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Climate of the Past Discussions

Interactive comment on "Coupled regional climate–ice sheet simulation shows limited Greenland ice loss during the Eemian" *by* M. M. Helsen et al.

Anonymous Referee #2

Received and published: 26 April 2013

This is a very well written manuscript concerning the contribution of Greenland ice sheet melt to the Eemian sea level highstand. Using an asynchronously coupled regional climate-ice sheet model the authors find a Greenland contribution between 1.2 and 3.5 m with a best estimate of 2.1 m, which is similar to the result from the recent NEEM Community members paper. They highlight that although their results broadly agree with ice core inferred elevation changes they cannot explain the inferred temperature record from the NEEM ice core in northern Greenland. They conclude that melt from Greenland is insufficient to explain the sea level highstand and hence implicates Antarctica.

As far as I am aware this is the first paper on Eemian sea level which uses a coupled regional climate ice sheet model and as result brings a new methodology to this area of research. It also includes a more sophisticated calculation of SMB than many recent published studies that use the Positive degree day scheme. Furthermore, this study suggest Dye-3 could have been ice free but with the southern dome still connected to the central dome with most melt from the south west region. This contrasts with a Dye-3 ice covered and a northern ice sheet retreat found in very recent work. The authors also include a sensitivity analysis to various parameters, physical schemes etc in an attempt to quantify some of the uncertainty in their estimate. The title for this manuscript is appropriate and the Abstract concise. I would recommend this manuscript for publication after addressing the following.

1. Has it been shown that the asynchronous coupling between climate model and ice sheet model is satisfactory? A study by Calov et al. (2009) using an Earth System Model of Intermediate Complexity showed that an information exchange interval of 1000 years 9with the ice sheet model running continuously) leads to extreme reduction in simulated sea level drop. They argued that such an information exchange interval is too long for a realistic simulation of glacial inception. Obviously due to computational costs I realise that increasing the number of regional climate model simulations is not feasible but some discussion of the effects of the asynchronous coupling on the Eemian results would be useful, even if it is negligible.

2. A few more details on the experimental setup would be useful. For example, what bedrock topography is used in the ice sheet model? When ice is receding is it only replaced with tundra? What are the albedo values of this tundra? What are the orbital parameters used in the Eemian simulations? What greenhouse gas values do you use in your simulations?

3. Perhaps also including a plot of the spin-up of temperature from the regional

climate model over Greenland either in the main manuscript or supplementary information would be informative to satisfy the reader that the regional climate model is sufficiently spun-up in 30 years of model time.

4. Anomaly plots of temperature and precipitation patterns over Greenland for your control simulation at the time when the Greenland ice sheet shows minimal extent would be useful since it is these patterns which have been used to explain the Eemian northern retreat of the ice sheet in recent studies. How does yours compare? Furthermore, does the regional model for modern day tend to overestimate, underestimate precipitation in any specific region compared with observations? This may indicate where biases exist.

5. The summary and conclusions of this manuscript are very brief. I think it would be very beneficial to include a comparison detailing the similarities and differences with other recent modelling studies (e.g the lack of northern retreat) and why your result might be more robust. The authors should also address the implications of their work and what the next future steps might be.

Minor/Technical corrections

P1737, line 15: Please also include the following reference: Stone, EJ, Lunt, DJ, Annan, JD Hargreaves, JC 2013, Quantification of the Greenland ice sheet contribution to Last Interglacial sea level rise. Climate of the Past, 9, pp 621-639. Please also include in any other relevant sections in the manuscript.

P1738, line 18: Please change a-synchronous to “asynchronous”

P1742, line 21: Perhaps insert “interglacial” after “Holocene” for clarity

P1743, line 4: What is the justification for the lapse rate value you chose? A different value of this parameter could alter the results.

P1748, line 23 onwards: What simulation (i.e. which interval during the Eemian) do

you use to compare with proxy data? A plot showing this or more details in the text would be useful as the CAPE data only represents the maximum Eemian warmth.

P1753: line 24: An explanation of why 2.1 m is the best estimate should be included. It is not clear to me why this is the case.

Table 2: Please give more detail in the caption of the sensitivity experiments. It may also be useful to include the actual numbers after the description e.g. sliding halved, late start etc.

Figure 4: The inset on Fig.4b is very difficult to see. I suggest making this substantially larger.

Figure 6a: I suggest highlighting the feature at 72N, 50W with an open circle so that it is easily identified.

Figure 6b: As far as I can see there is no reference to this sub-figure in the text. Please include a reference to it.

Figure 7: What does the grey shading represent? Is this the RMS between the sensitivity experiments and the control? Please clarify in the Figure caption.

Figure 8: Please increase the size of the ice core labels. Although the shaded region is explained in the main text, also indicate in the Figure caption what the shaded regions represent.

References: All the references appear to have random (?) 4 digit numbers at the end of the citation in the reference list. I assume these should be removed.

References mentioned in review: Calov R, Ganopolski A, Kubatzki C, Clausen M (2009) Mechanisms and time scales of glacial inception simulated with an Earth system model of intermediate complexity. Clim. Past, 5, 245-258

Interactive comment on Clim. Past Discuss., 9, 1735, 2013.