

Response to the Editor's Comments

December 21, 2016

1 Editor's Comments

We thank the Editor for his comments. Below, please find our point-by-point response (in blue color).

- 1. Abstract: Replace "...enables a larger number of relevant feedbacks to take place..." by "...enables inclusion of the relevant feedbacks in climate change quantifications..."

We slightly rephrased this sentence but would like to stress that it is too early to talk about "climate change quantifications".

- 2. The paper may cause different reactions to the readers depending on whether they read the paper with the eyes of a (more physical) climate modeller or with the eyes of a marine ecosystem modeller (see the spread in the reviews). Therefore, it would be good to state up-front what this paper is about. Please, insert a sentence directly after the sub-heading "1. Introduction": "This perspectives paper deals with the marine ecosystem component of Earth system models and the quantification of respective feedbacks as well as impacts." (or something along these words)

We introduced a new opening sentence.

- 3. At end of page 1/beginning of page 1 you write: "To consider more biological variables in models is clearly the right way forward if one is interested in the response of the marine ecosystem to climate change (see Le Quéré, 2006, for a discussion)." Can you add reasons for this? I think this issue is debated. More complex models do not necessarily provide better results, especially when many not well constrained processes are added to models. I think one needs the appropriate level of complexity tailored to a specific purpose. Ernst's outstanding strength was to discriminate between important and unimportant processes in his modelling. Perhaps, you can add a paragraph discussing the trade-off between complexity and understanding? What

use is a model that is so complex that cause-effect links cannot be anymore identified?

We agree that this issue is under debate and thus changed the text accordingly.

- 4. Page 2, line 8: Replace “...trigger climate feedbacks...” by “...cause feedbacks to climate...”

Our understanding of a feedback is that it goes from A to B and back (and not just from A to B). We therefore just replaced “trigger” by “cause”.

- “Bacteria decompose the organic matter while sinking down and thereby determine the efficiency of the organic carbon pump.” This reads as if the bacteria are sinking down; moreover bacteria decompose also non-sinking organic matter. Please, reformulate so that the meaning is unambiguous.

We rephrased the sentence.

- 6. Page 3, line 9: “The climate relevance of the organic carbon pump has been evaluated by quantifying the air-sea fluxes of CO₂ without this mechanism.” This sentence does not make sense. I know what you mean, but for the unexperienced reader this is enigmatic. Please, reformulate.

We agree and rephrased the sentence.

- 7. Page 5, line 27: “Another important long-lived greenhouse gas is N₂O with a global warming potential for a 100 year time horizon that is approximately 300 times higher compared to CO₂ (Ramaswamy et al., 2001).” This cannot be. Or I have misunderstood what you write. The specific greenhouse potential (per molecule) of N₂O is larger than that of CO₂, but CO₂ is and will be by far the largest agent in radiative forcing. Please, correct and use the newest results from IPCC AR5.

That CO₂ is the strongest agent becomes clear when taking into account the actual atmospheric content of the GHG that is 3 orders of magnitude higher for CO₂ than for N₂O. However, we refer to GWP. We mentioned the original paper Ramaswamy et al., 2001 that was cited by the AR2. The new AR5-report gives the same number (295) but we agree that the newest reference should be taken, here and thus changed the reference accordingly.

- 8. Page 5, line 35: It would be good to mention potential destabilization of gas hydrates as well as sub-seabed permafrost and the conversion of the respective CH₄ to CO₂ by microbes.

While these processes may well be relevant for climate, we do not think that this is the right forum, because these pools are not related to **living** organic matter

(biota). The microbial conversion of CH₄ to CO₂ is a respiration pathway which is negligible compared to oxygenic respiration and will continue to be so in future (the release of CH₄/CO₂ by melting or destabilization may become climate relevant but the **biologically**-driven part plays a minor role). Thus, we chose not to add these processes here.

- 9. Page 6, sub-heading “3 What are the future impacts” You motivate the paper with quantification of climate relevant feedbacks. Therefore, the “impact topic” now comes a bit as a surprise. I do not know whether “impacts” is the best word here, as it is often contrasted to feedbacks. Maybe “What are the future implications for ecosystems and climate change?” is a more correct heading.

We agree and changed the sub-heading.

- 10. Page 8, line 20: “Nevertheless, it is expected that an expansion of oxygen minimum zones will increase the production of N₂O (Naqvi et al., 2010), because the highest production rates occur at the anoxic-oxic boundary layer.” Nitrification is named as the key marine N₂O production mechanism (Freying et al., 2012, Phil. Trans. R. Soc. B (2012) 367, 1245–1255). Boundary layers are usually associated with the friction layers at the top and bottom of the sea. It is not clear what is meant with “the highest production rates” – production rates of what? This sentence needs reformulation and correction. It may be wise to split the text into several sentences. The statements need backing by references.

We rephrased the sentence, so that it is hopefully more clear now.

- 11. Please, give the manuscript to a native speaker for a language check and respective improvements. The respective comment by reviewer 2 (“The English is poor. . .”) is not very diplomatically formulated (I know this hurts). Nevertheless this reviewer has a point and this needs to be addressed carefully.

We have given the manuscript to Dr. Christine Nam, who is a native English speaker and a guest scientist at MPI-M, to check for language and have incorporated her suggestions in the manuscript.