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Biogeosciences Discussions

Interactive comment on "Impact of atmospheric and terrestrial CO_2 feedbacks on fertilization-induced marine carbon uptake" *by* A. Oschlies

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I thank Birgit Schneider for her careful review and constructive criticism and valuable suggestions for improving the manuscript!

1. Different behavior under CO2 emission scenario: A main point addressed in her general comments is that the system would operate differently when including the anthropogenic perturbation. While I agree that the entire system changes (e.g. because of elevated pCO2 and elevated temperatures), the results of the study here would be still valid. When accounting for anthropogenic CO2 emissions, atmospheric pCO2 is expected to rise. In agreement with the reviewer, I would, for reasonable fertilization

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intensities, not expect a net flux of carbon form the atmosphere to the land. The perturbation of the flux of carbon from the atmosphere to the terrestrial vegetation on reducing the increase of atmospheric CO2 by ocean fertilization would, however, be of reverse sign, i.e. from the land to the atmosphere. Thus, the results of the current study essentially apply to perturbation fluxes in scenarios both with and without background CO2 emissions.

There is, however, a quantitative difference between simulations with and without anthropogenic CO2 emissions. This is due non-linearities in the system, such as the increasing oceanic buffer factor (Revelle factor) under elevated CO2 and non-linear sensitivities of the terrestrial carbon pools to the expected substantial changes in atmospheric CO2, temperature, and the hydrological cycle. Unfortunately, it is more complicated to set up runs equivalent to VEGconst (and to some extent CLIMconst) with increasing background CO2, than it is for constant background CO2. To keep climate and/or vegetation constant relative to an increasing background CO2, one would have to prescribe the evolution of climate and/or vegetation for the fertilization run. An experiment corresponding to ATCO2const is easier to perform by prescribing the increasing atmospheric pCO2. The results of such an experiment resulted in an atmospheric CO2 drop of 27.5PgC for increasing C:N ratios compared to the ATCO2const run with increasing background CO2. This is about twice as high as for the experiment with constant pre-industrial background CO2 (12.7PgC, Table 1 of the paper). The larger sensitivity of atmospheric CO2 to changes in the C:N ratio (or ocean fertilization) is essentially caused by an increase in the Revelle factor with oceanic CO2 uptake under increasing background CO2 (Kurz and Maier-Reimer, 1993). Additional nonlinearities come from the terrestrial biosphere's response to changes in background CO2, temperature, and hydrological cycle. A discussion of these matters is added as a new section 3.4 in the revised paper.

2. Imbalance in terrestrial carbon cycle I agree that ultimately respiration and net production must balance to the extent that river runoff and burial in deeper reservoirs can

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be ignored. However, the turnover times of the terrestrial vegetation and soils are very different, with much longer (up to centennial) timescales for some soil components. This is accounted for in the model together with the large carbon pool size of the soils, which allow respiration to continue for centuries even if production were shut down.

3. Would mechanism work in reverse mode? An interesting point I had not considered considered before. Because most of the carbon that can exchange with the land is ultimately in the ocean, with the atmosphere only being the (inflatable) pipe connecting the two large reservoirs, much of the carbon taken up via fertilization or afforestation on land will come from the ocean. For example, regrowth of terrestrial ecosystems (forests) after the last ice age has taken up hundreds of GtC, while there was very little change in atmospheric CO2 (at most a few tens GtC).

Minor points:

p.4503: The technical part of this section has been moved into the model description, section 2. The C:N ratios of these experiments were constant, as is now mentioned in section 2.

section 3.3: The text has been modified. The climate feedback discussed here is only the feedback from fertilization-induced climate change. The 2 PgC additional uptake are essentially due to the solubility pump and arise from the increase in atmospheric pCO2 as a result of enhanced terrestrial remineralization at higher temperatures.

Table 1. Many thanks for pointing out this inconsistency! Unfortunately, there were two errors in the original Table 1: Firstly, the conversion of pCO2 to atmospheric carbon mass contained a wrong atmospheric volume. Secondly, the figures for the carbon change in the ocean used a reference point a few years off and neglected the small (0.4PgC) increase in organic carbon. This has now been corrected in Table 1 and also in Figure 3. As the errors were relatively small, this does not affect any of the conclusions of the paper.

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typos have been corrected

headings Table 4: The headings are correct, but the figure caption was not. This is now corrected. Thanks for pointing this out!

Fig.2b: I prefer to leave this figure that demonstrates that the large changes in fertilization-driven oceanic carbon uptake are not caused by differences in the export production (as mentioned at the end of the introduction of section 3).

Interactive comment on Biogeosciences Discuss., 6, 4493, 2009.