ASSESSMENT OF TEMPERATURE AND SALINITY SAMPLING STRATEGIES IN THE MEDITERRANEAN FORECASTING SYSTEM

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Abstract

Different temperature and salinity sampling strategies are studied using Observing System Simulation Experiment techniques, by assessing their impact on a Mediterranean GCM via bivariate data assimilation. Such sampling strategies consist of combinations of XBTs and CTDs deployed along Volunteer Observing Ships (VOS) tracks. The sampling strategy assessment is made by means of identical twin numerical experiments, and is quantified as the error reduction achieved in the assimilation run relative to the free run.

Keywords: Mediterranean Sea; numerical modelling; Observing System Simulation Experiments; data assimilation.

Introduction

The spatial and temporal coverage provided by oceanographic data sets is usually limited, therefore a general aim is to design as effective sampling strategies as possible, real optimization generally being difficult due to logistic and economic constraints. A programme of XBT data collection along VOS tracks was established in the Mediterranean Forecasting System Pilot Project (MFSPP) (1, 2) and is a component of the MFSTEP (MFS Towards Environmental Predictions) project. An assessment programme is included in MFSTEP to study the effectiveness of sampling strategies already used in the project or representing realistic evolutions. Sampling strategies are assessed by quantifying their impact in a Mediterranean GCM via data assimilation. To this purpose, Observing System Simulation Experiment (OSSE) techniques are used, consisting of identical twin numerical experiments.

The assessment of several sampling strategies involving temperature only was performed in the framework of MFSPP (3). That study was limited by the use of univariate temperature data assimilation, enabling only temperature correction. Present work is a preliminary assessment based on multivariate temperature and salinity data assimilation, which provides corrections for both variables.

Methods

Each twin experiment consists of: a) A control run, defined as the truth, from which temperature and salinity data for subsequent assimilation are extracted; b) an assimilation run, with different initial conditions and assimilation of temperature and salinity data taken from the control run; c) a free run, with same initialisation as the assimilation run but without data assimilation. The Mediterranean GCM is MOM-1 with $1/8° \times 1/8°$ horizontal grid spacing and 31 vertical levels, forced by ECMWF 6-hr operational analyses. Data assimilation is performed by means of the reduced-order optimal interpolation scheme implemented in the SOFA code (4) and corrections to temperature and salinity are computed every 7 days. The order reduction is achieved by projecting temperature and salinity profiles onto vertical bivariate EOFs (5). Each experiment lasts 12 weeks and is initialised on 1 February 2000, i.e. in winter conditions. The assimilation and free runs are initialised one year earlier.

The convergence of the assimilation run towards the control run is assessed by means of the standard deviation (the 'error') of the difference between assimilation and control runs. It measures the effectiveness of data assimilation in driving the model towards the truth starting from incorrect initial conditions. The analogous error involving the free run is used for reference, since it measures the model convergence due to the atmospheric forcing only. The assessment is made for the western and eastern Mediterranean regions and three vertical layers, namely surface (L1, 5-240 m), intermediate (L2, 280-400 m) and deep (L3, 440 m - bottom).

In this work the sampling strategies simulate the acquisition of temperature only or temperature and salinity profiles along the VOS tracks described in (2, 3), representing XBT and XCTD data, respectively. The latter are not yet adopted but represent a possible development of the present observing system. Each track is covered once a week except the Haifa-Messina-Gibraltar, which is covered fortnightly.

Four configurations are compared here: the first is the already studied (3) univariate assimilation of XBT data (labelled "UT"). Two other configurations involve bivariate assimilation of XBT (BT), where salinity is estimated via bivariate EOFs, or XCTD (BTS) data. The fourth consists of the periodic repetition in space of two XBT and one XCTD profiles (BTTS). It should be noted that strategy UT is the sole retaining the full temperature signal, while in the others the EOFs carry only a fraction. The profiles positions and times are the same for all configurations.

Results and concluding remarks

A general result is that temperature and salinity data impact is larger in the western Mediterranean than in the eastern, particularly in L2 and L3. This different behaviour can be related to the typical winter vertical structure of the water column, which exhibits distinct layers in the eastern Mediterranean, among which the Intermediate Levantine Water, while the western basin, frequently affected by convection, is significantly more homogenous. Strategies BTS and BTTS show essentially identical impacts on temperature and very close impacts on salinity, BTTS being slightly less effective since one third of salinity profiles is used.

Concerning temperature, in L1 all strategies are almost equivalent, with temperature error reduction of 25-30% in the western basin and 20% in the eastern. In L2 and L3 of the western basin, strategy BTS becomes the most effective only after 10-11 weeks, with 40% error reduction, while its impact is the same as UT in L2 and even smaller in L3; the error reduction reaches 20% at the end of the experiment. In the eastern basin all strategies are almost equally effective, but UT turns out to be the best after several weeks in L2 and L3 with 20 and 10% error reductions, respectively.

In the case of salinity, strategies UT and BT have negligible impact (less than 10% salinity error reduction). In the western basin the introduction of salinity data enable to achieve 30% error reduction in L1, 20% in L2 and about 10% in L3. In the eastern basin even strategy BTS does not achieve more than 10% error reduction.

The lower error reduction, i.e. data impact, in the eastern Mediterranean may be partly due to the more complex variability of the water column than in the western basin, a fact that might not be adequately captured by the EOFs.

Acknowledgements. This work was partly funded by EC Projects "Mediterranean Forecasting System Pilot Project" and "Mediterranean Forecasting System Towards Environmental Predictions".

References

1 - Pinardi N., and Flemming N.C. (eds.), 1998. The Mediterranean Forecasting System Science Plan. EuroGOOS Publication No. 11, Southampton Oceanographic Centre, Southampton, UK, 49 p.

2 - Manzella G.M.R., Scoccimarro E., Pinardi N., and Tonani M., 2003. Improved near real-time data management procedures for the Mediterranean ocean Forecasting System – Voluntary Observing Ship program. *Ann. Geophys.*, 21: 49-62.

3 - Raicich F., and Rampazzo A., 2003. Observing System Simulation Experiments for the assessment of temperature sampling strategies in the Mediterranean Sea. *Ann. Geophys.*, 21: 151-165.

4 - De Mey P. and Benkiran M., 2002. A multivariate reduced-order optimal interpolation method and its application to the Mediterranean basin-scale circulation. Pp . 279-303. In: Pinardi N., and Woods J. (eds.), Ocean Forecasting Conceptual Basis and Applications, Springer-Verlag, Berlin.

5 - Sparnocchia S., Pinardi N., and Demirov E., 2003. Multivariate Empirical Orthogonal Function analysis of the upper thermocline structure of the Mediterranean Sea from obrservations and model simulations. *Ann. Geophys.*, 21: 167-187.