SATELLITE-DRIVEN MODELING OF THE UPPER OCEAN CO_2 FLUXES IN THE MEDITERRANEAN SEA

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ABSTRACT

A one-dimensional (1d) physical-biological-chemical model was developed and tested by Antoine and Morel [1995, AM95 hereafter], with the aim of assessing upper ocean carbon fluxes. This model was specifically designed to be driven by satellite data, and it was used to evaluate the upper ocean CO_2 fluxes at station P in the NE Pacific. Another validation of this model has been carried out at the DYFAMED station (NW Mediterranean), where time series of biological and physical observations are available. This validation is a first step before the basin-scale application to the Mediterranean Sea, as presented here for the period 1998-2000.

INTRODUCTION

In situ estimates of carbon fluxes are generally sparse and unevenly sampled, so they are not necessarily well adapted to assess global and basin scale budgets. A possibility is to use satellite-derived information that provide regional to global scale high quality and high resolution observations. When combined with models, they allow the role of the upper ocean dynamics in the general carbon cycle to be investigated. Such a coupled satellite-modeling approach has been tentatively applied to the entire Mediterranean Sea.

MODEL DESCRIPTION

The AM95 method simulates CO_2 upper ocean dynamics by assimilating satellite data into a 1d physical-biological-chemical model, which is initialized using climatological fields (salinity and temperature profiles for the physical module, Total Inorganic Carbon (TCO2) and Total Alkalinity (TA) profiles for the chemical one). The 0-300 m water column physical characteristics are simulated by an eddy kinetic energy model [*Gaspar et al.*, 1990] forced by surface wind stress and heat fluxes. The latter are evaluated via bulk formulas or directly estimated from satellite data (see later). Similarly, wind stress is calculated from wind intensity components, as obtained from space or from meteorological models. The carbon-based biological compartment of the simulation is driven by surface chlorophyll (Chl) and by the surface photosynthetically available radiation [*Morel*, 1991], and it computes the net autotrophic primary production in the productive layer. In this frame, the chlorophyll biomass is not predicted by the model but is on the contrary an input to the simulation, as provided by satellite ocean color sensors.

RESULTS

The AM95 method was first applied in a purely 1d context, simulating the CO_2 dynamics at a particular Mediterranean open ocean site where *in situ* data are available (i.e. DYFAMED). This exercise allows an evaluation of the best set of forcing and initialisation data before the model is applied at the scale of the entire Mediterranean. The basin scale dynamics of the CO_2 in the Mediterranean was then evaluated.

The 1d approach: the DYFAMED station

The time series of biological and physical observations available at the DYFAMED station (NW Mediterranean) [*Marty*, 2002], coupled with satellite (SeaWiFS) Chl, allowed tuning of our simulations for the years 1998-2000. Measured profiles of TCO2 and TA were used as initial conditions for the carbonate compartment [*Begovic and Copin-Montegut*, 2002]. The results of the simulations are shown in Fig. 1 (including the 3 years of model spin up), and demonstrate the good performances of the approach to reproduce the observed physical and chemical dynamics at the DYFAMED station.

The basin scale approach: the Mediterranean

For the basin scale approach, the physical model was forced by a combination of ECMWF-ERA 40 data, Meteosat-derived short-wave radiation fluxes and satellite wind measurements (QUIKSCAT). SeaWiFS data provided the surface Chl, while the initialization fields were derived from the MODB data base. Because no climatology of TCO2 and TA exist for the Mediterranean, their initial fields were derived from temperature and salinity, using previously developed empirical regressions [*Begovic and Copin-*

Montegut, 2002].The whole Mediterranean was covered with an array of model runs, at a 0.5° resolution. For each run, the CO_2 dynamics was evaluated over the three simulated years. The preliminary results (Fig. 2) demonstrate the feasibility of the approach. Upcoming improvements will concern the initialization fields for TCO2 and TA, the introduction of an advection scheme where necessary, and comparison of the basin-scale carbon fluxes with those derived from 3D models.

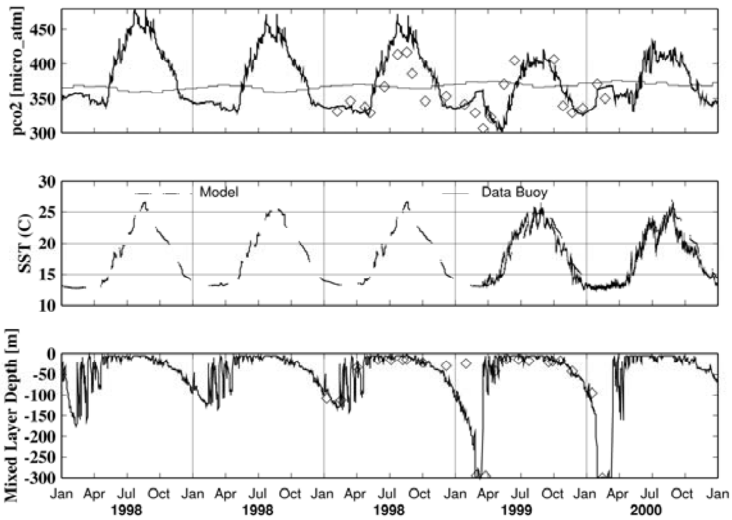

Fig. 1. Comparison between measurements and model outputs at the DYFAMED location. Lower panel: mixed layer depth (Continuous line: model output; diamonds: *in situ* estimations). Central panel: Sea Surface Temperature (Dotted line: model output, bold line: in situ measurements). Upper panel: oceanic CO_2 partial pressure (Bold line: model output; diamonds: DYFAMED *in situ* measurements. Thick line: atmospheric pCO_2 measured at Lampedusa island in the south Ionian sea).

CONCLUSION

A coupled satellite-modelling approach, aiming at the assessment of the upper ocean CO_2 fluxes, was successfully applied to the Mediterranean. It can provide a suitable complement to 3D prognostic modelling approaches.

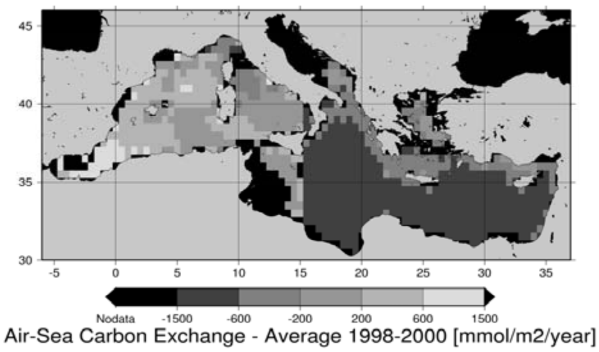

Fig. 2. Three years average of the air-sea carbon fluxes in the Mediterranean Sea, as obtained from the presented approach. Negative fluxes represent a loss for the water column.

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