A Sensitivity Study of Short-Range Forecasts over the Atlantic METAREA V with HYCOM and the Cooper and Haines Scheme Using Different Sea Surface Heights

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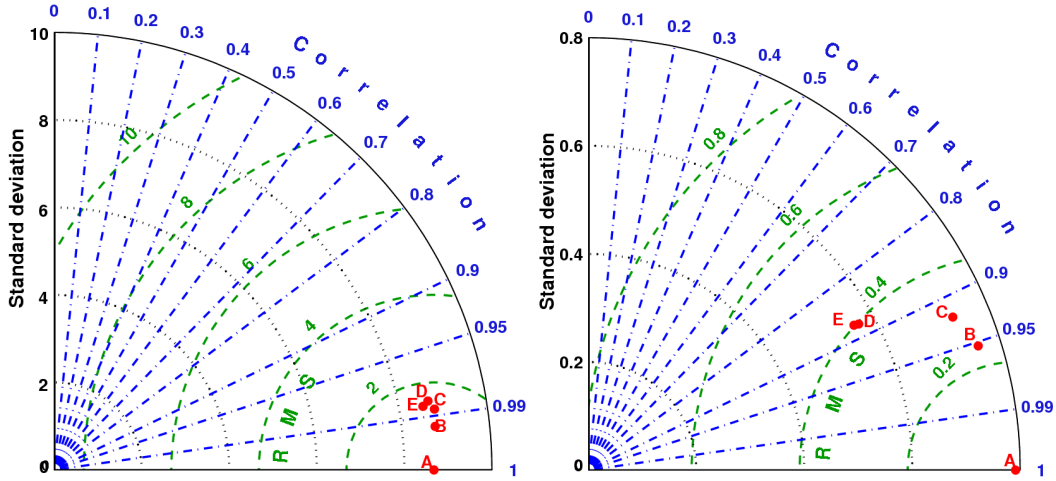
The Hybrid Coordinate Ocean Model (HYCOM) (Bleck 2002) is currently employed to produce operational short-range forecasts for the Atlantic Ocean METAREA V (36°S-7°N, 56°W-20°W) in the Brazilian Navy Center of Hydrography (CHM), under the Oceanographic Modeling and Observation Network (REMO). Two grids are employed. One with 1/12° of horizontal resolution for the region 45°S-10°N, 65°W-18°W containing the METAREA V, nested in a grid with 1/4° of horizontal resolution for the whole Atlantic Ocean. Both versions use 21 vertical hybrid-coordinate layers. The models are forced daily with the Global Forecast System (GFS) atmospheric forecasts from the American National Centers for Environmental Prediction (NCEP) to produce 7-day ocean forecasts. The initial condition is restrained only by sea surface height (SSH) via the Cooper and Haines (1996) scheme (C&H).

The goal of this work is to take different SSH fields and assess the 1/12° HYCOM predictability. Four experiments were carried out. In the first, EXP-NRL, the SSH given to C&H was from the global HYCOM+NCODA (Navy Coupled Ocean Data Assimilation) global system with 1/12° resolution from the American Naval Research Laboratory (NRL) (Chassignet et al. 2007, Cummings et al. 2009). In the second, EXP-ALONG_TRACK, along-track SSH anomalies (SSHA) from AVISO (Archiving, Validation and Interpolation of Oceanographic data) were assimilated with an optimal interpolation scheme taking as the background field the 24 h forecast. In the third, EXP-MERCATOR, SSH was given by the 1/4° global analysis of the Mercator-Ocean project. In the

fourth, EXP-CONTROL, a free model forecast without C&H was produced. All runs were nested in the 1/4° grid in which C&H was applied with SSH from the HYCOM+NCODA analysis. Seven-day forecasts from February 1 to March 31, 2010 were produced for all runs, leading to 60 7-day forecasts. The initial condition of all experiments on February 1, 2010 was constructed with temperature and salinity information from the HYCOM+NCODA analysis retrieved from the HYCOM Consortium home page. In the present work, only the skills of 24-h forecasts were assessed.

The forecasts were compared with 747 hydrographic profiles of temperature and salinity from surface until 2000 m collected by Argo drifters. Root mean squared errors, standard deviations and correlations were calculated to compare the results of the four experiments. The NRL-EXP experiment produced the closest averaged temperature profile to Argo data, with the highest correlation (0.99) and the smallest error (0.99^{o}C). Its standard deviation (8.76 °C) was very close to one found in the observational data (8.67°C), as seen in Figure 1a. The results also showed that the NRL-EXP produced the best representation of the salinity profile with the highest correlation coefficient (0.95), the smallest error (0.24 psu) and standard deviation (0.76 psu) also very close to the Argo data (0.79 psu), as seen in Figure 1b. Salinity forecasts below 600 meters were overestimated (not shown). The second best result was produced by the EXP-ALONG-TRACK, the third best by the EXP-MERCATOR and fourth best the EXP-CONTROL.

The results also indicate that the initialization on February 1, 2010 with HYCOM+NCODA information provided skills to all forecasts up to 60 days, including the control run in which no SSH correction was applied. Therefore, the current operational system will be eventually reinitialized with the HYCOM+NCODA temperature and salinity three-dimensional information to try to keep the model without drift. REMO forecasting systems are under development, particularly, with respect to ocean data assimilation. The daily use of C&H scheme – taking as input the SSH analysis from the HYCOM+NCODA system – will be maintained in the operational forecasts until a data assimilation system is not implemented.



(a) (b)

Figure 1. Taylor diagrams for (a) temperature and (b) salinity considering 747 vertical profiles of Argo data (A); EXP-NRL (B), EXP-ALONG-TRACK (C) and EXP-CONTROL (D). Units of errors and standard deviation for temperature and salinity are ^{o}C and psu, respectively.

References

Bleck, R.. 2002: An oceanic general circulation model framed in hybrid isopycnic-Cartesian coordinates. *Ocean Modelling*, **4**,:55–88.

Chassignet, E.P., H.E. Hurlburt, O.M. Smedstad, G.R. Halliwell, P.J. Hogan, A.J. Wallcraft, R. Baraille, and R. Bleck., 2007: The HYCOM (HYbrid Coordinate Ocean Model) data assimilative system. *Journal of Marine Systems,* **65**, 60–83.

Cummings, J., L. Bertino, P. Brasseur, I. Fukumori, M. Kamachi, M. Martin, K. Mogensen, P. Oke, C. Testut, J. Verron, and A. Weaver, 2009: Ocean Data Assimilation Systems for GODAE, *Oceanography*, **22** (3), 96-109.

Cooper, M. and K. Haines. 1996. Altimetric assimilation with water property conservation. *Journal of Geophysical Research*, **101**, 1059-1077.