THE MEDITERRANEAN SEA RE-ANALYSIS: 1985-2007

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Abstract

A simulation and two re-analyses from 1985 to 2005 have been produced for the Mediterranean sea circulation using different assimilation schemes: a Reduced Order Optimal Interpolation and a new three-dimensional variational scheme. The general circulation model used is the OPA 8.1 code. The observational data sets assimilated are vertical temperature and salinity in situ profiles and along track satellite sea level anomalies (SLA); daily mean fields of Sea Surface Temperature are used for correcting the fluxes. The results of both reanalysis are comparable and they are qualitatively consistent to the known structures of the circulation in the period of interest.

Keywords: Circulation Models, Inverse Methods

Introduction

Re-analyses are different from analyses because they are consistent for the whole period since the oceanic state estimates are produced without changes in the modelling assumptions and they are usually done with systems, which are more advanced then the available systems at the time of the observations collection. A fundamental part of a re-analysis system is the data assimilation scheme, which minimizes the cost function penalizing the time-space misfits between the data and the numerical solutions, with the constraint of the model equations and their parameters. In this work we will compare ocean circulation estimates provided by pure simulation, a system in which the assimilation scheme is based on a sequential algorithm: Optimal Interpolation (OI) and a three-dimensional variational scheme (3dvar).

Method

The OGCM used in this work is based on OPA 8.1 code [1], which has been implemented in the Mediterranean Sea by Tonani et al.[2]. The model has 1/16th horizontal resolution and 71 unevenly spaced vertical levels. The present model formulation uses a realistic water flux with river runoff that improves the realism of the simulation. One re-analysis is produced with the Reduced Order Optimal Interpolation (ROOI) [3] and the other with OceanVar[4]. The observational data sets assimilated for both reanalysis are: 1) the historical data archive of MedATLAS [5] which contains vertical in situ profiles of temperature and salinity from bottles, XBT, MBT and CTD sensors;2) temperature and salinity profiles collected in the framework of MFSPP and MFSTEP (Mediterranean Forecasting System) projects;3) CLS along track satellite sea level anomaly data from ERS1, ERS2, Envisat, Topex/Poseidon, Jason1 satellites [6]. Reanalyzed daily mean fields of Sea Surface Temperature (SST) from Medspiration [7] and the Delayed-Time operational product of CNR-ISAC have been used to relax the model SST. The Mean Dynamic Topography of Dobricic [8] has been used for both experiments. The model is forced with a combined dataset of ECMWF analysis when available and ERA-15. The precipitations are monthly mean climatology of the NCEP re-analysis [9], the river runoff data are monthly mean climatology from the Global Runoff Data Centre (GRDC) and from Raicich [10] for the minor Adriatic Sea rivers.

Results

Both re-analyses show significantly better results than the simulation reducing both bias and root mean square error even though the structure of the error remains almost the same of the simulation: the largest error for tracers is confined in the thermocline especially in summer, highlighting a problem in the mixing parameterization; the major error for SLA is confined in the most dynamically active areas. Satellite altimetry observations appear to be a fundamental dataset to constrain model solution. Since its homogeneity in the sampling the SLA dataset permits a consistent assessment of the model behaviour. During the years without SLA observations in-situ observations give a less accurate assessment, because their sampling is extremely inhomogeneous both in time and space. The model results permit the recognition of gyres, jets, boundary currents, recurrent eddies, etc, typical of the Mediterranean Sea mean circulation. The results are promising for the detection of the timing of current reversal in the Ionian Sea, the salinity changes and the outflow from the Aegean Straits, its spreading and accumulation phase.

Conclusions

This study describes the development of modelling and data assimilation tools for the production of re-analysis for the entire Mediterranean Sea. In order to carry out a re-analysis two major steps were undertaken in this work. In the first, the general circulation model was upgraded to have the correct air-sea water fluxes. In the second, two assimilation schemes, one new and the other consolidated, were compared to show their impact on the quality of the re-analysis. The general circulation model used in this study is shown to be capable of reproducing quite accurately the ocean dynamics of the Mediterranean Sea. The results have shown that the model solution is in agreement with data and observations, even though some parameterizations of the model should be improved (i.e. heat flux and mixing processes). The new implementation of a realistic water flux, proposed in this study, has improved the model solution so that re-analysis is possible. The study of these re-analysis shows that both products are sufficiently accurate for appropriate climate studies. Both assimilation schemes show good capabilities in correcting the solutions provided by the dynamical model. Moreover the ability of both systems in retaining this information and projecting it in the future has been shown. Eventually, even for very complex non linear systems, with millions of prognostic variables, the equality between the Sequential Kalman Filter Approach and the Variational method as been demonstrated.

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