SYMPOSIUM OP'24 ADVANCING OCEAN PREDICTION SCIENCE FOR SOCIETAL BENEFITS

SynObs UN Ocean Decade Project

Met Office

Theme 4

Evaluating observation impact in the Met Office 1/12th degree global ocean forecasting system

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Introduction

State of the art ocean forecasting systems require good quality, timely observations to produce accurate predictions of the ocean state. It is important that the ocean forecasting community assess the impact of observations in their systems to inform observation network design, to provide quantitative support for observing missions and to highlight deficiencies in the data assimilation methods. Observing System Experiments (OSEs) where observation are withheld from the forecasting system are commonly used to assess the relative impact of observations.

The Synergistic Observing Network for Ocean Prediction (SynObs) is a UN decade project. The SynObs Flagship OSEs are a coordinated set of observation withholding experiments using different ocean forecasting systems (Fujii et al; 2024). The OSEs allow us to evaluate the impact and synergy of different observation types in ocean forecasting systems. One of the participating systems is the Met Office 1/12th Forecasting Ocean Assimilation Model (FOAM, Barbosa Aguiar et al; 2024).

Here we present a first look at the results from Met Office OSEs which withhold altimeter and Argo observations. We verify the OSEs against independent Argo floats and independent drifter velocities

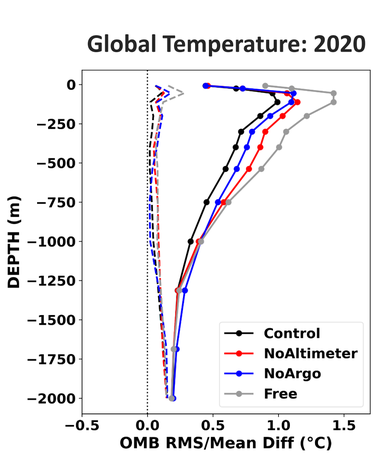
Observing system experiments

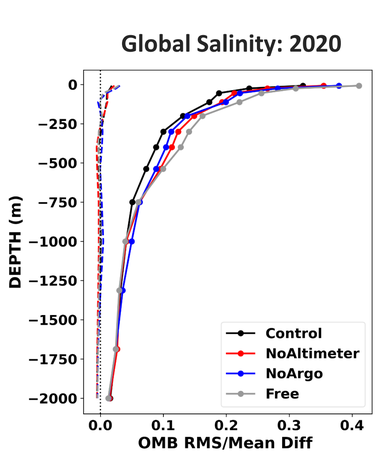
Experiments are run for 1 year in 2020 and were spun-up for the last 3 months of 2019 starting from a run which assimilated all standard obs types. In all experiments, 20% of Argo floats (those with IDs ending in 8 or 9) were withheld for independent assessment.

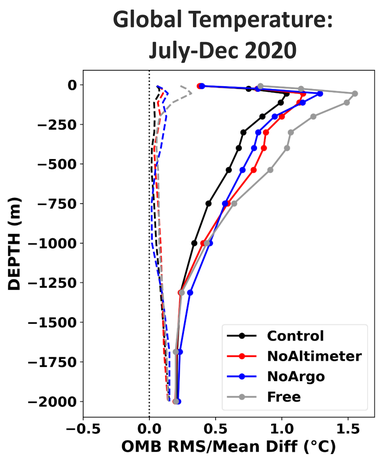
	Experiment description
Free	No assimilation
Control	All standard observations assimilated
NoArgo	Same as the control but all Argo withheld
NoAltimeter	Same as the control but all altimeter withheld

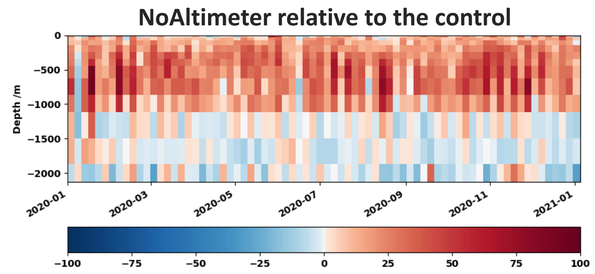
Assessment against independent Argo floats

The daily mean model analysis temperature and salinity fields were compared to non-assimilated Argo floats (floats with IDs ending in 8 and 9).

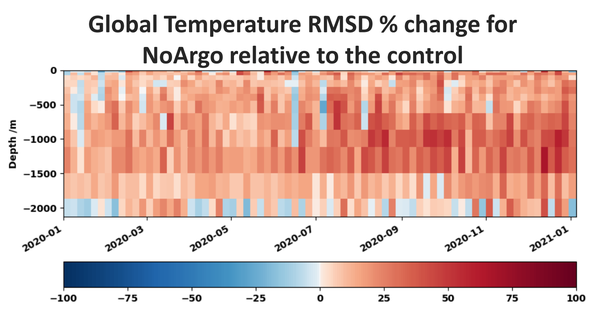








The profile results calculated over the full year show that withholding altimeter data has a larger impact on temperature RMSE between 200m and 1000m and salinity RMSE between 250m and 750m than withholding Argo observation. The Argo observations are more important for constraining the near surface and below 1000m. NoArgo produces worse results than Free below 1000m which highlights the difficulties of assimilating altimeter data without Argo data for the deep ocean.



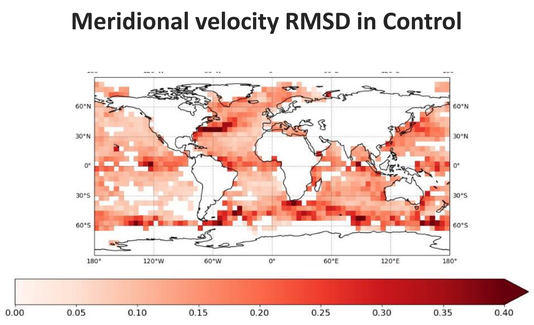
Hovmoller results show that the temperature RMSE is increasing between January and July in the NoArgo experiment, suggesting that the impact of withholding Argo data does not spin up for at least 9 months (there was an additional 3 month spin-up period).
The temperature profile results for July to December show that overall impact of NoArgo and NoAltimeter is similar for this later period.

FOAM system

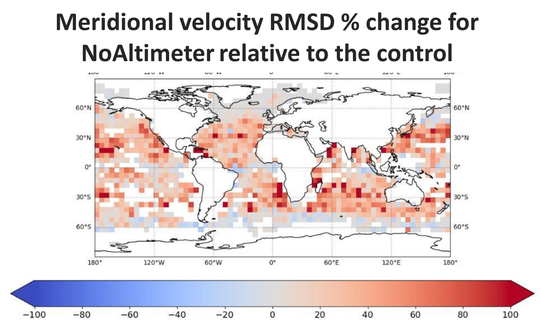
- NEMO 4.0 Ocean model, SI3 ice model (Mignac et al; 2024)
- 1/12th degree horizontal resolution, 75 vertical levels
- NEMOVAR data assimilation: 3DVAR FGAT with multivariate balance
- System assimilates in-situ salinity and temperature profiles, in-situ and level 2 satellite SST, level 3 altimeter SLA and level 3 satellite sea ice concentration.
- 24 hour assimilation window
- Assimilation increments are applied to the model during a 24 hour Incremental Analysis Update (IAU) step.

Assessment against drifter velocities

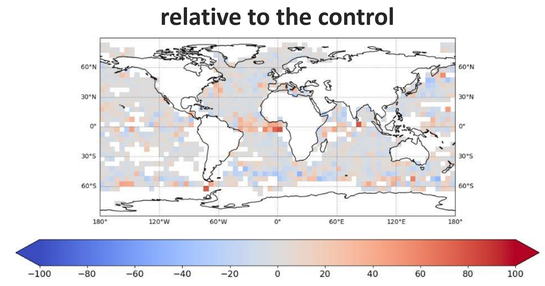
The daily mean model analysis velocity fields at 15m were compared to the CMEMS drifter velocity product. We calculated RMS of the obs-model differences on a 5x5 degree grid for whole year of 2020. Only grid boxes containing => 100 obs are plotted. Results for the meridional velocity are shown below, but similar results are found for zonal velocities.



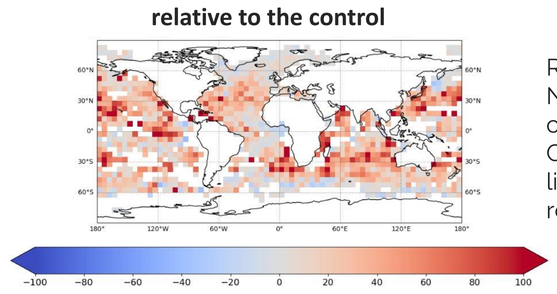
The meridional velocity RMSD in the control demonstrates that the largest 15m velocity errors occur in the Western Boundary currents, Atlantic circumpolar current and equatorial currents. In these regions the errors can exceed 40 cm/s.



When altimeter data is withheld, there is a substantial increase in the RMSD in the sub-tropics and mid-latitudes (between 5˚ N/S and 50 ˚ N/S). The multivariate balance in NEMOVAR uses geostrophy to produce balanced velocity corrections. The altimeter is crucial in correcting the geostrophic velocities in the Met Office system. We can see that the altimeter observations are not really constraining the velocity RMSD in the Antarctic Circumpolar region , which suggests that altimeter assimilation could be improved in this region.



Withholding Argo observation generally has a small impact on the velocity RMSD. However, we can see a region of increased RMSD in the Equatorial Atlantic which implies that Argo observations are constraining the velocities in this region.



Results from the free run are similar to the NoAltimeter experiment. We again see little change in the RMSD in the Antartic Cirumpolar Current, demonstrating the limitations of the data assimilation in this region.

Conclusion

We have provided some preliminary assessment of our OSEs investigating the impact of withholding altimeter and Argo observations in the Met Office global 1/12th degree system.
Our results emphasise the importance of altimeters for constraining both the near surface velocities and temperature and salinity down to 1000m.
The Argo data is particularly important for correcting the temperature at all depths below the surface layers (where SST data are abundant) and salinity at all depths. We can also see that the impact of withholding Argo takes a least 9 months to spin-up, accentuating the importance of running OSEs for at a least a 1 year period.
Additionally, these experiments highlight the potential for improving data assimilation impacts in FOAM in the Antarctic Circumpolar Current region.

References:
Barbosa Aguiar, A., et al., 2024. The Met Office Forecast Ocean Assimilation Model (FOAM) using a 1/12 degree grid for global forecasts. *Quarterly Journal of the Royal Meteorological Society, 150(763), 3827–3852.* https://doi.org/10.1002/qj.4798

Fujii et al; 2024. The international multi-system OSEs/OSSEs by the UN Ocean Decade Project SynObs and its early results. Front. Mar. Sci. 11:1476131. doi: 10.3389/fmars.2024.1476131.

Mignac et al; 2024. Updates to the Met Office's global ocean-sea ice forecasting system including model and data assimilation changes. Submitted to GMD.

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