Development of a Global Ocean Data Assimilation System

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An intermittent ocean data assimilation system is being developed in the Hydrometcenter of Russia. The system provides the estimate of a current state of large scale thermohaline and dynamic fields of the World Ocean in near-real time. The assimilation is performed in a cyclic manner according to the scheme "analysis–forecast". A 2D-Var method is used at the analysis step and an Ocean General Circulation Model (OGCM) at the forecast step.

1. Data

Assimilated data are temperature and salinity observations transmitted over the Global Telecommunication System in code forms SHIP, BUOY, BATHY, TESAC. The most informative source of data is Argo floats. The typical daily amount of data is from 700 to 900 temperature and salinity profiles globally. At each analysis step, data from preceding 10 days are assimilated jointly in order to provide acceptable observations coverage. After the quality control, the data are interpolated to 21 fixed levels in the depth range 0–1400 m and are combined into super observations by averaging neighboring observations within 30 km thinning distance.

2. Forecast Model

The OGCM (*Resnyansky and Zelenko, 1992; Zelenko and Resnyansky, 2007*) is used to produce the analysis first guess fields. It is based on primitive equations with conventional approximations for modeling large scale ocean dynamic. The model includes the parameterization of small scale mixing generated by wind and buoyancy flux in the upper ocean layers, which is implemented in the framework of fully mixed-layer scheme. The model domain encompasses the global ocean except for the Arctic zone to the north of 80.3° N with the horizontal resolution 2°×2° (latitudinal steps diminishing proportionally to cosine of latitude to the north of 40° N) and 32 unevenly spaced levels in the vertical. The time step is 12 min.

The atmospheric forcing used as the upper boundary condition in the ocean model (wind stress, heat and freshwater fluxes) is taken from the NCEP/NOAA operational global forecast system, which provides data every 6-h. These fields, prescribed on Gaussian grid with horizontal resolution about 0.3°, are linearly interpolated to OGCM grid and to each time step.

3. Analysis

The 3D-Var scheme is based on a covariance (stochastic) model of the spatial auto-regression and moving-average (SARMA) type (*Tsyrulnikov et al. 2006*). A two-dimensional version of the covariance model currently used is of the spatial moving-average type. The model is defined constructively, by formulating an explicit model for the underlying forecast-error random field, ξ:

$$\xi = W\alpha ,$$

where α is the white noise and W is a discretized isotropic horizontal integral operator

$$(W\alpha)(x) = \int w(\rho(x, y))\alpha(y)dy$$

(x and y are points on the sphere, ρ is the great-circle distance) generated by an empirically selected kernel function,

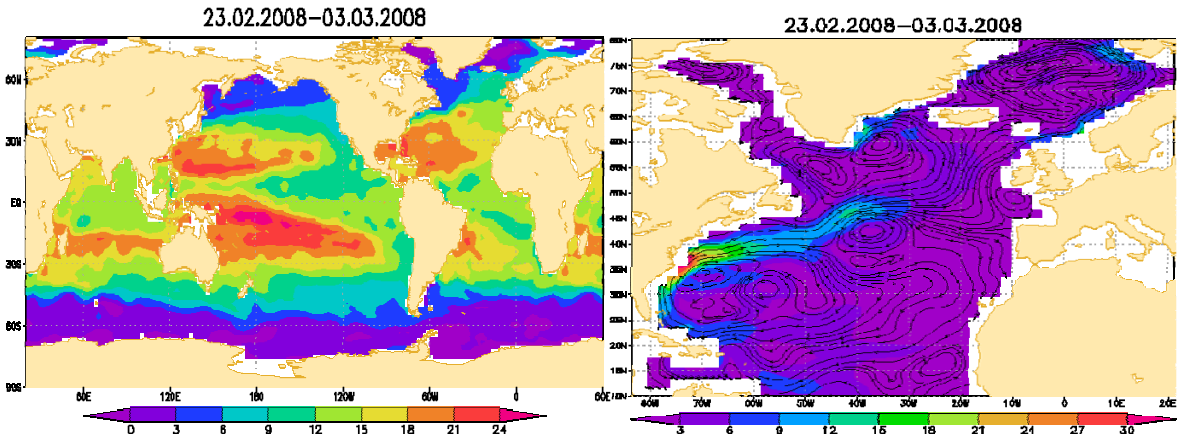
$$w(\rho) = (1+\rho/L)\exp(-\rho/L)\cdot\exp[-(\rho/\lambda)^4],$$

with L being the horizontal scale parameter and λ the support-size parameter.

This model has an advantage of being positively definite with any geographically varying changes in its parameters. It can be generalized to the 3-D case and can be used for meteorological data assimilation as well.

4. Assimilation Cycle and Results

The intermittent assimilation suite produces daily analyses each of which uses observations in a sliding 10-day window. Operational assimilation started in August 2006. Before first assimilation cycle the initial spin-up model run, started from climatological WOA-2001 state, with fixed atmospheric forcing was performed. The results of the system performance are available at the Web site (http://hmc.hydromet.ru/sea/ocean/godas/godas.html). An example of the operational analysis fields is shown in the figure.



Temperature (left) and current velocity (right) analysis fields at depth 200 m averaged over 10 days period (from February 23 to March 3 2008). The magnitude of current velocity (cm/s) is presented by color scale, and current direction — by stream lines.

5. Future plans

Work on increasing the forecast and analysis resolution up to 1° in horizontal, on replacing the 2D-Var scheme by a more advanced 3D-Var scheme of the same type, and on assimilation of SST and sea surface height satellite data are underway.

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References

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