Sea Surface Salinity from SMOS satellite: complementarity to in situ observations

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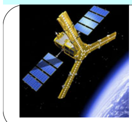
INTRODUCTION



The ESA/SMOS (European Space Agency/Soil Moisture and Ocean Salinity) satellite mission has been successfully launched in November 2009. We review here the present status of SMOS SSS retrieved with the most recent processings:

- Along track SSS retrieved from 2011 ESA reprocessing v500 (delivery of full SSS archive foreseen in February 2012)
- Mapped SSS retrieved from CATDS (Centre Aval de Traitement des Données SMOS) French Salinity Expertise center (CEC-OS)

and give example of some oceanographic application foreseen with SMOS SSS.

Along Track Sea Surface Salinity from new ESA v500 processings (July 2010 month)

Major improvements with respect to previous versions are a decreased pollution by land and ice and decreased orbital and seasonal biases related to antenna temperature and to Sun corrections.

Given the bidimensional field of view of SMOS (Fig 1.), SSS along the satellite track is retrieved with a resolution of ~40km from the combination of more than ~100 brightness temperature (Tb) measurements of the radiometer allowing a simultaneous retrieval of SSS, wind speed and SST and their associated errors (Font et al., 2011).
The error on these non averaged 40km SSS is on the order of 1; nevertheless they allow to detect large SSS gradients like the ones linked to river discharge (see the signature of the Amazone plume on Fig. 2).

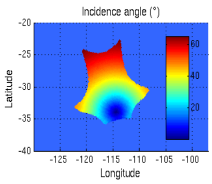


Fig. 1: SMOS Field of View (1200x1000km) and incidence angles

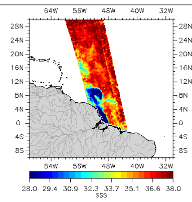


Fig. 2: Example of SSS retrieved along track (18 July 2010) showing the large freshening in the Amazone plume region

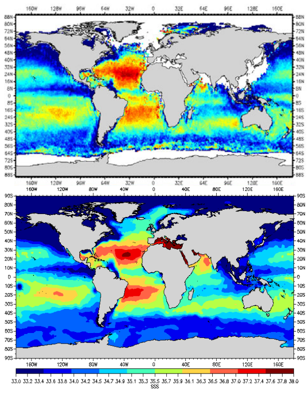


Fig. 3: top) Global SMOS SSS maps in July 2010 at 1° resolution (only conditions with wind speed between 3 and 12m/s and measurements at +/- 300km from the center of the swath are kept); bottom) SSS map derived from ARGO measurements (Gaillard et al., 2009). .

SMOS samples the global ocean after 3 days. Averaging over 10 days or 1 month makes the SSS precision to improve to 0.2-0.6 (preliminary results) with better precision in the warmest regions.
At global scale (Fig 3), while large oceanic features are well reproduced, blank areas (north Atlantic Ocean, Asiatic coasts, Mediterranean Sea) are due to bad consistency between SMOS Tbs along a dwell line and correspond mostly to regions affected by Radio Frequency Interferences (RFI). Some biases remain e.g. in the eastern Southern Atlantic Ocean along South African coast and close to ice in the Southern Ocean.
At regional scale, the rms error (=$\sqrt{bias^2 + std\_diff^2}$) between 10 day-100km SMOS SSS and ARGO SSS is 0.2 in a warm and non rainy region (Fig 4 top) and 0.4 in a rainy region (Fig 4, bottom). In the rainy region, the statistical distribution of the difference exhibits a slight negative tail, maybe the signature of a larger rain freshening closer to the surface (as seen by drifters, poster by Morrisset, Reverdin et al.).

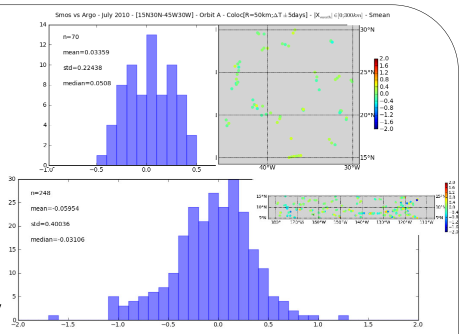


Fig. 4: SMOS SSS averaged over 10 day-100km compared with ARGO SSS measured between 5m and 50cm depth in July 2010. Top: north subtropical Atlantic Ocean (SPURS campaign region): 15N-30N; 45W-30W; Bottom: north tropical Pacific region (ITCZ region) : 5N-15N, 180W-110W.

SMOS Sea Surface Salinity from French CATDS-CEC OS

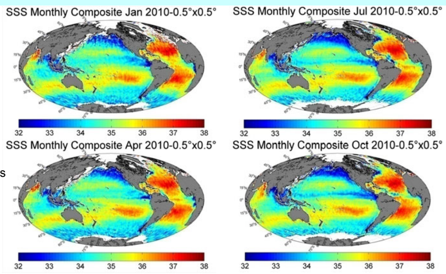


Fig. 5: Global SMOS SSS maps in January, April, July and October 2010 at 1° resolution (1O days resolution and 0.25, 0.5° resolution products also available) .

In order to identify the origin of the large biases observed on first versions of SMOS data, a simplified processor has been developed at the expertise center of Centre Aval de Traitement des Données SMOS (CATDS-CEC-OS). The whole 2010 year has been reprocessed. In order to sort out outliers linked to RFI, consistency checks based on yearly SMOS data have been performed before retrieving SMOS SSS. It leads to a better RFI sorting than ESA processing (e.g. less contamination in the eastern Southern Atlantic) and to less outliers in the Southern Ocean (Fig. 5 & 7). When comparing monthly 1° SMOS SSS with ships, ARGO and moorings in situ SSS performed at global scale, the rms error is <0.3 (Fig. 6); 0.25°-10day SMOS SSS compared with drifters SSS show rms error <0.4 in the open tropical Atlantic Ocean with larger differences in eddying regions linked to high SSS spatial variability.

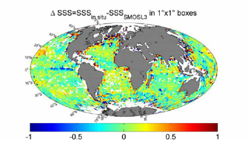


TABLE III: **SMOS LEVEL 3 1°X1°** MONTHLY COMPOSITE ΔSSS 95% PERCENTILE ERROR STATISTICS (PSS) OVER THE COMPLTE YEAR 2010

Statistics	Global Ocean	Arctic Ocean	North Atlantic	Tropical Atlantic	South Atlantic	North Pacific	Tropical Pacific	South Pacific	Indian ocean	Southern ocean
Mean	0.0060	1.6256	-0.0473	0.0698	0.0528	0.0132	0.0170	-0.0151	0.0279	-0.0266
Standard Deviation	0.2876	1.0250	0.5720	0.2775	0.2580	0.3046	0.2525	0.2095	0.2470	0.2559

Fig. 6 : In Situ SSS minus SMOS SSS (see statistics of the comparisons in the Table). Large biases in the equatorial Pacific are linked to inaccurate modeling of roughness effect using ECMWF wind speed only.

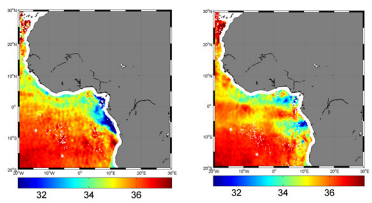


Fig. 7: SMOS SSS in the Gulf of Guinea in January 2010 (left) and May 2010 (right): SMOS SSS CEC-OS allows to follow the spread of fresh water associated with large river discharges, even in this region affected by RFIs.

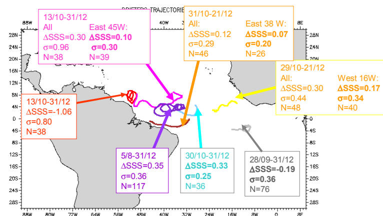


Fig. 8: SMOS SSS at 0.25°-10day resolution compared to drifters SSS (dayly means; large rain-freshening events removed).Far from coast and from eddying regions, the rms error remains <0.4.

SUMMARY AND PERSPECTIVES

New SMOS processings demonstrate the capability of retrieving SSS with a precision of ~0.3 on SSS averaged over 1° and one month after thorough filtering (e.g. RFIs). The advantage of an interferometer with respect to a real antenna radiometer is its large swath and its relatively high spatial resolution (~40km). In particular, fronts can be more precisely located. Using singularity analysis technique (Turiel et al., 2009), the Barcelona Expertise Center (BEC) has implemented a detection of SSS fronts which can complement and be improved from the detection of SST fronts (work in progress).
However the GODAE requirements (precision of 0.1-0.2 over 10 days-200km or 1 month-100km) are not fulfilled. Major improvements are expected from improved image reconstruction and direct modeling:
-SMOS is the first interferometer radiometer in space; a complicated image reconstruction process is necessary to retrieve brightness temperatures. Dedicated teams are working on improving this process.
-The modeling of the impact of roughness and scattered galactic signal onto L-band brightness temperature remain imperfect. Comparison of SMOS and Aquarius measurements should help refining this modeling.

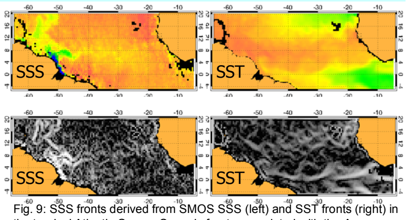


Fig. 9: SSS fronts derived from SMOS SSS (left) and SST fronts (right) in the tropical Atlantic Ocean. Oceanic fronts associated with the Amazon plume much better tracked from SSS fronts.

More details about along track SMOS ESA processing available on www.argans.co.uk/smos/, about LOCEAN/IPSL SMOS Cal/Val activities on www.locean-ipsl.upmc.fr/smos, about CATDS processings on http://www.catds.fr/, about BEC processings on http://www.smos-bec.icm.csic.es/.

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