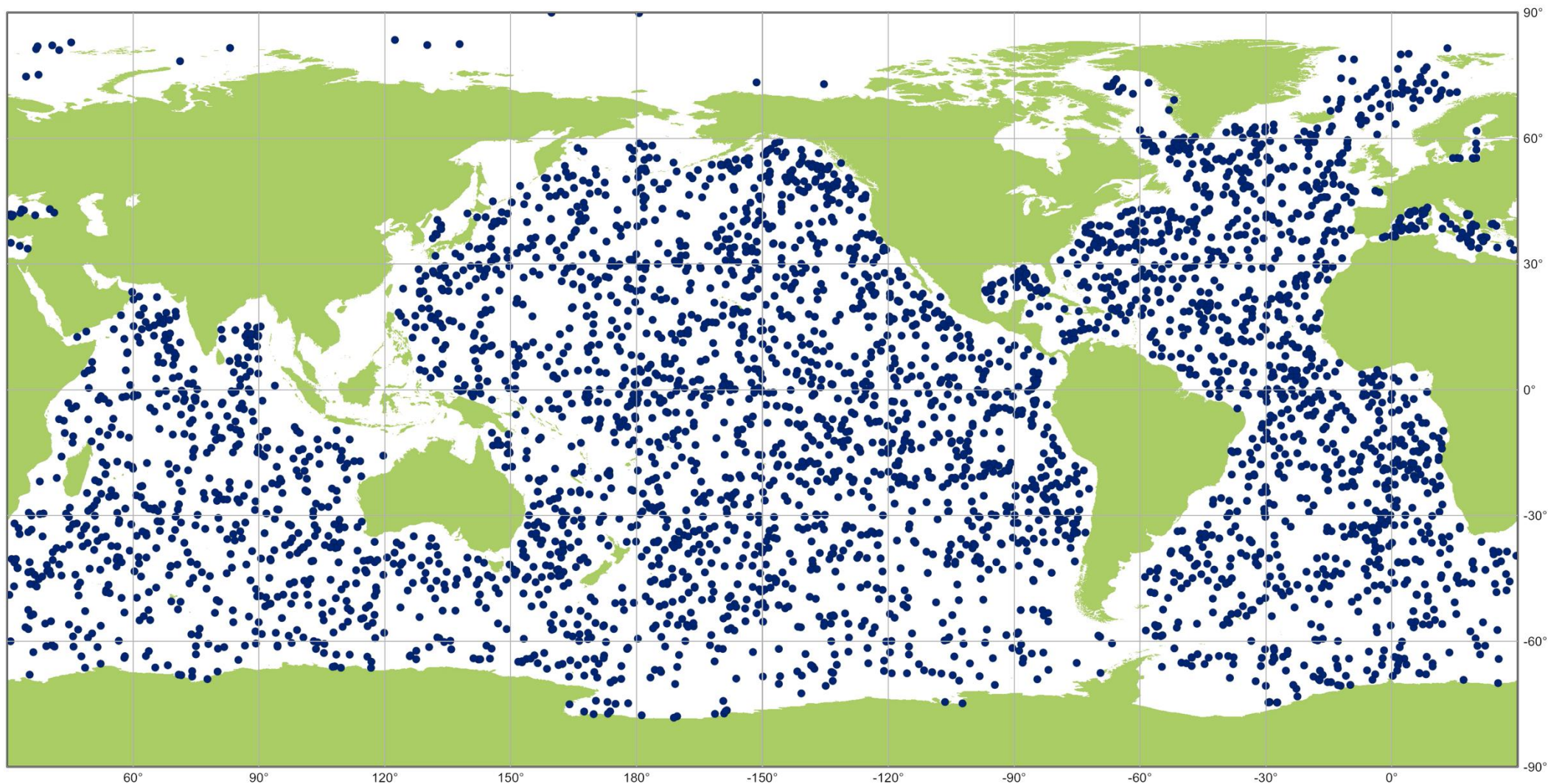
3856 Operational Floats

February 2016





# Changes in Surface Salinity Measurements



Argo

3879 Operational Floats

May 2024



- We have more matchup data than ever before
- Depths are becoming increasingly representative
- Triple collocation
- See Jesse's poster on SVDS

Minimal Flags

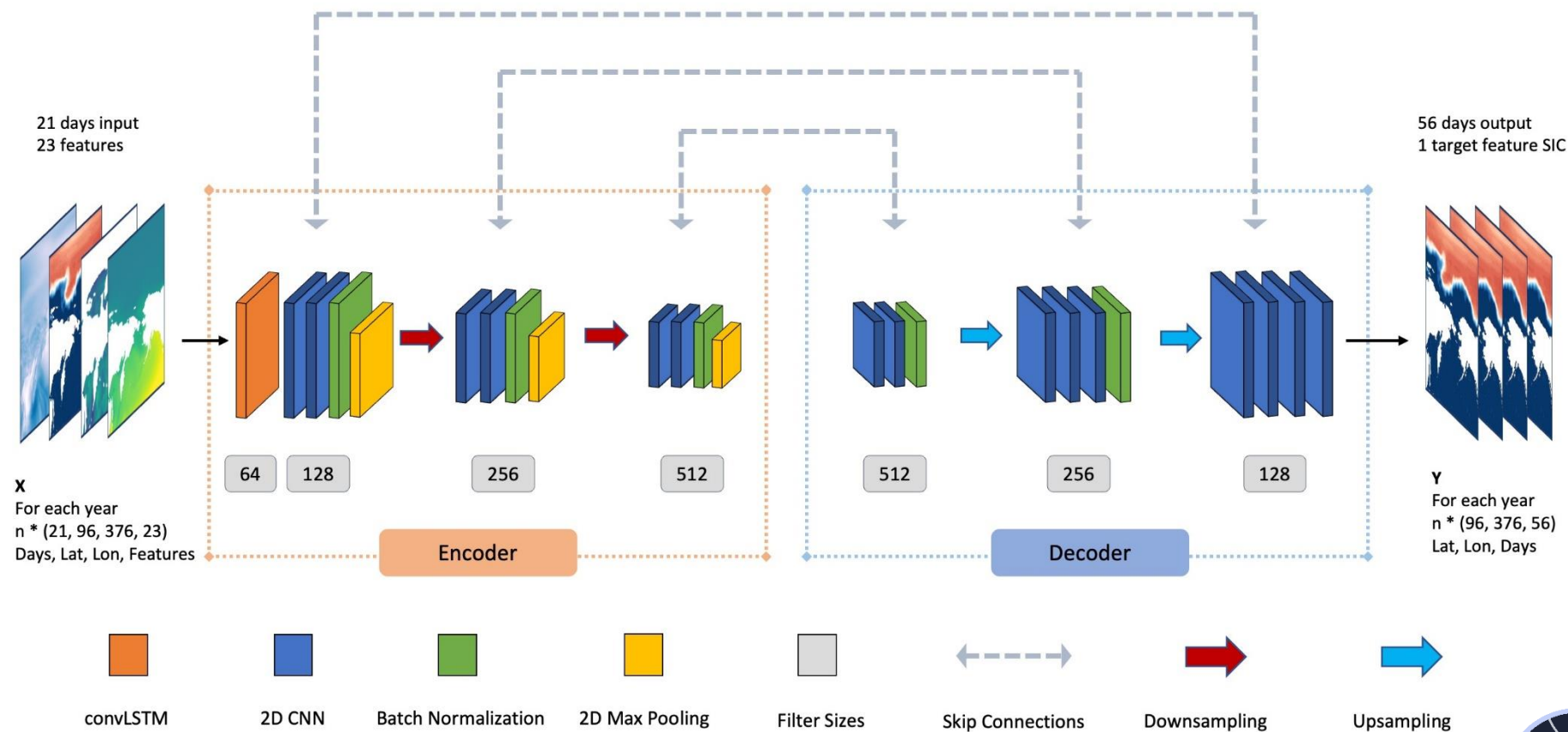
|             | <b>SMAP</b> | <b>SMOS</b> | <b>EN4</b> |
|-------------|-------------|-------------|------------|
| <b>v5.0</b> | 0.090       | 0.294       | 0.065      |
| <b>v6.0</b> | 0.110       | 0.350       | 0.075      |
| <b>v6.3</b> | 0.078       | 0.242       | 0.050      |

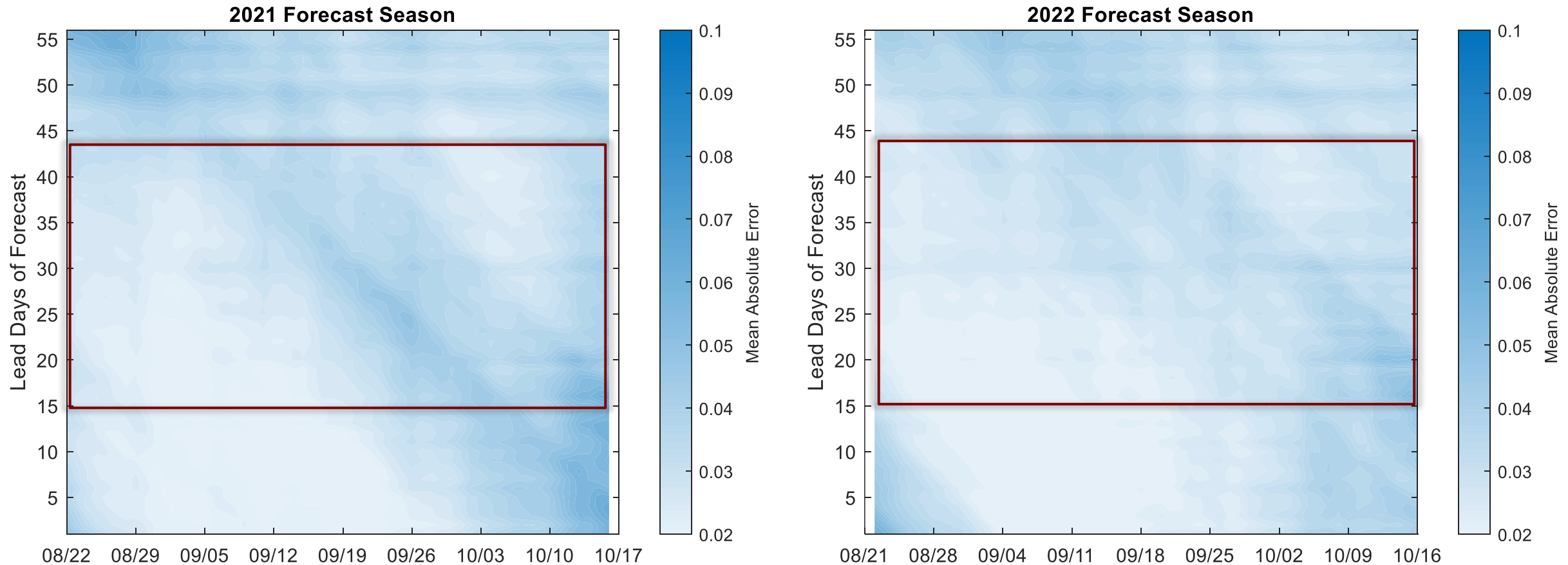
All Flags

|             | <b>SMAP</b> | <b>SMOS</b> | <b>EN4</b> |
|-------------|-------------|-------------|------------|
| <b>v5.0</b> | 0.053       | 0.160       | 0.043      |
| <b>v6.0</b> | 0.049       | 0.147       | 0.038      |
| <b>v6.3</b> | 0.049       | 0.142       | 0.035      |

- Adapted from MTIceNet
- Custom loader reduces memory use
- Completely Open Source/Open Science (full release in progress)
- SSS based on OISSV3 (Oleg Melnichenko)

## The NESSIE Convolutional Long-Short-Term Memory (LSTM) Neural Network model



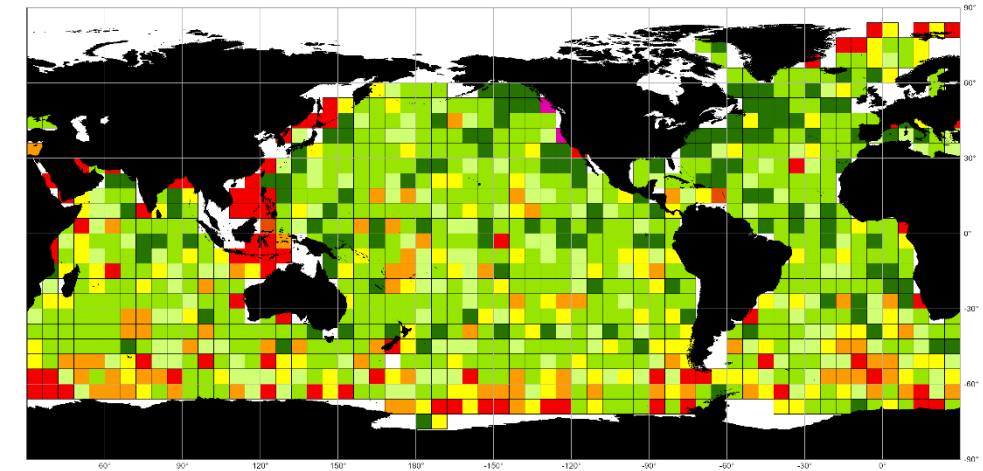


- Very good performance at lead times of 2-6 weeks
- Area-weighted MAE of 0.031 for 2021 and 2022 seasons

- Regional evaluation shows a likely influence of salt transport through the Bering Strait, as shown by feature importance in Bering and Chukchi Seas:
- Beaufort: SST, SIC, Qnet, **SSS**
- Bering: SST, **SSS**, SIC, Qnet
- Chukchi: SIC, **SSS**, SST, Qnet
- East Siberian: SIC, Qnet, SST, **SSS**
- Laptev: SST, Qnet, **SSS**, SIC



- SSS in situ validation data are historically sparse in the Arctic
- We evaluated several SSS datasets, with ESR's experimental OISSS v3 release (merged Aquarius, SMAP, SMOS) performing best, followed by SMAP RSS V6.3 and SMOS
- We plan to do a systematic comparison, as the SIC prediction performance is a good indicator of SSS data quality
- Possible integration into calibration-validation workflows or platforms (e.g. SVDS, Salinity Pi-MEP)



Argo

Density - simple

August 2025

Profiling floats density, 6° x 6°, normalized on Argo Global design (grey-listed excluded)

Generated by ocean-ops.org, 2025-09-04  
Projection: Plate Carree (-150,0000)

**salinity pi-mep**

Home Overview Data Reports Case Studies Tools Outreach About PI-MEP Changelog

Latest news

2025-06-15 **2025 Living Planet Symposium**  
23-27 June 2025 at Vienna (Austria)  
[More details](#)

2025-06-15 **PI-MEP match-up database update**  
New satellite products, Symbol update  
[More details](#)

2024-12-15 **PI-MEP match-up database update**  
New satellite products, Symbol update  
[More details](#)

2024-07-29 **SMOS Science Conference & 15 Year Anniversary**  
4-6 November 2024 at Castello San Marco, in Calatabiano, Sicily  
[More details](#)

Latest reports

2025-06-15 **In-situ**

2025-06-15 **GO - aquarius-14-ipc-v6-1m vs tsg-amunden**

2025-06-15 **GO - aquarius-14-ipc-v6-1m vs tsg-eric-utm**

2025-06-15 **GO - aquarius-14-ipc-v6-1m vs tsg-legos-survostral**

2025-06-15 **GO - aquarius-14-ipc-v6-1m vs tsg-2025-06-15-2025-06-15**

**Salinity Pilot-Mission EXPLOITATION PLATFORM**

A hub for validation and exploitation of Satellite Sea Surface Salinity data

salinity pi-mep

The Soil Moisture and Ocean Salinity (SMOS) mission was launched in November 2009 as the second Earth Explorer Opportunity mission. It has been continuously providing brightness temperature data in L-Band since January 2010, which are used to retrieve Soil Moisture (SM) and Sea Surface Salinity (SSS) data over land and ocean, respectively. This project funded by ESA aims at implementing a Pilot Mission Exploitation Platform (PI-MEP), with a primary focus on ESA's SMOS mission, to support enhanced validation and scientific process studies over the ocean. Since 2019, through sustained partnership with NASA, the Platform has extended its focus also to SMAP and Aquarius satellites, becoming an overall satellite salinity Platform.

Product 1 (SoilMoist) Product 2 (SoilMoist) T100 SSS T Product 3 (SoilMoist)

Dashboard - recent activities

Map of the temporal STD of Satellite SSS in 1°x1° boxes over 2010-2023

Map of the temporal mean of Satellite-Argo in 1°x1° boxes over 2010-2023

- Don't underestimate the patchiness of salinity
- We have undersold the quality of SSS retrievals
- In situ data are better and more representative than ever before
- Other communities have defined criteria (accuracy, traceability, depth) for FRMs – is the SSS community ready?



# Conclusions (II)

- We can utilize methods beyond traditional matchup analysis to assess SSS data quality
- SSS can significantly improve sea ice concentration forecasts
- We are better together: OISSSv3 outperformed all tested versions of SMAP-only or SMOS-only products

Thank You!  
Questions?

