

Interactive comment on “Impact of spatial resolution on the modelling of the Greenland ice sheet surface mass balance between 1990–2010, using the regional climate model MAR” by B. Franco et al.

Anonymous Referee #1

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General comments

This paper analyses the effect of model resolution on the surface mass balance estimates of the regional climate model MAR, specifically for Greenland. Simulations on different resolutions were done (15 to 50 km). Analyzed is the effect of model resolution and the relative contribution caused by smoothed topography. Furthermore, the methods do downscale model results are analyzed.

In general this manuscript is well written, the research consistently performed, ana-
C129

lyzed and discussed. Some paragraphs needs to be rewritten because they aren't clear now, see specific comments below. From that point of view, I have no major comments.

However, my concern is that this paper, in its present form and focus, will have little impact. It shows that high resolution (< 25 km) is not always needed for a good estimation of the Greenland SMB, and that clever interpolation can reproduce high-resolution fields from lower resolution output rather well. But points are not worked out to their fundamental question and solution: a) which model resolution is needed to resolve an ice sheet (section) with a typical topographic length scale X ? b) What is the best method to get the most out of a low-resolution regional climate model simulation?

- a) Add an analysis of the local typical length scale of the topography of Greenland and relate this to the local quality of the RCM on different resolutions. From this, estimate the resolution needed to resolve the SMB of the Greenland ice sheet – and other glaciated areas on the world.
- b) Somehow I got the impression that the authors still work on the optimal interpolation method (p. 657, l. 12). In that case, I suggest to remove the analysis of this preliminary method from this manuscript and focus entirely on question a) and the resolution effects. Why present something, which you will improve very soon? If this (a paper on the best method to interpolate low resolution fields) is not planned, then improve this method to a final product and show the results here, or leave out the suggestion that the method must be developed further.

These concerns are not severe enough to inhibit publication, but I strongly advise the authors to take this additional step and improve the manuscript.

Comments

- The English is ok, but consider rewording 'diminishing resolution', 'depleting skill scores', 'debased topography'. For me it sounds like that the resolution is gone soon, the model runs out of skill score and the topography became morally wrong. So check if these words are indeed 'the right words'.
- Is it possible to number the figures in the supplementary material (S1 to Sxxx) and use this numbering when referring to it in the manuscript?
- I know that I'm a (too big) fan of abbreviations, but is it an idea to define abbreviations for the different simulations, and make a table with the different simulations? For example, define 25ST for the 25 km simulation with smoothed (=50km) topography simulation. Now I get lost somewhere in section 7, due to the numerous simulations and their comparisons.
- p. 640 l. 14-19: The K-transect ends on Russell glacier, an ice sheet promontory. Therefore, it requires a very high (< 2 km) model resolution to resemble the glacier outline on this area. My point is, hence, 'distance to the ice sheet margin' is not a good tuning parameters for matching model data with K-transect data. It is better to use the elevation of S9 and S10 to match the relative grid point locations. Elevation is more important on the SMB than distance to the margin.
- p. 641 & 666: Add to figure 1 a comparison of model/observed SMB as function of elevation.
- p. 641 l. 19-28: I don't get the point of this paragraph. For example, which computation time is saved by the interpolation? Likely the authors refer to the calculation time of high resolution run, but that is what I conclude after reading the whole manuscript. Please rephrase.

C131

- From p642 onwards: Use Gt yr^{-1} , that's the common used dimension. Moreover, $\text{km}^3 \text{ yr}^{-1}$ is unclear, is it ice, snow or water equivalents?
- p. 643 l. 4-9: I only understood this paragraph after several times rereading, please rephrase. It's in my view not really a control reference, these tests give an idea how good or bad a certain skill score is.
- p. 648 l. 6-16: Indeed the 25-20 km resolution captures most of the SMB (components) variability since for most of Greenland the typical topographic length scale is larger than 25 km. For the rugged parts of Greenland (deep south and southeast) 15 to 25 km is still too coarse to capture the SMB correctly. This connection of model skill and topographic length scale is essential and should be added here.
- Section 6.1: The method remains vague to me. It's not 3D interpolation; it's not 2D x-y or xy-z interpolation. Please make it more specific and add an explaining figure in the supplementary materials. In the end, this method supports one of the main conclusions of this paper, i.e., high resolution is not always needed.
- Section 6.4: Since one of the main conclusions is that precipitation can't be improved by clever interpolation, this should be supported by Figures. Probably there was not much to show, but still. Space permitting, add it to Figure 6, otherwise to Figure 16.
- p. 654: I don't get entirely clear what is shown in Figure 7f and 7i. Is it the 'smooth surface 25km simulation' corrected to the 'real surface at 25km' or the 50km simulation cleverly interpolated to the 25km grid?
- p. 656, l. 15: '...harshly challenge...' I would say that the differences in precipitation estimates by the different models are more a problem than their different responses to grid resolution.

C132

- The conclusions, i.e., the last part of Discussion and conclusion, can be a bit more focused to the research questions. The conclusions are now clouded by possible improvements and unresolved problems.

Minor comments

- p. 637 l. 15: Add a reference to the aims and goals of ICE2SEA.
- p. 640 l. 6: Benefited? Where is the profit? I would use '...which needed an enlarged domain ...'
- p. 641 l. 3: It is not too cold for significant snow fall, there is still 300 mm yr⁻¹. What is actually meant? In fact the surface slopes are similar for all resolutions, so snowfall differences should also disappear.
- p. 641 l. 15-17: Can you give, using the topography, an estimate of the resolution required to resemble S4 and S5? < 2, 5 or 10 km?
- p. 646 l. 7: include the word 'annual' or include the dimension yr⁻¹ to the number.
- p. 646 l. 9: Consider expressing the trend as 10 Gt yr⁻² (values is my guess).
- p. 647 l. 5: To my memory, the increase of RACMO precipitation for smaller resolution is due to enhanced orographic precipitation in SE Greenland. Orographic precipitation is much more vigorous in RACMO than in MAR. For even higher resolutions, this increase in RACMO stops since more high accumulation points fall outside the ice sheet mask. MAR instead excludes the coast of southeast Greenland from the ice sheet. So, I don't see this results as un-explainable.
- p. 648 l. 22: Why 8 points, not 9 (a 3x3 square)?

C133

- p. 649 l. 17: Interesting to see that this method works better than Helsen et al (2011). Does this method allow estimating SMB components out of the elevation window of the 8 points?
- p. 650 l. 10-17: Make more clear when is referred to the interpolation to 15 km and when to the original 15 km simulation.
- p. 652 l. 21-22: Consider rephrasing to something like: 'In this section, the effect of coarse resolution topography is investigated by analyzing high resolution (X-Y km) simulations which use coarse resolution (50 km) topography.' It now takes very carefully reading to grasp the intention.
- Table 1: Provide actual relative computing times or add 'estimated' to column caption.
- Figure 5: The caption is not very clear. Clearly state that a positive value implies a decrease (?) compared to the original grid. Consider removing the comments on interpolation. Add 'original grid' and 'extended grid' to the pink/red/green texts below the figures. Furthermore, expand the figure domain so that the expanded and original extend of the domains can be plotted.
- Figure 7: I assume that this figure will be larger in the final version. I think individual subfigures should not be smaller than 3 cm wide otherwise readers need a microscope. In the current version, Figure 7 has subfigures of almost 2 cm wide.

Interactive comment on The Cryosphere Discuss., 6, 635, 2012.

C134