MODELING CARBON CYCLING AND SEQUESTRATION IN THE ADRIATIC SEA

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Abstract
Biological and continental shelf pump play a major role in carbon cycling and sequestration in the intermediate and deep layers of the sea. A state of the art numerical model of the Adriatic Sea general circulation is coupled with a biogeochemical model to study and quantify these processes. Two scenarios are examined in detail: winter 2006/2007 and winter 2007/2008. In the former, mild weather conditions did not trigger any relevant dense water flux, which, instead, has been measured for the 2007/2008 case study. The results of the simulations show different biogeochemical properties and different air/sea CO_2 exchange rates, both in good agreement with experimental observations.

Keywords: Adriatic Sea, Carbon, Models

Marine systems play a crucial role in the global carbon budget, in particular, the oceans are thought to absorb about 40% of the antropogenic CO_2 [1]. The biological pump and the continental shelf pump are two among the mechanisms that foster the transport of carbon in the intermediate and deep layers of the sea (Fig. 1). The components of these processes are:
- primary production (PP) which uses the carbon (DIC) taken up through air/sea exchanges;
- sinking of organic material (POC);
- vertical transport of dissolved organic (DOC) and inorganic (DIC) carbon through downward fluxes associated with dense water formation.

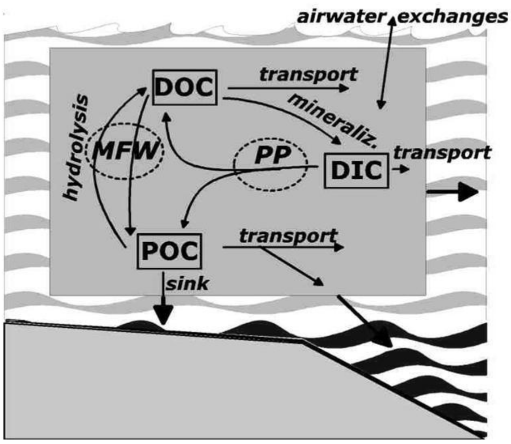

Fig. 1. Simplified scheme of the biological and continental shelp pump

The Adriatic Sea is considered to be a key area for the sequestration of atmospheric carbon in the interior of the Mediterranean Sea. This study presents the results obtained by running a numerical model of the Adriatic Sea for the period november 2006 - august 2008. The simulations, set up in the framework of the VECTOR project, aim at understanding the dynamics and fluxes of the biogeochemical properties of the basin, paying particular attention to the formation and transport of dense water masses (~7°C, 38 psu, 1030 kg/m^3), which originate in the Northern Adriatic Sea in winter and spread southward along the basin. Model features can also help in investigating the seasonal variability of the mesoscale structures and the effect of air-sea interactions on the general circulation.

The simulations are carried out customizing the MITgcm, a three-dimensional, finite volume, non-hydrostatic, general circulation model [2]. The physical model is coupled with a medium complexity biogeochemical model specifically developed for the Adriatic Sea [3] and a model which solves the carbonate chemistry system [4]. The computational domain spans north of the Otranto strait (from latitude 40.3° N to 45.9° N), with a horizontal resolution of 1/32° (~3.4 × 2.4 km) and 51 unequally spaced levels. Initial and open boundary conditions are obtained from the 1/16° operational model of the Mediterranean Sea run by INGV. The main rivers flow rates are derived from in situ measurements (when available) or yearly averages and are modeled in such a way as to consider both the thermohaline and momentum contribution. Surface atmospheric forcing is interpolated from high resolution atmospheric models (ETA006 and ALADIN).

The physical model reproduces the mesoscale seasonal variability correlated with the thermohaline properties of the water column. Short term (few days) response to the major atmospheric forcings (Bora and Scirocco wind) also show a good agreement with experimental observations. The biogeochemical model simulates carbon and phosphorus cycles paying particular attention to production, sinking and recycling processes.

The integrated model has been tuned to reproduce several experimental observations related to different environmental conditions. In particular, two scenarios are examined in detail: winter 2006/2007 and winter 2007/2008. In the former, mild weather conditions did not trigger any relevant dense water flux, which, instead, has been measured for the 2007/2008 case study. For both scenarios, the carbon budgets are estimated in three relevant sub-basins, vertically organized as follows:
- northern continental shelf;
- central pits (subdivided into 2 sub-layers);
- southern pit (subdivided into 3 sub-layers).

The results of the simulations show different biogeochemical properties and dynamics for each of the six boxes, and different air/sea CO_2 exchange rates, both in good agreement with experimental observations.

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