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Climate of the Past Discussions

Interactive comment on "Heinrich events show two-stage climate response in transient glacial simulations" *by* Florian Andreas Ziemen et al.

Anonymous Referee #1

Received and published: 28 June 2018

The study of Ziemen et al. studies H-events with a coupled climate-ice sheet model. The model finds internal oscillations with a recurrence time of approximately 5kyr, in reasonable agreement with the observed climate record. This study is one of very few coupled climate model studies of H-events, given that the timescales involved are so large that it has, until now, not been feasible to run these types of experiments.

The authors report a two-state response to the internal H-events in the mode. The first state is characterised by freshwater release from land based ice sheets (dominated by the Hudson Bay area), while the second phase is characterised by a reduction in ice-sheet elevation (mostly Hudson Bay) and changes in atmospheric circulation and precipitation.

The paper is well written and is highly novel as it is one of very few, if any, coupled

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climate-ice sheet models of this detail studying the H-events of the last glacial period. However, there are a few concerns which should be considered before publication in climate of the past.

GENERAL COMMENTS:

The results of the study are clearly novel and of great importance to our understanding of H-events and instabilities of the ice sheets surrounding the Atlantic Ocean during the last glacial. The model includes several assumptions which should be better discussed. In particular, the coupling scheme includes period-synchronous 1:10 coupling. Still it is not clear from reading the methods section what this means, and how this choice of coupling method might impact the results. Please elaborate on this.

Another key assumption in the model is that the freshwater input is associated with a negative heat input when ice enters the ocean. However, it is not clear from the manuscript how this impacts the results. More detail should be given to this point. How important is it for the response observed?

The authors choose to study H-events in a transient glacial climate simulation which makes the analysis challenging. It is not clear how this change in boundary conditions impacts the results, and it is not clear why the authors choose a composite of several transient runs in their results description. This should be better explained/discussed in the revised manuscript. Note, however, that including a transient glacial climate is also of interest ast it could give clues as to how the H-events change with time. It would be of benefit to the study if such an assessment were to be included.

Note also that the duration and amount of freshwater for the different experiments are surprisingly similar (See table 1). The reasons for this should be discussed.

The glacial state is not well defined in the manuscript. More detail should be given to the difference between the background climate states at the time of the H-events simulated in the model.

And finally, one of my major concerns with this study is the lack of comparison of the results with proxy data. Given that there is a wealth of data highlighting changes in ocean, and atmosphere climate during the glacial and across H-events the model results should be discussed in relation to these. In particular, as the study clearly states its relevance for studying H-events of the past.

SPECIFIC COMMENTS:

Line 11, page 3: chose either 2D or 3D. Would assume it is both which are relevant here, but only 2D fields can be shown in the paper.

Line 14, page 3: it is stated that PDD method is applied. Please give more details of how this is implemented in the model.

Line 7, page 4: there is a reference to spurious ice over Siberia. What is this and what does it mean? Give more detail with reference to figure e.g. . ..

Line 8, page 5: The pre-surge AMOC has a strength of 19Sv, whereas the PI AMOC is 15.8 Sv (see Section 3.1). Why is there a difference, and why is the glacial run AMOC stronger? How does this compare with other model studies and with data?

Line 11, page 5: it is stated that the Laurentide is connected to Greenland at the glacial in the model, including the entire Greenland shelf. This is an interesting result which should be further discussed. Is this expected from data, are there similar findings by other studies?

Line 15, page 5: it is stated that the Hudson strait Ice stream has a cycle in surging, whereas other ice streams are constant. Explain why. It is clear from the results that the Hudson Bay system is special, with binge-purge type oscillations. Why is this only the case here? Are there other similar systems?

Line 30, page 6: it is stated the convection depth changes. However, this is not clear form figure 5. It would be beneficial to add more details in terms of change in e.g. mixed layer depth or similar.

Line 18, page 7: it is stated that the freshwater is drawn down by deep water formation. What is this based on? If this is true, please show it in a figure or similar. Puzzling that freshwater can be drawn down given its low salinity.

Line 15, page 10: it is stated that the jet stream changes. Why is this? Explain.

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