Biogeosciences Discuss., 4, S2423–S2425, 2008
www.biogeosciences-discuss.net/4/S2423/2008/

Biogeosciences Discussions

BGD

4, S2423–S2425, 2008

Interactive Comment

Interactive comment on "The impact on atmospheric CO_2 of iron fertilization inducedchanges in the ocean's biological pump" *by* X. Jin et al.

X. Jin et al.

Received and published: 19 January 2008

Reply to Reviewer 2 (Anand Gnanadesikan): Part 1 — Summary

We are grateful to Anand Gnanadesikan for his extensive comments on our paper. We found his comments and suggestions useful for improving the manuscript and for clarifying our arguments. We have modified the manuscript to address many of his specific concerns. In some instances, our interpretations differ with those of the reviewer, in which cases we have revised the manuscript to clarify our arguments and detail below our reasoning for not altering the manuscript as suggested. Before we start with our detailed responses, we start with a summary of the reviewer's comments and our answers.

Full Screen / Esc

Printer-friendly Version

Interactive Discussion

Discussion Paper

Summary:

In a nutshell, the reviewer liked our study, but was very critical of our argument that the depth distribution of the stimulated export production is the primary factor controlling the atmospheric uptake efficiency. He argues that the high correlation with the depth distribution that we identified in our simulations is due to another process, in particular a process he calls "borrowing", i.e. that export is stimulated on the basis of nutrients that come from outside the stimulated patch or from periods outside those during which iron was applied. In addition, the reviewer argues that it is impossible for our atmospheric uptake efficiencies to be so large, as this is in contradiction to basic scaling arguments.

In our responses below, we maintain our position and continue to argue that the depth distribution is key in controlling the atmospheric uptake efficiency. We base our arguments on several lines of evidence. But perhaps the most important one is the argument that we obtained from repeating and modifying some of the experiments of Gnanadesikan et al. (2003) using their nutrient restoring model. In particular, we computed the atmospheric uptake efficiencies after 10 years from a nutrient restoring simulation, where we "fertilized" a patch just at the surface and one where we "fertilized" the same patch but across the entire euphotic zone (as done by Gnanadesikan et al. (2003)). The results from these simulations clearly support our hypothesis, since the former (surface only) resulted in an uptake efficiency that is 3 times larger than the latter (across all levels), exactly as predicted by our argument. This difference exists regardless of whether the simulation was done with a one-time experiment (as done by Gnanadesikan et al. (2003)), or by "fertilizing" continuously for 10 years. This difference argues strongly against borrowing being important, since one would have expected substantial differences in the way nutrients are borrowed across time. Furthermore, we will show that the scaling arguments, once properly applied, are actually in agreement with our findings.

In response to these arguments, we added following new paragraphs to our submitted manuscript, i.e.:

"We tested this inference by conducting depth-dependent fertilization simulations with the nutrient restoring model of Jin and Gruber (2003) (the same model as that used by Gnanadesikan et al. (2003). In a first set of cases, we restored the limiting macronutrient phosphate to zero over the entire euphotic zone as done in all previous studies. In a second set of cases, we restored phosphate to zero only in the surface layer of the model. For both sets, we conducted one-time (3 months) and continuous fertilizations for a duration of 10 years. The atmospheric uptake efficiencies over ten years from these sets of simulations clearly support our hypothesis, i.e. we find atmospheric uptake efficiencies in the near-surface fertilization cases that are three times larger than those from the entire euphotic zone fertilization cases, with little difference between the one time and continuous fertilizations. Budget analyses of these simulations show that these differences in the atmospheric uptake efficiencies are associated with the depth distribution of the anomalous production, with a more shallow distribution of the anomalous production favoring higher atmospheric uptake efficiencies.

Other factors, such as the "borrowing" of nutrients from other regions and other periods leading to reduced production downstream in time or space, a mechanism suggested by Gnanadesikan et al. (2003) and taken up by Aumont and Bopp (2006) can play only a minor role. If this mechanism were important, one would expect strong differences between one-time and continuous fertilizations, as the borrowing would follow different transport mechanisms. No such differences are seen in our simulations, as there is little change between corresponding one-time and continuous fertilization simulations."

Interactive comment on Biogeosciences Discuss., 4, 3863, 2007.