

Earth Syst. Dynam. Discuss., referee comment RC2
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Comment on esd-2022-28

Anonymous Referee #2

Referee comment on "How does the phytoplankton-light feedback affect marine N₂O inventory?" by Sarah Berthet et al., Earth Syst. Dynam. Discuss.,
<https://doi.org/10.5194/esd-2022-28-RC2>, 2022

OVERVIEW

The authors study the effect of light absorption by phytoplankton on the heat content of the ocean and subsequently on N₂O. They run simulations with full/partial representation of this process and study its effect. They demonstrate that indeed the biooptical coupling influences N₂O and the heat content of the ocean. I propose some modification to this manuscript prior to publication, which are given below.

GENERAL COMMENTS

- The model was spun up considerably longer than the simulation runs. Please elaborate as to why not use longer simulation runs?
- The overall text seems to be missing a thread and has too many shorthand notations. While familiar to the authors and others in the field, this hampers the flow of the paper substantially. I suggest reducing the usage of shorthand notation and move some of the technical parts to the supplement.
- Given the paper deals with the effect of the biooptical coupling I suggest the authors add exact mathematical expressions which describe this process. It is described somewhat shortly in lines 218 to 224. For example: please state the exact equations which model how phytoplankton affects light penetration. Subsequently, how does this affect the rate of phytoplankton growth, rate of heating at depth, and so on. I consider this to be of high value for non-experts. Also, it would make the model more easily reproducible.
- Please state the governing equations for phytoplankton dynamics: in particular the growth term of phytoplankton as a function of light, nutrients and temperature. What limits growth? How is the loss term parametrized? Does light penetration feedback onto the growth rate? Does temperature effect the growth rate? Is the model time step adequate to resolve this?
- Please add a figure displaying the model structure, highlighting the part related to biooptical coupling and the link to nitrous oxide, as it is the core of the paper.

- The effect of phytoplankton on the mixed layer depth is mentioned in line 447 (I assume the authors mean heating due to the biooptical feedback). Here the effect of wind is stated to alter the mixed layer depth more strongly than phytoplankton. However, it is known since Platt et al. (2003) that the phytoplankton change their biomass so that the Critical depth (Sverdrup, 1953) matches the mixed layer depth. This occurs due to the biooptical coupling that the authors explore. Please elaborate more on this.

REFERENCES

Sverdrup, H. U. (1953). On conditions for the vernal blooming of phytoplankton. *Journal du Conseil International Pour l'Exploration de la Mer*, 18: 287–295.

Platt, T., Broomhead, D. S., Sathyendranath, S., Edwards, A. M., Murphy, E. J. (2003). Phytoplankton biomass and residual nitrate in the pelagic ecosystem. *Proceeding of the Royal Society A*, 459: 1063–1073.

SPECIFIC COMMENTS

L14 Please rephrase the sentence starting with "Considering..."

L65 Change "into" to "through".

L67 Please remove "(because the same)".

L72 – L109 Suggested references on this effect from the literature:

Edwards, A. M., Wright, D. G., Platt, T. (2004) Biological heating effect of a band of phytoplankton. *Journal of Marine Systems*, 49, 89-103. doi: 10.1016/j.jmarsys.2003.05.011.

Edwards, A. M., Platt, T., Wright, D. G. (2001) Biologically induced circulation at fronts. *Journal of geophysical research*, 49, 89-103. doi: 10.1016/j.jmarsys.2003.05.011.

L152 Please rephrase the sentence starting with "In that perspective...".

L209 Table 1 should be on top of the table. Suggest renaming chl_inter, clim_zcst, clim_zvar so as to drop the "_".

L231 - L317 Please move to the Introduction.