

## ***Interactive comment on “Impact of melt water on high latitude early Last Interglacial climate” by E. J. Stone et al.***

### **Anonymous Referee #1**

Received and published: 12 February 2016

Stone et al. present an interesting and thorough model-data comparison focusing on the issues surrounding the early Last Interglacial climate evolution: Why were the Southern Ocean and Antarctica warm when the North Atlantic still appear to have been relatively cold compared to full interglacial conditions? And what were the potential roles of meltwater from remnant ice sheets, the Atlantic Meridional Overturning Circulation and the West Antarctic Ice Sheet? It is a good study and well structured paper that is well suited for publication in *Climate of the Past*. Below I've listed a number of comments that I think should be included to clarify and improve the manuscript.

#### Main comments:

An important contribution and the most novel part of this work, is the simulations in which both a NH meltwater source and changes in the WAIS are simulated. Currently

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this topic is only introduced in the very last line of the introduction and the simulations are not even mentioned in the conclusions. I think this part of the manuscript should be discussed more comprehensively in the introduction, including previous work (e.g. Goelzer et al, 2016, Steig et al., 2015) and indications that such a WAIS collapse has occurred during or previous to the LIG. In the conclusions question could be addressed such as 'What did the WAIS simulations tell us?', or 'How should future simulations on this topic be improved in order to better address the issues discussed in the manuscript'?

#### Minor comments:

Page 1 line 17: As discussed in the manuscript, a number of previous studies used a model-data approach to investigate the impact of Northern Hemisphere freshwater forcing on the early LIG climate, so perhaps 'for the first time' is a little too strong, although this study is certainly more thorough and presents, as is mentioned, a more 'integrated model-data approach'.

Page 1 line 22: If the LIG is from 129-116ka, can one still consider 130ka as early LIG? Perhaps a technical detail, but on the other hand a good illustration of the broader issue that defining deglacial and interglacial periods is not trivial and perhaps not even desirable.

Page 2 line 14: What is meant with 'partially account for changes in seasonality of precipitation'? Do the uncertainty estimates account for this or can part of the ice core oxygen isotope changes be accounted for by changes in the seasonality of precipitation?

Page 3 lines 7-9: It is mentioned that Loutre et al. (2014) already performed a model-data comparison including NH freshwater fluxes for the early LIG, but that their work still showed model-data mismatches. Doesn't the present work still show these? Perhaps they became smaller? Or we have a better understanding of why these mismatches occur?

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Page 3 lines 16-19: Both Bakker et al. (2013) and Loutre et al. (2014) included a model-data comparison, be it small and less rigorous than the one presented here. Another such model-data comparison for this time interval was performed by Sanchez-Goni et al. (2012).

Introduction: The recent work by Goelzer et al. (2016) should be discussed as well since it is closely related to the questions that are addressed in this manuscript.

Experimental design: Discuss some aspects of the experimental design in a little more detail: Are 200 year simulations are sufficiently long to investigate a bi-polar seesaw response? Hosing a large region between 50-70N seems highly idealized. What do we know about the distribution of meltwater during that period and what difference could it make to include a more realistic meltwater scheme? Meltwater from the WAIS is neglected. Why and how could this impact the results?

Page 4 lines 28-30: What about model uncertainties or inter-model differences in simulated temperature anomalies, can those explain the model-data mismatch?

Page 6 lines 4-16: It does not really become apparent from this paragraph that another important reason to perform simulation in which the WAIS is removed is because this could explain the persisting SH model-data mismatch.

Page 6 line 18: From table 2 it appears to me that the numbers are identical so why is the model-data match slightly improved?

Page 6 line 24: Why would you replace it with shrubs? Is there any indications that those would grow there during the LIG? And related to that, why is such a big impact found between replacing it with bare ground or shrubs, I would expect that that region is covered with snow year round?

From the last paragraph of the results section and figures 4 and 6 it is not fully clear to me how SH temperatures evolved during the LIG and how this relates to the limited NH freshwater forcing after 127ka. This scenario would suggest that after the early LIG,

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when the NH freshwater returned to a low baseline, the bi-polar seesaw seized, potentially leading to cooling in the SH. Is that seen in the 125ka time-slice of Capron et al. (2014)? If not, how could this be explained? Please discuss this very interesting topic in more detail in this paragraph and perhaps include suggestions for future research on this topic.

Table 2: The improvement of the SH and EAIS model-data match when included the NH 0.2Sv meltwater forcing is surprisingly small. What are we missing?

Table 2: The lowest two lines (125ka) are they also compared with the 125ka time-slice of Capron et al. (2014)? Please explain in the caption.

Table 2: Mention in the caption which simulations were previously published and which are newly performed for this study.

Figure 1: Consider including a proxy records showing the AMOC evolution during this period. For instance one of the  $\delta^{13}C$  records shown by Sanchez-Goni et al. (2012) and Govin et al. (2012).

Figure 1: An additional vertical axis showing the rate of sea level change in Sv would be easier to compare with for instance figure 9.

Figure 1: the 'early SH warmth' is not very clear in EDC temperatures. Please clarify.

Figure 1: please include in the caption a description of the grey band shown in the figure.

Figure 3: This could perhaps also be shown in another figure that shows a map of the North Atlantic region.

Figure 6: Why is the model response so different over Antarctica while it is so similar over the Southern Ocean? It seems unrelated to the changes in the North Atlantic. Is this difference also there at 130ka?

Figure 8: Why does the North Atlantic show a warming in figure c?

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Technical comments:

Page 1 lines 13-17. Line is very long and difficult to read. Please rewrite.

Page 1 line 22 and 27: At multiple locations double brackets are used, either like (...(..)) or like (...)(..). Consider adjusting.

Page 2 line 2: consider removing 'build'.

Page 2 line 5: consider rewording to 'evidence of hemishperic surface temperature asynchrony'.

Page 2 line 7: above 40S can be interpreted erroneously.

Page 2 line 15: is there a difference between non-synchronous and asynchronous or are they equivalent?

Page 2 line 16: ice core records are not 'summer', correct?

Page 2 line 22: Not all models used by Bakker et al. (2013) are of intermediate complexity.

Page 2 line 27: 'neglected to take into account', consider rewording.

Page 2 lines 28-30: not sure what the purpose is of this sentence at this place.

Page 2 line 29: mostly 'mismatch' is used instead of miss-match, consider rewording.

Page 3 line 17: at several places there is an underscore between the bracket after a reference and the next word ")", *perhaps a latex issue*.

Page 3 line 21: what is meant here with 'delay'? Would we expect the two hemispheres to show synchronous maximum warmth?

Page 4 line 27 and 31: year is missing after Capron et al.

Page 5 line 2: are the model values from single grid cells?

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Page 5 line 7: what is the basis of the chosen grouping?

Page 6 line 20: Perhaps replace 1C by 1.5C in accordance with table 2.

Page 6 line 21: Where was this 1Sv of freshwater added, in the North Atlantic or in the Southern Ocean? Please clarify.

Page 6 line 34: Is that an average over the whole North Atlantic or only over the locations for which Capron et al. (2014) provide proxy-records?

Page 7 line 11: From Figure 1 an age of 127ka seems more appropriate.

Figure 4 line 7: Space missing between 'The' and 130ka.

Figure 8 line 4: (a) should not be bold I think.

References: Goelzer et al., 2016: doi:10.5194/cp-2015-175, 2016

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Interactive comment on Clim. Past Discuss., doi:10.5194/cp-2016-11, 2016.

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