Loop Current in Gulf of Mexico Hindcasts at Different Resolutions

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Introduction

Presently RTOFS (Real Time Ocean Forecast System)-Global (Mehra et al., 2015), an operational system at National Centers for Global Prediction (NCEP), produces daily ocean forecasts at 1/12° resolution in the global domain. RTOFS version 1.1's core uses the Hybrid Coordinates Ocean Model (HYCOM, Bleck 2002) at 1/12° resolution and 41 vertical hybrid layers coupled with the Los Alamos Community sea ICE (CICE) model. The model is initialized daily from analyses produced at the U.S. Naval Oceanographic Office (Metzger et al., 2014). RTOFS generates daily forecasts for 2 days in the past and 8 days in the future using NCEP atmospheric forcing.

The production at NCEP of daily ocean analyses by coupling RTOFS to the Navy Coupled Ocean Data Assimilation (NCODA) system (Cummings and Smedstad, 2013) is under development.

Simulations

We present results of daily analyses and 1-day forecasts produced for two model configurations. The first uses HYCOM+CICE cycled with NCODA 3Dvar on a Global 1/12° horizontal resolution domain, and the second uses HYCOM cycled with NCODA 3Dvar on a Gulf of Mexico 1/25° domain. The global domain uses 41 vertical hybrid layers, while the Gulf of Mexico domain uses 36 layers. Both simulations are initialized using the 1/12° NAVOCEANO hindcast valid on 31 January 2017. Daily NAVOCEANO hindcasts are used as nesting boundary conditions for the Gulf of Mexico high resolution (1/25°) model. The Gulf of Mexico simulation covers February-March 2017, while the global simulation is being advanced through 2017.

The simulations are forced with analysis quality forcing from the NOAA/NCEP Global Data Assimilation System (GDAS) for 2017.

Externally produced quality controlled data are used in this study to test the assimilation procedure, while the NCEP production of quality control (QC) ocean data is presently being developed for near real time. The observational data consists of the following: sea surface height (SSH) from the CryoSat, Jason, Sentinel, Altika altimeters; sea surface temperature (SST) retrievals from NOAA (18,19), and METOP (A,B); surface temperature from in-situ measurements (fixed and drifting buoys, ships); subsurface profiles of temperature and salinity from Argo, XBT, and CTD; and sea ice coverage from SSMI/S and AMSR2.

The 3D-VAR analysis is performed using a 24-hour update cycle with the analysis time centered on the update cycle interval. The observations are pre-processed using the following methods: altimeter sea surface height is incorporated using bi-monthly climatological relationships between SSH (dynamic height) and temperature and salinity at depth in the form of synthetic temperature and salinity profiles; SST observations are averaged to form super-observations to remove data redundancies using local correlation length scales; background error variances are computed from a 15-day time history of forecast differences using forecasts separated by a 48-hour time interval (twice the analysis update cycle). The NCODA analysis is done directly on the HYCOM horizontal grid (tri-polar for global, Mercator for Gulf of Mexico), and uses hybrid vertical coordinates valid at the analysis time.

The 3D-VAR analysis increments for temperature, salinity, velocity and layer thickness are incorporated into the forecast model using an incremental analysis update procedure. The global ice coverage analysis was incorporated through the CICE model. For the global domain, the analysis increments are inserted into the forecast model starting 3 hours earlier than the analysis time. The forecast is then issued from this balanced initial state.

Results

For the global simulation, SST and Argo float verifications show small biases; the RMS verification error of 0.5°C for SST and 0.85°C for Argo profiles are stable, with SST RMS error slightly increasing in the Northern Hemisphere summer. The global SSH for the end of July shows the main features of the ocean circulation (Figure 1).

For both resolutions, the Loop Current and extension position are in agreement with various SST analyses (NOAA-RTG, NOAA-AVHRR). The Gulf of Mexico 1/25°circulation develops a relatively more intense loop current (3-5Sv, not shown) than in the global simulation. The high resolution Gulf of Mexico simulation SST seems to reproduce the NOAA/AVHRR

SSTanalysis slightly better than the global simulation, as for the westward plume off the Loop Current (Figure 2).

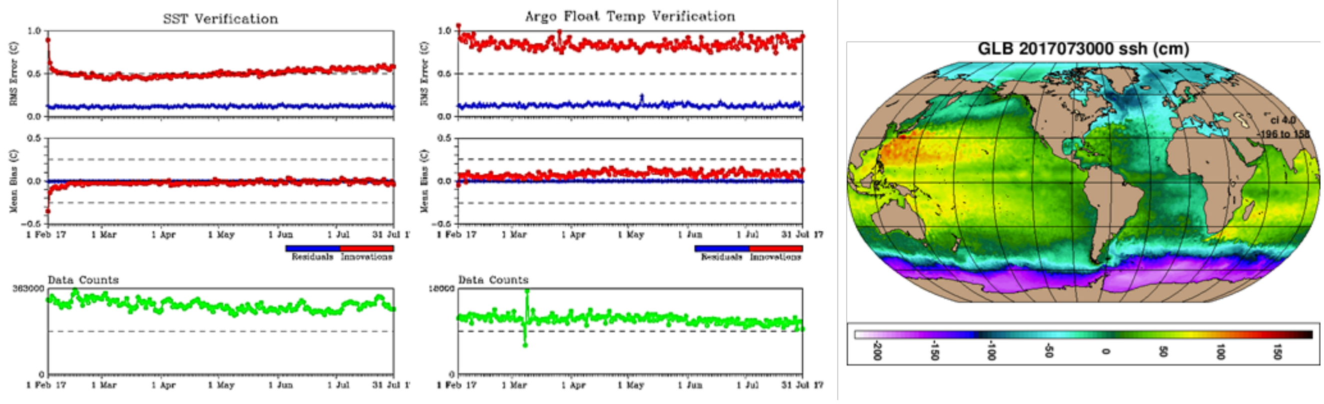

Figure 1. Left: SST verification: RMS error and mean bias, and data counts, Feb-July; center: same for Argo float temperature verification; right: SSH (1 day forecast) for July 30 2017.

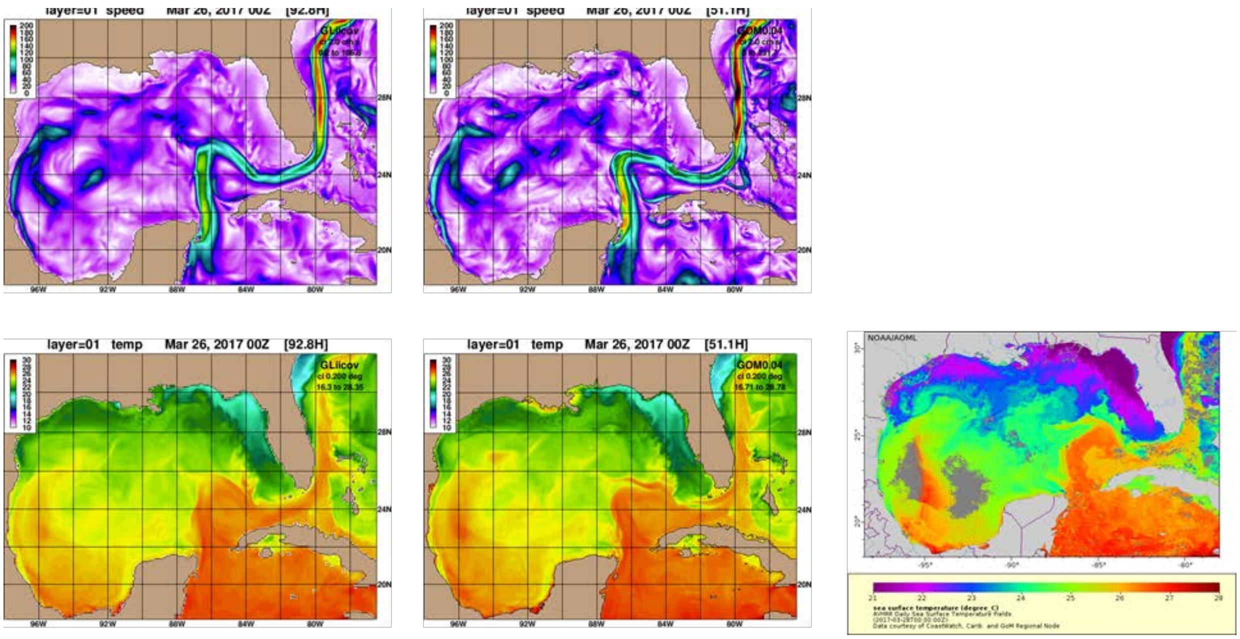

Figure 2. Top: Gulf of Mexico speed for March 26, from the global 1/12° (left) and Gulf of Mexico 1/25° (right) hindcasts. Bottom: SST (same day) from the global hindcast (left), Gulf of Mexico hindcast (center) and NOAA/AVHRR SST analysis (right)

At the end of July, the global simulation shows good agreement between the model SST and NOAA-AVHRR analysis for the Gulf of Mexico and the loop current signal (Figure 3).

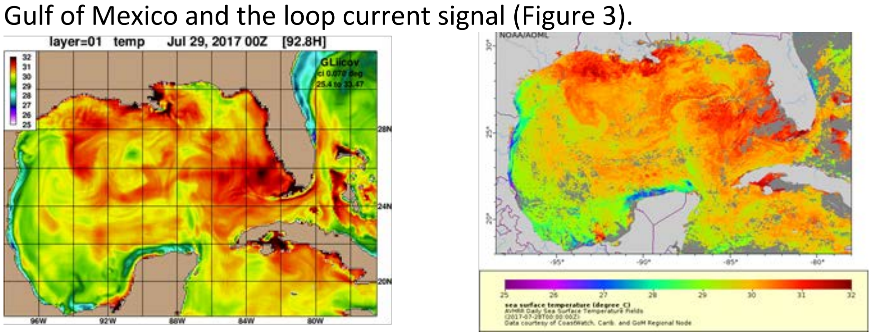

Figure 3. Left: SST from the global simulation for July 29, 2017; right: NOAA-AVHRR analysis for the same day.

References

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