Modeling the biogeochemical dynamics of the Northern Adriatic Sea with an explicit benthic-pelagic coupling

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Introduction

In the framework of the European Project H2020 "ODYSSEA" (Operating a network of integrated observatory systems in the Mediterranean SEA, http://odysseaplatform.eu/) a **forecasting modeling system** of the coupled physical and biogeochemical conditions of the North Adriatic Sea (figure 1) is under development. The modeling system consists of the on-line coupling of the European general circulation model **NEMO** (Nucleus for European Modeling of the Ocean, https://www.nemo-ocean.eu/), with the marine biogeochemical model **BFM** (Biogeochemical Flux Model, bfm-community.eu/). The biogeochemical component of the model includes the simulation of the biogeochemical processes of both water column and sediments and their coupling (see figure 2).

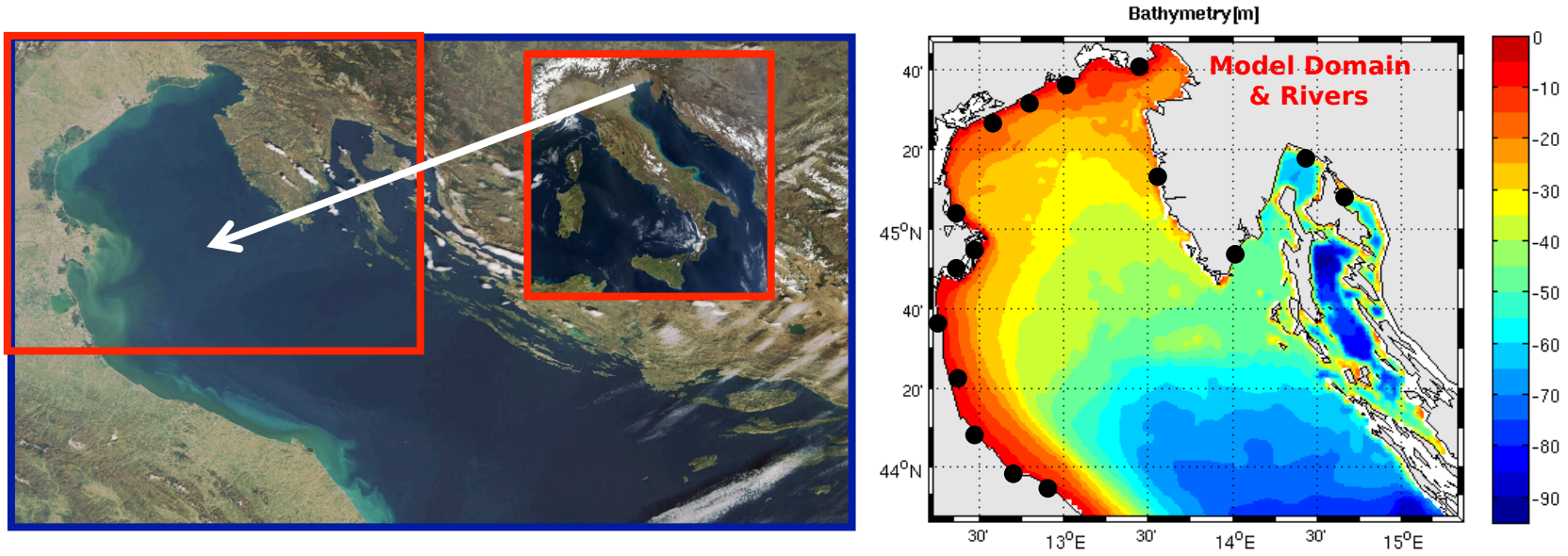
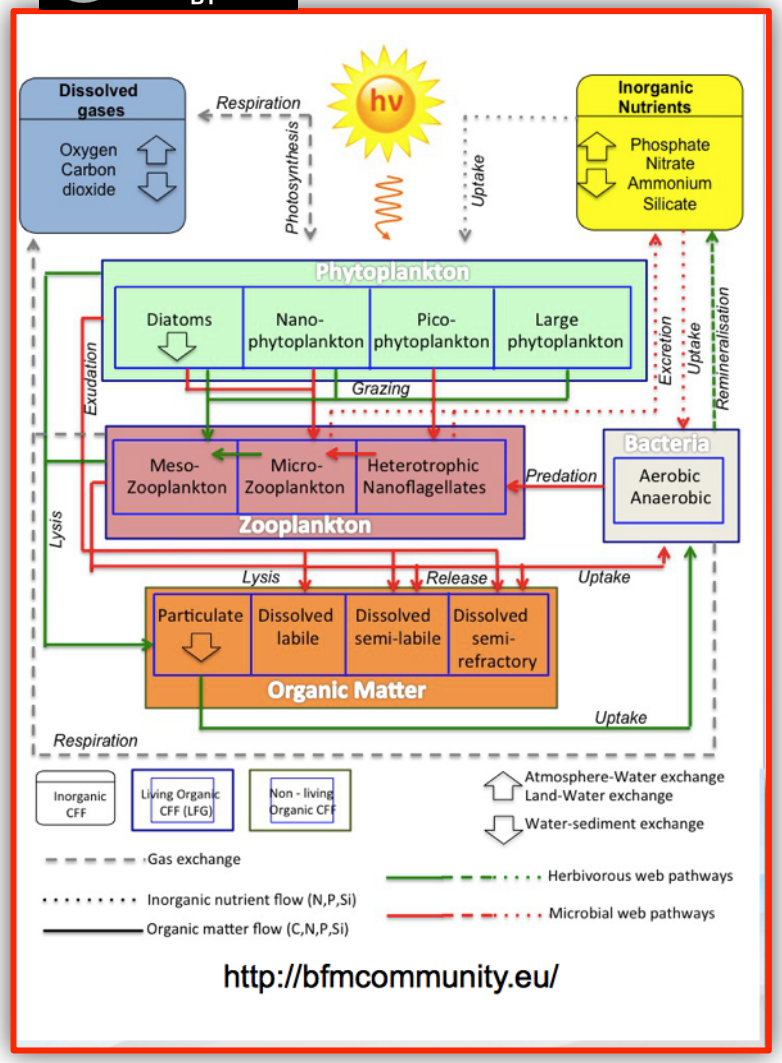


Figure 1. On the left, the map of the **case study** of the North Adriatic Sea, defined whithin the red line. On the right, the model domain with the **bathymetry** and the location of the **riverine inputs** (black points).

3D Coupled Physical Biogeochemical Flux Model



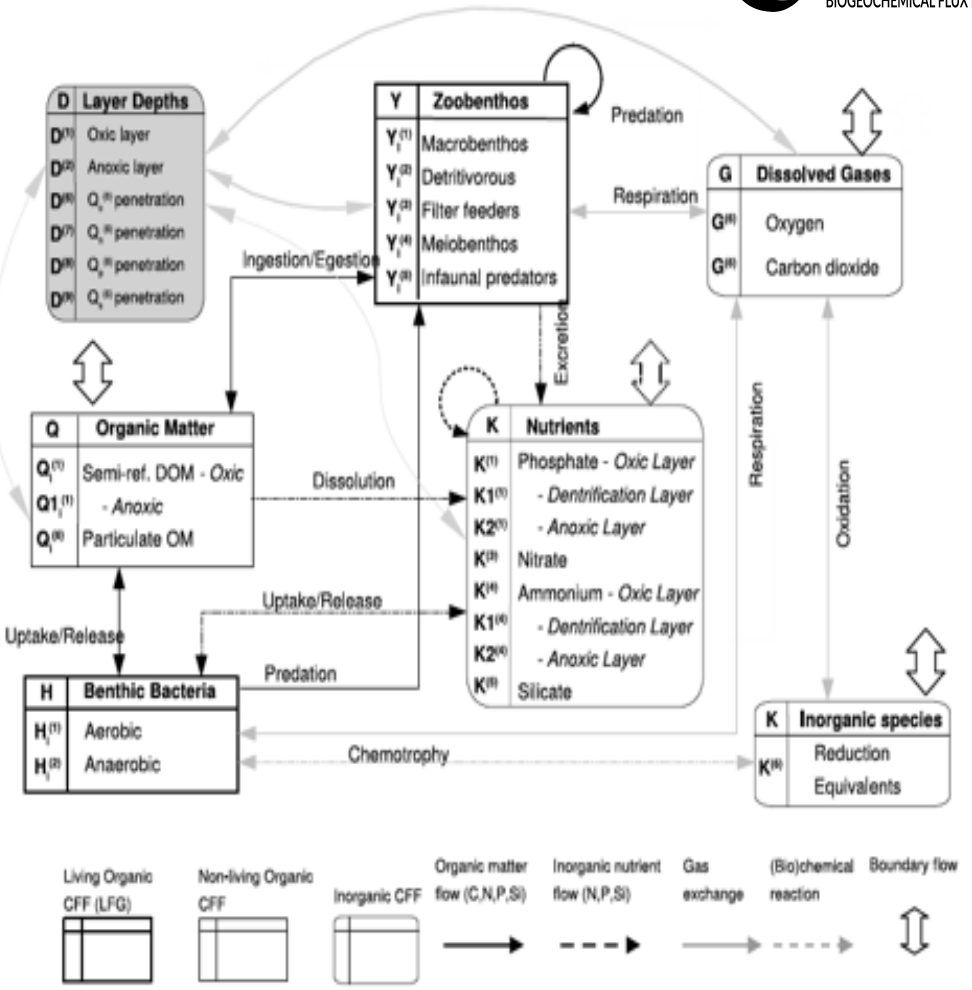


Figure 2. On the left, scheme of **the pelagic state variables and interactions** of the BFM. On the right, scheme of the **benthic state variables and benthic interactions** of BFM. The BFM component of the modeling system now includes a detailed and explicit representation of the benthic biogeochemical cycling (benthic fauna, organic matter, nutrients), as well as the dynamics of the benthic-pelagic processes.

Implementation of the Modeling System

Grid: 315 x 278 cells, horizontal resolution of 800 m and vertical resolution of 2 m, z coordinates.

Initial and Open boundary physical conditions
Off-line nesting with data from Copernicus Marine Environment Monitoring Service (CMEMS, http://marine.copernicus.eu/).

Atm. Forcing and runoff
ECMWF 6hr analysis atmospheric fields.
River fresh water discharge for the main northern Adriatic Rivers based on the monthly data of Ludwig et al. (2010).
Po river runoff from direct runoff daily measurements.

Initial and Open boundary conditions for the Biogeochemical component
From a previous simulation effort encompassing the whole Adriatic Basin and carried out with the Princeton Ocean Model directly coupled with BFM (Zavatarelli and Pinardi, 2003; Chust et al., 2012).

References

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- Zavatarelli M, Pinardi N. (2003). The Adriatic modeling system. A nested approach. Annales Geophysicae. doi:10.5194/angeo-21-345-2003.

Temperature

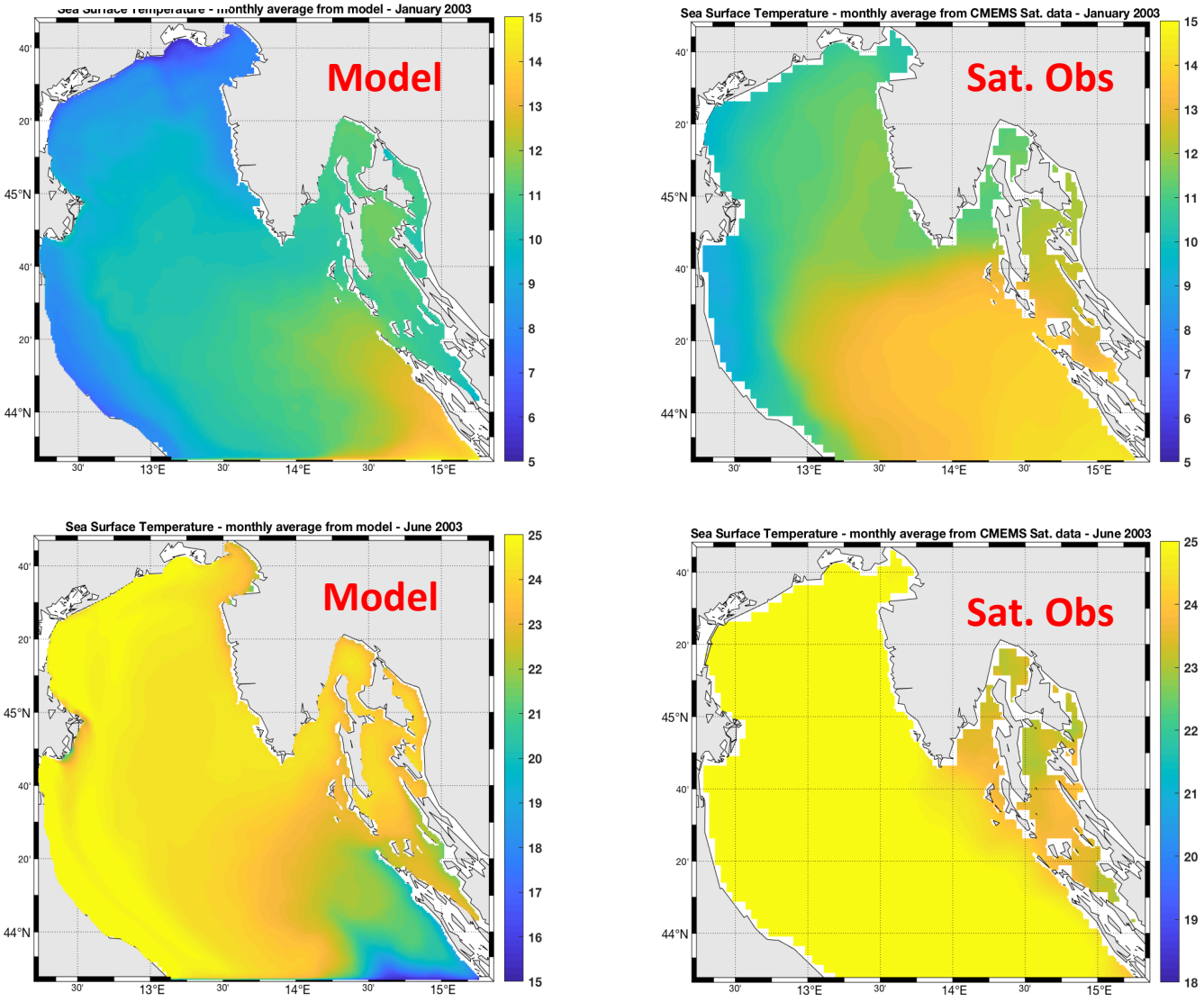

Figure 3. Maps of ***Sea Surface Temperature*** in degree C – monthly average for January 2003 in the upper panels and June 2003 in the lower panels. Model results on the left and satellite data from CMEMS on the right.

Chlorophyll-a

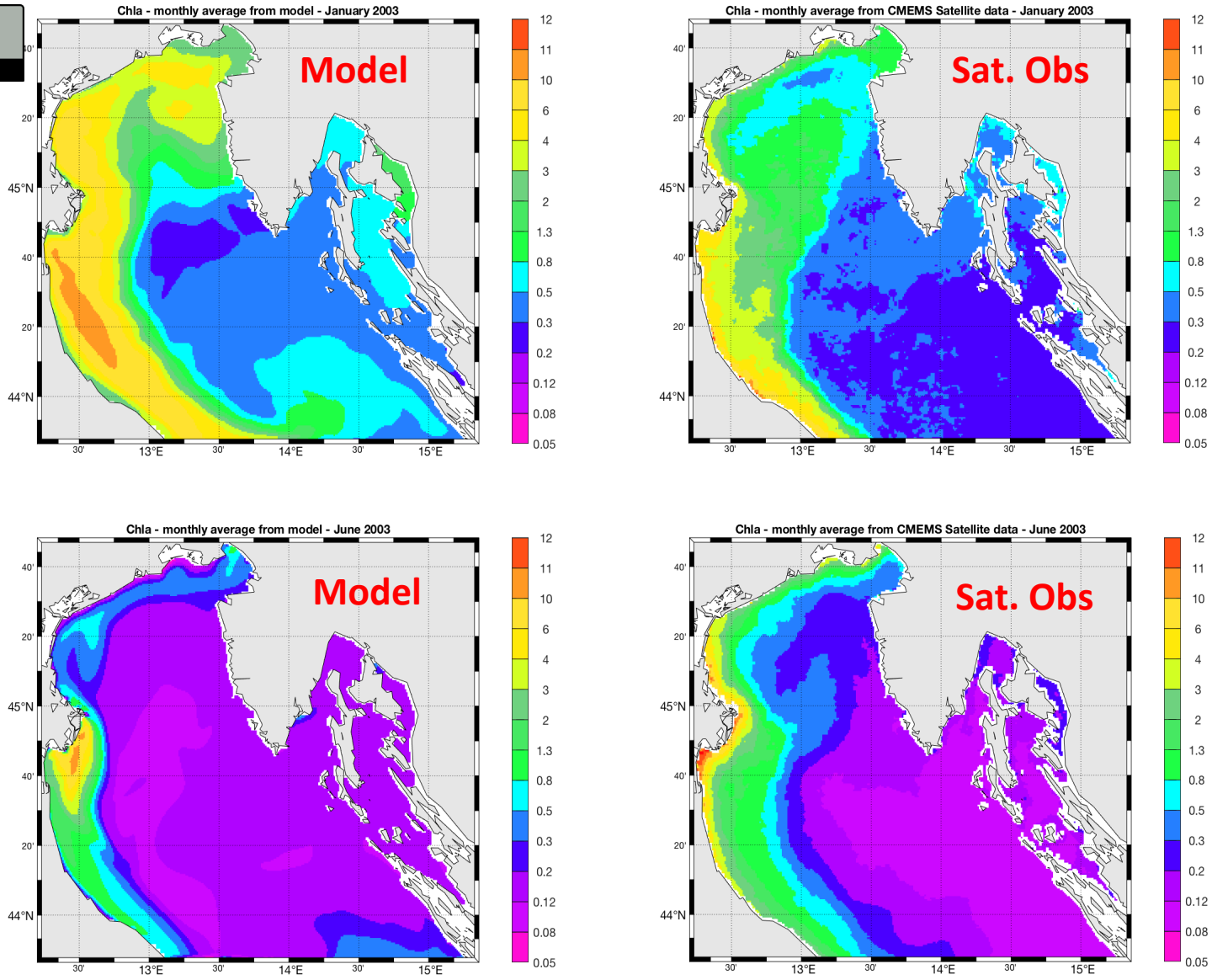

Figure 4. Maps of ***surface Chlorophyll-a*** in mg Chl/m^3– monthly average for January in the upper panels and June 2003 in the lower panels. On the left, model results; on the right, satellite data from CMEMS.

Benthic variables

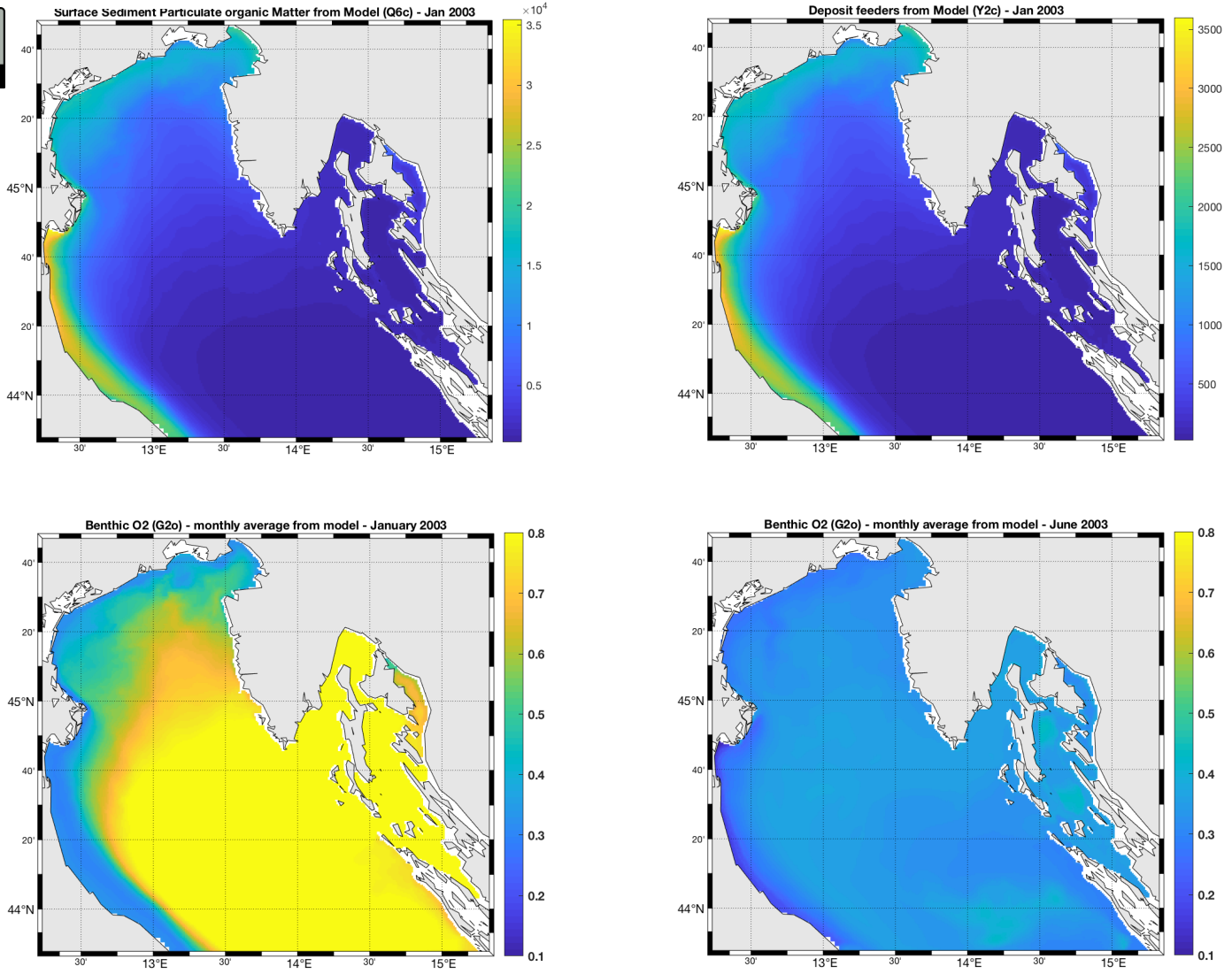

Figure 5. Distribution of some **benthic state variables computed by the model** for the year 2003. In the upper panels, surface sediment particulate organic matter (mg C/m^2) on the left and deposit filter feeders (mg C/m^2) on the right, for January 2003. In the lower panels, benthic oxygen (mmol O_2/m^2) in January 2003 on the left and in June 2003 on the right.

Preliminary Results and Future Developments

In this work, the model is run for the first time with an explicit benthic-pelagic coupling. Some preliminary results obtained from hindcast simulations of recent years are shown in comparison with observations from satellite platforms, for sea surface temperature and chlorophyll-a. Some results for benthic state variables are shown too.

Preliminary results indicate that the distributions of the pelagic biogeochemical state variables (see figures 3 and 4) are in reasonably good agreement with remote observations; also the benthic state variables concentrations are simulated in line with the known characteristics of the North Adriatic benthic ecosystem.
In particular, the seasonal variability of the benthic oxygen concentration (see figure 5) shows clearly the strong impact of the water column stratification (winter to summer) on the temporal dynamics of such state variable.

The inclusion of the benthic dynamics in the 3D biogeochemical modeling of a shallow coastal basin, such as the Northern Adriatic Sea, represents an innovative application in the field of coastal and shelf biogeochemistry, since benthic biogeochemical processes can significantly constrain the coastal environmental dynamics.
The operational forecasting system is foreseen to be ready in the next months, once completed the testing and the validation against the available observations from in situ and satellite platforms.

Aknowledgments

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