

Interactive comment on “Sensitivity of the North Atlantic climate to Greenland Ice Sheet melting during the Last Interglacial” by P. Bakker et al.

Anonymous Referee #1

Received and published: 17 November 2011

The goal of this study is to provide insight into how increased freshwater flux from Greenland into the Atlantic during the Eemian could have affected both ocean circulation and the regional climate. An attempt is also made to constrain Eemian Greenland Ice Sheet melting rates at the time via changes in the ocean circulation. It is a nice idea and several aspects of the study are quite interesting. The use of an ensemble of model runs provides credibility and context to the results and useful information can be learned from highlighting geographical areas where changes could potentially be detected in the geological records. Still, there are a few major concerns that I think should be addressed in order to improve the paper.

General comments

Rates of SLR. A large part of the motivation for this study appears to be the potential

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for high rates of sea level rise during MIS5e. The authors quote the upper-bound estimate of 2.5m/century globally from Rohling et al. (2008) as possible for at least a short period of time. But then rates of FWF this high are applied in the simulations continuously, which implies that the global 5-9m of Eemian sea level rise would have impossibly occurred within 2-4 centuries. Kopp et al. (2009) show that an average rate of 0.6-1.0m/century globally is more plausible. Thus, if there were in fact episodes of rates as high as 2.5m/century sea level rise, they must have been very short (probably less than a century time scale) and necessarily transient in nature. Therefore, I think in the introduction, these rates should be discussed more realistically – now the data appears somewhat misrepresented. Moreover, if 0.29 Sv translates to 2.5m/century, then it would seem that even a level as high as 0.1 Sv would be very high and that a portion of the runs considered could be directly discarded.

Experimental setup. The model is run for 500 years with a constant FWF level and the average of the last 100 years is used for evaluation – meaning the model is in quasi-equilibrium. How can results from such an experiment be used to gain insight into transient changes in circulation and climate during the Eemian? This may be a valid approach for the lower values of FWF (that could possibly be considered as the average output from the GIS over the time period), but it's not clear to me how this is appropriate for most of the FWF values applied in these experiments. I would suggest that the authors clarify the justification for the experimental setup used here. I think the manuscript would benefit from a more clear explanation about the time scales involved (eg, time scale for melting Greenland versus that for collapse and restart of the MOC), as well as justification of how the experiments handle these time scales appropriately.

Constraining the FWF. It is concluded that the FWF associated with Regime 2 is most likely, since the overturning in the Labrador Sea for this regime is comparable to reconstructions. However, the forcing needed to reach Regime 2 will crucially depend on the initial state of the circulation. This is especially true because deep-water formation and the AMOC can respond non-linearly to the applied forcing. Furthermore, the authors

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are attempting to constrain FWF rates based on quantities (Labrador Sea deep water formation, AMOC strength) which are themselves very poorly constrained. Thus it seems unlikely that constraining the FWF is possible. A more plausible approach could be to constrain the overturning to a realistic regime, and only consider the FWF in the context of a sensitivity analysis.

English and organization. There are many sentences that could be formulated more succinctly and the grammar improved. There are a few typos and the word order needs rearranging in several places. Also some sections seem overly long. I would suggest careful revision of the manuscript with this in mind, so that the messages of the paper come across more clearly. Particularly, from Section 3.4 and onwards, the discussion becomes more difficult to follow. For example, Page 2778, line 5-9: this sentence is extremely confusing.

Specific comments

Section 3: The discussion begins with the relationship between the AMOC and the FWF and the corresponding “regimes” of circulation. But it is very difficult to see such regimes in Fig. 2 and the definition of the regimes seems to be based on Fig. 3 and the sea ice extent. Consider first discussing sea ice extent in order to introduce the regimes, rather than the circulation.

Section 3.1: Please change the wording in this section from “sudden” to “abrupt”. The word “sudden” seems to imply a short time scale, when I believe what is meant is “abrupt” (ie, a small change in forcing causing a large response).

Conclusions: Suggest putting the conclusions in paragraph form. Also, one point appears twice.

Figure 1: It appears that the river outflow in the Northeast is not adjacent to the land mask (so that river outflow appears in the middle of the ocean). Is there a reason for this?

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Figures 2 and 3: Consider changing the order of these figures (as mentioned above). Currently, Figure 3 clearly shows why the freshwater forcing levels are separated into the 3 regimes that are discussed throughout the text.

Figure 7: What is represented by the two colors in the circles? It is difficult to understand whether this is explained in the caption or not.

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