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Biogeosciences Discussions

Interactive comment on "The combined impact of CO_2-dependent parameterisations of Redfield and Rain ratios on ocean carbonate saturation" *by* K. F. Kvale et al.

Anonymous Referee #1

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The manuscript 'The combined impact of CO2-dependent parameterisations of Redfield and Rain ratios on ocean carbonate saturation' by authors Kvale et al. is a model sensitivity study testing a potential combined effect of changes in carbon to nutrient ratios of exported organic matter and pelagic calcification on the calcium carbonate saturation state of seawater. The main conclusion is that as a consequence of ocean acidification both effects will act as a positive feedback on a reduction of deep ocean calcite saturation, while the simple sum of both individual effects would yield a lower feedback. The topic ocean acidification is presently of high scientific interest, the study is clearly written and the results are interesting. However, the rationale for the respective parameterisations is not well explained. Furthermore, the study lacks model

validation, so that overly strong effects may be achieved by strongly biased background conditions.

Major comments: The study quantifies the sensitivity of the organic and inorganic carbon pumps on ocean acidification via potential feedbacks on seawater saturation with respect to CaCO3. The dependence of the calcification rate on seawater calcite saturation is taken from a study by Ridgwell et al., (2007). However, since calcite dissolution uses an exponential depth profile, the sensitivity of the calcium carbonate pump feedback is only partly covered. Furthermore it is stated that below 3000m PIC is completely dissolved (p. 6273, l. 19-20). Is this really true? How do the resulting alkalinity distributions look like?

The impact of increased CO2 on organic carbon fixation is derived from the Mesocosm study by Riebesell et al. (2007). A scaling factor is calculated that scales the flux of organic carbon to pCO2. The exact motivation of this parameterisation is not clear to me. First, I don't know whether this refers to atmospheric or seawater pCO2. Second, where does the ratio 2/700 in equation 5 come from? What does it represent? Third, the model is spun up with an atmospheric pCO of 278, which means that the scaling factor at starting conditions would be slightly below one. This deviation is probably unimportant, but needs to be clarified. If the scaling factor for the organic carbon flux refers to in-situ pCO2 (what I assume after reading the manuscript), this would yield spatially differing scaling factors already for the preindustrial state. Are there any data supporting this spatial distribution? Due to the strong spatial variability of pCO2 in the modern surface ocean this should be detectable, probably at least in the tropical Pacific where the scaling factor yields a value of 1.09.

The study does not provide any model validation. The high amount of export production (20 GtC/yr) is probably an overestimation and would shift the sensitivity of the organic carbon pump towards the upper end. Furthermore, a model-data comparison of the carbonate system variables would be very interesting, since the distribution of Omega looks fairly different from the Glodap data. The depth of the calcite saturation level would also be a suitable indicator to assess model performance, and it would also be interesting for the results section which vertical movements of the saturation horizons can be expected in the present study. An assessment of model performance including a critical discussion of the effects of potential model misfits would be highly desirable.

I think the notation of linear and non-linear feedbacks (Figure 3) is confusing, since even the individual feedbacks are probably non-linear. Why should their combination end up as linear? I would suggest to call them 'combined' and 'added' feedbacks. Furthermore, what is explaining the negative 'added' feedback (last row in Figure 3)? Do both feedbacks head into different directions and one is overcompensating the other, or is simply the combination of both yielding a stronger effect than the sum of the individual effects. It would be very illustrative to show also the results from the individual effects in Figure 3.

Why are the feedbacks so strong in the eastern tropical Pacific and why only there? Does the model have exceptionally high export production in this area? Please show map of carbon export, which also needs to be defined in the manuscript. Is it the carbon flux at 100 m depth?

Minor comments:

The use of the term Redfield ratios is confusing. According to Redfield et al. (1963) the Redfield ratios are constant elemental carbon to nutrient ratios for C:N:P of 106:16:1. Even if well motivated, any deviations from these ratios are simply element ratios and should therefore not be called Redfield ratio.

p. 6266, l. 2: what is a 'biogeochemical climate'? Do you mean biogeochemical cycles?

p. 6266, l. 3: replace 'on' by 'of'

p. 6266, l. 20-21: The impacts of ocean acidification on the organic and inorganic carbon pumps are presently not clear, but heavily debated. Therefore, it should be

more carefully mentioned that there is a potential for changes, which will be tested in the present study.

p. 6267, l. 10: replace 'a' by 'the'

p. 6267, l 18: please define 'export'

p. 6267, l. 17-21: what do you expect from this reorganisation in terms of oceanic carbon sink and saturation state?

Equation (5): what is the data base for this equation? What does the 2/700 represent?

p. 6270, l. 26: what 'physical' feedback do you mean? Maybe the use of 'biogeochemical' would be more appropriate.

p. 6272, l. 8-11: remove the two sentences, this is all seen in Figure 3.

p. 6273, l. 15: which 'global mean profile plots' are you referring to?

p. 6274, l. 25: why is the PIC export insensitive to Omega?

p. 6275, l. 8: replace 'CO2' by 'CO-induced'

p. 6275, l. 13-15: Yes, but the biggest changes are seen at depth, while calcification appears at or close to the surface, where changes are much smaller.

Figure 1: In the text it is stated that the blue line in the left panel is actually above the black line. However, since this is not visible in the Figure, the difference is probably not significant and not worth mentioning.

Figure 2: I don't understand Figure 2. What are the bold arrows standing for? And why does the ultimate direction of a combination of feedbacks depend on the number of individual contributions? Shouldn't the individual strengths also play a role?

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