

Letter for resubmitting the manuscript "FESOM2.1-REcoM3-MEDUSA2: an ocean-sea ice-biogeochemistry model coupled to a sediment model"

Dear Dr. Arndt and dear reviewers,

we are writing to resubmit the revised manuscript titled "FESOM2.1-REcoM3-MEDUSA2: an ocean-sea ice-biogeochemistry model coupled to a sediment model," originally submitted on September 4, 2023. We appreciate the constructive feedback provided by the reviewers and have thoroughly addressed their comments and suggestions in this revised version. This resubmission is made with the consent of all co-authors.

We would like to highlight again the key revisions made in response to the reviewers' feedback:

1. We slightly changed the structure of the manuscript by changing the names of simulations and titles of subsections so that the revised manuscript more focuses on the coupled simulation with FESOM2.1-REcoM3p-MEDUSA2;
2. MEDUSA2 was re-tuned to with a higher degradation rate for the low C:N organic matter;
3. Mass correction was applied in the coupled simulation to minimise the effect by asynchronous coupling;
4. The loss of nitrogen through denitrification in sediments was compensated by adding the corresponding amount of DIN in the bottom water boxes;
5. Based on the changes of the model code mentioned above, $R_{coupled}$ was rerun for a longer period: 2000 model years instead of 1500 years in the submitted version. The results of this new $R_{coupled}$ were shown and discussed in the revised manuscript;
6. More analyses of MEDUSA2 results were done and three new subsections focusing on the degradation of organic matter in sediments, solute exchange across the sediment-water interface and the burial fluxes were added into the result section and compared to available data where possible;
7. Two tables of model parameters were added in the appendix. For FESOM2.1-REcoM3p it shows the parameters modified in this study (for the configuration targeted for paleo-application) compared to Gurses et al. (2023). And for MEDUSA2 the table shows all reaction rate law expressions and parameter values used in this study;
8. The model-data comparisons of DIC, Alk, O_2 and nutrients (basin-averaged profiles) were completed to illustrate the initial conditions of the coupled simulation and the impact of the complex sediment model on marine biogeochemistry;
9. The model-data comparisons of seafloor deposition rates and burial fluxes were revised and Table 1 was corrected and completed.

While working on the revisions we decided in a few points to deviate slightly from the changes that we had announced in our response to the reviewers. This concerns the following points:

1. We gave in the Introduction a clearer description of the carbonate chemistry with a citation that describes its details and added chemical notations. We chose, however, not to show

the basic chemical equilibrium relations of the carbonate system as Reviewer #1 suggested, because these can be easily found in the cited publication;

2. We did show the zonal distribution of DIC, Alk, DIC and O₂ in two ocean basins in the response letters. In the revised manuscript, however, we decided to show the basin-averaged vertical profiles of DIC, Alk, DIN, DSi and O₂ of the simulation with a one-layer sediment representation and of the simulation with MEDUSA2, in comparison with observations instead, since we think that these illustrate the model performance in each basin in a much clearer way and allow for a better comparison with observation-based values.

We believe that the revised version addresses the concerns raised during the review process and have substantially improved the manuscript, making it more robust and suitable for publication in GMD.

Thank you for your time and consideration. We look forward to hearing from you soon.

Sincerely,

Ying Ye for all co-authors