A New High-Resolution Sea Surface Salinity Product for the Southern Ocean

We are pleased to announce the publication of the new dedicated **Level-4 SMOS Sea Surface Salinity (SSS) product** (and its uncertainty) **for the Southern Ocean** with an unprecedented **6.25 km resolution**. This new development was carried out within the framework of the H2020 EU **CRiceS project** (AO/1 –10461/20/ I–NB, grant no. 101003826).

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The new product has the following specifications:

Geographical coverage	180◦ W – 180◦ E; 30◦ S – 90◦ S
Temporal coverage	2011-02-01 to 2023-03-31
Spatial resolution	6.25km x 6.25km
Coordinates reference	EASE-SL 6.25km
Temporal resolution	Daily
DOI	https://doi.org/10.20350/digitalCSIC/17709

What is this new product?

The product is created by **fusing**:

- **SMOS SOFRESH Level-3 SSS data** (https://doi.org/10.20350/digitalCSIC/15493)
- **MUR SST** daily fields

This multiscale fusion method allows us to resolve much finer ocean structures than SMOS alone following the methodology described in Umbert et al. [2014] and Olmedo et al. [2016].

The MUR SST product (Chin et al. [2017]) from the JPL MUR MEaSUREs Project is used for the template in the fusion algorithm. This product provides a Level-4 Global Foundation Sea Surface Temperature Analysis. This SST product is originally provided at a resolution of 0.01º × 0.01º . Therefore, before applying the fusion algorithm, we performed a regridding to the final EASE grid at 6.25 km × 6.25 km.

Validation assessment

Validation has been performed against many in situ datasets by using the Pi-MEP platform. The statistics reveal clear differences in performance across the various in situ platforms. Argo exhibits the lowest dispersion (Std = 0.18 psu, RMS = 0.18 psu) and the highest R^2 (0.40), confirming it as the most consistent reference for SMOS, with negligible median and mean differences. Marine mammals show similarly small biases (Median = 0.00 psu), but slightly higher dispersion (Std = 0.25 psu) and lower correlation (R^2= 0.08), reflecting their operation in dynamically active frontal regions. See figures 1 and 2 below.

Why does it matter?

The Southern Ocean plays a key role in global climate, ocean circulation, and atmosphere– ocean exchanges. High-resolution SSS helps to:

- Identify freshwater inputs and mixing
- Improve ocean and climate model validation
- Resolve small-scale fronts and filaments

The new **L4 SSS Southern Ocean product** represents an important step forward in observing salinity at high resolution in a region where data are scarce. It will support research on ocean dynamics, sea-ice interactions, and climate processes.Data is freely available at BEC Data system and open to users in secure ftp (sftp) service in bec.icm.csic.es/data-access-ftp/.


Figure 1: Validation statistics against ARGO floats data


Figure 2: Validation statistics against Marine Mammals CTD measurements

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New release of the SMOS SSS product for the Arctic region

We are pleased to announce the publication of the **new** dedicated **Arctic Ocean SMOS Sea Surface Salinity (SSS)** products produced at BEC (DOI: https://doi.org/10.20350/digitalCSIC/16251). This new SMOS **(v4)** data set has been created under the **ESA ARCTIC+SSS CCN project** (contract Nº 4000125590/18/I-BG).

The retrieval of satellite SSS in polar regions is challenging due to several technical difficulties, such as the low sensitivity of L-band radiometry to salinity on cold waters, the contamination of the radiometric signal close to sea ice and the scarcity of in-situ measurements, which limits the validation of the new products .

In this context, we have developed algorithm improvements from the level 0 to level 3 for the generation of this dedicated SSS product. The main improvements are:

- to use the Nodal Sampling technique (González-Gambau et al., 2016) to avoid contamination close to ice edges (allowing the reduction of the radiometric errors very significantly),
- modification of the Debiased non-Bayesian retrieval method (Olmedo et al., 2017) to correct systematic biases as a function of the distance to sea ice, and
- the annual reference has been modified to WOA2023.

This product has been extensively validated through the comparison to in-situ measurements from Argo, drifters, ICES data, marine mamals, thermosalinographs on board opportunity ships and other in situ measurements available in the Pi-MEP platform (Salinity Pilot-Mission Exploitation Platform). The validation of BEC ARCTIC v4 SSS results in: (i) the spatial and temporal variability is consistent with those of in situ datasets with an RMS between 0.3 and 0.7 psu depending on the region, (ii) there is an improvement on RMS (of about 20-25%) and correlation versus the previous version (BEC ARCTIC v3.1) , being more significant nearer than 100 km from ice edges and coast, (iii) there is a significant increase (about 30-40%) on the number of retrievals near the ice edges, (iv) the product describes more properly the freshwaters from rivers runoff.

This product has been shown to be suitable for understanding rapid changes in the last years in the Arctic and to compute the freshwater content and fluxes in the region.

Please, be aware we will keep the former version in our sFTP for 3 months, then it will be discontinued and available on request to smos-bec@icm.csic.es.

New paper on a machine learning based methodology to retrieve Arctic sea ice thickness from SMOS measurements

Exciting News!

We are thrilled to announce the publication of a new paper titled "**A Machine Learning Approach on SMOS Thin Sea Ice Thickness Retrieval**" in the **IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing** (10.1109/JSTARS.2024.3406921). This research is part of the ARCTIC-MON project and an industrial PhD collaboration with isardSAT.

Monthly average of the predicted sea ice thickness, compared to the ESA's official product.

In this study, we developed a novel approach to enhance existing SMOS thin sea ice thickness products. To address the scarcity of in situ data in the Arctic, we created a training dataset through a **model-based** simulation. This dataset was then used to train two **machine learning** algorithms—random forest and gradient boosting—resulting in a **hybrid** approach.

Processing of the variables used as inputs to predict the sea ice thickness.

Our methodology shows strong agreement when compared with ESA's official product. Furthermore, validation with in situ data from moorings in the Beaufort Gyre indicates **better** correlation and **reduced** error, highlighting the **potential** of this methodology to improve current products.

While there is still room for improvement, which we are actively working on, we plan to make this product **operational** and publicly **available**. Stay tuned to **BEC** for more updates!

New dedicated SSS product for the Southern Ocean

We are pleased to announce the publication of the **first** dedicated **SMOS Sea Surface Salinity (SSS)** products for the **Southern Ocean** produced at BEC (https://doi.org/10.20350/digitalCSIC/15493). These new SMOS Sea Surface Salinity products specific for the Southern Ocean have been created under the **Southern Ocean Freshwater (SO-Fresh) ESA project** (contract AO/1-10461/20/l-NB).

The retrieval of satellite SSS in this region is a grand challenge due to several technical difficulties, among them: (i) the contamination of the radiometric signal close to sea ice, (ii) the low signal-to-noise ratio of SSS due to the low sensitivity of L-band radiometry to salinity on cold waters and (iii) the reduced variability of SSS in the SO, which implies that more accurate retrievals are needed over the Southern Ocean.

In this context, we have developed algorithm improvements from the level 0 to level 3 for the generation of this dedicated SSS product, mainly focused on the aspects highlighted above. In particular, we have adapted the Nodal Sampling (González-Gambau et al., 2016) to avoid contamination close to ice edges, allowing the reduction of the radiometric errors very significantly and we have modified the Debiased non-Bayesian

retrieval (Olmedo et al., 2017) to correct systematic biases in salinity as a function of the distance of the measurement to sea ice. In addition, a dedicated study has been performed to select the best sea surface temperature product over the region to be used in the SSS retrieval.

This product has been extensively validated through the comparison to in-situ measurements from Argo, Astrolabe and in situ measurements provided by marine mammals and the Barcelona World Race and Vendée Globe regatta. The use of these in situ databases has allowed a global analysis but also a seasonal analysis and as a function of the distance to the ice edge. The SO-FRESH SSS product shows:

- a very high performance far from the ice edge (null bias and ~0.17 psu of STD),
- a proper description of the Antarctic Circumpolar Current,
- where there's freshwater near the ice, but sometimes the satellite detects saltier levels, especially within the first 100 kilometers of the ice's edge
- a seasonal and interannual variability consistent with the variability shown by the model GLORYS.

Therefore, this product has been demonstrated to be suitable for understanding rapid changes in recent years, encompassing ocean warming, freshening, reduced sea ice extent, and the emergence of the offshore Weddell Polynya, characterized by ice-free areas within the sea ice zone.

More information about how to access the data and its metadata can be found in the SO-FRESH Product User Guide. Please, do not hesitate to contact us in case you have any questions or comment at smos-bec@icm.csic.es. Your feedback is most welcome!

2024 OCEAN DECADE SATELLITE EVENT – MONITORING THE OCEAN

Join us in Barcelona, April 8th 2024!

BEC, PTI-Teledetect and GHRSST are pleased to invite you to an **official satellite event to the UN Ocean Decade Conference**. The objective of this satellite event is to draw attention of policymakers to the need for high-resolution observations and continued in-situ observations for monitoring the ocean health and its impact on the Earth system.

The agenda of the event will include two elements:

- **Panel discussion**: experts in the panel will unpack: the importance of newly launched high-resolution satellite missions, in-situ observations for ocean monitoring, how models can be improved with new data from in-situ and satellites, how models can be used for impacts, and how supercomputers can help modelling and the next challenges of high performance computing. More details on the agenda coming soon.
- **Photo Exhibition of fieldwork/satellite** images from monitoring the ocean and **Social Event** on the ICM terrace

Register for the event here by 29 March 2024!

New release of BEC SMOS soil moisture products

We are pleased to announce that all SMOS soil moisture products have been reprocessed based on the last versions of the ESA SMOS data, particularly the v724 for the L1C brightness temperature and v700 for the L2 soil moisture.
The new BEC SMOS L3 soil moisture v4.0 at 25 km significantly improves the accuracy of the soil moisture data over most of the globe compared to its previous version. Moreover, the current L3 files include also the vegetation optical depth (VOD) retrieved alongside, in addition to the global soil moisture.

Temporal extension of the current global BEC L3 and L4 SSS products

We are pleased to release the **temporal extension** of the **current global BEC L3 and L4 SSS products** for the period **January 2020 to May 2021**. This new release has been created as part of the European Marine Observation and Data Network Physics (EMODnet Physics) project – EASME/EMFF/2020/3.1.11/Lot4/SI2.838612.

The new time series comprises almost 11 years (2011- mid 2021). A detailed explanation of the algorithm can be found in Olmedo et al. 2021. The performance of the new products for the years 2020 and 2021 when compared with Argo floats are included in the updated BEC Global SSS Products Description .

Please, do not hesitate to contact us in case you have any question or comment at smos-bec@icm.csic.es. Your feedback is most welcome!

Enjoy the products!

The BEC team
http://bec.icm.csic.es

New Black Sea SMOS-derived Colored Detrital Matter (CDM) product

We are pleased to announce the publication of the experimental Colored Detrital Matter (CDM) derived from the regional SMOS Sea Surface Salinity (SSS) products for the Black Sea produced at BEC. This new experimental CDM product, specific for the Danube mouth, has been created under the funded ESA project ITT Earth Observation data for Science and Innovation in the Black Sea (EO4SIBS) (contract 4000127237/19/I-EF).

New Black Sea SMOS Sea Surface Salinity products

We are pleased to announce the publication of the first dedicated SMOS Sea Surface Salinity (SSS) products for the Black Sea produced at BEC. These new SMOS Sea Surface Salinity

products specific for the Black Sea region have been created under the funded ESA project ITT Earth Observation data for Science and Innovation in the Black Sea (EO4SIBS) (contract 4000127237/19/I-EF).

New Baltic SMOS Sea Surface Salinity products

We are pleased to announce the publication of the first dedicated SMOS Sea Surface Salinity (SSS) products for the Baltic basin produced at BEC. These new SMOS Sea Surface Salinity products specific for the Baltic region have been created under the funded ESA project ITT Baltic+ Salinity dynamics (4000126102/18/I-BG).