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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 #2

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Calov et al. present new projections of Greenland melting contribution to sea level rise for 300 years into the future with their Greenland system model. They also estimate future evolution of sub-shelf basal melting rate for two outlet glaciers. Whilst the paper does not bring much of novelty it is nonetheless very nicely written and presents recent promising model developments. I therefore fully support its publication. I have however listed a few minor corrections/suggestions below that the authors should consider for their revised paper.

General comments:

- It is not clear, at least to me, how you deal with ocean-ice interaction. Does SICOPOLIS simulate any ice shelves in your experiment? If yes, what do you choose as sub-shelf melting rate? Please make this clearer.

- Whilst the different model sub-components are generally well described I had difficulties in understanding what is the 1-D glacier model presented in Figure 1. My guess is that it corresponds to the coupler between the plume model and SICOPOLIS? Similarly as for your other arrows, you could add in Fig. 1 what is exchanged between the 1-D glacier model and the other components. In particular I do not understand what the right-to-left arrows stand for since the models are not interactively coupled yet.

Specific comments:

P3L29-30 Please show on a map where these two glaciers are located.

P6L7 How is defined the "shape of the glacier front"?

P7L8 "surface melt/runoff" → It is not clear what this is. I assume it is the runoff provided by the MAR model (∼rain minus retention due to refreezing?) and not surface ablation only?

P7L8-9 In your framework, you use the routing scheme of HYDRO (i.e. based on effective pressure) to route the water generated by surface melt. A fair amount of surface melt could be routed using surface gradient instead. Could you comment on how this can affect the pattern of discharge to the ocean?

P7L29-30 The gradients are not well defined for the accumulation regime because of precipitation that has a much more complex spatial pattern than temperature (and by extension ablation). I would guess that the vertical gradients for runoff are not well defined neither since a large part of runoff is composed by liquid precipitation. Could you comment on that?

P8L8-9 How is the surface temperature elevation gradient computed?

P8L25-27 A list of limitations of such an approach is welcome here, thanks. However I think you should expand more on the discussions of these. In particular, I think that taking into account the free-evolving topography during past cycles will have a large impact on simulated temperature profile as the ice thickness has considerably changed

during the last termination (Vinther et al., 2009) and the stress regime will be largely different with an ice sheet extended towards the continental shelf in glacial conditions. An other limitation of the SMB anomaly method to drive the spin-up is that an artificial SMB term is used to compensate all the model deficiencies in term of ice dynamics. A discussion on these points would be much appreciated.

P9L27-29 Please rephrase.

P10L9 Can't we expect a regional freshening due to the Greenland ice sheet melt? Why this could not be tested here as well with idealised scenarios (as for temperature)?

P10L22-24 The change in resolution certainly has an impact on the stress regime simulated by SICOPOLIS. Could you compare the state of your Greenland ice sheet (internal temperature) and your inferred surface mass balance (Mimpl) for present-day at 5 and 10 km resolution? Maybe you could add a few words on why doing the spin-up at a coarser resolution is not a problem in your case. It could also be interesting to have the future projections at 10 km resolution.

P10L25-26 Similarly to the change in resolution: have you tried to switch the hybrid mode before 500 years or after? How big is the impact on the simulated Greenland ice sheet? I assume that the thermal regime might be largely affected by the change in dynamics. . .

P11L4-5 Would it make sense to discuss the RMSE in SMB instead of the total difference in SMB?

P11L6-11 In the paper it could be worth discussing the spatial pattern of your difference in surface elevation and surface mass balance. From b-c we can really see that you have an important model drift at the margins: except for the NEGIS region your velocities seem too high (confirmed by Fig. 5) leading to negative surface elevation difference (compensated by artificial positive SMB anomaly). Related to this, why could you not find a Cb value minimising this model drift?

P11L13-14 Do you need to spin-up HYDRO as well?

P11L24-25 The simulated surface velocity does not seem smaller to me when you look at the western flank of the ice sheet.

P11L26-27 Please reformulate.

P11L29-30 Why?

P12L18 There is no change in ice volume visible but it does not mean that the ice thickness is not changing as you have compensating errors.

P12L20-21 How this correction has been made? Do you use a point by point correction of ice thickness or do you simply use a correction of volume based on an averaged number? If the latter, how large would have been the difference when using the point by point correction?

P12L30 The effect is stronger with RCP8.5 when looking at the absolute value but relative changes are in fact smaller. Which is in agreement with Vizcaino et al. (2015).

P28 Fig. 3 Maybe you could add to these the evolution of total volume and RMSE of SMB for the different relaxation time.

P29 Fig. 4 Could you add more levels to your colour scale?

P31 Fig. 6 Do you have floating points? If yes, you should highlight them on this plot.

P32 Fig. 7 Could you comment on why you have sub-glacial lakes when the base is frozen?

Technical corrections:

P3L31 Dot instead of semicolon

P6L2 No capital S for "submarine"

P35 Fig. 10 Typo towards the end of the second line.

References

Vinther, B. M., S. L. Buchardt, H. B. Clausen, D. Dahl-Jensen, S. J. Johnsen, D. A. Fisher, R. M. Koerner, D. Raynaud, V. Lipenkov, K. K. Andersen, T. Blunier, S. O. Rasmussen, J. P. Steffensen and A. M. Svensson (2009), Holocene thinning of the Greenland ice sheet, Nature, 461, 385-388. doi: 10.1038/nature08355.

Vizcaino, M., U. Mikolajewicz, F. Ziemen, C. B. Rodehacke, R. Greve, and M. R.van den Broeke (2015), Coupled simulations of Greenland Ice Sheet and climate change up to A.D. 2300. Geophys. Res. Lett., 42, 3927-3935. doi: 10.1002/2014GL061142.

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