Observing System Simulation Experiments with SWOT into HYCOM+RODAS over the Southwest Atlantic

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INTRODUCTION

The Surface Water and Ocean Topography (SWOT) mission will generate a large amount of new altimetric data with high horizontal resolution, probably from July 2024 on. This new data will contain errors different from those of the 1-D data obtained by conventional satellites. Thus, all data assimilation systems, particularly those employed in operational systems, should be adapted to assimilate SWOT data and tested in advance.

A well-known way to carry out these tasks is with Observing System Simulation Experiments (OSSEs). In the present work, the impact of SWOT synthetic data will be investigated with OSSEs employing the Oceanographic Modeling and Observation Network (**REMO**) data assimilation system, called RODAS, and the Hybrid Coordinate Ocean Model (HYCOM).

A version of **HYCOM+RODAS** runs operationally in the Brazilian Navy Hydrographic Center (CHM) since 2015 in support of activities of the Brazilian Oil Company Petrobras, the Brazilian Navy, OceanPredict, and others.

OSSEs were performed over the Southwest Atlantic (11°S-34°S, west of 32°W) considering 1 and 2 SWOTs. SWOT data was produced using the 2021 version of the Gaultier et al. (2017) code.

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DATA AND METHODS

Synthetic Data

- A free run from the Regional Ocean Modeling System (**ROMS**) with 1/24° of horizontal resolution and 32 vertical levels was employed as Nature Run and to offer data for the OSSEs.
- Sea Surface High (SSH) (SWOT and conventional satellite data) were generated using the simulator by Gaultier et al. (2017).
- Sea surface temperature (SST) and Argo T/S profiles also retrieved from ROMS.

HYCOM

- The HYCOM version 2.2.18 was used with 1/24° of horizontal resolution and 32 vertical layers covering a region in the southwest Atlantic (32°W – 54°W, 11°S – 34°S)
- The model was nested in a HYCOM configuration with 1/12° of horizontal resolution and 32 vertical layers covering a region in the Atlantic region 20°W – 60°W, 45°S – 10°N) which was nested in a HYCOM run covering the whole Atlantic Ocean
- All runs were forced with CFSR NCEP/NOAA reanalysis atmospheric fields each 6 h.

The REMO Ocean Data Assimilation System RODAS

- RODAS employs the EnOI scheme, based on the equations (Evensen, 2003):

$$X^a = X^b + K(Y - HX^b)$$

$$K = \alpha(\sigma \circ B)H^T[\alpha H(\sigma \circ B)H^T + R]^{-1}$$

$$B = \frac{A'A'^T}{(N-1)}$$

OSSEs

Three experiments with assimilation each 3 days were performed in 2011 and 2012 using 126 ensemble members, in addition to the HYCOM **FREE** Run:

1. **NO SWOT**: assimilation of SST, "Argo" T/S and along-track SLA data
2. **SWOT:** including assimilation of 1 SWOT data
3. **2 SWOTS**: including assimilation of 2 SWOTs data

RESULTS

ROMS Nature Run

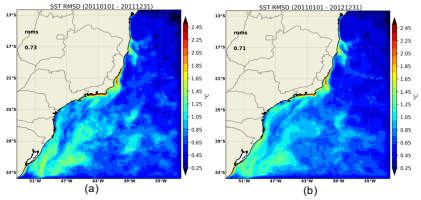

Fig. 1. SST RMSD (°C) between ROMS and OSTIA UK MetOffice for (a) 2011 and (b) 2012.

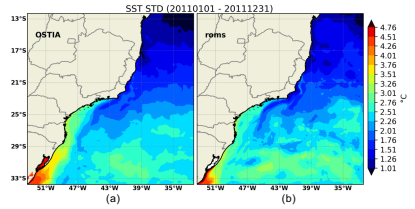

Fig. 2. SST standard deviation (°C) according to (a) OSTAI and (b) ROMS during 2011.

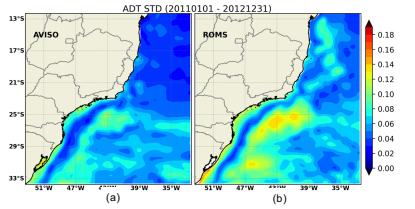

Fig. 3. SSH standard deviation (m) according to (c) AVISO and (d) ROMS during 2011 and 2012

OSSEs

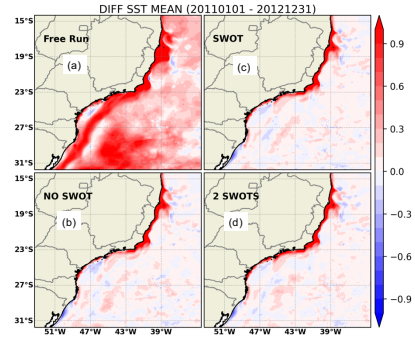

Fig. 4. SST mean difference (°C) (exp minus Nature Run) for (a) HYCOM Free Run, (b) NO SWOT, (c) SWOT and (d) 2 SWOTS during 2011 and 2012.

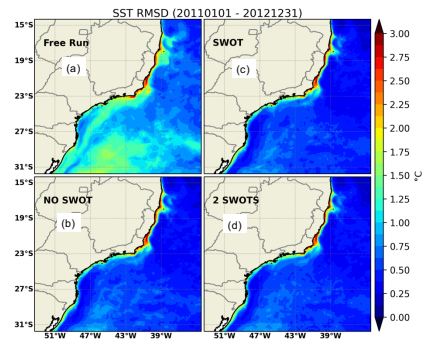

Fig. 5. SST RMSD (°C) with respect to the Nature Run for (a) HYCOM Free Run, (b) NO SWOT, (c) SWOT and (d) 2 SWOTS during 2011 and 2012.

RESULTS (Cont.)

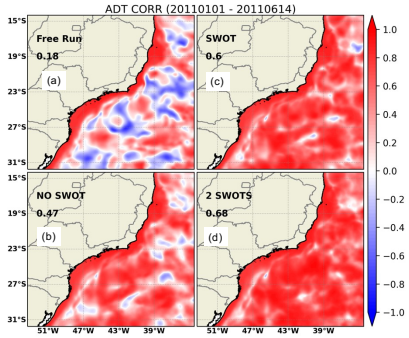

Fig. 6. SSH Correlation with respect to the Nature Run for (a) HYCOM Free Run, (b) NO SWOT, (c) SWOT and (d) 2 SWOTS from 1 Jan 2011 until June 14, 2012.

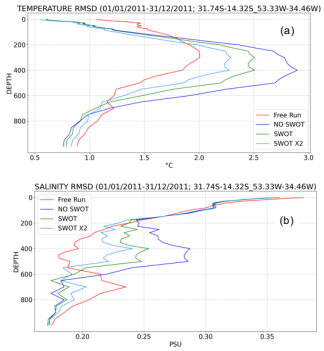

Fig. 7. RMSD of (a) T (°C) and (b) S (psu) with respect to the Nature Run for the Free Run (red), NO SWOT (dark blue), SWOT (green) and 2 SWOTS (light blue) from 1 Jan 2011 until 31 Dec 2011.

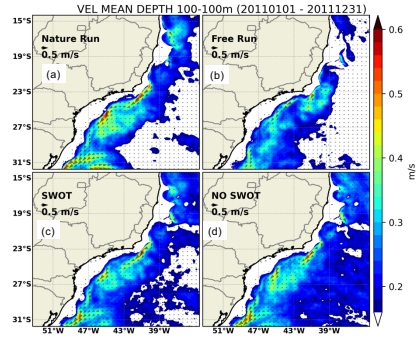

Fig. 8. 100 m depth mean currents (m/s) for (a) for the Nature Run, (b) Free Run, (c) SWOT, and (d) NO SWOT from 1 Jan 2011 until 31 Dec 2011.

CONCLUSIONS

- HYCOM+RODAS was adapted to assimilate the SWOT synthetic data.
- SST with and without SWOT maintained the same skill, i.e., SWOT data did not degrade SST analysis.
- The largest SSH correlation was attained with 2 SWOTS indicating a large potential of the new SWOT in improving the representation of mesoscale structures and their short-term predictability.
- The use of along-track data degraded T/S in the subsurface, but SWOT and 2 SWOTs reduced this degradation.
- In general, 2 SWOTS improved the solution with respect to NO SWOT and SWOT.

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Gaultier, L.; Ubelmann, C.; Fu, L.L. SWOT Simulator Documentation. 2017. Release 2.3.0. Jet Propulsion Laboratory, National Aeronautics and Space Administration. <https://github.com/SWOTsimulator/swotsimulator.git>.

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