

Geosci. Model Dev. Discuss., referee comment RC2
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Comment on gmd-2022-12

Anonymous Referee #2

Referee comment on "CANOPS-GRB v1.0: a new Earth system model for simulating the evolution of ocean–atmosphere chemistry over geologic timescales" by Kazumi Ozaki et al., Geosci. Model Dev. Discuss., <https://doi.org/10.5194/gmd-2022-12-RC2>, 2022

This carefully prepared paper describes an Earth System model of intermediate complexity that captures Earth's C, N, P, O, and S cycles. The model is well-described and two relevant applications are presented to demonstrate the capabilities of the model. The model is particularly useful for simulations on long (geological) time scales. The model code is made available allowing the work to be reproduced (but see additional comment below).

I read this paper with pleasure and have relatively few comments. Most of the detailed comments below are suggestions to rephrase the text to improve the clarity. The manuscript is quite long but because it is well-written, I don't think that is a problem.

Detailed comments

- Lines 25 and 1650. The authors write that "The model source code is available on GitHub and represents a unique community tool" and later "The CANOPS-GRB code is provided freely but with the requirement that prospective users contact the corresponding author with their research plans...". I don't think the latter requirement is appropriate. Other scientists should be free to use the model without the author's consent or knowledge. That's open science.
- Line 151. "preferred" instead of "required" since this will depend on the application.

- Line 173. Suggested change: "of the Earth system"
- Line 258: "to describe the overall design of the biogeochemical cycles"
- Figure 2. caption needs editing. Line 267: "anaerobic" instead of "anoxygenic"
- Line 278 and 283: "are transformed each other" needs rephrasing.
- Line 312: change to "the water column"
- Line 318. "2x60 sediment segments." Can you explain why this is two times 60?
- Table 2: Better to use the term "Fe bound P" since a lot of the P is not sorbed and instead is more strongly bound.
- Table 2: typo in "simulated" and "denitrification"
- Line 344. AOM is more commonly referred to as "anaerobic oxidation of methane"
- Line 345. "as a CH₄ degassing flux"
- Line 399-401. There is more work that is relevant in this context. You could cite Algeo and Ingall (2007) since they clearly showed the role of hydrogen sulfide in P retention and/or Papadomanolaki et al. (2022; Science Advances) who show a potential role for acidification and warming.
- Line 544: change to "papers"
- Line 797. Here, methanogenesis is termed "organic matter production from carbon dioxide" whereas this is a degradation process. Needs to be reformulated.
- Line 802: remove "most"
- Line 803: You write: "oxidants for organic matter decomposition change gradually, depending on the amount of each oxidant". Gradually with time? Or depth? Any change will also depend on the supply of reductants.
- Line 804: "on previous studies of early..."
- Line 817: change to "in the geological past"
- Line 821: "oxidation to" not "oxidation by"
- Equation (32) remove the dot.
- Line 831: change to "using a bimolecular.."
- Line 834: by definition, the suboxic layer does not contain hydrogen sulfide so it would be better to reformulate.
- Line 844 Sentence needs reformulation for clarity
- Line 858. Change to "are listed in"
- Figure 6: the line corresponding to "This study (oxic)" is not visible in the figure.
- Line 925. Here the authors write "such as" but it appears that these are the only terminal electron acceptors considered.
- Line 960 See earlier comment on "Fe-sorbed P"
- Line 1011-. Better to write "sediments overlain by oxic bottom waters". This will only hold for sediments with a relatively low input of organic matter. Otherwise the Fe-bound P will be lost, as observed in many modern coastal sediments.
- Line 1021-1025. See earlier comment.
- Line 1270 change to "until reaching steady state"
- Line 1291 change to "LD and HD regions"
- Line 1380-1381. It's not clear what is meant by "(Gray dots represent the unknown dissolved O₂ concentrations)".
- Figure 13b and lines 1404 and further. The authors focus on the benthic flux of P here but this gives a very large spread – as is commonly the case with benthic fluxes. No attempt was made to compile P burial fluxes from the literature. This needs some justification in the text, i.e. were there insufficient data to compare to or was there another reason?
- Lines 1450. Here you mention the role of the coastal ocean for N cycling. This is also relevant for the P cycle, since most P burial takes place in the coastal ocean. This could be mentioned somewhere in the text.
- Line 1508. "...leads to a lower"
- Line 1511. "leads"