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The Cryosphere Discussions

Interactive comment on "Estimation of the Greenland ice sheet surface mass balance during 20th and 21st centuries" *by* X. Fettweis et al.

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General comments This is an interesting paper with new and novel results that is of relevance to the journal. The basic concept is that temperature and precipitation anomalies can, to a first approximation, be used to describe SMB anomalies for the Greenland Ice Sheet (GrIS). This is a reasonable premise and the authors clearly state the caveats and limitations of trying to push this approach too far. They use the approach to look at SMB anomalies back to 1900 and for the next century.

One of my main criticisms, however, is that this has been done (at least for the future), at least twice before, using AR4 simulations, to produce estimates for response of the ice sheet and there is little discussion of how these results i) compare with previous work and ii) whether they are any more reliable or an improvement on this previous

work. There are big differences (see below) and it is unclear why. The two studies I am aware of (and there may be others) are by Oerlemans et al (Oerlemans, Bassford et al. 2005) who use climate sensitivity estimates with AR4 simulations to predict GrIS future SMB and (Gregory and Huybrechts 2006)who use an approach that is inherently closely related to the one presented here. There is no real discussion, however, whether the results here agree/disagree, confirm/refute earlier conclusions and so on? What new are we learning about the future response of the ice sheet?

I make a number of specific comments below that the authors should address. I think this paper will be suitable for publication after addressing the comments made here, which I would expect to involve substantial revision of the text and so on.

Specific comment

Given that the authors estimate the coefficients a and b why do they not present them but only the ratio? I don't understand this. Is not the coefficient a, effectively the sensitivity of the SMB to DT? If so, then how does the sensitivity of the MAR SMB scheme compare with other SMB models for Greenland and the value obtained by Oerlemans et al?

How did you select region 1 for calculating a? From fig 1 it looks like most of the ice sheet shows the same correlation and the choice of the region appears arbitrary. Does it make any difference to the results, with a different choice?

Line 25, p 228. 'The excellent agreement'. There is good agreement in terms of correlation between the different estimates of DSMB but there also some significant differences. For example, in the early 80's MAR deviates by ˜50 km3 from Hanna and Box but more serious is the discrepancy that exists from about 2000 onward. This is explained by the use of operational analysis (OA) rather than reanalysis data but I don't understand this explanation because if all models are using the same input data it should make no difference. If the authors are saying that post 2002 they are using different releases or versions of the OA then the comparison post 2002 is not really

TCD
2, S134–S137, 2008

very meaningful and hard to interpret. The authors need to clarify this point and if they use the same OA data explain why it should worsen the agreement. But, to be clear, differences post 2000 are as much as 200 km-3 which is almost as large as the SMB in the near future.

Fig 6 and 7 are not clear. It is hard to make out the mean and other coloured lines. They need to be redrafted to make them clearer. Fig 7 is similar to Fig 4 of (Gregory and Huybrechts 2006) but only to 2100 and only for A1B. As far as I can tell the SMB trend, however, is significantly smaller in this study even for the case of a/b=-2. 1 mm SLR= 360 Gt/yr or 392 km3/yr. The largest value in (Gregory and Huybrechts 2006) at 2100 for A1B is around 3.5 mm/yr or -1372 km3/yr compared with the estimate of about -150 km3/yr in this study. This is a huge difference. Why?

I don't really understand Table 5. There appears to be no correlation between DT and DP, which seems counter-intuitive and non-physical. In fact, in (Gregory and Huybrechts 2006) they quote a value for the effect on DP of DT, and it is around 5% K-1 for both Antarctica and Greenland. If this is really the case in the simulations that there is no relationship then the authors need to explain why, whether this is physical (I don't think it is) and what impact it has on their results.

Why do the authors chose A1B to do the future predictions with? Is this the most likely SRES scenario or?

Line 23, p 231. Authors claim SMB 'approximately balances' glacier discharge. This entirely depends on what is meant by approximately and the time period considered. It is, for the present day, incorrect, else the ice sheet would 'approximately' be in balance and it is not.

Line 17, p 232. The authors misunderstand the processes driving glacier acceleration in Greenland. They should cut this section altogether as it is not necessary to the paper, highly speculative and based on erroneous assumptions about ice dynamics.

TCD
2, S134–S137, 2008

L 13-14, p 235. The authors claim that because the multi-model average results agree with observations for 1970-1999 over a small area in Greenland the average 'can be used as a reliable estimate of future changes'. This is a dubious and unproven statement and, based on the analysis of the precip differences between the different AR4 models, quite possible wrong.

Typos and grammar

There are quite a few examples of transposed verbs (e.g. line 26, p 229) 'explain fully' should be 'fully explain'

Title: 'during' should be 'for the'

line 23, p 226: 1.25 x 10ˆ5 should be 125 K yr BP. line 3, p 228, &'re-solving' should be 'solving' line 23, p228, 'anomaly simulated by MAR' => 'anomalies simulated by the MAR' line 28, p228 'compares also' => 'also compares' line 25, 229. 'precaution' => 'caution'

References:

Gregory, J. M. and P. Huybrechts (2006). "Ice-sheet contributions to future sea-level change." Philosophical Transactions of the Royal Society a-Mathematical Physical and Engineering Sciences 364(1844): 1709-1731.

Oerlemans, J., R. P. Bassford, et al. (2005). "Estimating the contribution from Arctic glaciers to sea-level change in the next hundred years." Ann. Glaciol. 42: 230-236.

Interactive comment on The Cryosphere Discuss., 2, 225, 2008.