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The Cryosphere Discussions

Interactive comment on "Simulation of the future sea level contribution of Greenland with a new glacial system model" *by* Reinhard Calov et al.

Anonymous Referee #1

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General comments

This manuscript describes a model study with a new glacier system model that consists of polythermal ice sheet model SICOPOLOS version 3.3 coupled to a model of basal hydrology, HYDRO, and a parameterization of submarine melt for marine-terminating outlet glaciers. The system model is forced with climatology from MAR, 1961-1990, forced with ERA-reanalysis boundary conditions and future projections are made with surface mass balance anomalies derived from RCP4.5 and 8.5 scenarios created by the regional climate model MAR forced with boundary conditions from three CMIP5 models. Projections for sea level rise contribution are made until 2300 and total subglacial discharge analysed as well as for two outlet glaciers, Helheim and Store where the offline coupled model is applied as case study area. The authors state that the

outlet glacier model will be applied to further outlets in the future. This topic is timely and it is very important to develop models that are capable of including feedback mechanisms that can have significant effect on the future evolution of the large ice sheets as well as the climate system (here the ocean), in order to make realistic projections of future evolution of the Greenland ice sheet.

Specific comments

The manuscript is well organized and clearly written, but I find the discussion of the results and comparison with data or other studies quite qualitative and think it would improve the paper if the authors would make more quantitative analysis of their results, see numerous comments below.

The description of the forcing scheme is not clear (section 2.6) as it is not clear how the model applies the temperature defined in equation 8, as it seems that according to equation 10 the mass balance is only the difference between the modelled and measured elevation, divided by relaxation constant. Is this really the case, or is missing a description of a positive degree day method to compute the surface mass balance during the spin up period and current equation 10 would be one term of that forcing?

The naming of the implied flux (equation 11) is confusing, suggest to call it something that indicates surface mass balance.

The introduction section is comprehensive and gives a good overview of the current state of development of large scale ice sheet models, and there is an impressive reference list for this study. I find, however, that the first part of the introduction should have more references for the general statements (page 1, lines 21 and 22, as well as page 2 lines 1 and 2) or at least indicate that these are not the only papers stating those broad things, with "e.g." before that one reference.

Minor comments: Page 1 line 19 suggest to replace "melting" with "retreat"

Page 2 line 4-5, suggest to add something about the peripheral glaciers, that are not

attached to the ice sheets, as those are actually contributing considerably to the sea level rise, see for example: Machguth, H., P. Rastner, T. Bolch, N. Mölg, L. Sandberg Sørensen, G. AÃřalgeirsdottir, J. H. van Angelen, M. R. van den Broeke and X. Fettweis. 2013. The future sea-level rise contribution of Greenland's glaciers and ice caps. Environ. Res. Lett. 8, 025005 doi:10.1088/1748-9326/8/2/025005

Page 2, line 6, suggest to add "a" before interplay

Page 2, line 8 suggest to replace "thought" with "intended"

Page 2, line 10, suggest to replace "treating" with "treat"

Page 2, line 11 suggest to replace "fast" with something like "computationally effiecent"

Page 2 line 5, suggest to add references after "studies exist"

Page 2, line 19, suggest to replace "can serve" with "serves"

Page 2 line 20 suggest to delete "as" after "and"

Page 2 line 22 suggest to replace "elevation" with "ice thickness"

Page 2 line 23 suggest to replace "elevation" with "ice thickness"

Page 2 line 24 suggest to replace "due" with "according"

Page 2 line 25 suggest to add "the" before "projected"

Page 2 line 27, suggest to delete "in" after "yielding" and add "of" before "the present-day"

Page 2, line 28 suggest to replace "avoiding" with "avoids"

Page 2 line 32 and 33, suggest to add further references, suggest Rae, J. G. L. , G. AÃřalgeirsdóttir, T. Edwards, X. Fettweis, J. Gregory, H. Hewitt, J. Lowe, P. Lucas-Picher, R. Mottram, A. Payne, J. Ridley, S. Shannon, W. J. Van de Berg, R. Van de Wal, M. Van den Broeke. 2012. Greenland ice sheet surface mass balance: evaluat-

ing simulations and making projections with regional climate models, The Cryosphere, 6, 1275-1294, doi:10.5194/tc-6-1275-2012, 2012 - for line 33, as it compares several RCMs

Page 3, line 20 suggest to replace "their" with "the"

Page 3, line 24-25, this sentence is strange, perhaps replace "of being" with "to be"?

Page 5, line 8, add explanation of what H stands for

Page 6, line 27, is there missing "-1" on the unit for the decay parameter?

Page 6, line 28, suggest to add ",B," after Basal melt

Page 6, line 26, suggest to add ",W," after basal water layer

Page 7, line 6, "closest to the coordinates by Rignot and Mouginot (2012)" is no clear, suggest to edit to clarify what is meant here

Page 7, line 15 that statements "our method is already able to determine the subglacial discharge for each glacier" needs some quantification, how realistically do authors think the model results are?

Page 8, line 16, see comment above, is there something missing in the equation that uses the T from equation 9, to compute the surface ablation?

Page 8, line 20 and 28, see comment above, suggest to rename "implied flux" to something that has surface mass balance in the name

Page 9, line 10, suggest to rename "implied flux", see comment above

Page 9, line 24, suggest to add "in the 21st century"

Page 9, line 28, Why do you need forcing until 2300?

Page 10, line 14 how is the ice load changing? If the mass balance follows equation 10 the thickness is always kept close to the observed one?

Page 10, line 22 suggest to add reference for the “over-implicit ice thickness solver”

Page 10, in lines 21, 25 and 27 it is three times stated that the resolution is changed at 5 ky BP, suggest to edit to get rid of redundancy

Page 11, line 1, suggest to edit, it is not clear how many constants are tested, and at what time the comparison is made, is it at t=0?

Page 11, line 3, at what time is the comparison made?

Page 11, line 15, it is not clear what “from now on” means, after 1900?

Page 11, line 22, see comment above, what does “compares overall well” mean? At what time? Can it this comparison be quantified?

Page 11, line 24, see comment above, what does “slightly lower” mean, can it be quantified?

Page 11, line 25 see comment above, what does “somewhat smaller“ mean?

Page 11, line 25-26, what does this sentence mean? Is the mismatch acceptable?

Page 11, line 27-32 these sentences are strange and not encouraging for the reader to accept the comparison, what does “fully resolved” (line 29) mean, and if you cannot model outlet glaciers with floating tounge, how is the NEGIS then the only large scale feature you cannot reproduce properly (what does “properly” mean here?) suggest to edit whole section

Page 12, line 3, what does “do not fully match he simulations” mean, can it be quantified?

Page 12, line 4, what does “rather smooth compared to observations” mean?

Page 12, line 6, what does “agrees basically” mean?

Page 12, line 17, see comment above about renaming “implied flux”

Page 12, line 18, what does “almost no change” mean?

Page 12 line 19, what does “a tiny volume change” mean? And “comparably small scale” ?

Page 12, line 32 strange beginning of sentence, suggest to edit (Certainly much stronger. . ..)

Page 13, line 6, what does “is minor” mean can it be quantified

Page 13, line 14, what does “much higher” mean?

Page 14, line 1, suggest to add “to” after “compared”

Page 14, line 8, what does “does not show big impacts” mean, can you quantify?

Page 14, line 24-25, strange sentence, it is not clear to what is being referred to, needs more explanation or clarification

Page 14, line 31-32, also here is strange sentence that needs clarification, deepening of basal topography by what?

Page 15, line 9, what does “an even smaller impact” mean?

Page 15, line 22, also here some quantification would be interesting “reasonably well” and “compared well” does not say enough about the success of the study - and line 33 “relatively large” does not give enough information

Page 16, line 5, what does “showed to be important” mean?

Page 17, lines 3 and 8, it is not clear what “horizontal time slices” mean, is this spatially distributed?

Page 17, line 8-12, this whole section is not clear, what is “favorable sampling interval”? and “not enough time slices” is not clear and “interval too long” also needs clarification

Page 17, line 14, what does this mean? How much overestimation?

Page 17, lines 20-21 the sentence “Note that the totals. . . “ needs clarification

Page 25, table 2, Rows and columns have been put in wrong lines (interchange)

Figure 3, it is no clear at what time this comparison is made, would be useful to add that information to the figure caption

Figure 5, is 4b the difference between 5a and 5b? it would be useful to add third column with the difference and suggest to add boxes on 5C to show the location of smaller figures in Figure 6

Figure 6, suggest to add reference for observations, same as in Figure 5?

Figure 8, see comment above about renaming the term “implied flux”

Figure 9, is the green line, the total basal melt constant? Then give the exact number value in caption

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