TACKLING EXTREME BLOOM EVENTS IN THE MEDITERRANEAN SEA WITH THE COUPLED MITGCM-BFM NUMERICAL MODEL

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Abstract

Extreme algal blooms in the Mediterranean Sea were investigated using the MIT General Circulation Model coupled online with the Biogeochemical Flux Model, at a resolution of 1/12°x1/12°, with 75 vertical levels. Daily chlorophyll fields were analyzed with oxygen, nutrients and the main physical variables, to characterize the distribution of the blooms, at the surface and in the whole photic layer. A suitable definition of extreme blooms has been developed from the spatiotemporal probability density functions of the phytoplankton chlorophyll, considering peaks over thresholds, depending on the spatial location and the two ranges of depth. Preliminary results from a short run (years 1979-1981) are shown, in view of a longer simulation (1979-2012), which will provide both a suitable statistics and a climate value to the present study.

Keywords: Blooms, Phytoplankton, Models, Mediterranean Sea

Extreme events have been widely studied in hydrology and atmospheric sciences for several decades, whereas in the ocean sciences they have been analyzed only in more recent years, focusing mainly on wave height and sea level variability [1]. Investigating extremes in the ocean biogeochemistry is currently a new field of research, and it constitutes a major challenge in the characterization of the non-linear dynamics interconnecting the ecosystems biota and the physical environment. Three-dimensional coupled hydrodynamic-biogeochemical models are valuable instruments to describe the vertical processes in the ocean (e.g. the Ekman pumping, which brings the nutrients from the deeper layers up to the photic zone, 0-200 m), overcoming the limitation of the satellite data, which refer only to the first meters of the water column. Moreover, numerical models reproduce the spatial and the temporal dynamics of those biogeochemical properties that cannot be readily measured in wide areas at high frequency. This work aims to investigate extreme blooms in the Mediterranean Sea for the period 1979-2012 using the MIT General Circulation Model (MITgcm, [2]) coupled online with the Biogeochemical Flux Model (BFM, [3]). Our MITgcm implementation solves the incompressible Navier Stokes equations of the ocean on an Arakawa C-grid characterized by an horizontal resolution of 1/12°x1/12° and 75 vertical z-levels, forced at surface by the atmospheric fields (hflux, water flux and wind stress) dynamically downscaled (12 km) from the ERA-Interim reanalysis [4]. The BFM describes the mass fluxes of N, P, C and Si among the lower trophic level compartments, considering also chlorophyll, oxygen and other constituents in the plankton compartments, in the detritus and in the water dissolved phase. We forced BFM with the Era-Interim shortwave radiation [4] and with atmospheric ([5]) and riverine ([6]) inputs.

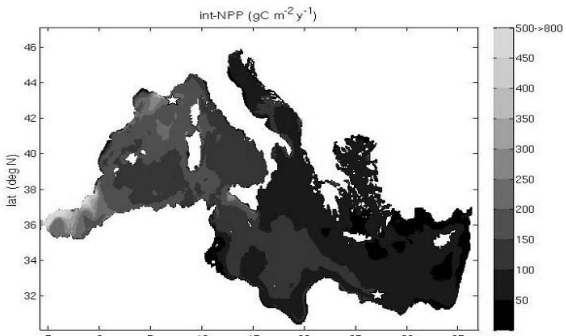

Fig. 1. Vertically integrated net primary production in the Mediterranean Sea derived by the MITgcm-BFM model for the 1981 year (gC m-2 y-1). Locations indicated by the white stars are a reference for the Figure 2.

Preliminary results from a short run were used to test the proper definition of the extreme events (i.e. suitable statistics to assess the extremes distributions and the temporal scale for climate evaluations), which will be used in the 1979-2012 run. The phytoplankton blooms were identified from the daily chlorophyll signals, triggered by the temperature, salinity and mixed layer depth dynamics and related to the nutrients and oxygen profiles and to the net primary production (Figure 1). In each horizontal grid point, the probability density functions (PDFs) of the chlorophyll integrated in the first 10 meters and in the photic layer were derived in order to provide a dataset comparable with satellite imagery and a complete description of the blooms, respectively. Extreme blooms were defined as peaks over the 99th percentile thresholds of the PDFs, depending on the horizontal location and on the two ranges of depth (Figure 2). Extreme blooms in the whole period considered will be finally mapped in space and time and investigated in connection with the external forcings, in order to evaluate how these latter can affect the extremes in the marine biogeochemistry.

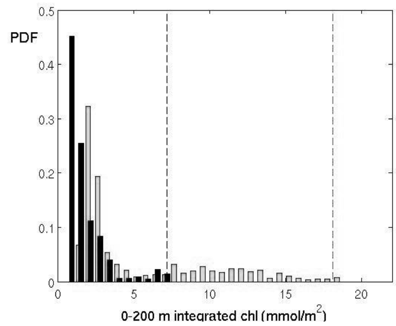

Fig. 2. PDFs of the model-derived chlorophyll integrated in the photic layer at 27°2' E, 32°5' N (black bars) and 7°29' E, 43°9' N (light gray bars) locations (white stars in the Fig.1), with dashed lines referred to the 99th percentile thresholds, for the years 1980-1981.

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