Multivariate data assimilation in support of forecasting of the North Atlantic and Mediterranean

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This Jason-1 proposal deals with short-range (days) and medium-range (weeks to months) prediction of ocean dynamical variables (typically, currents and tracers). This is done by assimilation of altimetry and in-situ data and the definition of ad hoc diagnostics. Two major applications to existing forecasting systems are included in the proposal: the Mediterranean Forecasting System Pilot Project (an EU project), and the French MERCATOR project.

Introduction

This Jason-1 proposal deals with short-range (days) and medium-range (weeks to months) prediction of ocean dynamical variables (typically, currents and tracers).
(1) A multivariate data assimilation code has been developed to control the trajectory of ocean models with altimetry as well as with other data types in near-real-time conditions.
(2) Applications to forecasting the Atlantic and Mediterranean at time scales of days to weeks are underway.
(3) Studies aimed at assessing the impact of various modus operandi (such as near-real-time operation) on prediction quality are also underway.

Europe-wide and national projects such as the Mediterranean Forecasting System Pilot Project (MFSPP) and the MERCATOR North Atlantic prototype (MNATL) have brought together ocean physicists, engineers, environment specialists and potential customers of ocean products in a common, integrated effort with a view to supporting programs such as GODAE and CLIVAR. Both projects involve a full range of data assimilation tools in R&D and production modes, some of them developed specially for the projects.

A multivariate data assimilation method for real-time applications

The SOFA 3.0 optimal interpolation scheme, a robust, flexible tool permitting large-scale state estimation on the basis of vertical EOFs has been devised as part of this Jason proposal [De Mey and Benkiran, 2001]. This tool is the assimilation scheme used by MFSPP and in MERCATOR. Several types of EOFs are being considered for SOFA, both in the Mediterranean [data-versus model-based: Sparnocchia et al., personal communication, 2001] and in the Atlantic [isopycnal EOFs: Faucher et al., 2001].

The Mediterranean Forecasting System 2000 Pilot Forecasting Experiment

The Mediterranean Forecasting System (MFS) is a European project aimed at forecasting Mediterranean circulation and ecosystem parameters at ranges from days to weeks. As part of its first phase, a pilot forecasting experiment (TOP - Target Operational Period) was conducted in the first half of 2000. A Voluntary Observing Ship (VOS) program was conducted in real time, and SST as well as ERS and TOPEX/POSEIDON data were transmitted to the forecasting center. There, a 1/8°-resolution configuration of the MOM model forced by ECMWF analyzed and forecast atmospheric fields was used to simulate the Mediterranean basin-scale circulation.

For these purposes, two implementations of the SOFA assimilation scheme are being used and compared in the MFSPP project:
1. The Mark-I Data Assimilation System is only univariate and was used to assimilate temperature profiles during TOP.
2. The Mark-II DAS is multivariate and permits assimilation of SSH, SST and temperature profiles. Order reduction on the vertical is implemented as a projection onto a reduced state of vertical EOFs.

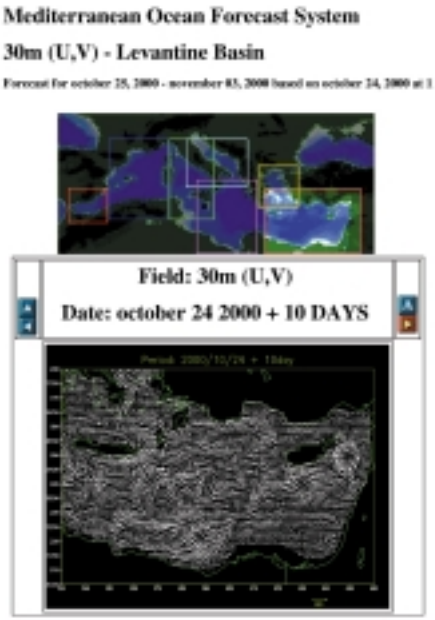

Figure 1: MFSPP quick-look products available on website

The real-time system runs every week, producing ocean analyses and short-term forecasts of velocities, temperature and salinity. As of February 2001, one to two VOS tracks are still operational about once a month and the altimetry data keep the model on track even in this degraded mode. The system has been proven to produce useful, physically sound analyses and forecasts (figure 1) for potential customers, which include the Mediterranean ocean science community, as well as an initial list of interested commercial users. The MFS is the current leading project of the EuroGOOS Mediterranean Task Team. More information and the latest analyses and forecasts can be found on the MFSPP website at http://www.cineca.it/~mfspp000.

The real-time forecasting was coordinated in Bologna, while the data assimilation R&D, in particular for altimetry, the calculation of EOFs and predictability studies, was conducted in Toulouse (De Mey, Benkiran) and Trieste (Sparnocchia, Raicich). Figure 2 shows the influence of assimilation on the improvement of temperature at depth as well as the value of using regionally-defined EOFs.

Data Assimilation R&D for MERCATOR forecasting in the North Atlantic

The MERCATOR project aims to forecast the ocean circulation at ranges from days to weeks on the global scale. It started in January 2001 with real-time analyses and forecasts of the North Atlantic circulation in a 1/3°-resolution model and will be extended to the Mediterranean and to the global scale in the next two years with increased spatial resolution and sophisticated data assimilation methods.

More information on the MERCATOR project can be found in [Bahurel et al, this issue] Analyses and forecasts appear every week on the MERCATOR website at http://www.mercator.com.fr.

The 2001 system assimilates satellite altimeter data with a univariate optimal interpolation configuration of the SOFA assimilation scheme. It runs every week, producing ocean analyses and short-term forecasts of velocities, temperature and salinity. Verification of the products involve comparisons with in-situ and satellite observations not used in the system as well as dynamical and statistical diagnostics. Investigators working on this Jason proposal are currently helping to define the multivariate system that will be put on line later this year and will assimilate temperature profiles and altimetry in a consistent manner. This is the data assimilation system that will assimilate the first Jason data in MERCATOR. Major upgrades are planned: in 2002, the data assimilation configuration will include the Mediterranean and will increase in resolution; and in 2003, the North Atlantic/Mediterranean system will be coupled with a new global ocean prediction system. Development of the assimilation system for GODAE is planned and should include a major upgrade to a SEEK-based algorithm.

Predictability and consistency diagnostics

This Jason proposal is centered around ocean prediction and the assimilation of altimetry data for that purpose. To this end, specific forecast analysis diagnostics are being added to the online MERCATOR data assimilation system. These include: ImA (information minus analysis) diagnostics, assimilation impact diagnostics (forecast vs. hindcast), statistics on biases, as well as internal consistency diagnostics (such as the “p/2” method, e.g. [Talagrand, 1997]).
The investigators are also currently working on the ensemble methods, which are powerful tools for studying predictability (Ayoub PEA project, Auclair’s results).

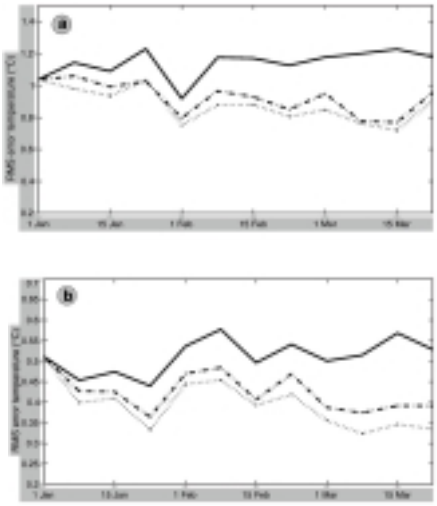

Figure 2: Mean-square seven-day range prediction error for temperature at two different depths over the first three months of 1998 for several simulations initialized with the January 1, 1993 conditions: free run (solid line), assimilation of altimetry and XBT profiles (simulated) using one basin-wide EOF (dash-dot line), assimilation using regional EOFs (dotted line). (a) 120 m; (b) 280 m. Unit: °C.

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