# Assessing Impacts of Ensemble Kalman Filter (EnKF) on the Remo Ocean Data Assimilation System (RODAS) Over the South Western Atlantic

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## Introduction

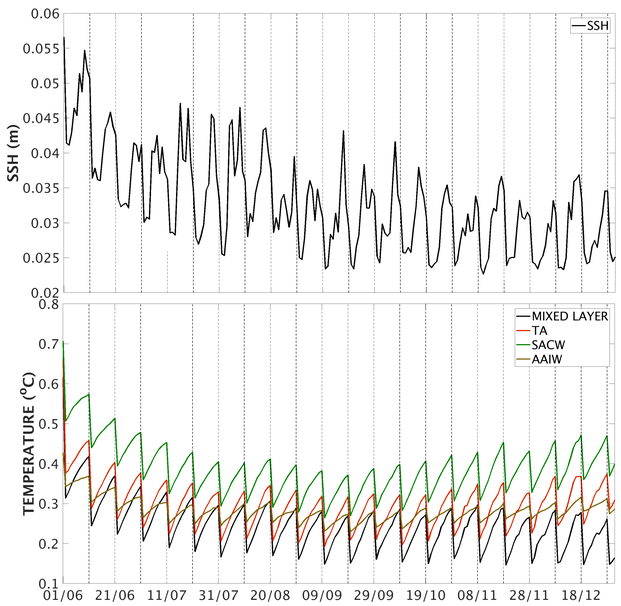
- The Oceanographic Modeling and Observation Network **(REMO)** Ocean Data Assimilation System **(RODAS)** employs Ensemble Optimal Interpolation **(EnOI)** and sequentially assimilates Absolute Dynamic Topography (ADT), Sea Surface Temperature (SST) and hydrographic temperature (T) and salinity (S) profiles into the Hybrid Coordinate Ocean Model **(HYCOM)**.
- This work presents preliminary results of a new version of RODAS that realizes a joint assimilation with the Ensemble Kalman Filter **(EnKF)**.

## Methods

- HYCOM was configured with **1/12°** of horizontal resolution and **32 vertical layers** over the Western South Atlantic. The model was forced on the surface by the Climate Forecast System (CFSv2).
- 1 June 2017 – 31 December 2017.
- Observations assimilated:
  - Gridded **ADT** from AVISO.
  - Gridded **SST** from OSTIA.
  - **TS profiles** from Argo, CTD and XBT.
- Radius of influence: **100 km.**
- Three experiments were performed for **seven months with assimilation cycle of ten days**:
  - **Control** with no assimilation.
  - **RODAS_EnOI** employing Ensemble Optimal Interpolation (EnOI). **α → 0.5.** Ensemble **126 members**.
  - **RODAS_EnKF** employing EnKF and **α → 1.05.**
    - Observations were perturbed considering its own error.
    - Forced with **perturbed atmospheric fields** created with anomalies from GEFS added to the CFSv2 atmospheric fields.
    - **11 members** initialized with different initial conditions from the free run selected from 2013 - 2016.
  - **RODAS_EnKF → Mean Run.**
  - **EnKF MEAN RMSD → Mean taken from individual RMSD for each member.**

## Results and Discussion

### RODAS_EnKF Ensemble Spread



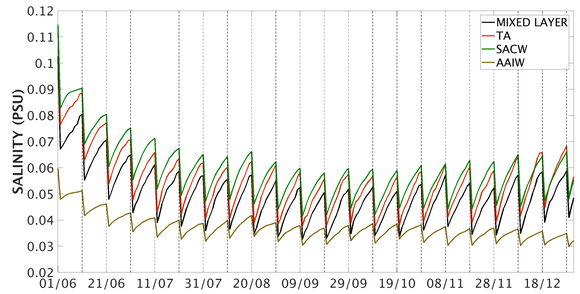
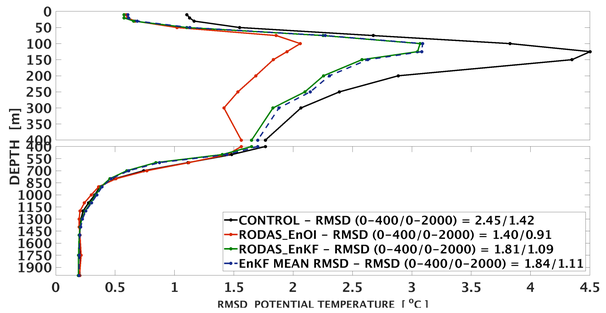




Fig. 1 - Ensemble spread for (a) SSH (m), (b) temperature (°C) and (c) salinity (PSU). Dashed lines represents assimilation day.

- Ensemble initially has a large spread which is reduced with about 7 assimilation cycles (07/31/2017) and then it maintains stable.
- Maximums occurs before assimilation (dashed lines) and minimums after assimilation.
- The temperature spread increase at the end of the experiment is probably associated with the southern hemisphere seasonal thermocline formation.
- The South Atlantic Central Water (SACW) has the largest spread as it contains the thermocline.

### RODAS_EnKF X RODAS_EnOI



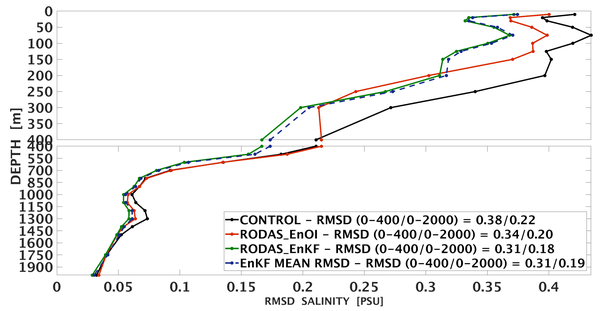




Fig. 2 – Temperature (°C) and Salinity (PSU) RMSD.

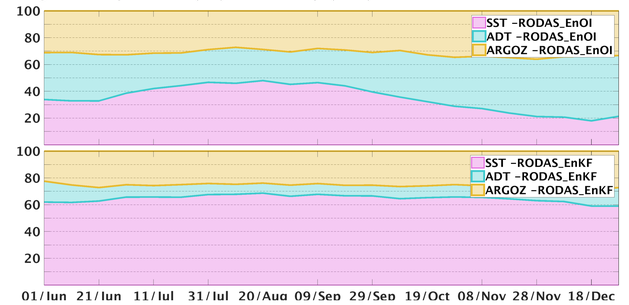
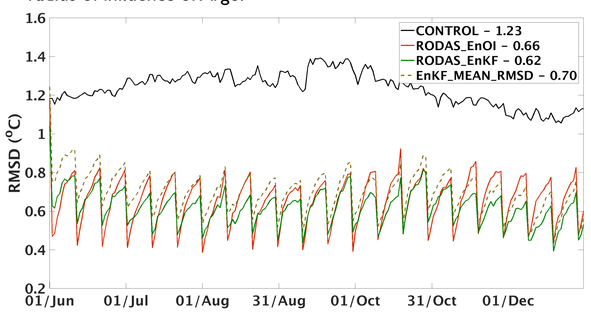



Fig. 3 – Analysis increment contribution (%) on the temperature of the SACW for each observation considering only model points inside radius of influence of Argo.



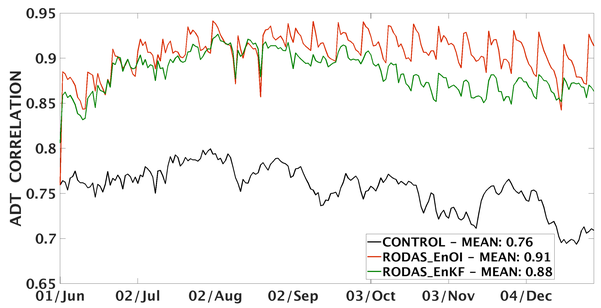




Fig. 4 – SST (°C) RMSD with respect to OSTIA and ADT (m) correlation with respect to AVISO.

- RODAS_EnOI and RODAS_EnKF reduced Control TS RMSD.
- RODAS_EnKF RMSD < EnKF Mean RMSD.
- RODAS_EnKF → Best salinity.
- RODAS_EnOI → Best temperature → 100 – 400 m.
  - Temperature analysis on deeper layers is greatly impacted by SST on RODAS_EnKF while for RODAS_EnOI is greatly impacted by ADT.
  - For RODAS_EnOI, seasonal thermocline formation during summer significantly changes how observations impacts on subsurface temperature.
  - This evidences the need to increase number of ensemble members for RODAS_EnKF.

- RODAS_EnOI and RODAS_EnKF reduced Control SST RMSD and increased Control SSH correlation.
- RODAS_EnKF RMSD < RODAS_EnKF Mean RMSD for SST.
- RODAS_EnKF → Best SST. RODAS_EnOI → Best ADT.
- SST RMSD minimums and maximums are observed on RODAS_EnOI.
  - RODAS_EnOI assimilation has a greater impact.
  - RODAS_EnKF preserves analysis quality longer.
  - Similar pattern observed for ADT.

- **EnKF was successfully implemented on RODAS.**
- **Still needs to increase number of ensemble members.**

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