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An application of biogeochemical model BROM with 1-D transport model for studying of the vertical biogeochemical structure of the Black Sea

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Climate change and anthropogenic impact drastically affect the biogeochemical regime of the Black Sea, the contains the largest in the world volume of sulfidic water. The volume of the oxic layer of the sea depends on vertical mixing, that transports dissolved oxygen (DO) from the upper euphotic layer in the deeper layers and dissolved oxygen consumption for oxidation organic matter (OM). Changes in the Sea hydrodynamic properties due to warmer winters restricts renovation of the Black Sea Cold Intermediate Layer and therefore the DO flux to the deeper layers. The main goal of this study was to model upper 350 m with emphasis on redox layer.

In the study we use the benthic-pelagic biogeochemical BROM model combined with 2DBP model for vertical and horizontal transport via FABM. BROM combines a relatively simple ecosystem model with a detailed biogeochemical model considering interconnected transformations of chemical species (N, P, Si, C, O, S, Mn, Fe). OM dynamics include parameterizations of production (via photosynthesis and chemosynthesis) and decay via oxic mineralization, denitrification, metal reduction, sulfate reduction and methanogenesis.

Hydrophysical forcing (temperature, salinity and northward and eastward sea water velocity) was hourly data for year 2010 for a point with coordinates 43.5 °N. 37.75 °E from the E.U. Copernicus Marine Service Information “Copernicus”. The data is the result of a reanalysis calculation based on the NEMO hydrodynamic numerical model.

The 2DBP/BROM model was applied for the 350 m water column with bottom boundary positioned in sulfidic layer. A steady-state solution was reached after 50 calculation years. The results of calculations were compared with the data of field observations of the expedition on the RV "Knorr" in March 2003. The obtained vertical distributions of hydrochemical characteristics are consistent with the existing understanding of the hydrochemical structure of the Black Sea. The dissolved oxygen has the similar structure in the model and observations occupying the upper 70 m layer, its onset was positioned shallower than the appearance of hydrogen sulfide at appr. 80. In the limits of the redox layer there were reproduced maxima of nitrite, Mn(IV), Mn(III), Fe(III), elemental sulfur and phosphate minimum. Below the redox layer the model reproduced maxima of Mn(II) and Fe(II).

Calculated seasonal variability in the upper layer shows seasonality in development of phytoplankton and corresponding changes dissolved oxygen and nutrients. Organic matter distributions changes in accordance with seasonality of its production and destruction. At the same time, the redox layer remains practically unchanged during the year.

At the present the BROM model is applied for the Black Sea and satisfactory validated against the data of observations. The calculated seasonal dynamics of the biogeochemical properties of the Black Sea will be used as an initial condition for studying of effects of changing in mixing (considering modeling interannual changes with difference in hydrodynamical scenarios) and allochthonous OM delivery on the biogeochemical structure of the Sea.

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