Interactive comment on “Bottom RedOx Model (BROM, v.1.0): a coupled benthic-pelagic model for simulation of seasonal anoxia and its impact” *by* E. V. Yakushev et al.

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Simulation of alternating oxic/anoxic conditions in coastal ecosystems on the fine spatio-temporal scales is useful for studies of specific questions, from an explicit description of the bottom boundary layer to a succession/alteration of multiple electron donor/acceptor agents to details of alkalinity composition and effects on the carbonate system, etc. Therefore the manuscript could be interesting to a wider audience and published also in the main body of Geoscientific Model Development papers. In that case, the manuscript demands a **major revision,** because both the form and content are rather sloppily observed and prepared. Many of specific issues and details of such revision have already been indicated by the first reviewer, Prof. J. Middelburg. I concur with almost all of them.

However, while trying to further expand the list of questions, suggestions, and requests, I got substantial doubts in the suitability of this specific manuscript for this particular journal, based on the following:

1. Categorization of this manuscript as a “model description paper” requires a **comprehensive model description**, which internal consistency is verified by **demonstration of its capacities**, **rather than a detailed validation** of its implementation as would be ex- pected from a “model evaluation paper”. The ambiguity of the paper’s goals is reflected in repeating expressions like “to develop a model AND analyse seasonal effects”. As it looks now, the manuscript describes a specific model implemented for studies of some particular biogeochemical questions rather than **presents some finished single product** that can be relatively straightforwardly borrowed and used by interested colleagues.

The text was extensively modified to become a comprehensive model description rather than a validation. We use an example of calculations to demonstrate the model capacity (this part was significantly reduced). The code was re-written in many parts and commented to facilitate its use by interested colleagues.

2. Such ambiguity starts already from rather inconsistent definition of objectives. The title announces “coupled benthic-pelagic model for simulation of seasonal anoxia”, the abstract indicates the goal as a capturing of “biogeochemical processes occurring at the bottom boundary layer (BBL) AND sediment-water interface (SWI)”, the last sentence of “Background” Section indicates the goal as a capturing of “key biogeochemical processes occurring at the bottom boundary layer” only. Even farther, “the main goal of the model was to reproduce the biogeochemical mechanism of transformation of oxic conditions into anoxic in the sediment–water interface”. Perhaps, such obscurity reflects also a story of development of BROM from ROLM by substantially expanding list of variables and their interactions. If, as it seems to me, the real focus and achievements lay in the “middle”, then

almost a sole goal of the water column and sediment parts is to generate consistent boundary conditions for interacting BBL and SWI. From the manuscript it is also unclear, why the focus is on seasonal dynamics and what prevents the reproduction of sporadic short-term alterations or long-term persisting states.

The title and formulations of the goals in the abstract and text have been harmonized. A focus on seasonal dynamics was also deleted from the title following the Reviewer's suggestions. For the example calculations we focus on a seasonal cycle because much of the strongest biogeochemical variability (including deoxygenation) typically occurs on this time scale. However, we are clear in the revised text that BROM can be applied to study variations on a broad range of time scales.

Then, for a further implementation in diverse geographical areas it should be stressed and clearly explained, where from should the user obtain the data about external inputs, internal dynamics and distribution on multiple forms of sulfur, manganese, iron, as well as on different functional groups of bacteria. At the least, recommendations should be given on some proxies that could be derived from the pelagic ecosystem models with less uncommon sets of variables and processes.

A step-by-step guide to applying the model in given geographical area has been added to the text (Appendix A: Running BROM step-by-step). This guide includes recommendations on where necessary model inputs may be found (i.e. observations data, models output, databases, literature estimates). The issue of missing model inputs/data is now clearly confronted in the General Description (section 2.1.1):

"We acknowledge that for many of these additional variables, site-specific estimates of associated model parameters and initial/boundary conditions may be difficult or impossible to obtain, and may in practice require some crude assumptions and approximations (e.g. universal default parameter values, no-flux boundary conditions, initial conditions from a steady annual cycle). Nevertheless, we believe that for many applications this will be a price worth paying for the additional process resolution/realism provided by BROM for important biogeochemical processes in the BBL and sediments."

Besides, we made references in the Tables 2 and 3 regarding the processes formulations and the coefficients values

Furthermore, there are several ad hoc features and patches pertaining, perhaps, only for this implementation that should be explicitly indicated for a prospective users, for instance, holding sea surface concentrations constant results in non-conservation; prescription constant coefficient of vertical transport in BBL, while arbitrarily modifying it by assumed bioturbation in the sediments; extensive use of squared availabilities (Nutrient/Biomass)ˆ2 instead of concentrations N in nutrient limitation and trophic functions.

In the modified submission we have improved the flexibility of the model code and clarified the use of simplifying assumptions, including references where possible in the model code and input .yaml files. The BROM-transport model now allows the use of 4 different types of boundary conditions: 1) no flux (Neumann) except where surface fluxes are parameterized (Robin), 2) fixed constant (Dirichlet), 3) fixed sinusoidal variability (Dirichlet), 4) fixed arbitrary variability read from netCDF (Dirichlet). Choices 2-4 will result in a non-conservative simulation in the sense that material is added or removed from the model domain without an explicit treatment of the boundary flux; however, this may in many cases be more realistic than assuming no flux or a fixed constant flux. Regarding vertical diffusivity, the variation in the BBL can now be parameterized in two ways: 1) as a constant value, motivated by simplicity, and 2) as a linear variation, corresponding to a logarithmic layer for velocity (Holtappels and Lorke, 2011). These are both, of course, simplifying assumptions but we believe that they are justifiable as a first approximation. In the sediments, bioturbation can be the dominant process contributing to vertical transport and so should not generally be neglected. In the present version we have a 3-parameter model for the vertical variation of bioturbation in the sediments, including a constant maximum level near the surface followed by an exponential decay below a certain depth. We believe this should be flexible enough for most users.

Regarding the use of squared availabilities an explanation has been added to the text:

"The redox-dependent switches are preferably based on hyperbolic functions that improve system stability compared with discrete switches. The nutrient limitation and trophic functions are preferably based on squared Monod laws for Nutrient/Biomass ratio, which also stabilizes the system compared with Michaelis-Menten and Ivlev formulations."

Fortunately, selected results, ideas and formulations can still be gratefully borrowed by interested colleagues with appropriate reference to the ever available discussion paper.

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