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Interactive comment on "Modeling the response of Lambert Glacier–Amery Ice Shelf system, East Antarctic, to uncertain climate forcing over the 21st and 22nd centuries" *by* Y. Gong et al.

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We thank Anonymous Referee 1 for their thorough review of our original manuscript. The referee requested some major revisions and we have in general agreed that they were needed and carried them out. We respond to the specific points made below.

"The applied ice model uses adaptive mesh refiÂĄnement (AMR) which in principal is a sophisticated method to handle the flow across grounding lines. In contrast, the model setup falls short. Unlike the SMB projections, which were directly adopted from two atmospheric models, the chosen perturbations at the ice-shelf base are rather questionable. This holds for all experiments except the "FESOM" simulations and is

one of my main concerns. Nothing is said about basal melting at new ice-shelf nodes after the grounding line would have retreated. I wonder if neglected melting would exclude a more drastic retreat of tributary glaciers, particularly if they flow over an inland deepening bed."

We have presented only the FESOM and additional sensitivity experiments, as requested, and disussed the issue of basal melting at new ice-shelf nodes. We will give more detail in response to the referees more detailed comments on these topics. We have also added a bedrock topography map that shows that the galcier beds do not deepen inland close to the present day grounding line.

"The structure of the paper is okay, but the quality of the presentation is far from being acceptable. Text and fiÂĄgures need to be thoroughly revised."

We have thoroughly revised the text and figures. Again, more detail will be given in response to the general and specific comments below

"I can't recommend the current paper for publication. Instead, I would reduce the experiments to the FESOM and the S0 cases. The latter stands for an instantaneous disintegration of the ice shelf and causes the highest impact so far. If, using an extra parametrization for melting at new ice-shelf nodes wouldn't change previous results, the conclusion about the stability of the catchment area would become much more confiÂĄdent."

We have reduced the experiments, much as requested. We removed the BRIOS cases, replacing some with additional FESOM cases, but we have kept the S1-S5 cases as they illustrate the relative importance of the narrow southern section of the ice shelf over the wider northern section in butressing Lambert glacier. We have run additional experiments that produce more melting at new ice-shelf nodes but lead to similar results.

General comments

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"A main caveat concerning the model setup is the performed use of basal melting data. I do not understand why the authors decided to use averaged values of available basal melting. By looking into Timmermann & Hellmer (2012), basal melt volumes from BRIOS and FESOM are strongly time dependent. The used method will bring forward the strong FESOM signal from the 22nd century."

We did not use time-averaged values of basal melting (although we showed images of the average). The melt rate was changed each year according to the available data. We now show the FESOM melt rates in three (1982,2100,2200) stages to avoid this misunderstanding.

"Unlike FESOM, BRIOS data cover just the northern part of the Amery Ice Shelf. But according to Walker et al. (2012) the distribution of melting is essential for the stability of grounding lines. Thus, neglecting melting in the deep places inevitably will lead to an advance as can be seen in Table 3. I think, BRIOS data cannot be used at all to investigate a grounded-ice volume loss."

This is a fair point, so we have replaced all the BRIOS runs with FESOM runs. The original idea was to show the importance of the melt-rate pattern as well as the average value, but the extreme sensitivity experiments are more informative in this regard.

"Further, nothing is said about melting under new ice-shelf areas evolving from a retreat of the grounding line, though the freezing point of a deep-drafting base would favor high melting and possibly a more vigorous retreat."

We added an experiment where the FESOM data is extrapolated into newly floating regions : it does not make very much difference.

"I'm missing a plot of the bedrock elevations to get an idea about how far the Lambert Glacier is from iroatation. An inland deepening bedrock could favor grounding-line instabilities in particular because the used ice model is able to represent high velocities of a narrow Lambert Glacier."

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A map of the topography was added (figure 1). Although Lambert Glacier does eventually deepen a little inland, at first it rises and in general the bed is quite shallow.

"The classification of WC, BC, N1 and N2 is confusing. I had to read the text and tables several times before I understood the meaning."

Without the BRIOS experiments, the classification had less meaning. Now the experiments are simply named after the forcing data

"Generally, the figure captions have to be revised. A better description of important features is essential."

A number of new figures have been added and a number of the originals removed, but we take the point in general and give more detailed descriptions in the figure captions.

Specific Comments

"There are several typos in the text which I don't point to."

The text has been entirely revised

"p 5688, from 6: This chapter describes model initialization and a relaxation towards a steady state. I understand that Ms-0 is not derived for the ice shelf. If so, Mb-0 covers both, surface accumulation and basal melting or freezing. Why and how are you decomposing Mb-0 â€˜ or is the distribution just a result of the continuity equation? Anyhow - you must present a plot of Mb-0!"

We have expanded this section to make it clearer how and why we decompose the melt rates (to allow high melt rates to follow the grounding line) and have included a plot. The parameters in the decomposition are derived from the continuity equation

"p 5688, 19: â€^{TM}addingâ€^{TM} should be â€^{TM}replacingâ€^{TM} if the perturbations are not changes with respect to Ms-0 and Mb-0. You have to reveal that just deviations from Ms-0 and Mb-0 had been added in your experiments. If not, the VAF is overestimated by mistake due to wrong accumulation rates. Also, the ice shelfâ€^{TM}s

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thickness and velocity ïÂňÂĄeld would be affected. P 5689,14 and 24 seem answer to this comment."

We have hopefully made it clearer that we add (say) RACMO2 anomalies with respect to the RACMO2 1980-1990 mean to Ms0 and Mb0

"p 5690, 4: You are certainly aware that a melt rate of 1000 m/yr is physical impossible. The reader should know that this number is virtual and just a synonym for â€$™instant ice-shelf disintegrationâ€$™. Presumably, 839 m/yr would lead to the same results."

Agreed. We have noted that 1000 m/yr is unrealistic and, as noted, a proxy for instant ice-shelf disintegration

"p 5690, 12: This sentence undermines the proïÂňÂĄt of AMR methods. Where in the text could I check the given imbalance (percentage)? Do we learn something about the smallest resolution necessary?"

We added a section to the results, including two figures, where we show that a resolution of around 1 km is required (for BISICLES, other models may need lower or higher resolution) in order for estimates of the truncation error to be small compared to the variation in climate forcing.

"p 5691, 4: A â€˙ Aitof should read A-Aâ€$™. You should introduce this as an intended along- ïÂňâĂŽow proïÂňÂĄle. (comment at ïÂňÂĄg. 5). It seems that the proïÂňÂĄle touches grounded areas in two places."

We replaced this straight line transect with a curve that follows Lambert Glacier onto the ice shelf and then follows the center of the ice shelf to the calving front. This contour crosses the grounding line just once.

"p 5691, 23: Suddenly, this statement appears and there is no reference to a place in the manuscript, where it could be checked. Figure 4 which was mentioned in the line above, doesnâ€$™t help though."

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This sentence was removed during the revision.

"p 5694, 8: There is absolutely no reference for Tamean explaining its relevance for the conclusion drawn in this sentence."

This sentence was removed during the revision.

Figures

"Fig. 1: The ïÂňÂĄgure is to dark, the mesh unclear and the grounding line not visible. The ïÂňÂĄnest resolution is 625m."

We made a figure with a finest resolution of 1.25 km (coarser than the 625 m we used in the experiments), it seems to print and display OK. The grounding lines are bolder, and layed on top of the mesh

"Fig. 3: Figures are too small and grounding lines are not visible."

We replaced these with some flowline plots (fig 6), the pattern of melting does not vary so much so fewer, larger plots can be used.

"Fig. 5: What means â€$™left 2 columnsâ€$™? Figure annotation numbers differ from those given in the caption. S0 case should give zero velocity numbers on the ice shelf. Does the proïÂňÂĄle perhaps cross the grounding-line? Was is the reason for the difference in maximum S0-velocity (2500 m/yr vs. 1600 m/yr)?"

Fig 5 is now fig 6, it has been modified as requested. The S0 peak speed drops as the ice relaxes toward a new steady state with a thinner front (hence, lower driving stress). There is also a map of speed change (fig 7) between 1982 and 2200 for one of the FESOM experiments

"Fig. 6: Changes in grounding-line position are hardly visible. S0 velocities should be zero for the entire ice shelf."

Fig 6 is now aplit into fig 7 and fig 9, which magnify the ice shelf. In fig 7 it is still hard

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to tell the differnce between a number of grounding lines because they are essentially identical, which we note in the caption

Tables

"Tab. 1: The caption needs to provide more information. Why is Tamean not given for RACMO? Use extra column for temperature. Explain trend parameters. Tab. 2: Caption has to be revised. Interactive Comment Tab. 3: Why are data for S1 to S5 missing?"

All the tables are different - we now just have summaries of the accumulation and melt rate anomlies in tables 1 and 2. We discuss ranges of sea level rise and grouding line rereat in the text in they are clearer in the figures.

References

"Agosta et al. (2013) is just an abstract."

Fixed

"Beckmann et al. (1999): Hellmer et al. (2012) is the appropriate reference for basal melt rates used in this manuscript."

Fixed

"Colella et al. (2000): Perhaps there is a citable application of this method available?"

Cornford et al. (2013) is cited and decribes the method in a fair amount of detail , and its references could be followed to other mansuscripts that describe Chombo applications and some of its many methods, but there is only this unpublished design document for the whole library - and the library authors have in the past asked us to name it.

Interactive comment on The Cryosphere Discuss., 7, 5683, 2013.