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Climate of the Past Discussions

Interactive comment on "Model sensitivity to North Atlantic freshwater forcing at 8.2 ka" *by* C. Morrill et al.

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The manuscript by Morrill et al. "Model sensitivity to North Atlantic freshwater forcing at 8.2 ka" analyses the response of different climate models to the freshwater forcing associated with the 8.2 ka events. Ultimately, modelling the 8.2 ka event can inform on weather IPCC class climate models can successfully simulate ocean circulation and climate changes associated with sudden release of freshwater to the North Atlantic ocean. There are still uncertainties in the causes of the 8.2 ka climate change and the amplitude and duration of the response, but we can nevertheless start using this period as a test case for climate models. This paper provides the first (to my knowledge) multi-model and model-data comparison of 8.2 ka climate model experiments. The results are clearly and succinctly presented through well chosen and well presented figures.

The manuscript identifies some consistencies in the model responses to the same freshwater forcing and shows that the experiments produce a significantly smaller and shorter climate response compared to the reconstructed 8.2 ka climate change.

The strength of the paper is that it includes three different climate models with different complexity, resolution and processes, some of which are used in the latest projections of future climate change. This therefore makes the paper relevant to the next IPCC report. Moreover, for one model, two different set of boundary conditions have been tested, allowing for direct comparison with the other simulations and informing us on some aspects of uncertainty in boundary conditions. All four simulations analysed have been forced with the same magnitude of freshwater forcing, which provides a point of comparison between simulations. This manuscript therefore provides an exciting opportunity to better understand climate models. The conclusions of the paper are well supported by the figures. The authors identify in this manuscript the main reasons for the discrepancies between model and data, which is useful for planning future model experiments and climate reconstructions, and could help refine hypotheses for the cause of the 8.2 ka event.

This manuscript is interesting and relevant to climate modellers, glaciologists, geochemist and geologists interested in the 8.2 kyr event. It represents an important first step in using the 8.2 ka event as a benchmark for climate models. I recommend this manuscript for publication with minor corrections to the manuscript.

My only criticism is that the manuscript suggests we know what the cause of the 8.2 kyr event was. I would be more careful in stating this. Although the 8.2 ka climatic event has been linked to the Agassiz lake discharge, the climate forcing is probably more complex than the freshwater flux used in this study. The lake release could have happened in two stages (Teller et al., 2002), potentially centuries apart and there may have been a pulse of meltwater from the Laurentide ice sheet (Gregoire et al., 2012). Törnqvist and Hijma [2012] provide a review of the 8.2 ka from a sea level point of view.

Here is a list of other comments and suggestions on the manuscript:

- p 3951 line 21 “the 8.2 ka event [...] duration [...] and forcing are well constrained”. I think “well constrained” is overstated.

- Model description page 3952 line 6 : there needs to be a bit more detail on what are the “simplifications applied to the atmosphere component” of LOVECLIM. It could be important for understanding the results. A sentence would be enough.

- page 3953 line 28 Why did you choose to use a ModelE-R experiment that was started from a period of weak AMOC ? Referring to the LeGrande and Schmidt, 2008 paper cited there, I can see that the weak AMOC state produces a better match to proxy records. I would like to see a bit more explanation on these AMOC states in this manuscript. If there were/are different AMOC states, is there a reason to think that the AMOC would have been in a weak AMOC state (no Labrador sea convection) at the 8.2 ka event ?

- page 3954 line 1 : “we reduced the influence of this unforced variability through examining “decadal” results for this model (i.e., the 10-yr mean of the MWP experiment less the 30-yr mean of the relevant control years).” I don’t understand what this means, can this be clarified?

- page 3958, line 16, add a reference to Morrill et al. 2012

- p 3959 line 6 : “Another factor in the model-data mismatch could be the size of the MWP”. Add here more discussion on the cause of the event and the fact that the freshwater forcing could be more complex.

- Discussion section, page 3959, line 28: “A last explanation for the model-data discrepancies is that the models are not sensitive enough to freshwater perturbations.” Would it be possible to add a comment on how sensitive these GCMs are compared to other CMIP or PMIP GCMs ?

- References: review the references carefully, I could not find any reference for Morrill

et al. 2012 or Hu et al. 2009.

- figure 5 : I find it difficult to interpret anomalies in sea ice area. Can you add contours of sea ice extent on these plots ?

- figure 8 : replace “the sign of the temperature anomaly” by “the sign of the precipitation anomaly”

- figure 8 : express the precipitation anomalies in % for consistency with the lower panel.

Gregoire, L.J., Payne, A.J., Valdes, P.J., 2012. Deglacial rapid sea level rises caused by ice-sheet saddle collapses. Nature 487, 219–222.

Teller, J.T., Leverington, D.W., Mann, J.D., 2002. Freshwater outbursts to the oceans from glacial Lake Agassiz and their role in climate change during the last deglaciation. Quaternary Science Reviews 21, 879–887.

Törnqvist, T.E., Hijma, M.P., 2012. Links between early Holocene ice-sheet decay, sea-level rise and abrupt climate change. Nature Geoscience 5, 601–606.

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