The Cryosphere Discuss., 7, C456–C459, 2013
www.the-cryosphere-discuss.net/7/C456/2013/

The Cryosphere
Discussions

Interactive comment on "Effect of uncertainty in surface mass balance–elevation feedback on projections of the future sea level contribution of the Greenland ice sheet – Part 1: Parameterisation" *by* T. L. Edwards et al.

Anonymous Referee #3

Received and published: 1 May 2013

This manuscript provides a new parameterization of the surface mass balance – elevation feedback for the Greenland ice sheet, derived from the regional climate model MAR. They derive this parameterization using a set of 8 RCM experiments using different topographies, and different climatologies. Next to optimized values of the 'SMB lapse rates', they find plausible ranges for these values, using a Bayesian statistical approach, which enables them to constrain results (in a companion paper) with credibility intervals. This is an important subject that potentially bridges the gap between (regional) climate models and ice sheet models, circumventing synchronously coupled

experiments. Therefore it contributes to constraining an important uncertainty in the discussion on the future contribution of ice sheets to sea level change. The manuscript is well written, and the methodology well described.

Although this work is important and worth publishing, there are some points that I would like to see addressed before publication:

My most important point concerns the choice of the authors to discard any spatial variability in their so-called "SMB lapse rate" (apart from a difference between north and south), to make their parameterization simple to implement and easy to apply. However, these results show that there is a large variability and a clear spatial pattern of the SMB adjustment as a function of elevation changes. This is most evident in the reversed (negative) values of the SMB lapse rate along the western (NonUn exp) and northern (-100 m and -50 m exp) ice sheet margin, the different $\Delta S/\Delta h$ slopes for the north and south, and accumulation and ablation areas, but also from the large variability apparent in the scatter plots of figure 5, and different slopes of the arrows in figure 4. Although there is evidently a spatial pattern in the SMB lapse rate, the authors refrain to show plots of this. Usage of a single value is preferred (more specifically 4 values based on accumulation/ablation, north/south) to enable an easy use in ISM experiments, at the cost of loss of spatial patterns. Could the authors give more information on this spatial structure, for example by extending figure 2 with two plots showing the spatial distribution of $\Delta S/\Delta h$? This allows an easy comparison to other SMB lapse rates as provided by e.g. Helsen et al (2012). Do these patterns look alike? How do absolute values of the SMB lapse rate compare? Another consequence of this approach is that all the spatial variability found in the SMB lapse rates translates into (maybe too) large credibility intervals (CIs).

At first it seems very straightforward to make a distinction between SMB lapse rates above and below the equilibrium line. However, looking at figure 4, it seems that the true shift in functional form of the SMB – elevation relation lies somewhat above the equilibrium line. This mainly results from the interplay between the (quite straightforward) decrease of run-off with elevation, and the more complex relation of precipitation with elevation. I understand that the authors wish to keep this distinction at SMB = 0 for simplicity and applicability in transient ISM runs, but it would be valuable to add a discussion on this subject. For example, a consequence of this choice is that the optimal values of SMB lapse rates as reconstructed for the accumulation area are still positive, whereas for some areas this is not right: where precipitation decreases when elevation increases, and other components of the SMB are of minor importance. This occurs in the southeastern sector of the ice sheet, as suggested by the red pixels in figure 2. Related to this issue: on page 643, lines 20-23: The fact that a complex relation between SMB and elevation is found above the ELA is worrisome for the use of a single value for the SMB lapse rate.

Using different values of SMB lapse rates north and south of 77N may lead to unexpected results. To which extent can this parameterization be used in ISM transient runs? What if the ice sheet retreats from north to south, and passes 77N, then a sudden shift in ice sheet retreat will occur. Some comment on this choice is needed.

More general, it is likely that different climatic regimes will also result in different SMB-elevation responses. What is the authors opinion on this?

Minor comments

Abstract, last line: This is a matter of taste, but isn't it better to restrict the content of the abstract to results of this paper, not of those in a companion paper?

Page 639, line 7: RCM is defined twice, also on line 4.

Page 640, paragraph starting on line 12: I had to read this paragraph a couple of times, and I still think it is not clear. This paragraph needs to be rewritten, I think you mean something like this: "Is we are to simulate SMB over time and also include the effect of the ice dynamical response (i.e. topography changes) on SMB, we must either couple an ISM and RCM, or use an ISM forced with RCM output, and additionally parameterize

the SMB – elevation feedback in terms of an "SMB lapse rate." Also in the next lines, it is not really clear if there is a difference between the coupling of an ISM with a GCM or RCM.

Page 641, line 24: unlike most RCMs, it includes the albedo feedback. Which RCMs are implied here? In the manuscript, a couple of other RCMs are mentioned, like RACMO, HIRHAM. I'm quite sure that RACMO also includes the albedo feedback.

Page 646, line 27 – page 647 line 5: It is argued that the reason for not using spatially variable gradients is because this method is independent of the shape of the ice sheet, but this method is also influenced by the shape of the ice sheet.

Page 647, line 5: The fact that parameterizations in PDD schemes also do not vary spatially and temporally is actually a manifestation of a shortcoming of PDD schemes, see Bougamont et al (2007, JGR) and Van den Broeke et al. (2010, GRL).

Page 648, line 12: add Δ?

Page 655: Regarding the differences of this approach relative to other published parameterizations of such SMB lapse rates: it should be noted that Helsen et al. did include validation experiments in which they used RCM runs with different topographies, which showed that their approach resulted in good agreement with their spatial SMB gradients.

Interactive comment on The Cryosphere Discuss., 7, 635, 2013.