Earth Syst. Dynam. Discuss.,
https://doi.org/10.5194/esd-2018-58-RC1, 2018

Earth System Dynamics
Discussions
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Interactive comment on "Ocean Phosphorus Inventory and Ocean Deoxygenation: Large Uncertainties in Future Projections on Millennial Timescales" *by* Tronje P. Kemena et al.

Anonymous Referee #1

Received and published: 7 December 2018

This is an interesting paper describing potential future changes in marine phosphorus (P) cycling over the coming two millennia as obtained with an earth system model of intermediate complexity. The major conclusions are that there are large uncertainties in these projections due to our lack of knowledge of the expected changes in P supply due to weathering and benthic release. An interesting observation is that, in this model, nitrogen fixation cannot keep up with P supply. The paper is generally well-written and deserves rapid publication. I do have a number of recommendations that I suggest the authors consider in a revision:

1. The presentation of the scenarios could be improved. In the model, 12 different

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runs were performed to explore how the marine P cycle responds to different model settings. The differences in the results of these scenarios play a crucial role but it takes the reader quite some time to figure out what is what. This could be improved if the sequence of the 12 scenarios in the text would be the same as in Table 1. A brief explanation of the various groups of scenarios could also be added in the caption of figure 2.

2. The reasons for the N limitation upon ocean deoxygenation could be mentioned explicitly in the abstract.

3. It would be helpful to the reader to explicitly discuss the model assumptions leading to N limitation including uncertainties in changes in Fe cycling. I also would suggest to move Fig. S2 to the main paper.

4. There is a lot of recent work on river fluxes of P to the ocean that would be appropriate to reference for context.

Detailed comments (partly overlapping): - Line 10: suggested change: "....that enhanced weathering and increased benthic phosphorus (P) fluxes"

- Line 14 and 15 and elsewhere: "until the year 2300"

- Line 25: suggested change: "In the model, nitrogen fixation was not able to adjust...":

- Line 25. Here, it would help if the authors clarify why nitrogen fixation does not adjust to the high P levels. Because these are model results, this can be specified.

- Line 27: "this contrasts with"

- Line 27. Here, the authors could clarify whether the palaeo reconstructions refer to model studies or reconstructions based on data or both and exactly how those results are different.

- Line 49. Suggested change "the Earth has experienced" or "the Earth experienced"

- Line 49. It's not clear what is meant by "climate OAE-like states". I would suggest to rephrase.

- Line 66. What about increased inputs of Fe from continental shelves upon ocean deoxygenation? Could they alleviate the Fe limitation in the model? What is the uncertainty in the dust inputs?

- Line 79. "and improved representations of"

- Line 96: "as the switching point"

- Line 98: "so that" (instead of "such that")

- Line 111 and Table 1: are benthic P fluxes equated to burial? I don't see the term benthic flux in Table 1. The terms need to be used consistently.

- Line 112: in a print, the purple and blue are very difficult to differentiate

- Table 1: please add much more detail on the abbreviations in the text (or can you think of an easier notation?). Now it is very hard for the reader to keep the various model scenarios apart. Note that the sequence doesn't match the text and that the anthropogenic flux not quantified.

- Line 136-138. Please explain this section on the organic C burial better: it seems contradictory that all organic C is remineralized but that there is still organic C burial.

- Line 258. "is essentially equal"

- Lines 225-226. It is very well known already for a long time that total P in rivers can be mobilized in the coastal zone and forms a key input of P to the coastal zone. These are not new findings of Benitez-Nelson, Compton et al. and Ruttenberg as suggested here, so I would suggest to rephrase this sentence.

- Same section: you could consider including a reference to the weathering & anthropogenic flux of P calculated from the Global News models (see the work of Seitzinger

et al. 2010; Global Biogeochemical Cycles) and follow-up studies (e.g. Beusen et al. 2016; Biogeosciences)

- Lines 258. Change to “essentially”

- Line 267. Change to “after the year” (note that “the” is missing before year in more places)

- Line 327: Change to “a consequence”

- Line 350. Change to “shown”

- Line 358-359. This is an important piece of information that also should be given in the abstract, see comment above.

- Don’t start a sentence with “So that”

- Line 440-443. Needs rephrasing since benthic P release is known to be important in the coastal zone from both experimental field studies and modeling.

- Line 459. The term “palaeo study” is vague. Please provide more information i.e. on the type of setting and time period.

- Line 460. “not able to compensate. . ..” Unless you are underestimating the Fe input to the ocean. A few lines on the uncertainties there (e.g. shelf Fe input, dustfield) would be useful.

- ‘line 480. Could be changed to “on benthic P fluxes in this model is eventually. . .” These results really depend on how the N and Fe cycles are parameterized – should be discussed in a few more sentences in the main text.

- Fig. S2: I would suggest to move this figure to the main paper.

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