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Assimilation of ARGO temperature profile, sea surface temperature and altimetric satellite data into an eddy permitting primitive equation model of the North Atlantic Ocean

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Sea surface height (SSH), sea surface temperature (SST) and temperature profiles at depth collected between January and December 2005 are assimilated into a realistic eddy permitting primitive equation model of the North Atlantic Ocean using Ensemble Kalman Filter.

The model circulation is simulated by the NATL025 configuration of the NEMO model. Prognostic variables are the three-dimensional velocity fields and the thermohaline variables. The model domain covers the North Atlantic basin from 20°S to 80°N and from 98°W to 23°E. Vertical discretization is done on 46 geopotential levels, with a grid spacing increasing from 6 m at the surface to 250 m at the bottom. The horizontal resolution at equator is 1/4°. Surface boundary layer mixing and interior vertical mixing are parameterized according to a TKE turbulence closure model. The forcing fluxes are calculated via bulk formulations, using the ERAinterim atmospheric forcing fields. The temperature and salinity fields are initialised using the Levitus climatology. The horizontal and vertical velocity fields are set to zero, as well as the SSH. The model spin-up time is 16 years.

Uncertainties in the system occur for many different reasons (model dynamics, parameters, forcing, initial and boundary conditions). It is an important duty of the assimilation system to make correct assumptions about the uncertainties. In these experiments, the ensemble is generated by adding noise in the forcing parameters. For this, the air temperature, the wind velocity, the long wave radiation and short wave radiation are considered. The perturbation is obtained by using the Fourier decomposition of the forcing variable vectors. Monthly variability is considered. The determination of the number of ensemble members required for reliable forecast error estimation is an unresolved issue for sequential ensemble data assimilation methods. In these experiments, 60 is taken as ensemble size based on the trade-off between the computation limitation and the model error space representation.

The daily SST data correspond to the gathered and processed AVHRR observations. The altimetric data consists of SSH satellite tracks (Jason-1), generated from the sum of the sea level anomaly (SLA) and a time invariant dynamic topography computed from the model. The temperature profiles are the ARGO profiles.

The assimilation experiment is performed every 10 days. The square root analysis scheme of the Ensemble Kalman Filter (EnKF) is taken as assimilation method. Incremental analysis update (IAU) scheme is applied in order to reduce spurious oscillation due to model state correction. The estimation vector is made up of the temperature and the salinity. The forcing variables are removed from the state vector, based on the analyse of correlation between the observed ocean state variables and the forcing variables in 10 days.

The results of the assimilation are analysed and assessed by means of three metrics:

1) The RMS misfit between the observations (SSH, SST, temperature profile) and the analyses obtained from the assimilation sequence.
2) The assessment of unobserved quantities such as the wind velocities by comparison with our prior knowledge.
3) The validation with independent data (Envisat altimetric data for SSH, Mercator reanalysis for SST).