SO Fresh
Southern Ocean Freshwater

Satellite Sea Surface Salinity products for better understanding freshwater fluxes in the Southern Ocean

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2024 European Polar Science Week

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ARGANS (3)
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- EO SSS maps in the Southern Ocean
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SO-FRESH project

Understand freshwater fluxes in the Southern Ocean, and their role as a **driving factor of climate**

Establishment of user requirements for EO SO SSS

Development of high-quality SSS product

Generation of satellite long-term open access SSS product

EO developments

Causes & consequences of recent sea ice changes

Causes & consequences of Weddell Polynya opening

Changes in coastal processes, impact on ice sheet melting and abyssal water formation

Scientific case studies

Contribute to strengthen the European research projects in the SO

ESA funded project
2021-2023

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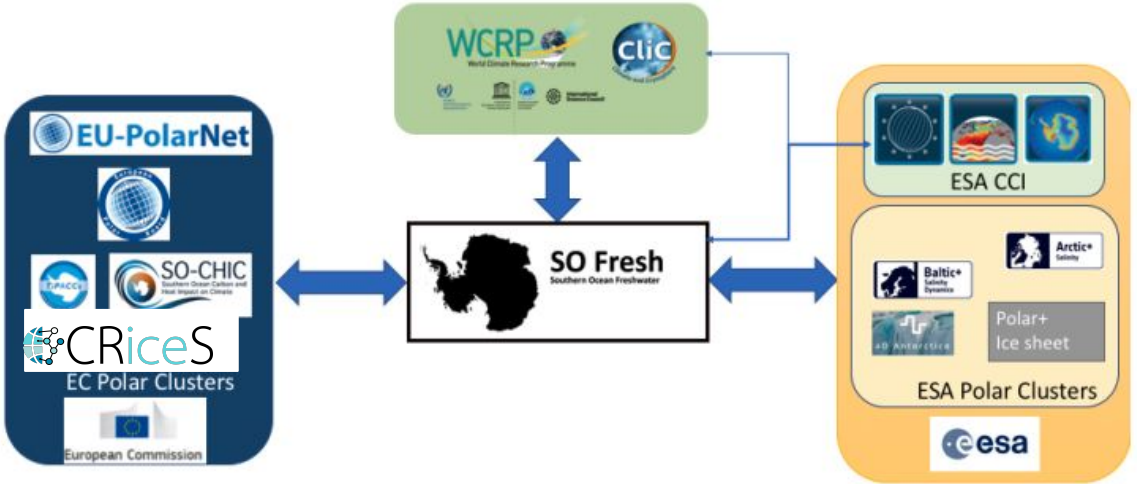
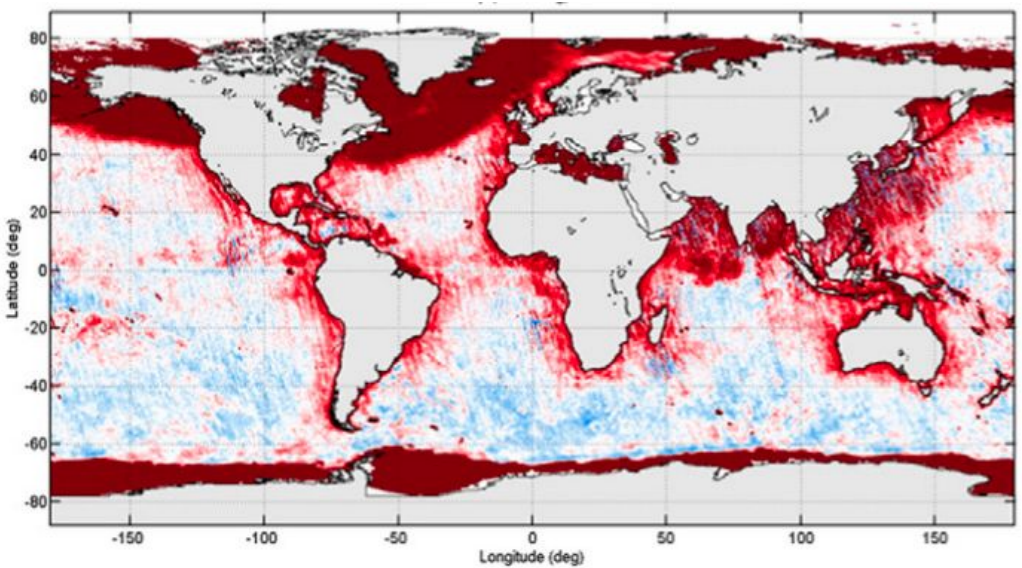
Contribute to strengthen the European research projects in the SO



ESA funded project
2021-2023

EO SSS in the Southern Ocean: Challenges

- Contamination of the radiometric signal close to coast & ice edges
- Low sensitivity of satellite measurements to SSS in cold waters
- Low SSS variability in the region



[Corbella et al., 2015, GRSL]

EO SSS in the Southern Ocean

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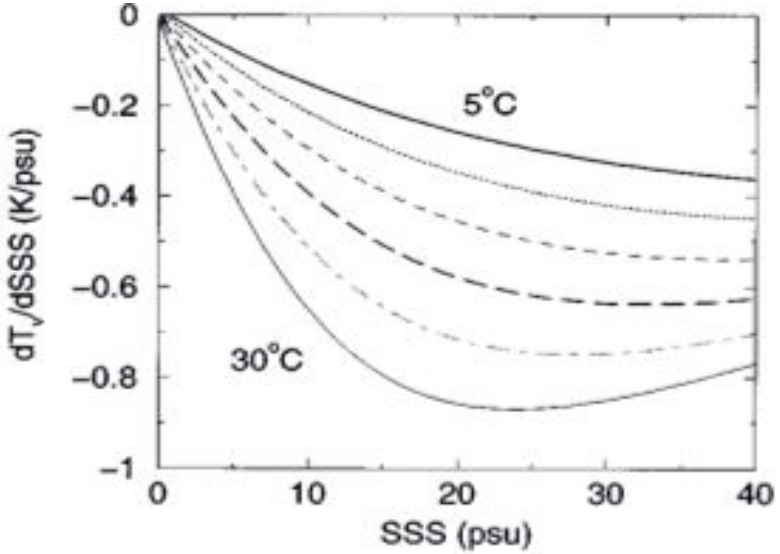

[Yueh et al., 2001, TGRS]

EO SSS in the Southern Ocean

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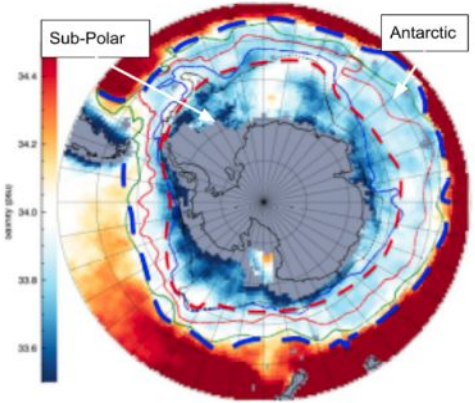
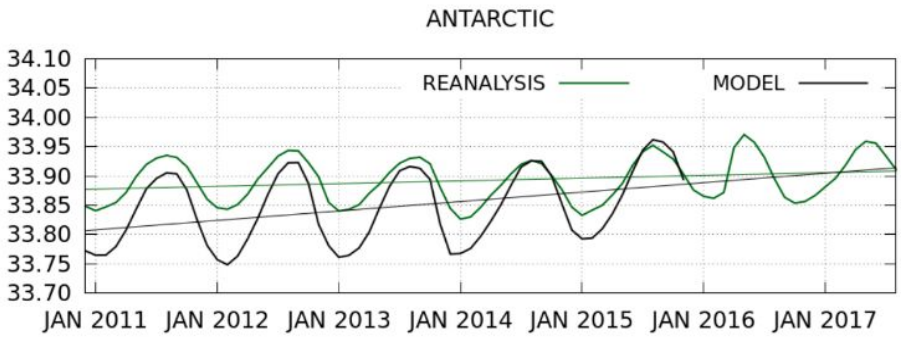
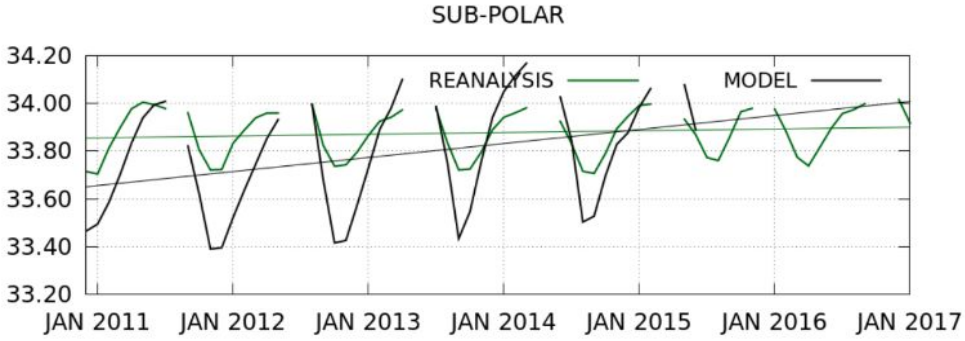
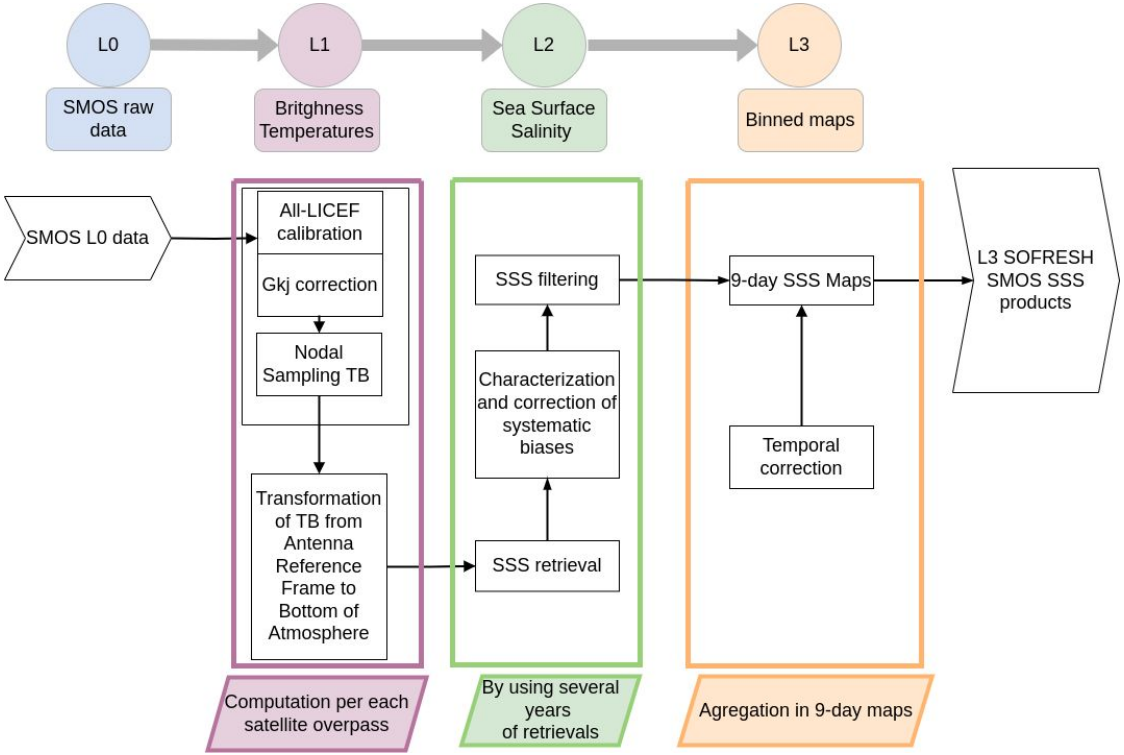






Algorithm development: L0-L1



Method:
ALL-LICEF+Gkj correction [1, 2, 3]

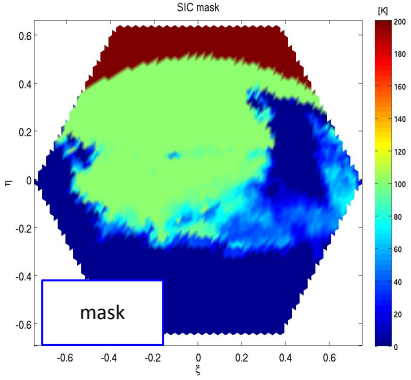
Impact:
Improved stability
Mitigation of land-sea/ice-sea contamination on TB

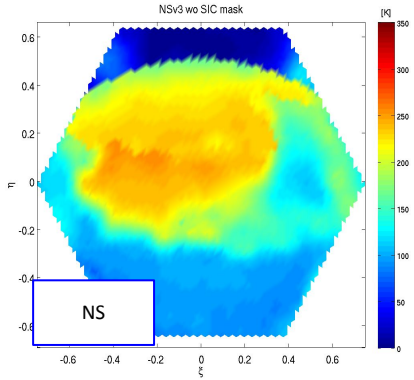
Method:
Nodal sampling [4,5]
with dynamical sea ice mask

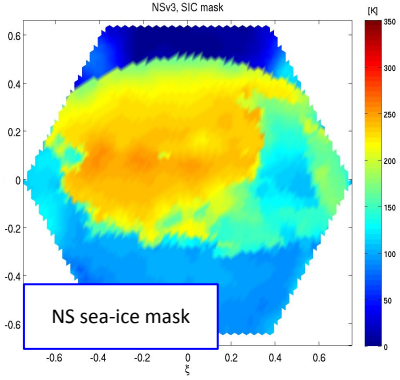
Impact:
Reduction of radiometric noise
(improvement of signal to noise ratio)

[1] (Corbella et al., 2016, IGARSS Proc.)
[2] (Corbella et al., 2015, GRSL)
[3] (González-Gambau et al., 2017, JSTARS)
[4] (González-Gambau et al., 2016, RSE)
[5] (González-Gambau et al., 2018, IGARSS Proc.)

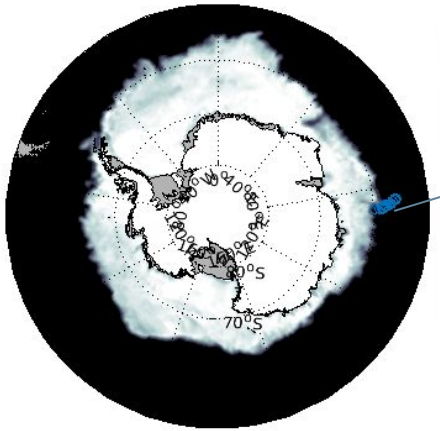
Nodal sampling with dynamic sea-ice mask

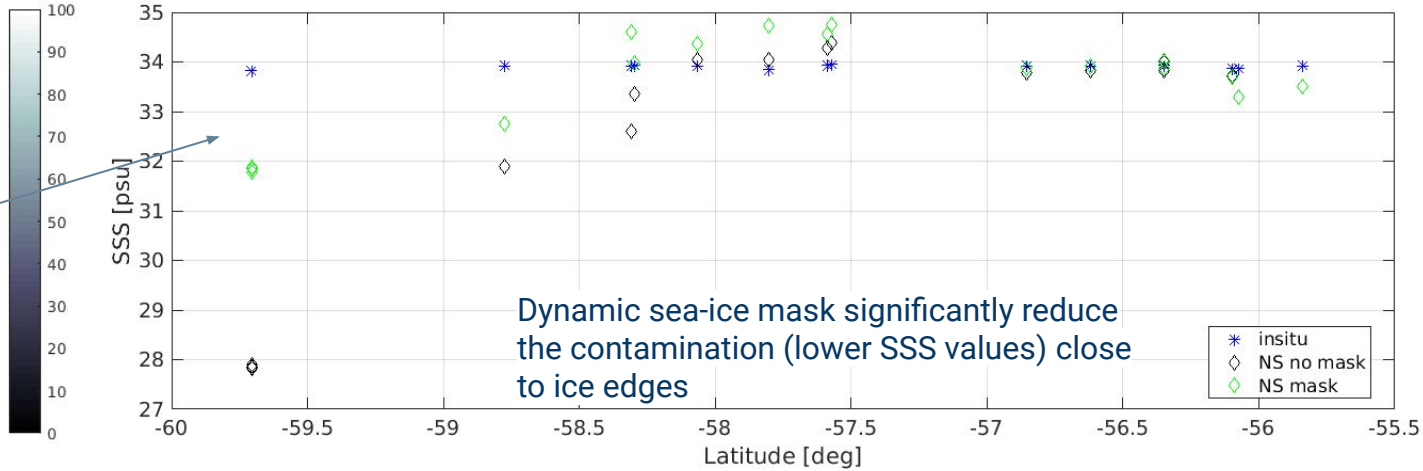






NS selects nodal points based on their type: land, ocean, sky, or have the same SIC or in a range of ± 10%





Dynamic sea-ice mask significantly reduce the contamination (lower SSS values) close to ice edges

Algorithm development: L2-L3

Method:
Debiased non-Bayesian retrieval [6] **as a function of sea ice distance**

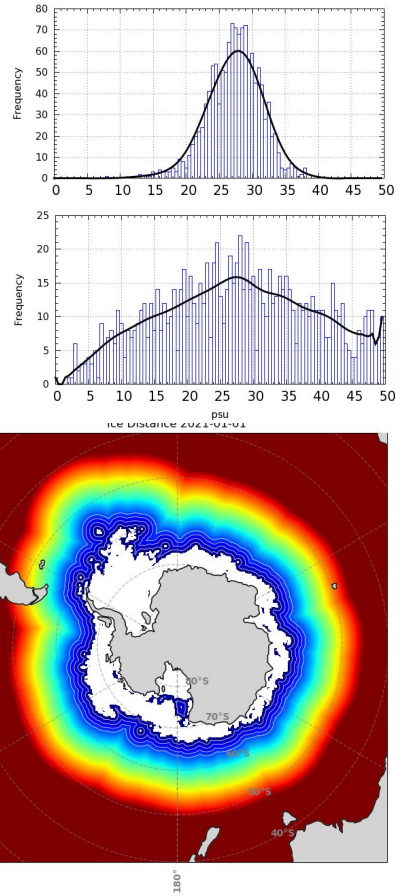
Impact:
Mitigation of spatial systematic SSS biases and increase of coverage close to ice edges

Method:
Spectral analysis (effective spatial resolution), singularity analysis (geophysical consistency)

Impact:
Selection of the most accurate auxiliary SST

Method:
Temporal correction of L3 maps with Argo [7]

Impact:
Mitigation of temporal biases

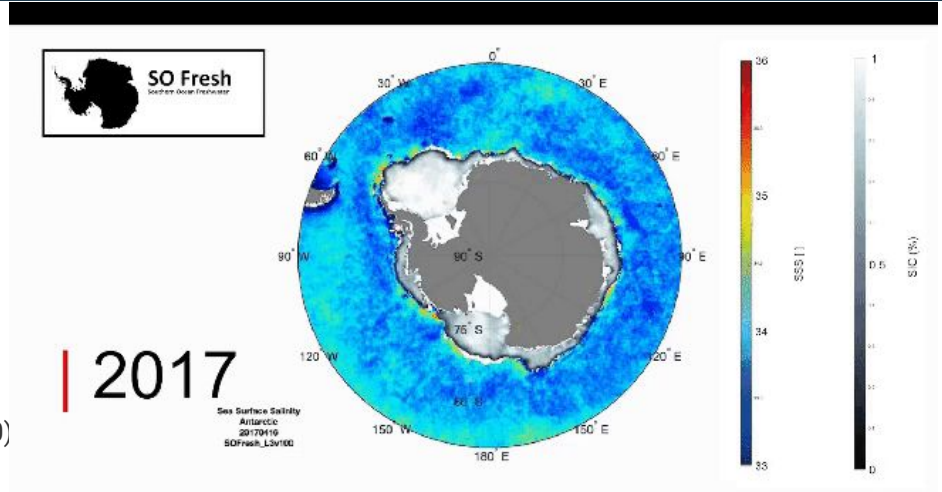


[6] (Olmedo et al., 2016, RSE)
[7] (Olmedo et al., 2018, Remote Sensing)

SO-FRESH L3 SSS product

SO-FRESH L3 SSS product	
Geographical coverage	$180°W$ -> $180°E$; $30°S$ -> $90°S$
Temporal coverage	2011-02-01 to 2023-03-31
Spatial resolution	25km x 25km
Coordinates reference system	EASE-SL 25km
Temporal resolution	9-day maps generated daily
Version	1.0
DOI	https://doi.org/10.20350/digitalCSIC/15493
Source	BEC FTP

González Gambau, V.; Olmedo, E.; García Espriu, A.; González-Haro, C.; Turiel, A.; 2023; "Southern Ocean Sea Surface Salinity Level 3 maps (V.1.0) [Dataset]"; DIGITAL.CSIC; https://doi.org/10.20350/digitalCSIC/15493



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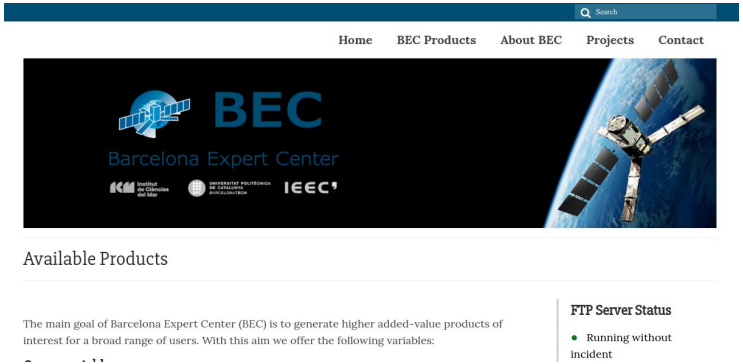
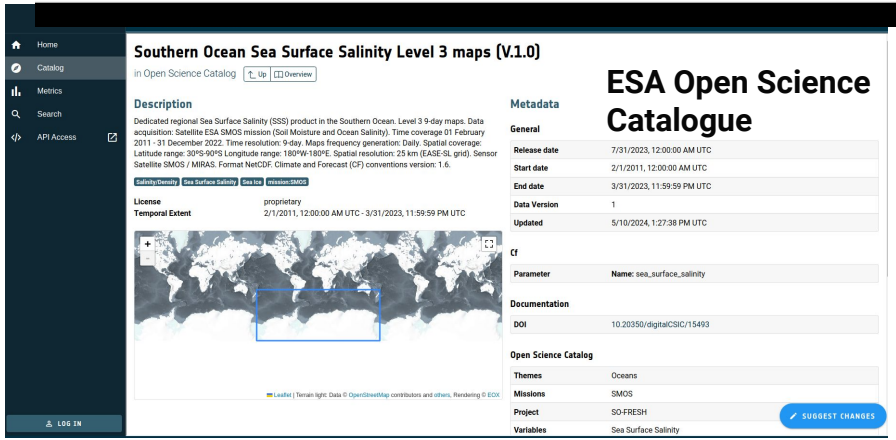


ESA Open Science Catalogue



Product performance: close to coast & ice edge

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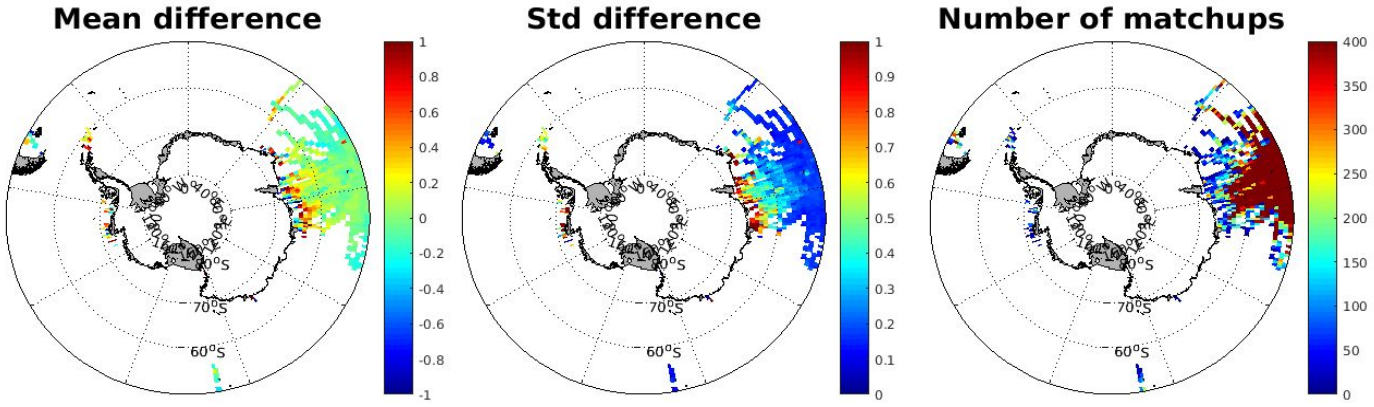
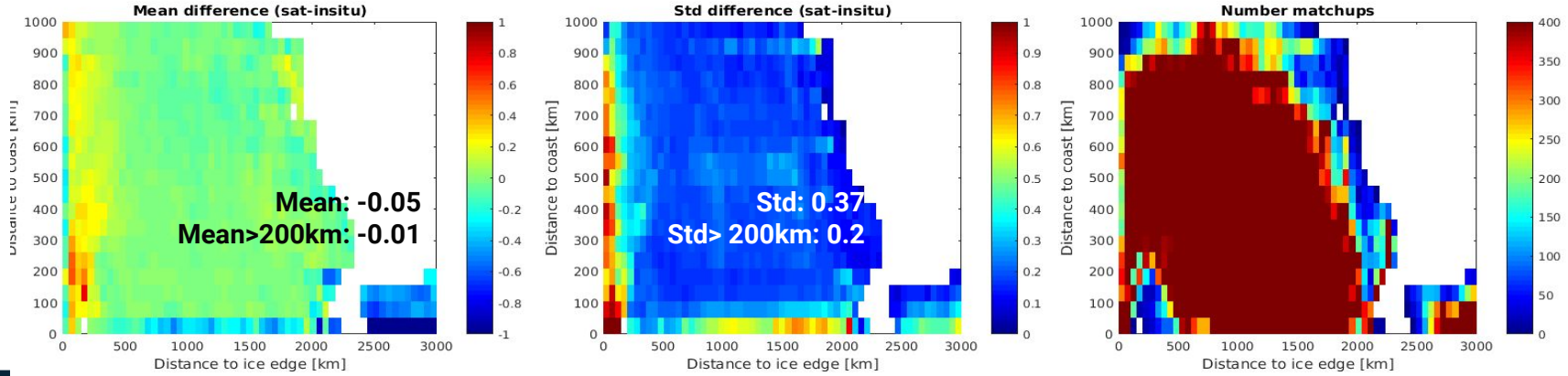
Marine mammals, https://doi.org/10.17882/45461, 2024-03 release

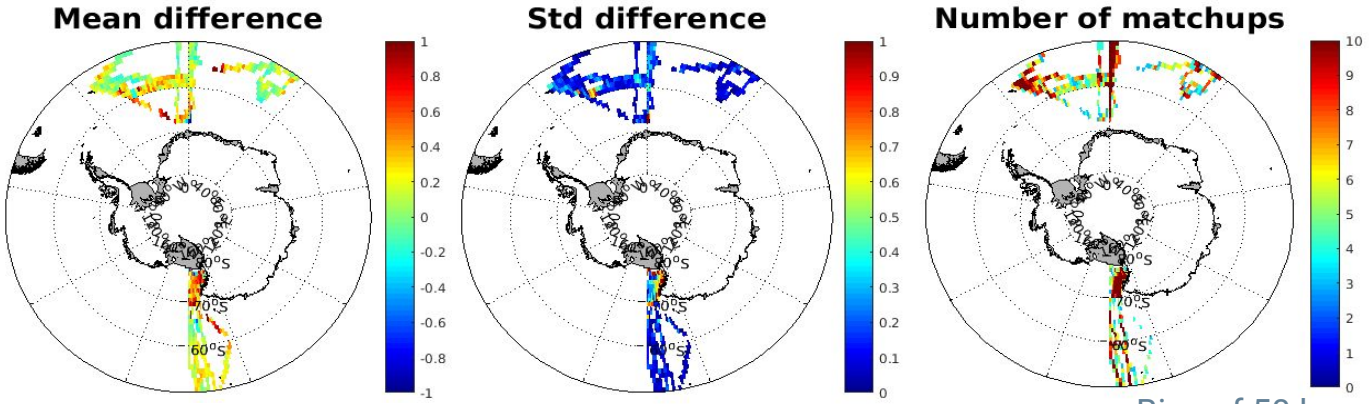


Spatial stats in 1° grid:
Median RMS: 0.31
Number matchups: 723991



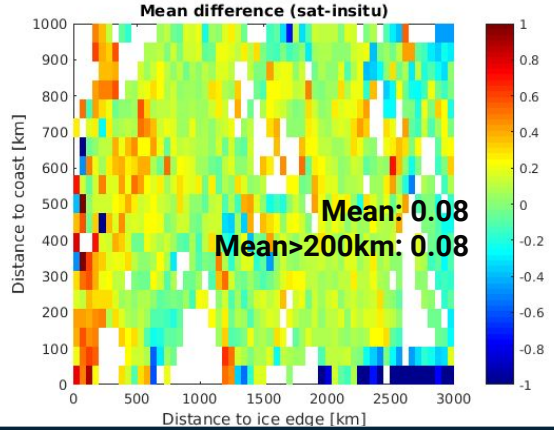
Product performance: close to coast & ice edge

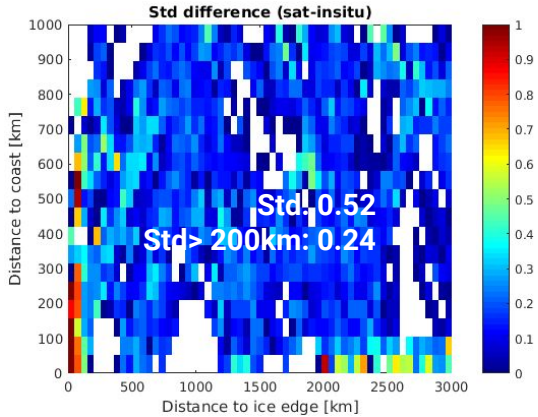
Data from TSG research ships provided by G. Aulicino & Y. Cotroneo

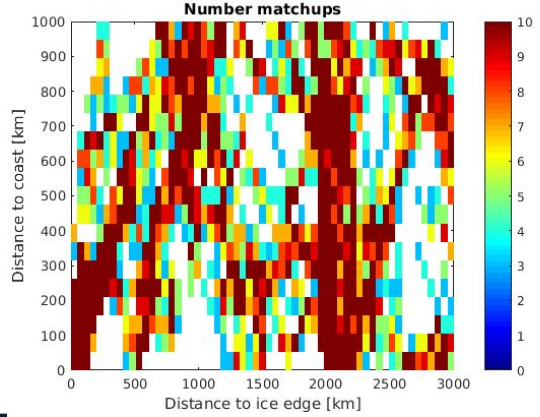


Spatial stats in 1º grid:
Median RMS: 0.23
Number matchups: 11402

2D histograms:
Bins of 50 km of distance to coast/ice edges

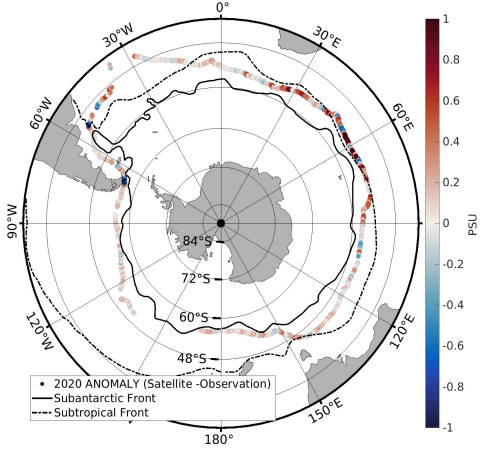






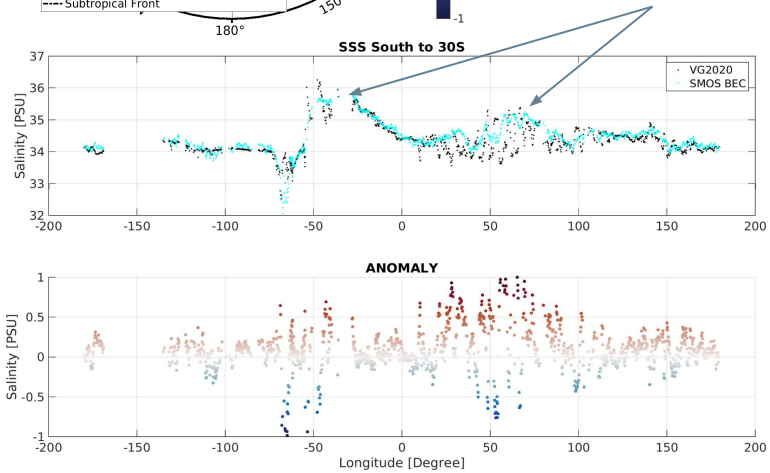
Product performance: Subantarctic & subtropical fronts

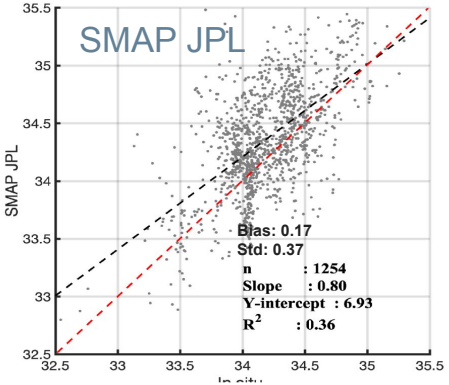
Vendée Globe and Barcelona World Races

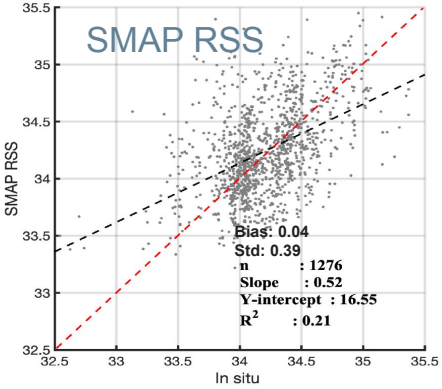


Year	Mean	SDD	R
2011	0.3	0.33	0.83
2015	0.05	0.27	0.78
2020	0.11	0.31	0.81

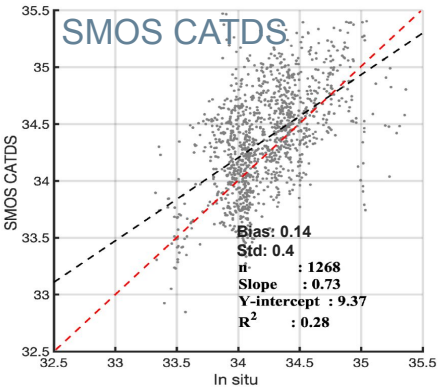
Differences associated to representativeness can be higher

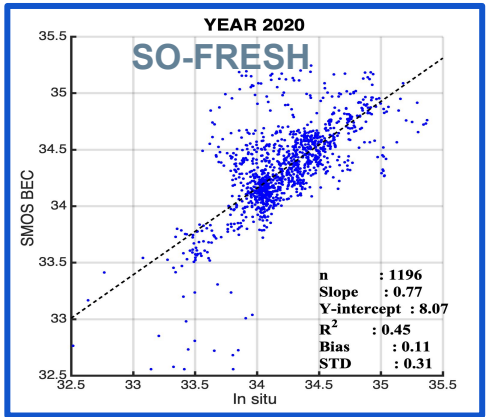






[Umbert et al., 2022]





Quite similar stats, slightly better in SO-FRESH product (highest correlation, lowest STD)

Product performance: Interannual variability

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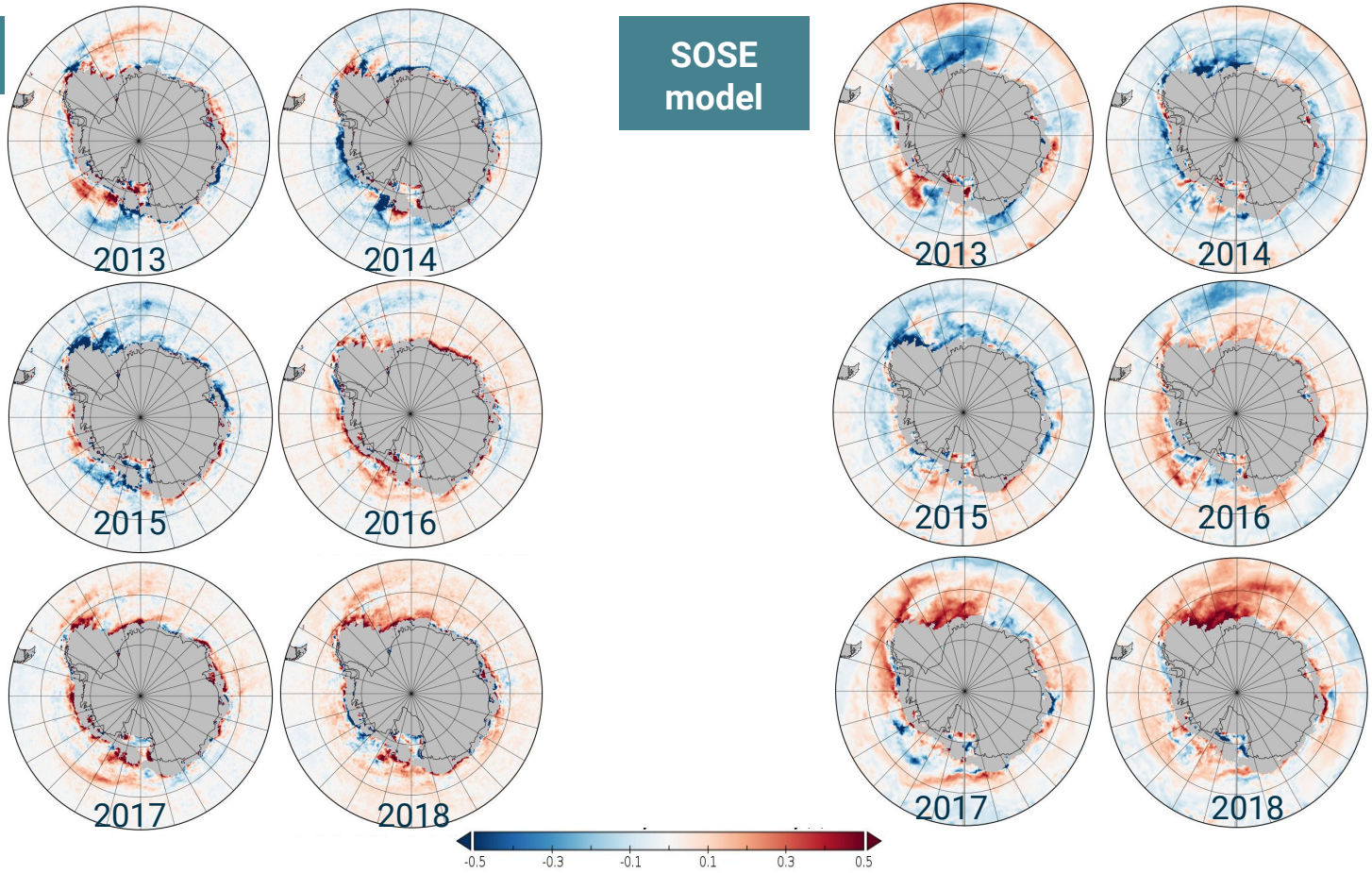
SOSE model



Product performance: Seasonal variability

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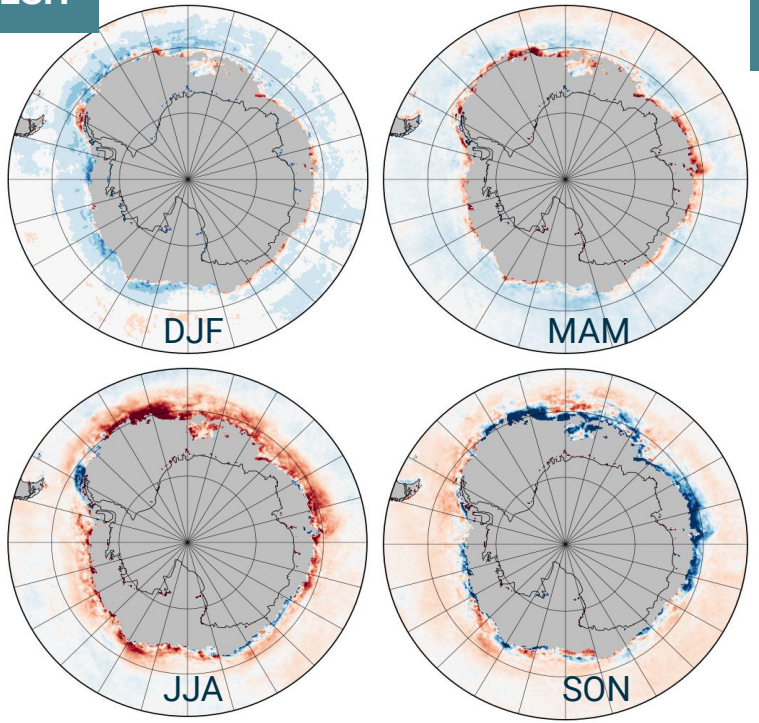
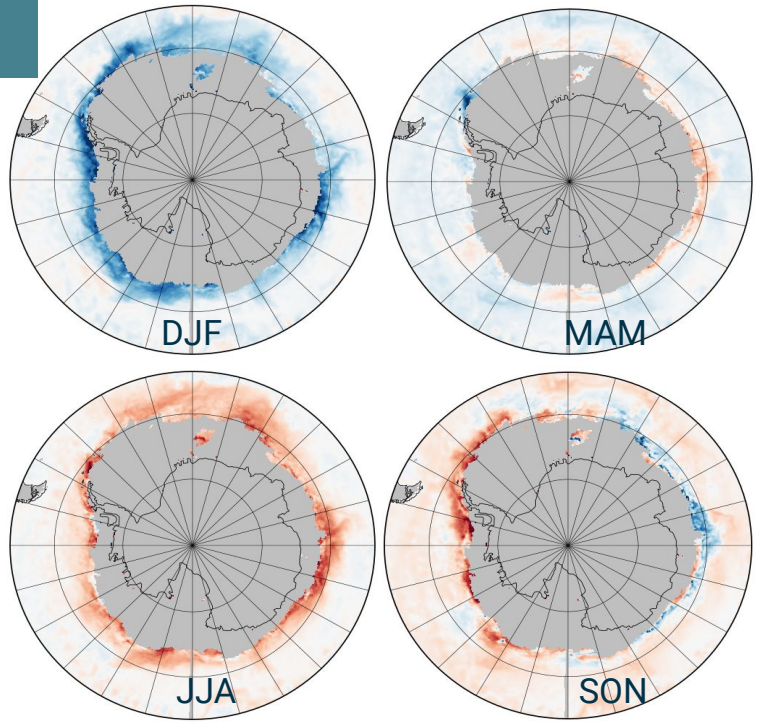


SOSE model



Conclusions

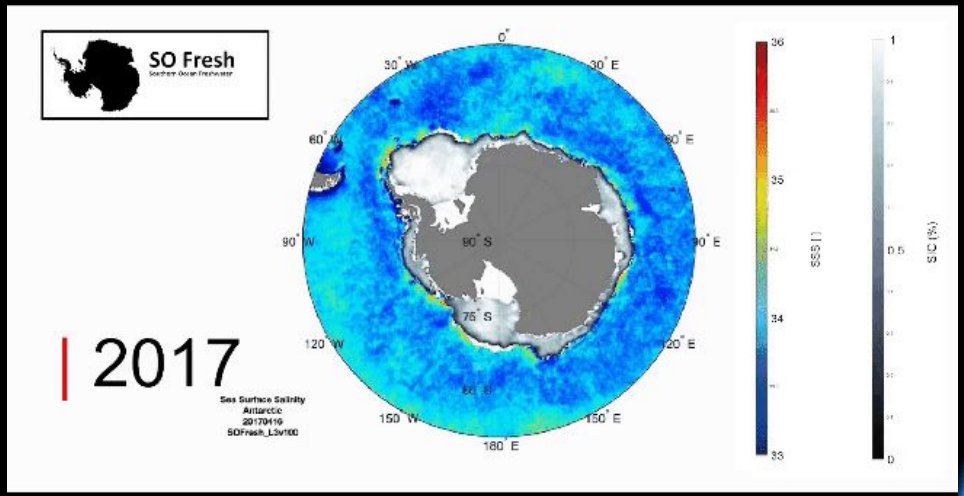
- **Algorithm developments** were specially focused on the **quality improvement close to ice edges**.
- The **performance assessment** of the **SO-FRESH L3 SSS product** shows:
  - a very high performance far from the ice edge (null bias, ~0.17 psu of std.dev.),
  - considering 200 km far away from the ice edge, bias is in the order of ~0.05 and std.dev. ~[0.2-0.39],
  - a proper description of the Antarctic Circumpolar Current,
  - where there's freshwater near the ice,
  - a consistent seasonal and interannual variability with the regional SOSE model,
  - sometimes, in the first 100-200 km of the ice edge, the satellite detects saltier levels than in situ measurements
- **SO-FRESH L3 SSS product has been shown to be useful**
  - To gain a deeper **understanding** of the **mechanisms driving the decline in sea ice extent** in the recent years
  - To improve the understanding of the drivers of **polynyas formation**.

Way forward

- **Reduce the SSS uncertainty very near the ice edges** to at least 0.5 (ultimate goal: 0.1)
    - Fusion with other ocean scalars, such as the surface temperature
    - Synergies with other sensors
- **Assimilate EO SSS data to improve the quality of the models** in the Southern Ocean
- **Ensure the continuity of the satellite SSS time series**, crucial to understand drivers of the very recent changes
    - Continuity of high-resolution L-band missions is crucial

Satellite Sea Surface Salinity products for better understanding freshwater fluxes in the Southern Ocean

https://doi.org/10.20350/digitalCSIC/15493



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