**Climate
of the Past
Discussions**

Interactive
Comment

Interactive comment on "A comprehensive, multi-process box-model approach to glacial-interglacial carbon cycling" *by* A. M. de Boer et al.

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Biogeochemical mechanisms behind the glacial pCO2 cycles are not well understood. To shed more light on interconnections among oceanic circulation, nutrient utilization, and atmospheric CO2, de Boer et al. use a simple box model in an original way by doing extensive exploration of the model parameter space. They look at an old problem from a new angle and the paper is interesting to read. My main recommendations are that the manuscript should be written more clearly and that limitations of the approach should be discussed more in depth.
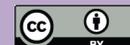
General comments

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Interactive Discussion

Discussion Paper

The paper structure is often confusing. For example, the key assumption of the model that atmospheric CO2 depends only on preformed nutrients and not on pCO2 of different boxes (which in turn depends on alkalinity, temperature, etc.) should be clearly stated in the model description. Instead of this, it is now presented in the results section. This is very confusing: is the relationship between CO2 and preformed nutrients (shown on the figure 2) the model result or is it a part of the model itself? In the later case, the section 3.1 should move into the section 2 which could be called Methods for a better orientation of the reader. The section 4 could be called Discussion and it should be always made clear in this section whether the authors have in mind the real ocean processes or the model results.

Using of terminology in the paper is confusing as well. Sometimes they refer to their model compartments as model "boxes", sometimes as "regions", and sometimes use other terms like "SO" which I guess is the same as the Antarctic box in the model. I would propose that the authors keep using the term "box" as long as they talk about the model results. If they use another geographical terms, for example during discussion of observations, they should make it clear what are relations between new terms and the model boxes. The same is valid for the processes they consider. For instance, they choose "Northern upwelling flux" as one of the five independent parameters describing circulation. Later, however, they list "North-mix" as the circulation parameter in the Table 2 and do the same in discussion (p. 867, l. 11-12): "The circulation parameter which undergoes the greatest change in the glacial is the Antarctic bottom water (13 Sv average decrease), followed closely by mixing in the Northern high latitude regions (12 Sv average decrease)." Is the northern mixing a parameter (i.e. the model input) or the model result (i.e. the model output using the chosen set of parameters?). This sort of sloppy usage of terms is very irritating. The paper should be re-written carefully in the terms of the model setup to avoid the reader confusion.

A serious drawback of the approach is that the box model configuration is fixed to a setup which is not fully appropriate for studying biological pump. In the real ocean,

nutrient utilization is taking place in the upper 100 meters or less, while the box model assumes the surface waters to be as deep as 300 - 500 m. This chosen box geometry could influence the results stronger than the processes they consider.

Minor comments.

The title "A comprehensive, multi-process box-model approach" does not reflect the paper content. Is it a comprehensive box model (I do not think so – for example, the BYCICLE model is much more comprehensive) or a comprehensive approach? What are multiple processes of the box model? There are only two processes studied – the circulation and the nutrient utilization. Why not to mention them explicitly in the title?

Introduction, 1st para: "The pCO_2-temperature correlation is much stronger in the Antarctic (AA) than in the Northern hemisphere records which suggest that the Southern Ocean (SO) played a dominant role in the glacial carbon cycle." I disagree. The air temperature over Antarctica depends on the atmospheric CO_2 content much stronger than the temperature over Greenland, and this is a good reason for the correlation as well. Besides, CO_2 is well-mixed gas in the atmosphere and it is not clear why southern sources of CO_2 are more important for Antarctica than the northern ones.

Section 2, title: discription -> description (a better title for the section is "Methods")

In the sections 3.2 and 3.3, list in a table all numerical criteria you use to select 2 x 300 solutions out of 10 millions you have in total.

p. 871, l. 17-19: "The purpose of this study is to identify which types of glacial circulation and productivity regimes are consistent with the observations and to relate these to current hypotheses for glacial oceanic uptake of atmospheric CO_2." What observations are meant here except of atmospheric CO_2 concentration? List them in a table (see a comment above).

p. 876, l. 4: "indicate that is may be wise" -> "indicate that IT may be wise"

p. 887, l. 3-4: "The strong link between temperature and CO_2 in the Vostok and Epica

ice core records suggest that the SO must be a player in the glacial carbon cycle." See the comment to the Introduction section above.

Figure 1: add labels for the 5 circulation parameters as well as for residual circulation and northern mixing. Add labels for the boxes.

Figure 3: labels are unclear (what does "eff" mean for the plot at the bottom)?

Figures 6 and 7: these scatter plots are almost identical. Do you need them at all? They are difficult to perceive anyway.

Interactive comment on Clim. Past Discuss., 6, 867, 2010.