MONITORING THE GLOBAL OCEAN MESOSCALE WITH A GLOBAL OCEAN FORECASTING SYSTEM AT 1/12°

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1. INTRODUCTION

The new global ocean forecasting system developed at Mercator Ocean will be the reference at the end of the European MyOcean project (2011). It consists of a global ocean and sea ice high resolution (1/12°) model NEMO (Nucleus for European Modelling of the Ocean) OGCM coupled to the data assimilation scheme named SAM2v1 (Système d'Assimilation Mercator) based on the SEEK (Singular Evolutive Extended Kalman) filter. Assimilation of both in-situ and remotely sensed data such as SLA (Sea Level Anomaly), SST (Sea Surface Temperature) provides the initial conditions required for numerical ocean prediction.
During the MERSEA (Marine EnviRonment and Security for the European Area) integrated project, Mercator-Ocean has developed a first version of a high resolution global ocean forecasting system (see [1] and [2]). Compared to the previous version, this system uses a new I.A.U. (Incremental Analysis Updates) procedure where analysis increments are inserted at every time step during the same period than the forecast trajectory (over the same period as the data window). This initialization procedure has the advantage of obtaining a smoother solution in time and removing spinup effects such as spurious waves and tropical convective cells [3]. Statistical background error covariances used in the data assimilation system have been calculated from an interannual simulation forced by ECMWF (European Center for Medium-range Weather Forecasts) atmospheric forcing without data assimilation. Moreover, these background error covariances are multivariate, inhomogeneous and have to reflect the different scales found in the free simulation, i.e., the anisotropy and the variability of the main meso-scale oceanic processes.
Forecast skills of the last simulation are shown.

2. THE OCEAN FORECASTING SYSTEM: OGCM AND DATA ASSIMILATION SCHEME

2.1. Ocean Model

The global ocean model (ORCA12) is built from the OGCM NEMO 1.09 [4]. It consists of an eddy resolving global ocean model coupled to the sea ice model LIM2 (Louvain Ice Model) [5]. An interannual simulation has been performed for 8 years (1999-2006) from which an ensemble of anomalies has been calculated in order to represent background error covariances used in the data assimilation scheme.

2.2. Data Assimilation Scheme

SAM2v1 is a data assimilation tool based on an approximate form of the Kalman filter where the formulation is based on the SEEK filter equations, see [6].
Hereafter are summarized the main characteristics of this ocean forecasting system:

- Analysis grid: Global 1/3°ORCA-type grid (sub-sampling of the 1/12°model grid)
- Innovation: Calculated from the FGAT (First Guess at Appropriate Time) approximation during a 7-day forecast period.
- Control vector: Barotropic height, *T*, *S*, *U* and *V*
- State vector : η, *T*, *S*, *U* and *V*
- Background error covariance: Ensemble of 3D intraseasonal anomalies from a free oceanic simulation model.
- Adaptive error variance: consistency with innovation vector (a posteriori diagnostic)
- Localization: Using the now-common localisation technique by the introduction of a negative-squared-exponential function.
- Initialization: I.A.U. procedure where increments are inserted over all model time steps (during the same 7-day forecast period).

3. FIRST 4 MONTHS OF A HINDCAST EXPERIMENT

A hindcast simulation using this new ocean forecasting system is being performed since the 1st of April 2009. This ocean forecasting experiment is being produced on the French Meteorological Office (Météo-France) super computer (NEC SX9). It enables to assess the PSY4V1 system ability to be deployed in near real time on this operational computer. This system is being performed on 4 nodes (1 Terabytes) of 16 processors for a total memory of 940 Gigabytes. Five hours (real time) are necessary to produce a one week hindcast.

The assimilated data consist of (i) on track altimetry measurements of SLA from DUACS (Data Unification and Altimeter Combination System), (ii) in situ temperature and salinity profiles from CORIOLIS (Circulation Océanique par Réseau Intégré d'Observations Longue durée In Situ) and (iii) ½° RT_SST (Real Time Global SST) products from NCEP (National Centers for Environmental Prediction).

Figure 1 represents the performance measures of the data assimilation system. Indeed, we show that both the innovation (7-day forecast) and residual errors are lows, respectively 8,5 and 7,5 cm. It seems to indicate (i) that the constraint coming from SLA is able to improve significantly the estimation of the meso-scale variabilities and (ii) that the analysis consistently reduces forecast error throughout the assimilative time period (7 days).

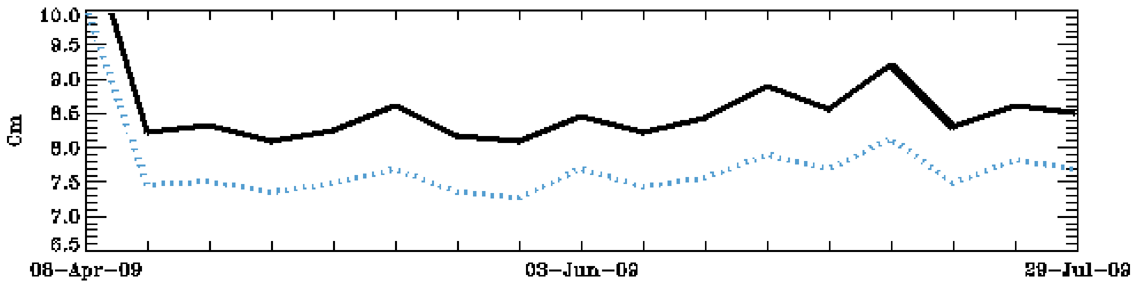

Figure1. Temporal evolution of RMS error (cm) for SLA (JASON2 along track data) over the global domain: innovation (Observation minus 7 day Forecast) in black line and residual (Observation minus Analysis) in dotted blue line.

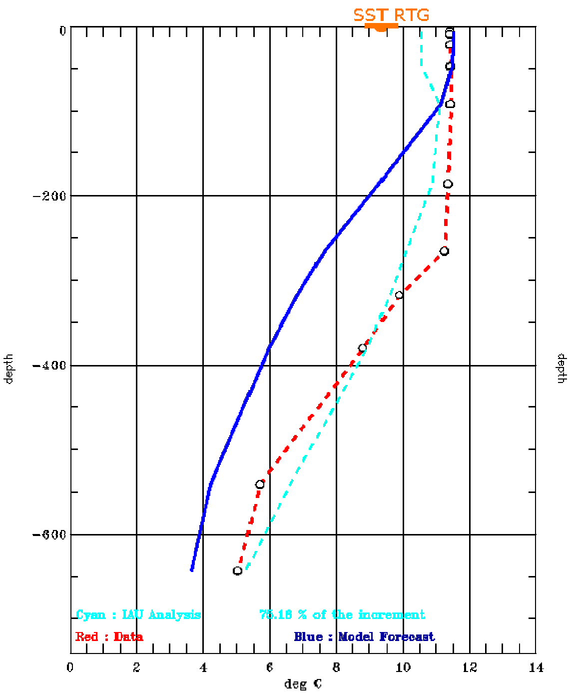

Figure 2. Temperature profile (°C) at 14.27E, 43.41S on the 28th July 2009: assimilated data (red dotted line), 6 days model Forecast (solid blue line) and analysis (75 % of the increment has been inserted from IAU procedure). The value of SST RTG is represented by the orange sign.

Figure 2 shows the ability of the ocean forecasting system to absorb information coming from various data sources and to give a consistent analysis even if only 75% of the analysis increment has been inserted. At surface, the best compromise has been found between the SST RTG value (orange) assimilated at day 7 and the in-situ profile value (red) assimilated at day 6. At depth (under 100 m), there is an excellent correspondence between the in-situ (dotted red line) and the analysis (dotted cyan line) profiles.

4. CONCLUSION

A first study [7] shows that the previous global ocean forecasting system at 1/12° depicted much more meso-scale variability and smaller scale features than the ¼° eddy-permitting system. In this new version where many improvements have been realized, mainly in the initialization procedure (I.A.U procedure), the impact should be stronger. Moreover, the first results demonstrate the current potential of this system, in particular its great potentiality in terms of performance (mesoscale variability) offering then new perspectives to monitor global ocean circulation at high resolution. The next step is to run routinely this global ocean forecasting system in an operational mode, i.e. in real time every week.

5. REFERENCES

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