Developments to the Data Assimilation Methods used by the Forecasting Ocean Assimilation Model (FOAM) System

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Introduction

The aim of the FOAM system is to provide real-time, operational, analyses and forecasts of the three-dimensional structure of the deep ocean and of sea-ice. A global version of the FOAM system has run each day in the Met Office's operational suite since it was introduced in 1997. The data assimilation scheme originally employed is described in detail in Bell et al. (2000). It assimilated thermal profile and surface temperature data using the analysis correction scheme devised by Lorenc et al. (1991). The accompanying report describes the development of high-resolution nested FOAM models and new data sources.

Tuning of Assimilation of Surface Data

The dependence of the assimilation of altimeter data based on the Cooper & Haines (1996) scheme in models with grid spacing between100 km and 13 km on several factors has been investigated (Hines 2001). The correlation scales, time-mean surface height and quality control measures used all had significant impact on the results. Subsequent work has shown the lifting and lowering of model profiles to be detrimental in the mixed layer

Similar investigations of the assimilation of surface temperature data have been made. Best results were obtained using forecast error covariances containing a broad range of spatial scales and making bias corrections to the satellite data using the in situ observations.

More timely assimilation of data

Observations retain their relevance to ocean analyses for many days. A method has been devised for making increments to the model fields close to the time of validity of each observation and thereafter giving additional weight to the model field according to the estimated retention of information from the observation. This method enables observations to be fully assimilated on the day that they arrive and does not require assimilation cycles to be repeated. The derivation of the method is described in detail in Bell et al. (2002).

Improved estimates of the forecast error covariance

We suspect that there are two main sources of errors in our ocean models and that they have distinctly different scales and characteristics: errors in the surface forcing with atmospheric "synoptic" scales; and errors resulting from mislocation of internal ocean "mesoscale" instabilities. Using data from a 3 year hindcast of our Atlantic model (35 km grid spacing) we have estimated the model error covariances as functions of the separation distance using pairs of observation minus forecast values and represented them as the sum of two second order autoregressive (SOAR) functions. For surface height and temperature data the variances and correlation scales can be estimated for 10^o grid boxes. The two correlation scales derived are clearly separated and vary quite smoothly with location. The synoptic scale variances depend little on geographical location but the mesoscale variances vary by orders of magnitude, being largest in the western boundary current regions. Information on the vertical dependence of temperature variances and the horizontal and vertical correlation scales have been estimated from profile observations for each component but as yet only as basin averages. The dependence on depth of the variance of vertical isopycnal displacements has also been calculated (as basin averages) from the thermal profile data.

A Bias Correction Scheme

Assimilation of thermal data near the equator was found to generate spurious vertical motions. A method for producing more balanced analyses is suggested in Bell et al. (2001).

References

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