Error Characterization of Sea Surface Salinity Products using Triple Collocation Analysis

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Abstract:

The monitoring of the global distribution of sea surface salinity (SSS) is vital to understand the ocean's role in the Earth's climate. Until the advent of the spaceborne L-band radiometers, SSS observations were mainly acquired by *in-situ* sensors (moored buoys, drifters, and thermosalinographs). As a result, knowledge of the spatial and temporal variability of salinity has been scarce due to the lack of a comprehensive set of salinity observations. While *in-situ* data (e.g., Argo floats) were being used in a growing number of studies, numerical models were also widely used as a complementary source of such information. The spatiotemporal resolution achieved by satellite salinity measurements has no equivalent among the other existing salinity observations systems. Since the launch of the Soil Moisture and Ocean Salinity (SMOS) mission (2009) and then the Aquarius mission (2001), more than seven years of satellite-derived SSS data, with a spatial and temporal resolution adequate for climate and ocean general circulation studies, have become available. The L-band radiometers onboard SMOS and Aquarius have proven to be challenging and various spatial and temporal averaging and data fusion techniques have been implemented to better recover structured and meaningful geophysical information from remote sensing SSS retrievals. A comprehensive validation is therefore essential to characterize the information provided by the different salinity products.

	TA09 (TS09)	***TA13 (TS13)***	***TGA (TGS)***	***TAS***
Representativeness error (r^2)	0.034 (0.020)	0.027 (0.011)	0.009 (0.023)	0.015

Table 1: Representativenesse error (r^2) for the following triplets : TAO-AV4-WOA09 (TA09) and TAO-SOA-WOA09 (TS09) denoted as T-09 ; TAO-AV4-WOA13 (TA13) and TAO-SMOS-WOA13 (TS13) denoted as T-13 ; and TAO-GLORYS2V3-AV4 (TGA) and TAO-GLORYS2V3-SOA (TGS) denoted as TG- ; and TAO-AV4-SOA.

The triple collocation (TC) technique allows the simultaneous calibration of three independent, collocated data sources, while providing an estimate of their accuracy. Here, the TC is adapted to validate different salinity data products along the tropical band. The representativeness error (i.e., the true variance resolved by the relatively high-resolution systems but not by the relatively low-resolution system) is accounted for in the validation process. A method based on the intercalibration capabilities of TC is used to estimate the representativeness error for each triplet. Such error (see Table 1) is found to impact between 15% and 50% the total error estimation of the different products (see Tables 2 and 3). The method also sorts the different products in terms of their

resolving spatiotemporal scales. This calibration study is limited to the year 2013, a year when all the products are available.

The six salinity products used in this study are: the *in situ* data from the Global Tropical Moored Buoy Array (TAO) available at https://www.pmel.noaa.gov/; the GLORYS2V3 ocean reanalysis output (from NEMO version 3.1) provided by Copernicus; the climatology maps provided by the World Ocean Atlas 2009 (WOA09) and 2013 (WOA13); and the satellite-derived SSS maps from Aquarius Level 3 version 4 (AV4) available at ftp://podaac-ftp.jpl.nasa.gov/allData/aquarius/L3/mapped/ and the Soil Moisture and Ocean Salinity (SMOS) objectively analyzed (SOA). The SOA product correspond to the Objective Analysis product distributed by the Barcelona Expert Center (http://bec.icm.csic.es/).

Errors at AV4 scale

SSS measurement	***TAO***	***GLORYS2V3***	***AV4***	***SOA***	***WOA13***	***WOA09***
Standard deviation error	0.178	0.175	0.167	0.244	0.290	0.314

Table 2: Estimated Standard deviation errors of the different salinity measurements at AV4 scales.

Errors at SOA scale

SSS measurement	***TAO***	***GLORYS2V3***	***AV4***	***SOA***	***WOA13***	***WOA09***
Standard deviation error	0.218	0.208	0.211	0.204	0.257	0.293

Table 3: Estimated Standard deviation errors of the different salinity measurements at SOA scales.

This validation approach aims to assess the quality of the different salinity products at the satellite-resolved spatiotemporal scales, i.e., those of AV4 (see Table 2) and SOA (see Table 3). The results show that the resolved scales of SOA are coarser than those of AV4. At the AV4 resolved scales, the Aquarius product (AV4) has an error of 0.17, and outperforms TAO, GLORYS2V3, and the SOA maps. However, at SOA resolved scales, the SMOS product has an error of 0.20, slightly lower than that of GLORYS2V3, AV4 and TAO. The WOA products show the highest errors. High order calibration may lead to a more accurate assessment of the quality of the climatological products.

Reference:

N. Hoareau, M. Portabella, W. Lin, J. Ballabreray-Poy and A. Turiel, “Error Characterization of Sea Surface Salinity Products Using Triple Collocation Analysis”, *IEEE Trans. Geoscien. Remot. Sens.*, in press, 2018, doi:10.1109/TGRS.2018.2810442.