Biogeosciences Discuss., 8, C3841–C3844, 2011
www.biogeosciences-discuss.net/8/C3841/2011/


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.

**K. F. Kvale et al.**

k.kvale@unsw.edu.au

Received and published: 26 October 2011

The authors would like to thank the reviewers for their helpful comments, which have improved the manuscript. Reviewer comments are shown below in boldface text. Author responses are shown in plain text. Revisions to the manuscript text are shown in italics.

**Reviewer 2 Comments**

**"Review of 'The combined impact of CO2-dependent parameterisations of Refield and Rain ratios on ocean carbonate saturation', by Kvale et al.**

**Overall, I found the article to be very interesting in the scientific questions it addresses, and the simplicity of the modeling approach is attractive and appropriate to the science question. The most important limitation of this study is that the authors do not provide any evaluation of their model against available data or data products. This is a serious deficiency, especially given the wide public availability of data collected over the last several decades. The authors could either consider individual comparisons with sections for the major basins, or gridded distributions from data products."**

The authors thank this second Reviewer for pointing out this key limitation of the original manuscript, which is the lack of model validation. This limitation was also pointed out by the first Reviewer. An additional "Model Evaluation" section (new Section 2.4) and figure (new Fig. 1) have been added to the manuscript, which compare model equilibrium DIC, alkalinity, calcite Omega and nitrate with GLODAP gridded data.

**"Another limitation of the study is that the scientific context for the parameterisations introduced needs to be more fully developed, and justified. In the 'Summary and Conclusions' section, the authors refer to several previous studies within the context of these results. I believe that the paper would be strengthened by modest restructuring, with a few additional paragraphs in the introductory section describing more specifically what kinds of issues arise in the real ocean (science context), what the unresolved problems are, and why the parameterisations proposed here are appropriate.**

**With these changes, the paper will be of broad interest and appropriate for publication in Biogeosciences, and I recommend that it be published with minor revisions."**

Additional and re-phrased background is now provided in the Introduction regarding model parameterisations and their impact on the global carbon budget, and is as follows for POC export:



BGD

8, C3841–C3844, 2011

Interactive Comment

*“The efficiency of the biological pump has historically been thought to be controlled not by the availability of CO2, which is abundant, but by temperature, light, and the availability of nutrients nitrate (NO3-) and phosphate (HPO4). Hence the fixed stoichiometry of the photosynthesis equation is typically applied to marine carbon cycle models, based on the empirically-derived Redfield ratio (Anderson, 1995). Thus enhanced CO2 model experiments show increasing POC production is accompanied by proportional depletion of nutrient pools, which limits primary production (Schmittner et al., 2008). Mesocosm experiments by Riebesell et al., (2007) suggest the above fixed carbon-to-phosphate stoichiometry may vary by as much as a factor of 6 under high-pCO2 conditions, significantly altering the efficiency of primary producers consuming DIC and reducing the effect of nutrient limitation. Near term (to 2100) high CO2 model studies which incorporate a variable C:N (or P) ratio (e.g., Schneider et al., 2004; Oschlies et al., 2008; Boudreau et al., 2010) yield only a small additional negative impact on the global anthropogenic carbon budget as coincident changes in ocean physics compensate internally and air/ocean exchange is limited by the solubility pump.”*

And for PIC export:

*“Sufficiently reduced carbonate concentration lowers Omega, reducing the biotic carbonate precipitation rate (Zhong and Mucci, 1993). Seventy percent of total calcification is performed by pelagic coccolithophores, foraminifera, and pteropods, making their response to Omega particularly relevant for the global carbon budget (Zondervan et al., 2001). The reduction of biological carbonate production (particulate inorganic carbon, PIC) as a response to increased pCO2 means less CO2 is released to the surface mixed layer as a by-product of calcification. This “CO2-calcification feedback” (Ridgwell et al., 2007) is only a minor player in global carbon budgets over the short term (Gehlen et al., 2007; Ridgwell et al., 2009; Gangsto et al., 2010) with an expanding (but still minor) role on a millennial horizon (e.g., Heinze, 2004; Ridgwell et al., 2007; Gehlen et al., 2007; Boudreau et al., 2010). The most salient effects of the CO2-calcification feedback are resulting changes to nutrient and carbonate pro-*



BGD

8, C3841–C3844, 2011

*files which could impact on ecosystem dynamics (e.g., Ridgwell et al., 2007; Boudreau et al., 2010). Carbon export away from the surface is also impacted by changes in calcification: sinking PIC acts as ballast for sinking POC (Klaas and Archer, 2002). Biogeochemical models often assume a fixed PIC:POC ratio (the Rain ratio) for this ballasting, but increasing pCO2 can reduce the aggregation of PIC by coccoliths and affect ballasting rates (Riebesell et al., 2000; Zondervan et al., 2001; Biermann and Engel, 2010). "*

---

Interactive comment on Biogeosciences Discuss., 8, 6265, 2011.



BGD

8, C3841–C3844, 2011

Interactive Comment