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Interactive comment on "Phytoplankton calcifiers control nitrate cycling and the pace of transition in warming icehouse and cooling greenhouse climates" *by* Karin F. Kvale et al.

Anonymous Referee #1

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This paper describes simulation experiments with the EMIC UVic v2.9, in which atmospheric CO_2 is prescribed in a warming (ramp-up, or RU) and a cooling (ramp-down, or RD) scenario, during which CO_2 changed by 1% per year for 150 years. Three different model versions with different details of the biological carbon pump (in detail, the implementation of coccolithophores) are compared and results of the marine carbon cycle are discussed — with respect to the differences of the warming and cooling and also with respect to the importance of the details in the biological pump.

This paper is a follow-up of a paper just published in ERL, in which the same warming and cooling experiments have been analysed, but with only one set-up of the biological

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carbon pump. The results are interesting and I found no major resason against its publication. However, there is a list of minor issues which I like the authors to go through in order to come to an improved version of the manuscript.

- Increasing atm CO_2 from 285 ppm by 1%/y is similar to $CO_2(t) = CO_2(0) \times (1.01)^t$, which gives for $t = 150$ years a values of 1268 ppm, while the authors end their ramp-up experiments at 1257 ppm. Similarly, ramping down from 1257 ppm for 150 years gives after $CO_2(t) = CO_2(0) \times (0.99)^t$ a CO_2 of 278 ppm, not 285 ppm which the authors get. So, something in the described CO_2 scenario is corrupted. Since one paper with the same forcing has already been published, I suggest it is enough to refine the descripion of the forcing, I do not think new experiments are necessary. Maybe this misfit can be easily solved (e.g. rounding error?), if so, explain it.
- The scenarios are called RD (ramp-down) and RU (ramp-up) here, but have been called COOLING and WARMING in the initial paper (Kvale et al 2018, ERL). I suggest that the authors stick to the original names, which would then make it much easier for the readers to follow both papers.
- The description of the 3 different model configurations is too short and weak. What is the difference between the scenarios CAL and NOCACO3TR? In the text it is written, that NOCACO3TR does not contain prognostic CaCO3 tracer. What does this imply? For my understanding, the tracer might be only an output variable, but it seems that it is also that parts of the model are different. How is this related to ballasting (which is given as motivation for this study in the introduction)? I believe the word “ballasting” is not mentioned in the methods section at all. One gets some ideas of what is different from Table 1, but this should be expanded in the text of the methods section.
- page 2, line 6. ... PIC production of 1-1.6 PgC/y should be only 1-3% of total annual POC export. This would imply that annual POC export is around 100

PgC/yr. This is a number which I believe is much too high. However, to really evaluate it one needs to know how the authors define export production — which the reader does not yet know. Typically this is the vertical flux around a water depth of 100 m, but sometimes other depths are taken and then fluxes have to be transformed (using assumptions on remineralisation rates) to make them comparable. POC export at 100 m water depth is around 10 PgC/y (e.g. see Table 4 in Laufkötter et al., 2016), not 100 PgC/y. Please revise, explain and probably correct. Please state once, to which water depth all calculations of export prodcutions refer to.

- page 5, line 7: The ramp-up experiment leads to a warming of 6.8 K. Since in the ramp-up CO_2 rises from 285 ppm to 1257 ppm a short notation on the climate sensitvitiy (equilibrium temperature rise for 2xCO_2) of the model would be helpful to set this into context with other models. It is furthermore said, that zonally averaged upper ocean warms by as much as 8.6 K. This would imply the ocean warms more than the atmosphere, which is difficult to understand, when the CO_2 rise is the initial driver for the temperature rise. Is this connected with ocean circulation changes? If so, are there areas in which the ocean cools? Maybe the average ocean warming might also help here. Please explain.

- page 5, line 28-30: *However, the inclusion of PIC ballast in CAL causes near-surface POC export not to increase because the expanding calcifier population provides protection to an increasing proportion of the total POC from near-surface remineralization (Fig. 2 and Kvale et al., 2015b).* This is opposite of what I would think. If near-surface POC is protected from remineralisation, then POC export should increase. Please check and explain.

- page 6, lines 18-19. Define shallow and deep POC export.

- page 7, line 2: “5 mmol O2” misses some units, probably 5 mmol O2/m^3.

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- Appendix A (Transitionary response of global integrated NPP): This should become part of the main text, e.g. start the result section with it, or if only of minor relevance be deleted.
- Reference list: Most papers have long and double entries with links to the papers. This should be reduced to one entry with the DOI, or at max with a full www address including the DOI (https.//doi.org/...). Please check all links, some are corrupted, including the link to the previous paper (Kvale et al 2018 in ERL).
- Ref to Balch et al 2018 is a journal paper, but contains editors, which is weird for journal entries, please correct.
- Fig 1: Fonts of x- and y-axes labels are too small, maybe order subfigures vertically, not horrizontally, and therefore be able to increase size of the figures.
- Fig 1c. These are only changes in temperature, please give also absolute values somewhere.
- Table 2: Why are the initial nitrate inventory different for the 6 runs? Is there a tuning target, which was achieved, if so, give details in methods. And what does these differences in the nitrate inventory imply for the comparision of the runs?

References

Laufkötter, C., Vogt, M., Gruber, N., Aumont, O., Bopp, L., Doney, S. C., Dunne, J. P., Hauck, J., John, J. G., Lima, I. D., Seferian, R., and Völker, C.: Projected decreases in future marine export production: the role of the carbon flux through the upper ocean ecosystem, Biogeosciences, 13, 4023–4047, doi:10.5194/bg-13-4023-2016, 2016.

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