Chapter 15

THE FORECASTING OCEAN ASSIMILATION MODEL (FOAM) SYSTEM

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Abstract: We present a detailed technical description of the present FOAM system and discuss some representative examples of the scientific investigations we undertake to track-down problems within the system and to understand the importance (“impact”) of the various inputs to it. We also provide an historical perspective on the development of the system and the changing demands for it, and describe the way in which we are adapting to meet these demands.

Keywords: Operational ocean forecasting, data assimilation, assessments.

1. Introduction

The Forecasting Ocean Assimilation Model (FOAM) is a system for assimilating oceanographic measurements into a coupled dynamical model of the deep ocean and sea-ice. It is used on a routine daily basis to make forecasts out to five days ahead representing/resolving the ocean’s mesoscale structure in selected regions. The system has been developed with funding from the Royal Navy and is used to support their operations. It also provides boundary conditions for a shelf-seas forecasting system operated by the Met Office. We aim to demonstrate in the near future that its analyses and forecasts of ocean currents are sufficiently skilful to be useful for search and rescue, oil spill drift prediction, and the deep-ocean oil and gas industry. We are also exploring the application of the system to monitoring of open ocean ecosystems and air-sea CO2 fluxes and management of fisheries and are likely to explore its application to short-range, coupled, atmosphere-ocean forecasts.

The second section of this chapter provides an overview of the FOAM system and a technical summary of its inputs, dynamical model and assimilation methods as they stood in the operational suite in August 2004. The third section attempts to give some insight into the intellectual
challenges inherent in developing these systems. It describes some representative examples of scientific trouble-shooting and some investigations of the impact of new observations and changes to assimilation methods on the performance of the system. The final section attempts to give an historical perspective. It summarises first the 20-year history of the FOAM project and then the changing world context in which it has been developing. Finally four major changes in the direction of the FOAM project are described and related to this changing context.

2. Description of the FOAM system

2.1 Overview and present configurations

The FOAM system produces 5-day forecasts of three-dimensional ocean temperatures, salinities and currents and sea-ice properties on a routine daily basis. It assimilates temperature profile data, surface height data from satellite-borne altimeters and satellite and in situ surface temperature data and is driven by 6-hourly surface fluxes from the Met Office’s Numerical Weather Prediction (NWP) system. High resolution model configurations are nested inside the global configuration. Statistics on the differences between the model forecasts and observations are routinely produced and reanalyses can be generated from 1997 onwards.

The FOAM configurations that are presently run on a routine daily basis within the operational suite at the Met Office cover the globe with a 1° grid; the Atlantic and Arctic Oceans and the Indian Ocean with 35 km grids; and the North Atlantic, the Mediterranean Sea and the Arabian Sea with 12 km grids. An Antarctic configuration with a 27 km grid is also run on a daily basis and is to be transferred into the operational suite in the first half of 2005. All of these configurations have 20 vertical levels. The global, Atlantic and Arctic, and N Atlantic configurations are illustrated in figure 1.

2.2 Inputs

Six-hourly full-resolution surface-flux fields from the global forecasts by the Met Office’s NWP system to 5-days ahead are currently used to drive all the FOAM configurations (in future fluxes from limited-area forecasts will drive some configurations). The flux fields used are the wind stress (vector with two components), wind mixing energy, penetrating heat flux, non-penetrating heat flux and precipitation minus evaporation. The NWP system calculates fluxes over sea-ice and open water (“leads”) separately and combines them using sea-ice concentration analyses generated by NCEP. The surface temperature and salinity fields are also weakly relaxed towards the monthly Levitus et al. (1998) climatologies.