THE EFFECT OF PHYSICAL FORCINGS ON THE NUTRIENTS GRADIENTS IN THE MEDITERRANEAN SEA: A NUMERICAL APPROACH

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Abstract

The oligotrophic regime of the Mediterranean, although widely accepted, remains, as yet, inadequately resolved in its space and time variability. Here a numerical approach is presented to evaluate the relevance of ocean dynamics on nutrient distributions. A three-dimensional hydrodynamical ecological model was developed to understand the roles of the subbasin-scale upper ocean features as well as lateral advective and diffusive processes, in this context. The model is able to reproduce the large scale zonal and meridional trophic gradients while the phytoplankton standing crop, as estimated by model and confirmed by CZCS data, exhibits the same large scale features. In particular, Ekman pumping seems to be related to the meridional gradient while subbasin cyclonic structures contribute to the perturbation of the general trophic conditions.

Key-words : Nutrients, geochemical cycles, open sea, ocean colours

Introduction

The general oligotrophic regime of the Mediterranean is explained by the inverse estuarine circulation with a net loss for nitrate at Gibraltar Strait ranging from 1.25 Mtons/year [1, 2] to 3.11 Mtons/year [3, 2], which seems to be only partially compensated by terrestrial inputs sources. This general picture needs to be refined in order to explain the east-west and north-south trophic gradients, which are present, on average, both in the surface layer and at depth.

This paper is focused on modelling these gradients in terms of interactions between general circulation processes and the biogeochemical fluxes, assuming that the first trophic level dynamics is nitrogen limited. The proposed nitrogen model explicitly includes the biogeochemical interactions that alter its form, in particular, autotrophic production and remineralisation via bacterial activity. In the following presentation, we will outline the model, and discuss the results proposing a dynamical explanation of the Mediterranean trophic gradients.

The model

The three-dimensional formulation is needed in order to appraise the influence of horizontal transport, of upwelling/downwelling processes and of vertical mixing on the nutrient distribution and cycling, and eventually on phytoplankton standing crop. For the sake of simplicity, the model complexity was held at a minimum, describing only the first trophic level with a trophodynamic scheme based on nitrate, phytoplankton and detritus (NPD) exploiting the advection/diffusion/reaction biological equations as presented in Civitarese *et al.* [4], enhanced with a cloudiness dependent irradiance submodel.

The coupling between physical and trophic dynamics is obtained through the advective terms and temperature dependencies present in the biological equations which are synchronously calculated with the dynamical fields. The hydrodynamics is simulated with a 31 level 1/4 degree MOM-like hydrodynamical model with "perpetual year" NMC wind forcings developed as in Roussenov *et al.* [5]. The MOM-NPD model has been described in detail in Crise *et al.* [6] together with a model sensitivity analysis to the trophic parametrization. The timestep was 2400 s and the biological runs typically lasted not less than three years after five years of spin-up for the hydrodynamics. The initial conditions for the NPD submodel were-basin wide laterally homogeneous profiles for phytoplankton and detritus (assumed initially as null) and averaged values calculated from experimental data for different subbasins (Alboran, Algero-Provençal, Ionian, Aegean, Levantine).

At Gibraltar, biological tracers were allowed to be exchanged with an academic ocean outside the Mediterranean, where climatological profiles of nitrate, phytoplankton and detritus are considered as constant over time.

Results

The model estimates of nitrate fluxes at Gibraltar Strait are in good agreement with literature data, ensuring proper conditions at the western boundary (a loss of 2.5 Mton/year predicted by model). The climatological distribution of the meridionally integrated nutrients as obtained by 24 months averaging exhibits a pronounced east-west gradient induced by the different physical and physically driven processes in the two basins, (fig. 1.a) with superimposed the average values derived from the data set shown in fig. 2. The maximum in the Alboran Sea can be ascribed to the biological impact, also relevant at basin scale, where the autotrophic activity is able to rapidly incorporate the inorganic nitrogen entering through the Gibraltar Strait.

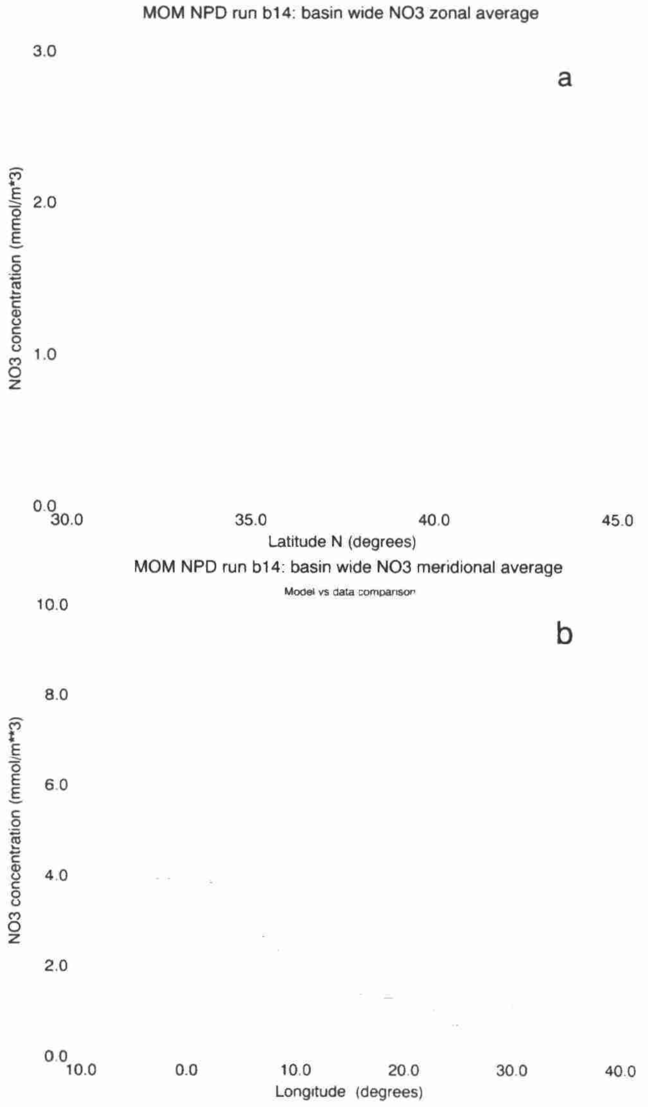

Figure 1 : Two year average of zonal (a) and meridional (b) means in the first 140 m layer: DIN (white dot) and experimental reference meridional averages expressed in mmol/m**3.