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A forecast experiment in the Balearic Sea

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Abstract

A forecast experiment in the Balearic Sea is presented which is based on the Harvard Ocean Prediction System (HOPS). HOPS is modular, containing a high-resolution primitive equations model, packages for objective analysis and data assimilation (Optimum Interpolation), an interface to implement atmospheric forcing and another interface for one-way nesting of HOPS into any other larger-scale circulation model. Here, to prevent false advection from open boundaries, HOPS is nested into the basin-scale DieCAST model [Dietrich, D.E., Haney, R.L., Fernández, V., Josey, S.A., Tintoré, J., 2004. Air–sea fluxes based on observed annual cycle surface climatology and ocean model internal dynamics: a non-damping zero-phase-lag approach applied to the Mediterranean Sea. J. Mar. Syst., 52, 145–165] and atmospheric forcing fields were provided in terms of HIRLAM fields by the Spanish National Institute of Meteorology.

The forecast capability of HOPS is demonstrated in terms of a hindcast experiment, utilising two observational data sets of a subregion of the Balearic Sea which were acquired in mid September and early October 2002. While the data of the first survey is used for model initialisation, that of the second survey serves for validation of the forecast products. The forecast skill of the system is evaluated quantitatively by three different objective methods, comparing the rms difference of vertical profiles and horizontal fields, and pattern correlations, both for temperature and salinity. In five out of six cases, the forecasted fields are closer to the validation data set than the fields used for initialisation, i.e. the forecast beats persistence and the forecast is successful.

Taking into account further available options of HOPS (implementation of additional tracers, tracking of Lagrangian particles, biological modules, two-way nesting), the system is operational for a wide field of possible applications.

Keywords: Mediterranean Sea; Balearic Sea; Operational model; Forecast model; HOPS; SOFT

1. Introduction

There is an increased demand to assess the present and predict the future state of the oceanic environment, a task which can only be accomplished by the use of numerical ocean nowcast and forecast systems. These systems in general consist of observational networks, data assimilation schemes and dynamical forecast models (Robinson et al., 1996). In the present paper, such a system is presented, enabling operational forecasts for the Balearic Sea (Western Mediterranean) on time scales of the order of days to weeks. The operationality, together with a forecast skill evaluation, is demonstrated in terms of a

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hindcast experiment. Ocean forecasts on such time scales are relevant for numerous customers: Fishermen are interested in predictions of the mesoscale variability of temperature and salinity, because they know about the favourite location of fish, e.g. in the vicinity of ocean fronts (Malakoff, 2004). For tourism managers it is important to know about the advection of harmful algae blooms (Hoagland et al., 2003). In case of fighting an oil spill, it is vital to have reliable forecasts of the spreading of the oil patch (Daniel et al., 2005), and military institutions are primarily interested in changes of the underwater sound velocity structure (Harding et al., 2005).

Presently, in the framework of the European project MFSTEP (Mediterranean Forecasting System Toward Environmental Predictions), there are numerous operational forecast models under development for the Mediterranean Sea, ranging from basin-scale (horizontal resolution 1/16°) over regional (3.5 km) to shelf scale (1.5 km, see Pinardi et al., 2003, and http://www.bo.ingv.it/mfstep/). In particular, there is a regional model of the Western Mediterranean under construction, encompassing the Ligurian Sea, the Gulf of Lions, and the northern part of the Balearic Sea. As the southern boundary of that model is at about the Ibiza latitude (Fig. 1), it is not suitable for predictions of the Balearic Sea dynamics because the Ibiza Channel and the Mallorca Channel are not properly resolved. However, as shown by Pinot et al. (1998), the flow through these channels is of first-order importance for the interior dynamics of the Balearic Sea.

The present investigation is intended to fill that gap: The prognostic Harvard Ocean Prediction System (HOPS) model has been set up for the Balearic Sea at high horizontal and vertical resolution. To prevent contamination of the dynamics in the interior of the model domain from the open boundaries, the HOPS domain is one-way nested into another basin-scale model of the Mediterranean

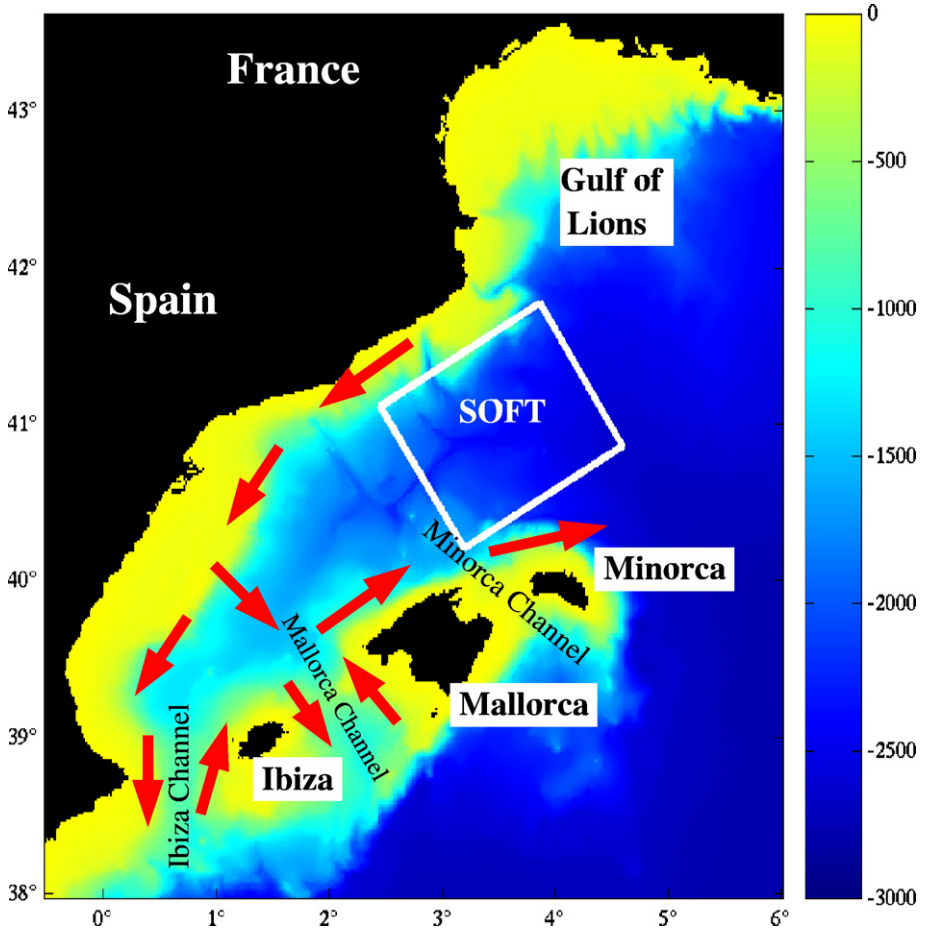

Fig. 1. The Balearic Sea. Major surface current regimes are sketched by red arrows, the white rectangle refers to the area of the SOFT campaigns (see text). The area of the chart is identical with the HOPS model domain.