CURRENT STATE AND RECENT TREND OF MEDITERRANEAN SEA BIOGEOCHEMISTRY DERIVED BY A HIGH-RESOLUTION REANALYSIS

S. Salon [1]*, G. Cossarini [1], G. Bolzon [1], A. Teruzzi [1] and C. Solidoro [1]
[1] OGS - ssalon@ogs.trieste.it

Abstract

A high-resolution reanalysis of Mediterranean Sea biogeochemistry was developed within the Copernicus Marine Environment Monitoring Services (CMEMS). The quality of the reanalysis was assessed against several available data sets, in terms of the main surface and sub-surface biogeochemical essential climate variables (chlorophyll, carbon dioxide partial pressure, ocean acidity, nutrients, oxygen). The model system was capable to reproduce spatial patterns, seasonal cycle and interannual variability of the assessed variables, allowing for a proper description of recent trends and present status of important MFSD descriptors (such as nutrient content and primary production).

Keywords: Chlorophyll-A, Mediterranean Sea, Nutrients, Primary production, Models

The quality of multi-year model estimates of regional marine ecosystems can be improved with reanalyses, which assimilate observations (as satellite-based surface chlorophyll concentration) into the most advanced version of operational models. Reanalyses of a regional sea biogeochemistry are also important when used as boundary conditions to evaluate the ecosystem state of its sub-basins and coastal domains, thus allowing to meet EU and member states environmental requirements (e.g. MSFD).

In the frame of the Copernicus Services (CMEMS), we recently completed a high-resolution reanalysis (1/16 horizontal resolution; 1999-2014) of the Mediterranean Sea biogeochemistry using the 3DVAR-OGSTM-BFM model system ([1], [2], [3] and reference therein) embedded in the CMEMS Mediterranean Monitoring and Forecasting Centre (Med-MFC). The physical forcings were provided within the Med-MFC consortium, while the satellite-based surface chlorophyll ESA-CCI data set, supplied by the CMEMS - Ocean Colour TAC, was used for the assimilation. Biogeochemical initial and boundary conditions (at Gibraltar Strait, rivers and atmosphere) were set up on literature estimates.

The quality of the reanalysis was assessed against available independent (moorings, research vessels and historical-based climatology) and semi-independent (satellite) data sets, in terms of surface and sub-surface biogeochemical essential climate variables (chlorophyll, carbon dioxide partial pressure, ocean acidity, nutrients, oxygen), using GODAE-like metrics [4]. Our results highlight the capability of the model system to reproduce the present-day status of spatial patterns and seasonal cycle, confirming the vision of the Mediterranean as a mainly oligotrophic ecosystem with the presence of a significant zonal E-W gradient. Interannual variability of the chlorophyll field (Fig.1) is significant in the most productive areas (e.g. NWM) and reflects the interannual variability of the atmospheric-oceanic conditions.

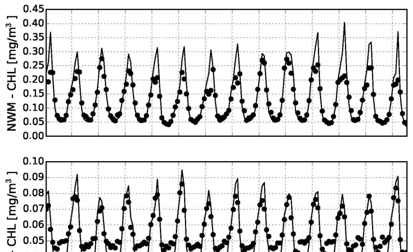

Fig. 1. Monthly mean surface chlorophyll concentration (solid line) compared with ESA-CCI satellite data set (dots) for North-western Med (NWM, top) and Levantine sub-basins (LEV, bottom).

Nutrients (phosphate and nitrate) and oxygen have been quantitatively evaluated against basin-wide estimates and in-situ observations (basically derived by research cruises in a specific time-spatial frame), which scarcely cover the basin-wide processes and are largely influenced by local and short-term processes. Indeed, the variability of reanalysis is lower than that of observations, due to the difference between the time discretization of the model outputs (monthly means) and the observations. However, the reanalysis well reproduces the basin-wide gradients and the mean vertical structures of the biogeochemical essential climate variables, and the error quantification represents a conservative measure of the model accuracy [4].

The current state of horizontal spatial nutrient distributions at surface (Fig.2, top) reflects the coastal-off shore interactions and the presence of areas with high mesoscale vertical dynamics (e.g. Northwestern Med, Alboran Sea) and of areas of permanent cyclonic structures (e.g. Cretan gyre).

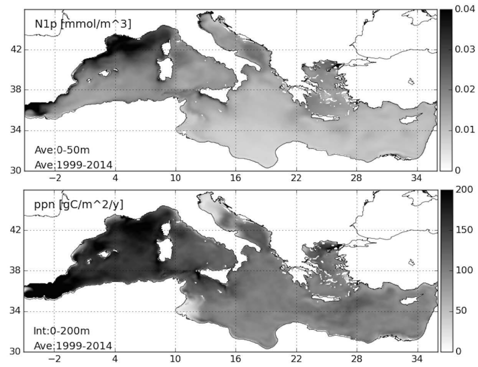

Fig. 2. Top: phosphate annual mean (0-50m; mmol P m^{-3}). Bottom: annual mean of 0-200m vertically integrated primary production (gC m^{-2} yr^{-1}).

Results of the reanalysis show a consolidated picture of the Mediterranean gradients (Fig. 2) and interannual variability. The system productivity (Fig. 2, bottom) is strongly related to the availability of nutrients during the winter period, which is a combination of nutricline height and vertical ventilation. Our reanalyses constitute a reliable dataset that can be used to estimate eutrophication MSFD descriptors, carbon cycle terms and the potential resources available for the higher trophic levels.

References

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