MERCATOR PSY2V2 operational system

Numerical model

The core of the system is based on the ocean general circulation model NEMO/OPA 8.1 (Madec et al. 1998, http://www.lodyc.jussieu.fr/NEMO). It solves the three dimensional primitive equations in spherical coordinates assuming hydrostatic equilibrium, Boussinesq and rigid-lid approximations. Model variables are arranged following an Arakawa C-grid formulation with fixed vertical levels (z-coordinate). Surface boundary layer mixing is parameterised according to the 1.5 turbulent closure model of Gaspar et al. (1990) adapted to OPA by Blanke and Delecluse (1993). Lateral sugbrid mixing is parameterised for both tracers and momentum with a biharmonic operator and constant viscosities/diffusivities. Side-wall boundary conditions are partial-slip while, at the bottom, a quadratic bottom stress is used. Finally, density is computed after the non-linear equation of state of Jackett and McDougall (1995). Table 1 contains a summary of the different model parameters.

Model domain and forcing

The model grid, shown on figure 1, spans almost the whole North-Atlantic (9°N to 70°N) and the Mediterranean sea. While the Atlantic part of the domain has a variable horizontal resolution (about 1/15° or 5-7 km), the Mediterranean part has a regular grid spacing of 1/16°. The vertical resolution comprises 43 levels spaced from 6 m at the surface to 200 m at the bottom of the Mediterranean sea and 300 m for the Atlantic. The bathymetry is calculated by interpolation of the Smith and Sandwell (1997) data set. This model has no open boundary so that Northern and Southern boundaries are closed. In these areas, temperature and salinity are restored to the Reynaud et al. (1998) climatology.

At the surface, the model is forced by daily analysis (wind stress - solar, infrared, sensible, latent heat fluxes - evaporation - precipitation) from the ECMWF (http://www.ecmwf.int). Surface flux is formulated after Barnier et al. (1995) by relaxing Sea Surface Temperature (SST) towards the Reynolds daily SST with a constant restoring parameter of 40 W/m^2. The evaporation minus precipitation flux is expressed as a virtual salt flux (Barnier 1998), including monthly river run off from 24 rivers. To avoid excessive drift, surface salinity is relaxed to the surface salinity of Reynaud et al. (1998) with a time scale identical to that given by the formulation of the heat flux correction.

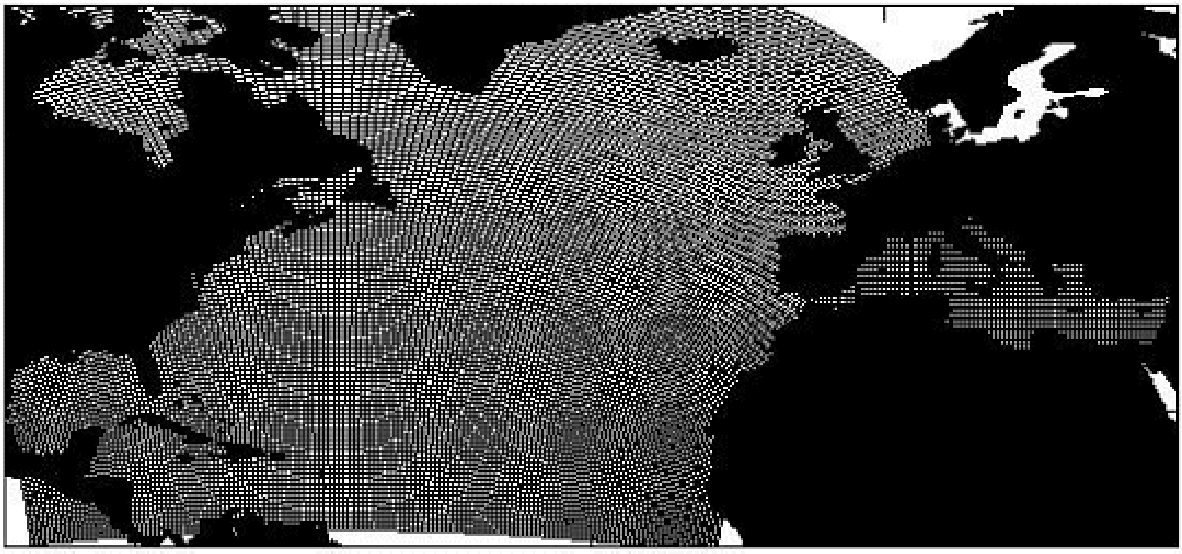

Figure 1:PSY2V2 model grid.

Assimilation method

The assimilation method (named SAM1V2) is based on the Reduced-Order Optimal Interpolation (OI) algorithm and uses 1D vertical multivariate EOFs to extract statistically-coherent information from the observations. The multivariate SAM1V2 system assimilates conjointly SLA altimeter data, SST and in situ observations (temperature and salinity profiles) and works as follows:

- The differences between SLA, T and S observations and model forecast are computed at appropriate time and data locations for a full week model integration.
- These misfits are projected in a 2D reduced space using a fully multivariate OI:
    - The estimation state vector is composed by the vertical profiles of temperature and salinity and the barotropic stream function.
    - EOFs of the estimation state vector are computed once at each point of the model grid from hindcast simulations.
    - The OI gain is computed for each of the EOFs independently (EOFs orthogonality) for a given number of dominant EOFs (order reduction up to 20 modes).
- The model state is updated by the sum of the contribution of each selected EOF to the gain multiplied by the innovation vector.
- The baroclinic velocity increments (which are not in the estimation state vector) are computed assuming geostrophy.
- A new model state analysis is updated using the innovation vector computed above.
- Starting from this new ocean state, the model runs for the next week of prediction, using the atmospheric forcing fields provided by the ECMWF.

References

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Model region		North Atlantic (9°N / 70°N) and Mediterranean sea
Horizontal coordinate system	*Type*	Spherical
	Grid spacing	1/15° for the North Atlantic, 1/16° in the Mediterranean sea (5-7 km)
Vertical coordinate system	*Type*	z-level coordinates
	Grid spacing	43 levels (vertical spacing of 6 m near the surface, 200-300 m at the bottom)
Open boundary conditions		None. Temperature/salinity relaxation to the Reynaud et al. (1998) climatology at the Northern and Southern boundaries with a 3 to 100 days timescale
Lateral boundary conditions		Partial slip
Bottom stress	*Type*	Quadratic
	Value	C_b=2.5x10^{-3}
Momentum advection scheme		Energy/enstrophy conserving (Arakawa and Lamb, 1981)
Tracer advection scheme		Centered
Time step		Dt=720 s
Vertical sub-grid scale parameterization		1.5 TKE closure (Gaspar et al. 1990)
Tracers horizontal sub-grid scale parameterization	*Type*	Biharmonic
	Value	A_t=-3x10^9 m^4 s^{-1}
Momentum horizontal sub-grid scale parameterization	*Type*	Biharmonic
	Value	A_m=-9x10^9 m^4 s^{-1}
Atmospheric forcing		Daily analysis from the ECMWF: Wind stress - Solar, infrared, sensible, latent, heat fluxes - evaporation - precipitation. Barnier et al. (1995) formulation for surface heat flux with relaxation to Reynolds daily SST.
River runoff		Climatological monthly runoff data from 24 rivers. Expressed a virtual surface salt flux.
Assimilation method		Multivariate optimal interpolation. Assimilates conjointly SLA altimeter data, SST and in situ observations (temperature and salinity profiles). Weekly analysis + 2 weeks forecasts.
Outputs		Daily averages of model variables: temperature, salinity, velocities, barotropic stream function and diagnosed sea surface height, vertical velocity, mixed layer depths, barotropic height,…

Table 1 : Summary of the PSY2V2 system.