Sea surface salinity observations from space with SMOS satellite: a new tool to better monitor the marine branch of the water cycle

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In the frame of the Salinity Processes in the Upper Ocean Regional Study (SPURS) project sponsored by NASA, the Ocean Surface Salinity (OSS) team, 1) performed a synoptic survey of the surface salinity in the subtropical North Atlantic, 2) in this area of interest, Sea Surface Salinity (SSS) monitoring is performed every month by ships of opportunity (Tocan and Collin). Here, we take advantage of this wide in situ SSS monitoring for validating the SMOS (ESA version 5) and AQUARIUS (version 2) SSS and evidence the gain of coverage and resolution of satellite product over in situ interpolated products (Argo, ISAS, WOA...).

2 - Saliinity Data

**SATELLITE SSS (level 3, monthly maps)**
- SMOS LEOCEAN derived from ESA LIOS v5 (wind-motol 1) SSS: SMOS LEOCEAN maps averaged over 0.25°x0.25°.
- SMOS OI: SMOS LEOCEAN 0.25° interpolated with similar method as the one applied to ISAS maps.
- SMOS CEC LEOCEAN: SMOS SSS (originally at ~43km resolution) maps are averaged over 100x100km² and oversampled every 0.25° (Boutin et al. 2013).
- SMOS IFREMER derived from ESA Level 1 product
- SMOS CEC IFREMER: SMOS-CATDS CEC IFREMER SSS maps, over a regular grid of 0.25° x 0.25°, with a daily 5° x 5° adjustment with respect to World Ocean Atlas 2001 climatology.

**AQUARIUS level 3 maps:** 2 products V2.0 and V2 CAP versions 1x1resolution in SITU SSS:
- Optimal Interpolation of ARGOS IFREMER In Situ Analysis System (ISAS) (Gallaud et al. 2009, DTCASA20 re-analysis, at ~5m depth) sampled at 0.5° but nominal resolved resolution of Argo area ~3°.
- SSS TSG (at ~5m depth) from Ships of Opportunity (Tocan, Colibri ship) from 2008 to 2011 and 2012 data from french ORCA.
- SSS thermosalinograph (TSG) from STRASSE campaign (08-09 2012).

![Fig 1: 14 transsects of TSG SSS](Image 6x3474 to 232x3596)

3 - Methods

**SSS seasonal variation in the SPURS region from SMOS and AQUARIUS is not well consistent with observations (Fig 2).**
Satellites do not retrieve properly the monthly and seasonal SSS values: on SMOS SSS (except CEC IFREMER adjusted to WOA), year to year consistent seasonal bias are detected (Fig 3).

In order to study the spatial variability of SSS, all datasets (SMOS and AQUARIUS) are corrected from a bias calculated for each month on the SPURS region, as following: bi = SSS - SSS0

![Fig 2: Averaged monthly salinity distribution on 0.25° grid between 2010 and 2012. Between 27°W and 27°E. The SSS values are observed due to a coastal effect on SMOS.](Image 23x437 to 862x755)

**Collocation SSS products with ship data: Level 3 SSS products at 0.25° (bilinear interpolation) are compared to TSG SSS, binned at 0.25°, except in Fig 10.**
Statistics are done during the overlapping period of SMOS and AQUARIUS. The region not affected by coast proximity was selected for statistics (green square): [50°W-27°W, 15°N-35°N].

4 - Mesoscale features

**SSS spatial anomalies in each product have been computed removing the monthly climatological ISAS maps (coloured in pink maps).**

**SMOS and AQUARIUS show higher SSS signal and smaller scales than in ISAS and SMOS OI product.**

**SMOS SSS and AQUARIUS SSS anomalies are significantly correlated with TSG SSS anomaly:** r² SMOS = 0.39, r² AQUARIUS = 0.23

**Despite a high noise level, it suggests that mesoscale features present in TSG ships are retrieved in satellite product.**

**At 1° resolution grid, after filtering TSG SSS at 300km (as interpolated products), SMOS OI have better correlation than ISAS:** r² SMOS = 0.34, r² ISAS = 0.28

**SMOS also more accurate than ISAS at 300km resolution, likely due to a better coverage of the SSS measurements.**

Example: In south western zone of SPURS area (red square, Fig. 7 and 9) SMOS and AQUARIUS retrieved better SSS because lack of ARGO data in this area.

**Satellite products better reproduce SSS mesoscale variability than interpolated in situ data.**

**SSS variability at scales of several hundreds of km is at first order consistent between SMOS, AQUARIUS and ISAS, but seasonal biases on satellite SSS first need to be corrected. After correction, the calculated RMSE of SMOS CEC LEOCEAN, AQUARIUS V2CAP and ISAS in respect to 14 transsects of SSS TSG from 09-2011 to 12-2012 was corrected to be 0.14. Global correlation coefficient was estimated to be 0.93.**

**Satellite products better reproduce SSS mesoscale variability (around ~100 km) than interpolated in situ data. SMOS performs better than AQUARIUS.**

5 - Conclusion

Sea surface salinity as detected by SMOS, AQUARIUS and by in situ sensors: In and around the SPURS / STRASSE experiment

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**Table 1:** Statistics of TSS in ISAS, SSS ISAS and AQUARIUS from (1) TSG, (2) ISAS, (3) AQUARIUS.

![Fig 5: Scatter plot of SSS SMOS CEC LEOCEAN versus ship SSS](Image 23x437 to 862x755)

**SSS maximum present a seasonal cycle, moving north from south to spring (Fig 6) from about 0.9°. In longitude, no seasonal cycle is observed.**

**Collocation of all SSS products with TSG SSS:**

![Fig 6: Position of the isopycnal (top) and isohaline (bottom) of the barycenter of the sea surface salinity maximum for SMOS, ISAS and AQUARIUS V2CAP](Image 23x437 to 862x755)

Visibility is impacted by the ESA SMOS+DIS (OSUG/SMOS) project. It is part of the ESA-SMOS/OLCI, Carbon and Biodiversity and Marine Biodiversity projects. The information in this database was collected, evaluated, and made available by CNES. The surface salinity dataset derived from thermostalinographs integrated for geostationary and polar-orbiting satellite data was collected, validated, evaluated, and made available by ISAS. The SMOS and AQUARIUS V2 CAP version were obtained from the Physical Oceanography Distributed Active Archive Center (PODAAC) provided by NASA's National Laboratory, Pasadena, CA, USA (http://podaac.jpl.nasa.gov).

**References**

