Review of egusphere-2024-1754

Glacial ocean cSediment fluxes dominate glacial-interglacial changes in ocean carbon inventory: results from factorial simulations over the past 780,000 years

by M. Adloff, A. Jeltsch-Thömmes, F. Pöppelmeier, T. F. Stocker, and F. Joos

The authors conducted an investigation into the differences in the ocean carbon cycle response during glacial-interglacial cycles, comparing scenarios with and without sedimentation processes. By incorporating various idealized forcings based on ice core and sediment core records, they analyzed not only atmospheric CO_2 but also $\delta^{13}C$ in the atmosphere and ocean, oceanic DIC, regenerated DIC, and CO_3^{2-}, comparing these with variations reconstructed from geological records. The study identifies the dominant processes driving these changes, with the authors concluding that variations in oceanic DIC are more significant than those resulting from changes in carbon inventory driven by atmospheric CO_2, thereby highlighting sedimentation processes as the primary driver of DIC variations. These findings are robust and significant, making them well-suited for publication in Climate of the Past. However, as another reviewer has noted, the main text and supplementary materials are quite dense, often requiring the reader to refer back to the experimental setup. Additionally, it can be difficult to discern which figures correspond to specific descriptions. Enhancing the clarity of these elements would greatly benefit the overall communication of the study's results.

General comments:

The supplementary material touches on changes in deep ocean circulation, but before diving into a more detailed discussion, it is useful to first introduce what happens in the BASE scenario to provide a clearer context.

In the sensitivity experiments, different forcings are applied. However, while the LGM-PI amplitudes are determined for each experiment, it would be helpful to provide a more detailed explanation of the rationale behind these choices. For example, why was an amplitude of -40 chosen for SOWI rather than -30 or -50? A clearer justification for these specific values would help readers better understand the experimental design.

It would be beneficial to clearly identify what this model successfully captures and what it may be lacking, based on the results of these experiments.

The point that simple changes in the DIC inventory do not fully explain atmospheric CO_2 variations is particularly compelling and aligns well with my understanding.

The size of the figure captions, plots of sediment core data, and the contrast in the line plots may currently lack sufficient clarity, which could affect the overall readability.

Specific comments:

L30: It might be helpful to introduce "Last Glacial Maximum" as "LGM" when first mentioned, and then use the abbreviation in subsequent references throughout the text.

L46: "… but not necessarily in open systems": Based on the current results s, do you have any discussions related to these previous studies? It is interesting to note that, depending on the experiment, DIC inventory either increases or decreases during glacial periods. Clarifying how these findings relate to or contrast with previous studies could provide valuable insights.

L117: How are the dissolution processes of organic matter and calcium carbonate in the sediment model formulated? Specifically, regarding the burial dissolution of organic matter, since it is also mentioned later when explaining changes in oxygen concentration, it would be helpful to explicitly describe the dependence of these processes on oxygen concentration.

L125: "balance...kept constant thereafter,": Does this mean that during initialization the river input is set to balance the burial rate and this value is used consistently throughout? If so, could you also clarify the specific values of these rates?

L142: Could the results be largely different depending on which variation (δD or $\delta^{18}O$) each experiment is concerned with?

L153: Is there a specific assumption or basis for the 30%?

L159: How was the alkalinity adjustment carried out?

L228: "However, … constant.": Which figure does this description correspond to?

L284: "40°CS" is a typo and should be corrected to "40°S."

L355: What is happening in the case of SOWI? Is the weakening of the AMOC leading to an increased accumulation of DIC in the deep ocean?

L370: As mentioned earlier, to clarify the relationship between oxygen depletion and the increase in organic carbon burial, could you provide the specific formulation used?

L393: "However … during the deglaciation." Which figure should be referenced to understand this description?

L433: "which may be linked to changes in weathering fluxes not considered here.": Does this mean that changes in weathering could lead to increased inputs of DIC with lower carbon values?

L457: "the reconstructions show…": Where can I find information on the changes in POC burial by region?

L484: “… better simulated in REMI”: Can this be understood from Figure 11c (BGC)?

L494: Does this imply that alkalinity is being removed too quickly in order to reproduce CO_2 levels?

L497: Which region's sediment core does Qin et al. (2018) refer to? There appear to be other reconstructions of [CO_3^{2-}] as well. Could you clarify why the comparison was made exclusively with this particular study?

L498: Why is it that, in Experiment BASE, CO_2 shows a significant change, yet there is little to no change in CO_3^{2-}?

L539: “… increased remieneralization of sedimentary organic matter …”: Does this contribute to the rise in CO_2 by the slow decomposition of organic matter once it has accumulated in the sediment?

L592: How does the change in AMOC affect atmospheric CO_2 in this model? Based on this description, does a weakening of the AMOC lead to an increase in CO_2?

L598: Does "increased Southern Ocean wind forcing" refer to a weakening of the wind forcing?

L608: typo: it should be "Menviel et al. (2011)" rather than "(Menviel et al., 2011)."

L686: typo: it should be "CO_3^{2-}" rather than "CO_3^{--}."

Table2: Since only CO_2 reflects the difference between the Holocene and the glacial period, it might be worth considering aligning the other variables as well for consistency.

Figure 9: Does $\Delta\delta^{13}C$ represent the difference from the modern value? It would be helpful to clarify this in the footnote, as it is not currently specified.

Figure 15: It might also be helpful to change the color of the lines to make them easier to distinguish at a glance.