CCI+SSS: Enhancing Satellite Observations of Sea Surface Salinity to Meet Climate Challenges

F. Bonjean*, J. Boutin*, J.L. Vergely, F. Rouffi, S. Guimbard, J. Jouanno, N. Reul, R. Catany, R. Sabia, and CCI-team

(fabrice.bonjean@locean.ipsl.fr, jacqueline.boutin@locean.ipsl.fr)

2026 Ocean Salinity Science & Technology Meeting

19-21 May 2026, Seattle, Washington, USA

Why sea surface salinity matters?

Salinity = amount of dissolved salt in sea water (g/kg ~ pss)

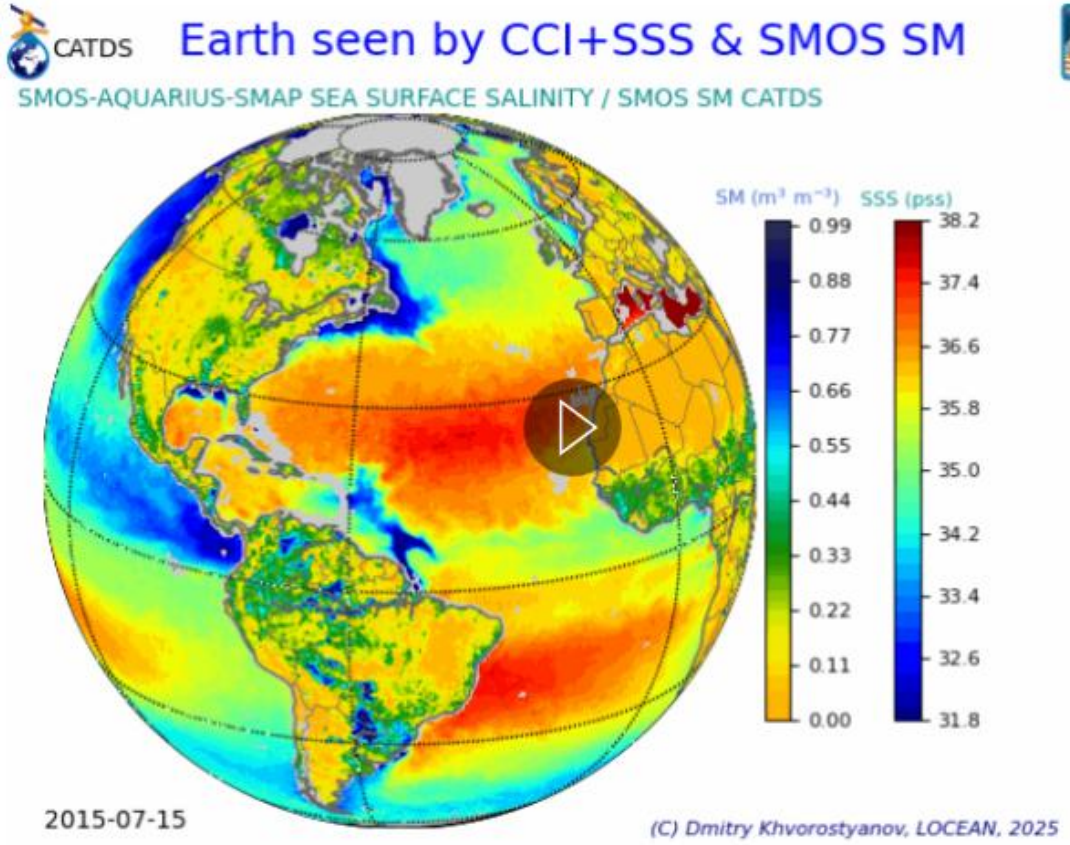
SSS reflects the global water cycle

- **Evaporation ↑ salinity**
- **Rain, rivers & ice-melt ↓ salinity**

+ Ocean transport

Ocean density driver

- **Ocean thermohaline circulation ←**
- **Near-surface stratification ←**



SSS is a key tracer of the ocean water cycle and an Essential Ocean and Climate Variable

Satellite missions used in CCI+SSS

CCI+SSS provides global and polar SSS fields, with uncertainty estimates, from L-band radiometry using temporal optimal interpolation *(Boutin et al., JGR 2021)*

SMOS
Soil Moisture and Ocean Salinity

ESA Earth Explorer (CNES PROTEUS platform)

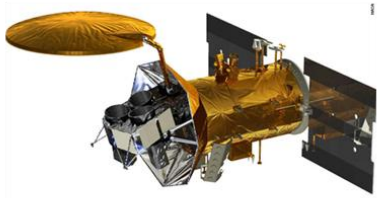
The first Interferometer for earth observation!

~43km resolution/3 day global coverage

Aquarius
Argentina-USA collaboration (CONAE/NASA)

3 radiometers + 1 scatterometer

~150 km resolution/ 7 day global coverage

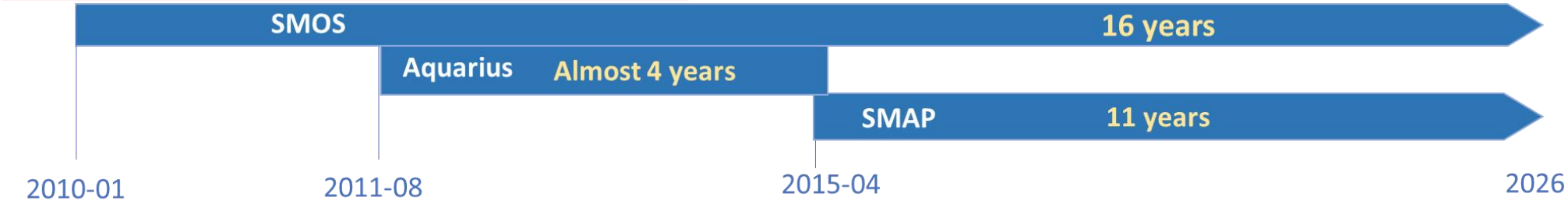


SMAP
Soil Moisture Active Passive (NASA)

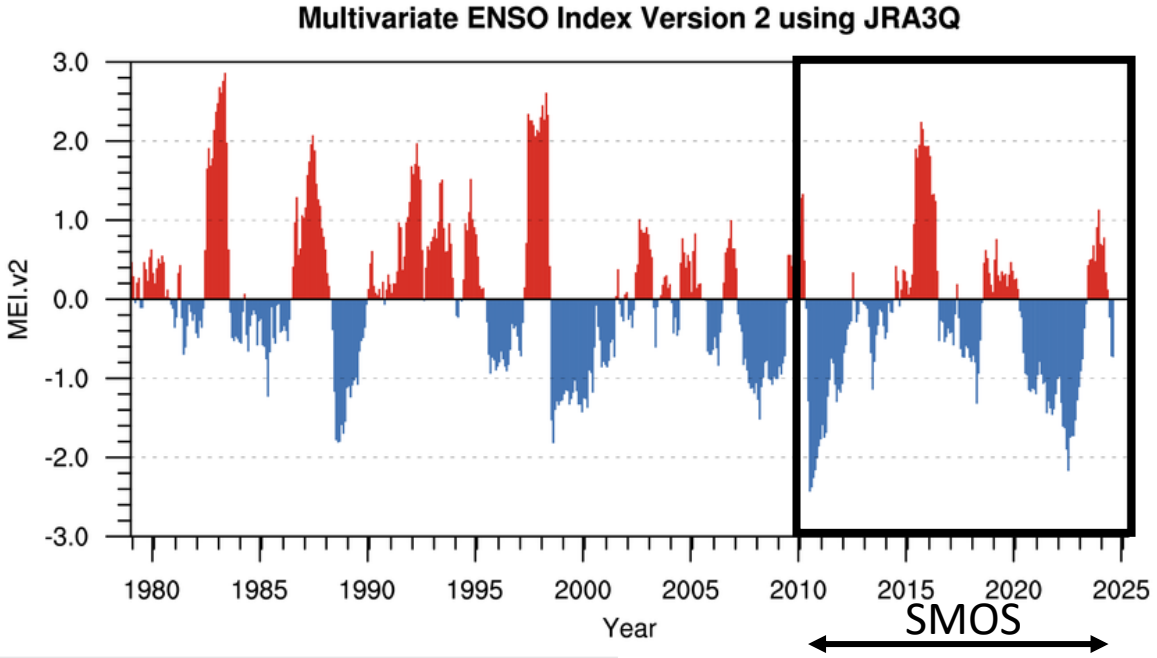
Radiometer

~43km resolution / 3 day global coverage

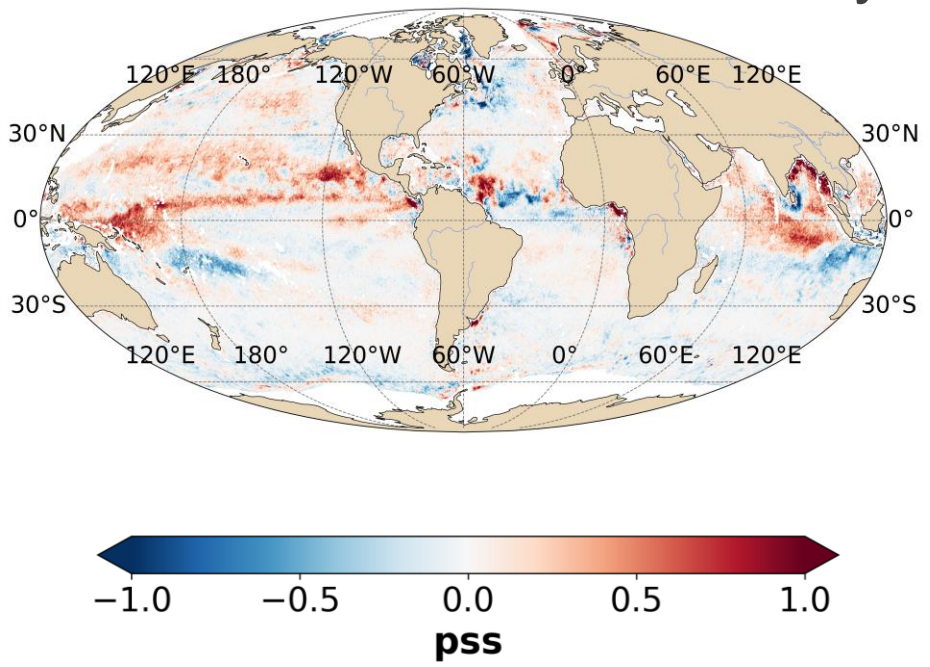
The longest operational ESA Earth observation mission!



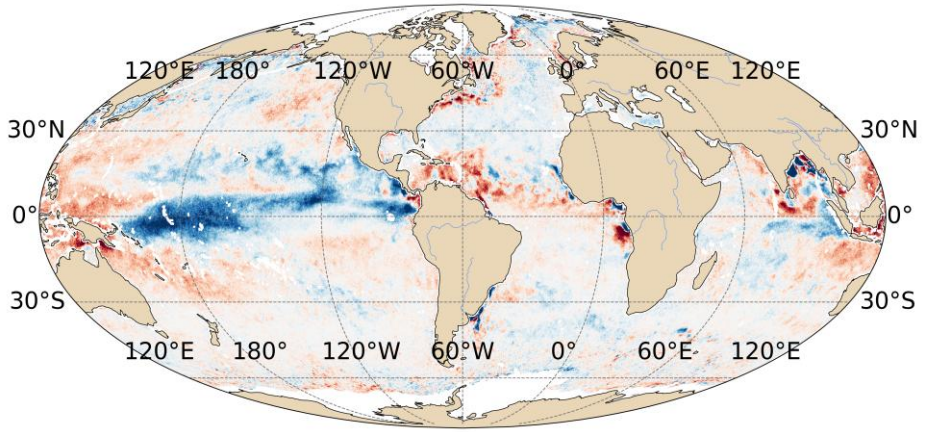
CCI+SSS 2010-2023 captures the two strongest and longest La Niña events since 1980



Nov. 2010 anomaly



Dec. 2015 anomaly



Satellite Microwave Radiometry at L-Band for Monitoring Earth's Essential Climate Variables

From Fundamental Physics to Sixteen Years of Global Climate Observations and Beyond

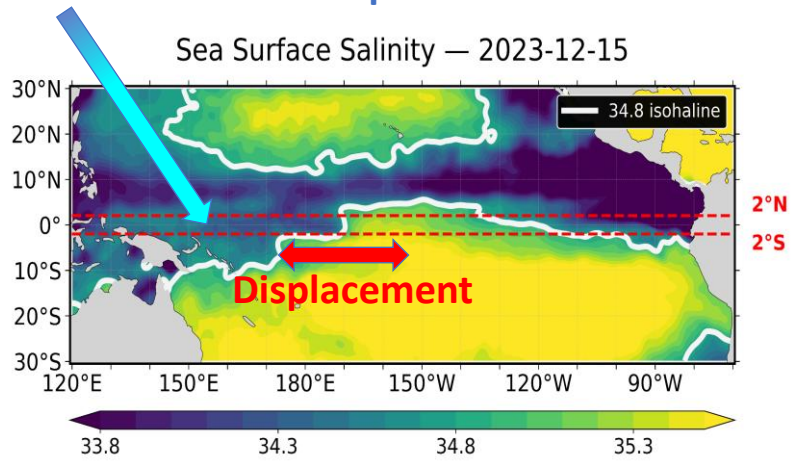
YIWEN ZHOU, MIKE SCHWANK, JACQUELINE BOUTIN, PHILIPPE RICHAUME, ARNAUD MIALON, MANU HOLMBERG, LARS KALESCHKE, PIERRE ZEIGER, MARION LEDUC-LEBALLEUR, ARDESHIR EBTEHAJ, DIVYA KUMAWAT, NEMESIO RODRIGUEZ-FERNANDEZ, ESTRELLA OLMEDO, ANDREAS COLLIANDER, EMMANUEL DINNAT, ANDREW FELDMAN, MEHMET KURUM, JUHA LEMMETYINEN, KIMMO RAUTIAINEN, GHISLAIN PICARD, NICOLAS REUL, STEFAN HENDRICKS, XIANGSHAN TIAN-KUNZE, RASMUS TONBOE, CRISTINA VITTUCCI, MARCO BROGIONI, KENNETH JEZEK, GIOVANNI MACELLONI, MATTHIAS DRUSCH, JOEL JOHNSON, ROGER H. LANG, DAVID M. LE VINE, DARA ENTEKHABI, AND YANN KERR

Zhou et al., 2026, *IEEE Geoscience and Remote Sensing Magazine, 2026*

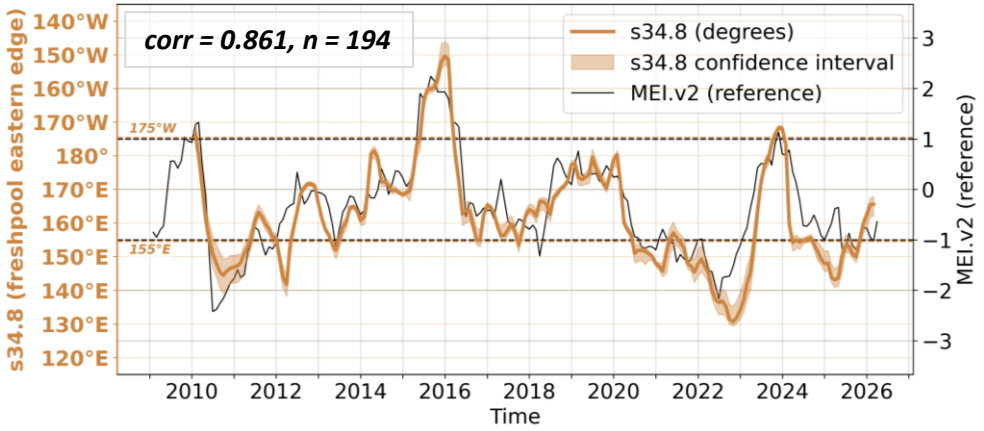
Tracking ENSO through the western tropical Pacific fresh pool

Climate Change Service

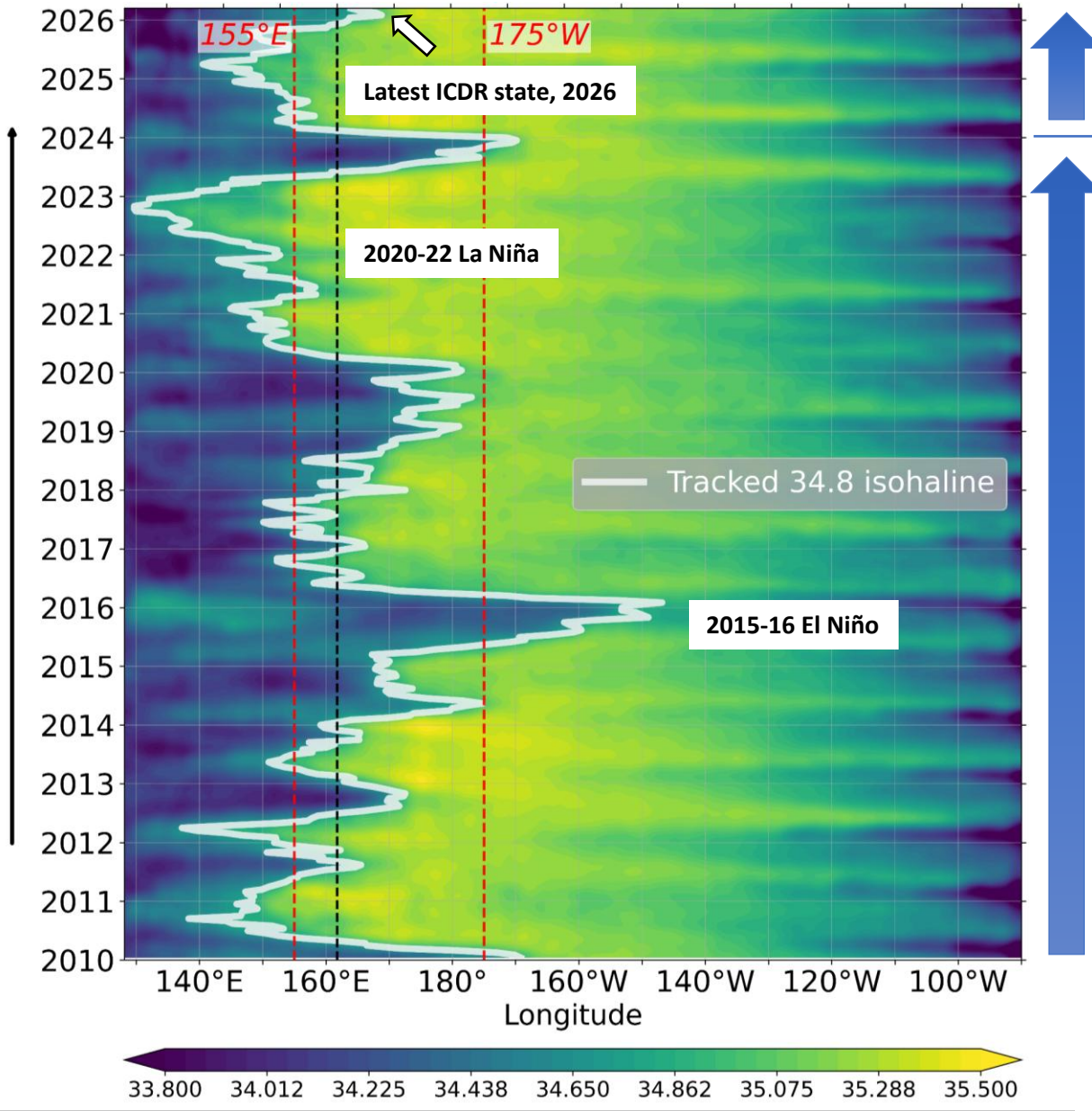
Western Pacific freshpool



S34.8: A salinity-based ENSO indicator



(Adapted from Tangdong Qu and Jin-Yi Yu, J Oceanogr (2014) 70:367–375)



CATDS OPER

2024/12

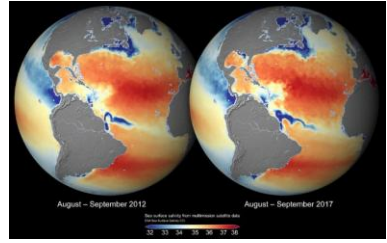
CCI V6 (CDR in progress)

CCI+SSS Version 5, 2010-2023

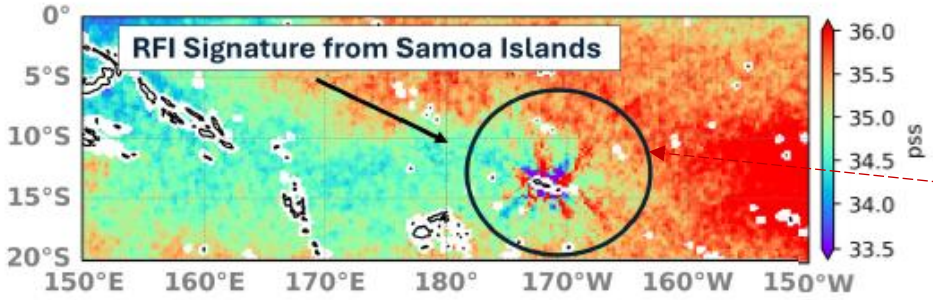
- Weekly and monthly maps at ~50km resolution

  0.25° rectangular grid globally; 25 km EASE grid in polar regions
- Available from CEDA: doi:10.5285/7294d93479654c139770f13fae4142d1
- Global precision against reference gridded data: 0.14 pss
- Product uncertainties agree with observations within ~30%
- Reduced RFI contamination relative to previous versions (Bonjean et al. 2025)

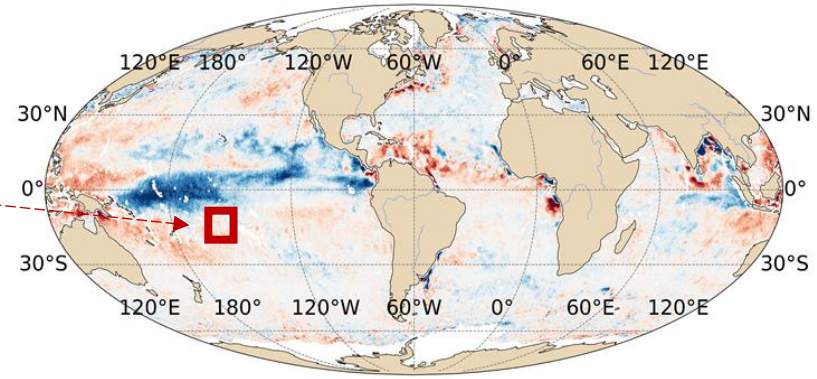
Why RFI mitigation matters for large-scale climate monitoring

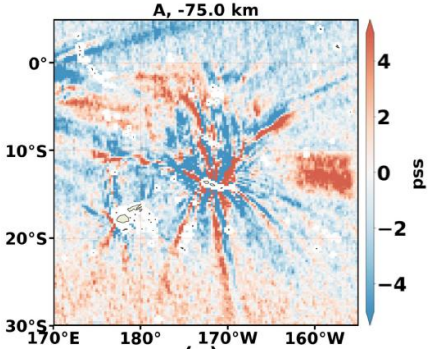


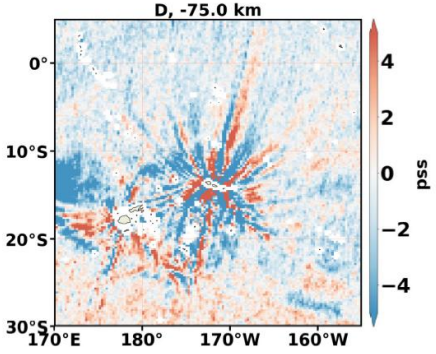
SMOS SSS in CCI v3



Dec. 2015 Anomaly (CCI v5)







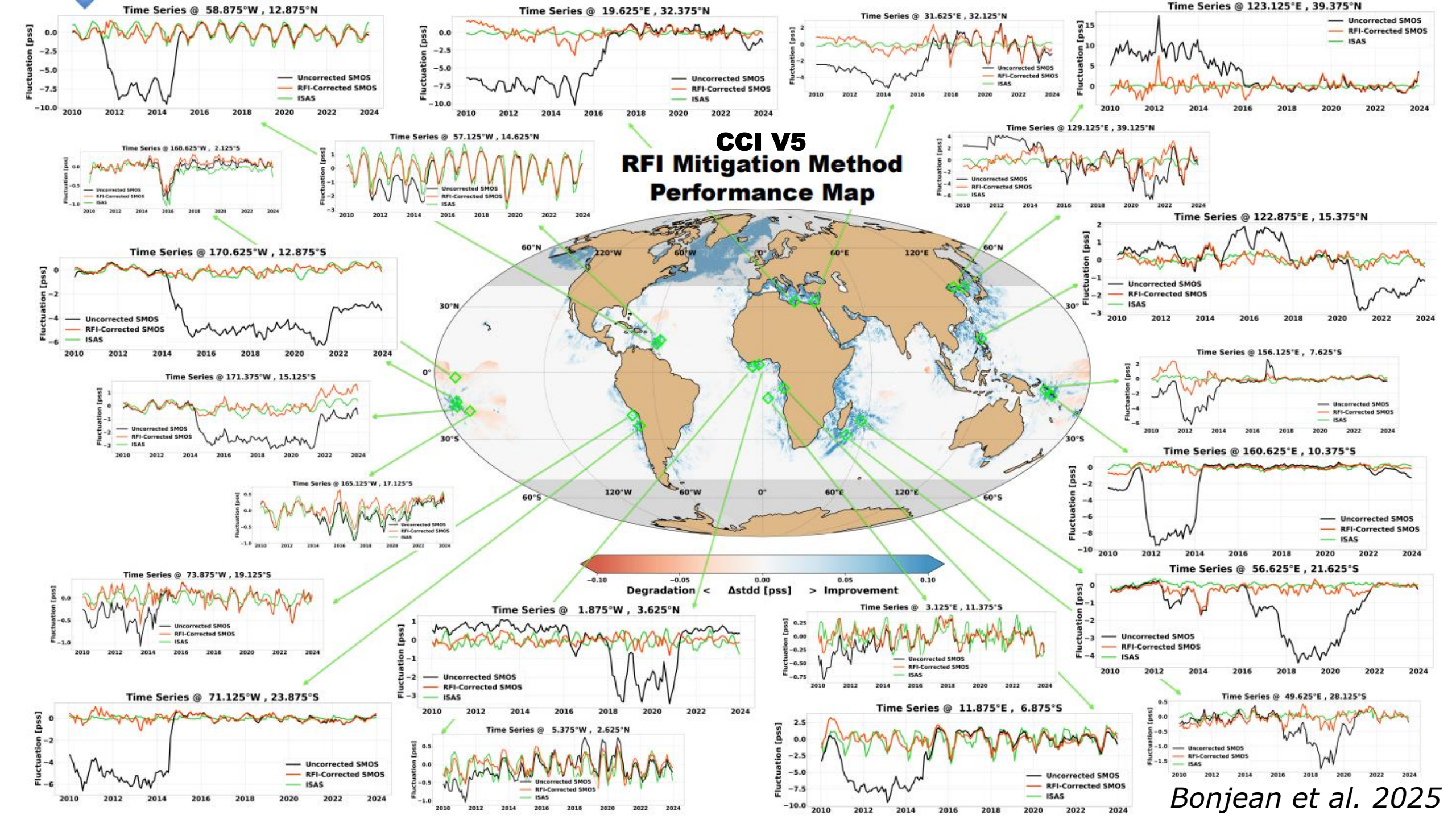
RFI source probability (P. Richaume)

Temporal modulation inferred from SMOS SSS & PCA

Correction principle: PCA is applied to SSS retrieved from different acquisition geometries to identify RFI-related temporal modulations and spatial patterns across the swath.

Bonjean et al., IEEE TGRS 2024

Without RFI mitigation, artificial signals can distort climate-scale SSS anomalies.



Bonjean et al. 2025

Towards CCI+SSS v6

- **Record extension**: 2010 - **2024**, with user delivery planned for mid-2026
- **Main algorithm updates in CCI+SSS v6**

  SMOS:

  - **L2OS reprocessing (OTT ISAS, priors ERA5, new TB-wind LUT)**
  - **SST diurnal cycle** from ERA5 (SMOS L2 processing)
  - **Correction for solar-activity-related contamination**
  - **SSS correction in the Southern Ocean related to distance to sea ice**
  - **Revised RFI mitigation**

  SMAP:

  - **RSS v6.0 & v6.3 in 2024 (thanks to T. Meissner, RSS)**
  - **SST diurnal cycle correction on SMAP SSS**
  - **Correction for solar-activity-related contamination**
  - **WS-SST correction**

Systematic bias corrections in CCI+SSS v6

- Accounting for SMOS sea-ice contamination in the Southern Ocean, solar contamination, and seasonal latitudinal biases.
- The correction model combines sea-ice proximity effects, latitudinal biases, and solar-cycle-related contamination.

$$SSScorr(t,lat,lon) = SSS(t,lat,lon) - \alpha(lat,x,month).sunBT(t) - \beta(lat,x,month) - \Upsilon(dice,x)$$

dice: latitudinal ice edge distance,

x: geometry and orbit dependency

Estimation of α, β and Υ by least squares.

Impact of v6 corrections on SMOS SSS relative to in situ ISAS

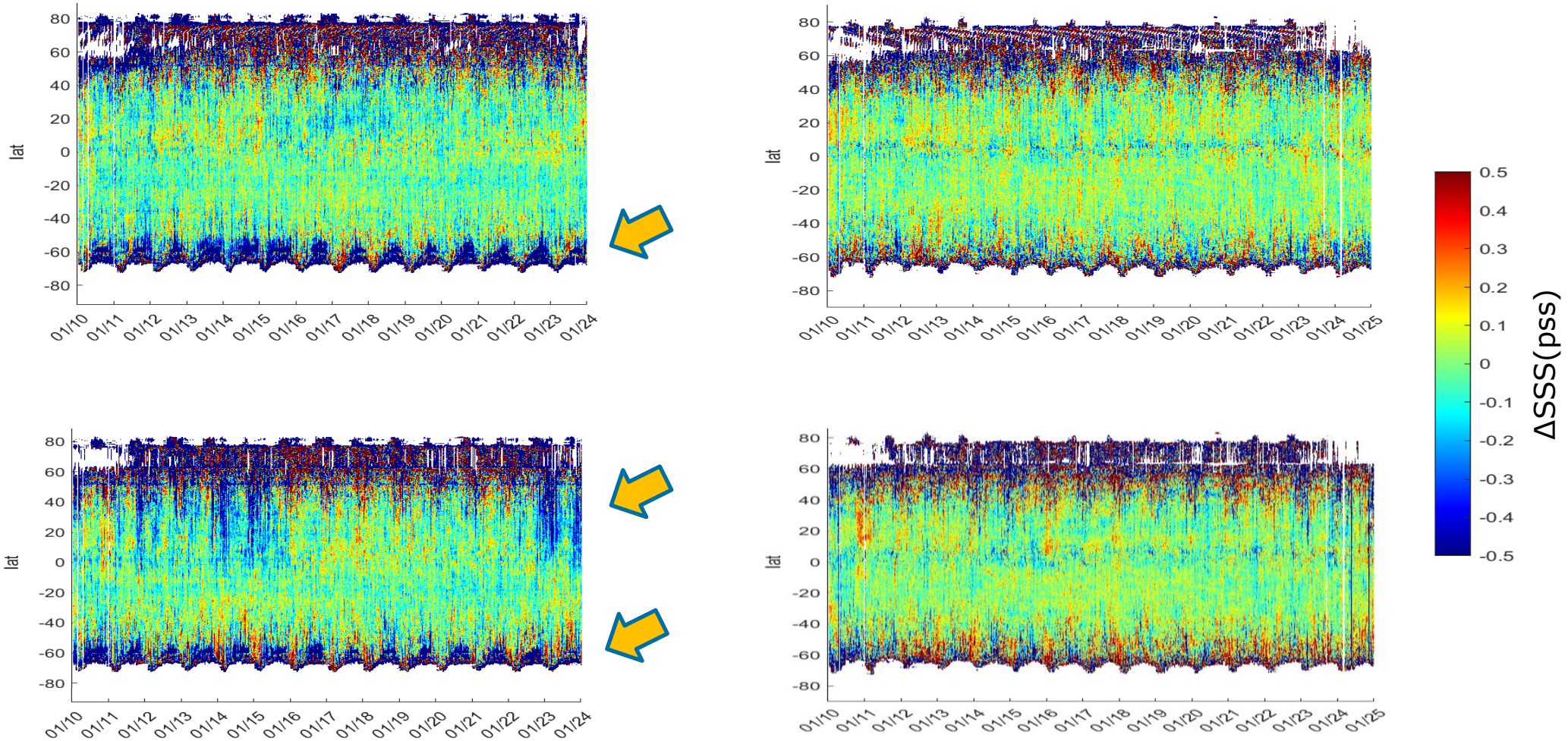
Solar brightness temperature, wind-speed/SST, and sea-ice corrections

SMOS_CCI V5

SMOS_CCI V6

Ascending (6AM)

Descending (6PM)



v6 reduces orbit-dependent and latitude-dependent SMOS biases.

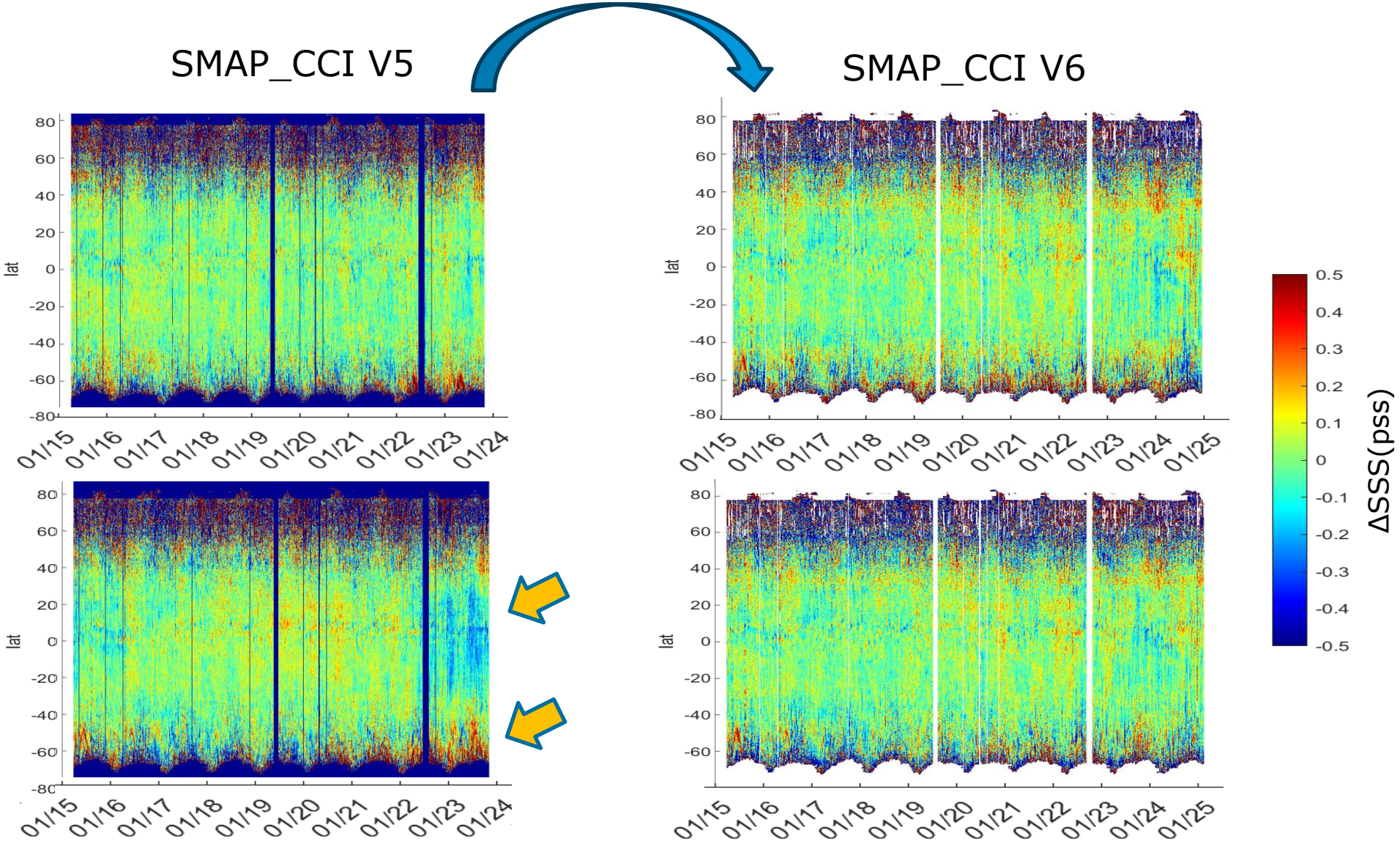
Impact of solar correction on SMAP SSS biases relative to in situ ISAS

SMAP_CCI V5

SMAP_CCI V6

Descending (6AM)

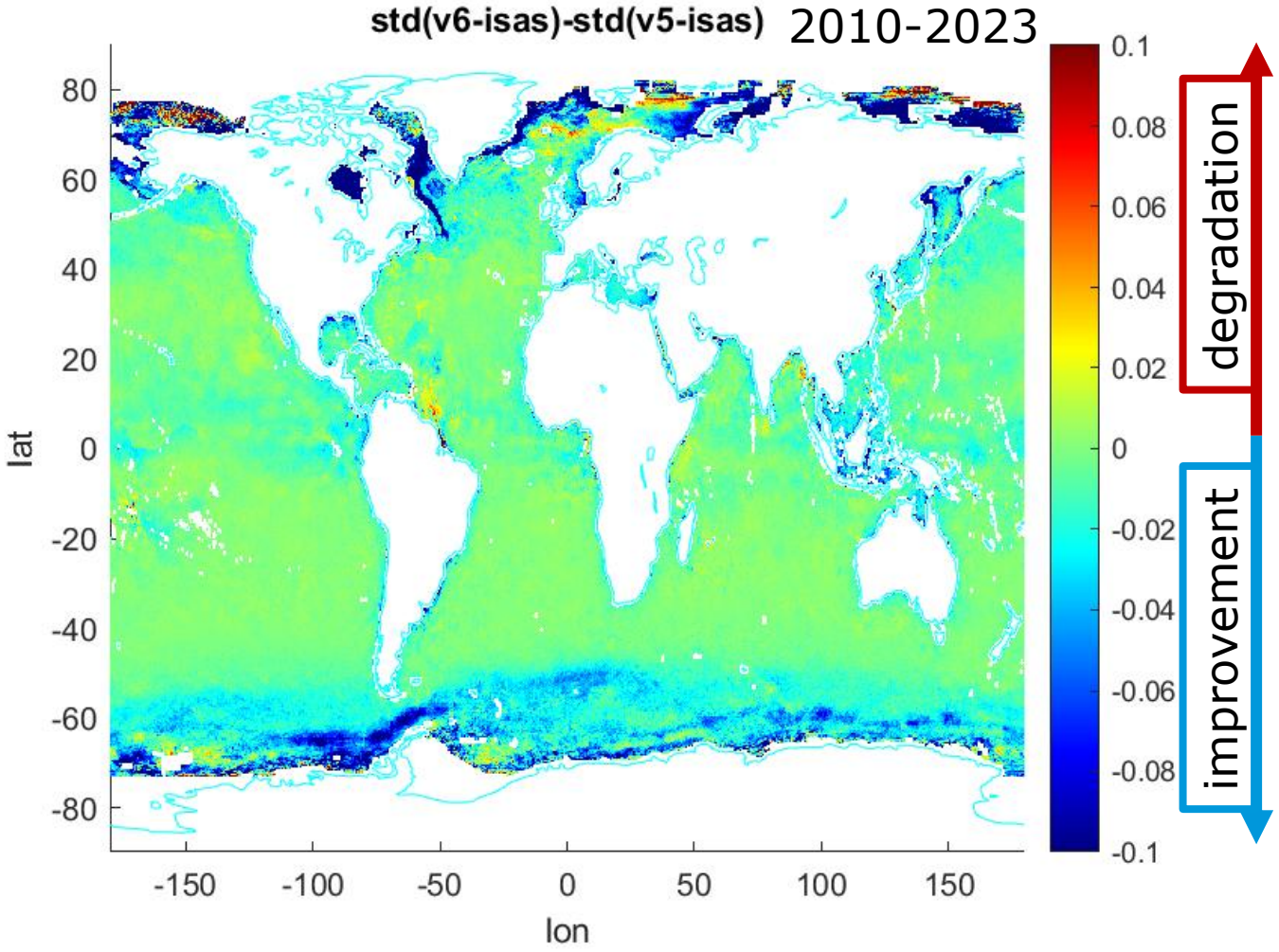
Ascending (6PM)

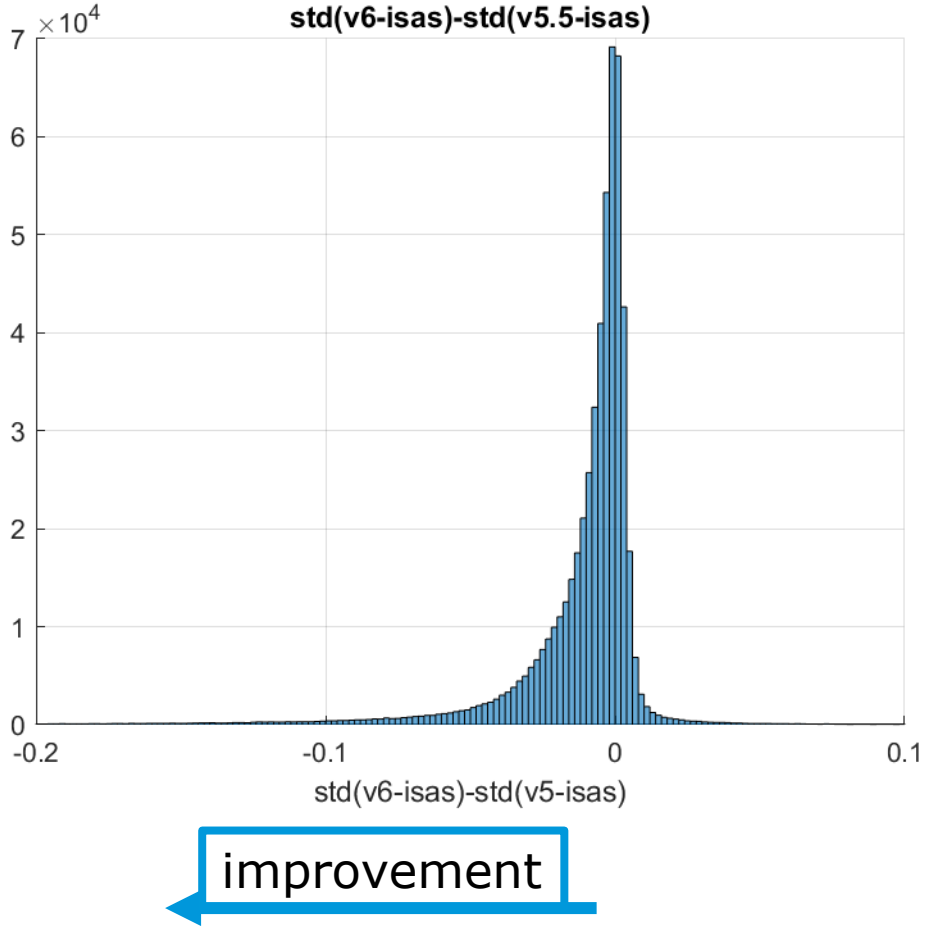


Solar correction improves SMAP consistency with reference fields.

CCI+SSS v6 reduces SSS error standard deviation relative to v5

Metric: std (CCIv6 – ISAS) - std (CCIv5 – ISAS)



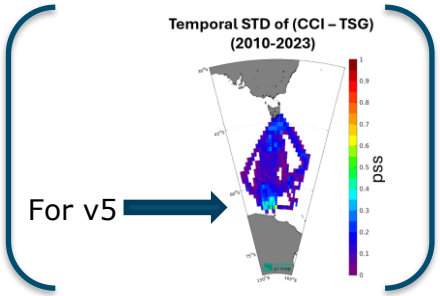


Vergely & Parc, ACRI-st, Preliminary results

Southern Ocean CCI v6 validation

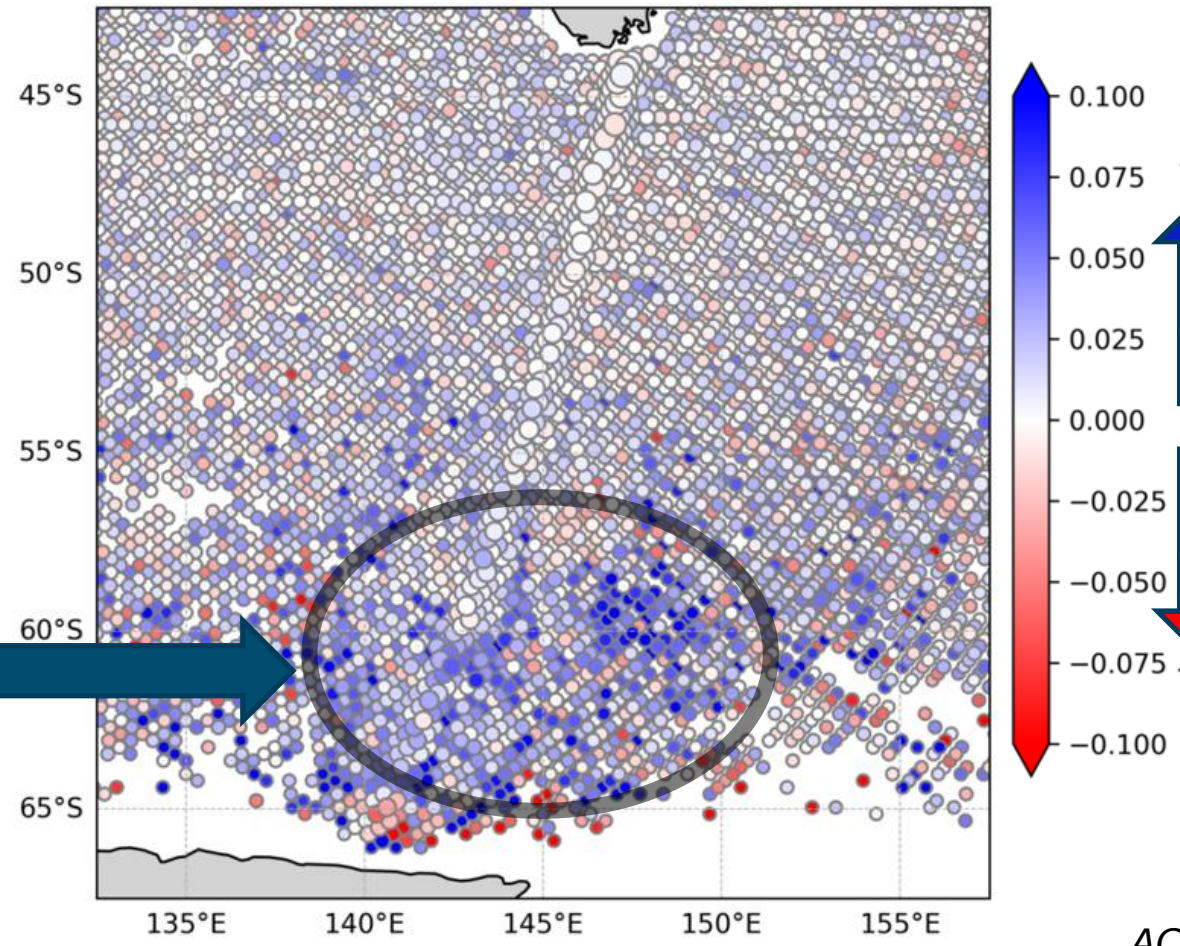
Preliminary results from algorithm team working on v6

v6 with sea-ice correction improves over v5



std(v5 – in situ) - std(v6 – in situ) (N > 3)

HEALPix grid colocation



ACRI-st, LOCEAN
Preliminary results
(Bonjean, PVASR)

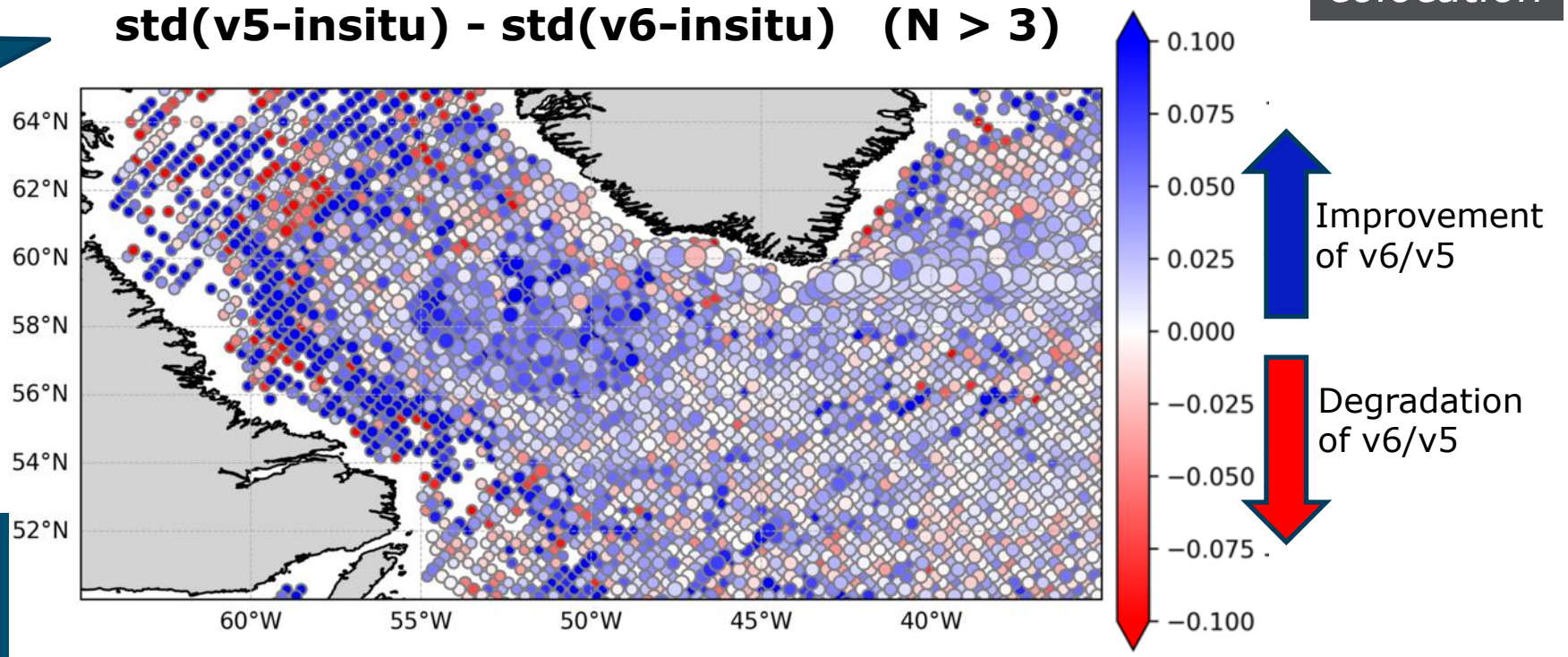
Preliminary result: v6 improves agreement with in situ data in several sea-ice-affected regions

Subpolar North Atlantic CCI v6 validation

HEALPix grid colocation

Preliminary results from algorithm team working on v6

v6 improves over v5 around southern Greenland and the Labrador Sea



ACRI-st, LOCEAN
Preliminary results
(Bonjean, PVASR)

Summary and next steps

- **CCI+SSS v5: weekly and monthly SSS fields, 2010-2023**
- **CCI+SSS v6: 2010-2024, planned for delivery in mid-2026**

Key improvements in CCI v6

- **Progressive RFI mitigation improvements: v6 > v5 > v4**
- **Solar contamination correction → v6**
- **Diurnal SST correction → v6**
- **Sea-ice correction → v6**

- **Towards near-real-time processing and C3S delivery of monthly SSS by late 2026, with ~1-month latency**