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Discussions

Interactive comment on "Sensitivity of atmospheric CO_2 to regional variability in particulate organic matter remineralization depths" *by* Jamie D. Wilson et al.

Anonymous Referee #2

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Wilson et al. present a sensitivity study of a simple global biogeochemical ocean model, in which they varied the particle flux exponent b globally and regionally, and investigate its effects on diagnosed atmospheric CO2 and global preformed phosphate in the ocean interior. Tracer transport is simulated using offline circulation matrices derived from the coarse-resolution MIT global model. Biogeochemistry is parameterised following Kwon et al. (2009), using a nutrient-restoring approach and a constant-export scenario. Their results show a large impact of b in the subantarctic region and western equatorial Pacific on CO2, and on preformed phosphate across regions. Compared to the effect of a global variation b (of ca. 80 ppm for b varying between 0.7-1.2), the local variation only adds some 5-15 ppm, i.e., seems to play a minor role.

I think this paper provides some very useful and new aspects regarding the importance of a potential regional variation of b, and its consideration in global biogeochemical models. Overall, the paper is well written, although I think the description of experimental design and analysis could be somehow improved. (I also noted some typos; see below.) My main concern is that the results are likely tied to the circulation model applied. As shown by Duteil et al. (2013; Biogeosciences, 10, 7723–7738, doi:10.5194/bg-10-7723-2013) the transport matrices from the MITgcm seem to suffer from far too large outcrop areas of dense waters in the Southern Ocean (their Fig. 2), indicating that the model circulation does not represent the real ocean in that region very well. Also, because of the very coarse resolution, this model might not represent the physical dynamics in the eastern equatorial Pacific very well. However, in the present study these two regions - the subantarctic regions and equatorial upwelling - have a large influence on CO2 (Fig. 3 and 5). Thus, whereas this study provides important and interesting information for other global model studies that apply similar circulations (as noted in Discussion and Conclusions), I think that a few sentences on this are necessary to caution readers not familiar with the advantages and disadvantages of global circulation models. (To illustrate or investigate this point further, one could, e.g., look at the density distribution or mixed layer depths of the model.)

There seems to be a strong sensitivity of CO2 to changes in b in the constant-export scheme (Fig 3), and also a clear relationship to export (Fig 4a). In contrast, normalized (by what?) preformed phosphate seems to be more sensitive in the nutrient restoring scenario (Fig 5 vs Fig S3), and no relationship seems to exist between CO2 sensitivity and export (Fig 4b). I think these contrasting patterns for both model types deserve a bit more discussion. Perhaps some section plots of, e.g., density across the Pacific and Atlantic (see above) could aid the disussion about the effects of circulation vs. export type ("biogeochemistry"). If the circulation model is anywhere near the real world, some insight regarding the "connectivity" of different regions might perhaps be gained from the data-constrained analysis of water fractions presented by Khatiwala et al. (2012; Earth and Planetary Science Letters, 325–326, 116–125).

Specific comments:

p 3, line 15: "MITgcm" sounds like technical slang to me - is there a better word for it?

Section 2.3: At first, I had difficulties understanding the experimental design; I would suggest to indicate more clearly that the "reference" experiments were carried out over a discrete set of globally uniform "b" values (how many?), and to distinguish this more clearly from the LHS experiments for the regional variation

Eqn. 2 and Table 1: The connection between beta_0 and beta_k of Eqn 2 and Table 1 is not clear to me: are beta in the table beta_k of equation 2? Is beta_0 constant?

p 5, line 11: "we fit linear regression models" - I suggest to refer here again to Eqn 2.

p 5, line 28-29: "However, the relative sensitivity ranked across regions remains similar, as shown by expressing b_k as a percentage (Table 1)." - relative to what?

Table 1: Please explain clearly what is shown in this Table: are beta the beta_k of Eqn 2? What does beta(%) mean - normalised by area? Are the two rightmost columns for the constant export experiments?

p 6 line 4 "positive"

p 6 second paragraph: is there a difference between "export production" and "export productivity"?

p 6, line 20 "is normalised" - by what?

p 7 line 3: "sensitivity"

p 11, line 5: "κ"

p 11, line 20: "function"

p 19, caption: "relects"?

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