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The Cryosphere Discussions

Interactive comment on "Greenland Ice Sheet contribution to sea-level rise from a new-generation ice-sheet model" *by* F. Gillet-Chaulet et al.

Anonymous Referee #2

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General appreciation

This paper is an important contribution to the advancement in numerical modeling of ice sheets, especially with respect to including realistic processes leading to discern the dynamic contribution to sea-level rise adjacent to the response of the ice sheet to changes in surface mass balance. Furthermore, this paper demonstrates why most present-day ice sheet models are unable to produce the observed large ice fluxes of glacier outlets and, therefore, are unable to predict the GrIS reaction to future changes in climate (and ocean). The model is initialized using two different inversion methods, yielding an initial state that is close to the observed state. The authors clearly explain in

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detail what the bottlnecks are in such inversion (data uncertainty, the need of relaxation, inversion for basal conditions thereby neglecting the current imbalance, ...), but by comparing two different methods yielding a similar result, the authors demonstrate the robustness of the applied methods. After this, a series of perturbations in basal sliding are made, similar to the SeaRise experiments. The derived basal friction field (spatially varying) is subject to three perturbations, i.e. none (sic), halving the friction, and gradually lowering the friction in the course of 100 years. Besides the sliding perturbation, two climate perturbations were applied. Results are briefly described and analyzed in terms of mass chnages of individual glaciers/basins. The authors briefly touch upon the future contribution of the Greenland ice sheet to future sea-level rise.

While the paper presents a very interesting piece of work, the intrinsic potential of the paper could be greatly improved by putting the major results in a broader framework. For instance, while it is not explicitly mentioned, the paper also underscores that to reproduce observed flow speed and mass loss of glaciers, higher-order physics is not sufficient, but resolving glaciers at high resolution (in which higher-order stresses play a decisive role) and initializing the model with robust inversions are essential building blocks for new-generation ice-sheet models and model predictions on decadal to century time-scales. A broader discussion could be given in the comparison of the numbers obtained from this work with numbers put forward by other authors. For instance, what is the main difference in approach of those studies? How do other GrIS model results compared to this study? What are their deficiencies? What is the further outlook in modelling the GrIS? What would be the potential effect of including calving? What can be done to improve the value of the projections (type of basal sliding perturbations)?

The conclusions should be made more firm, since the experiments are sufficiently robust. Major improvements should also be made to the English language to make the paper more readable, fluent and attractive. The native English co-author on the paper should definitely aid in an overhaul of the text. Many expressions are litteral translations

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from French (examples follow below).

I list below a series of more detailed remarks, some of them pertaining to the language. This is, however, not an exhaustive list of comments. The use of a spell checker could also help in eliminating a series of typos.

Especially the sections 'Results' (and the discussion thereof) and 'Conclusions' need some more work in bringing the important features upfront. If the authors take into account these elements, i find the paper acceptable for publication.

Detailed comments

p2790 l7: 'most usual ice-sheet models'. Rephrase using 'current ice sheet models', or present-day ice sheet models'

l18: rephrase: 'and on its own has a a stabilising effect'

p2791 l13: Van der Veen

p2792 l10-15: explain briefly why inverse methods are essential in modelling

l16: ... a new generation continental scale ...

l18: Stokes equations

p2794 l20: 'independent' or 'fixed in time'

l22: is a_s the prescribed accumulation? Shouldn't this be the whole surface mass balanceÂăterm, including surface melt (as shown in Eq 5)

p2795 l16: equally distributed

l18-19: Prior to the time-dependent simulation, the mesh size is optimised using the freely ...

l20: Mesh sizes decrease from 40km in the central part of the ice sheet to 1km in the outlet glaciers...

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p2796 l1-3: In general, ice sheets respond to changes in cliamte on multi-Century time scales, implying model spinup over long (glacial-interglacial) time scales.

l10: Moreover, inverse methods ...

l11: are currently restricted ..., hence limiting the ability to assimilate time series

l12: ... we use two inverse ...

l16: ... in a diagnostic model is unphysical

l17: ÂăThe free surface is then allowed to relax compared to the observed surface for a period of 50 years

l23: remove 'and are compared in the following'

p2797 Remove first sentence

l2: The method, detailed in A&G (2010), consists ...

l21: recently applied to

p2798 l1: As in Morlighem ...

l3: which is valid only for Newtonian

l6: remove 'here'

l11: obtained by

l14: change 'exact' into 'valid'?

p2799 l2 and 7: obtained by or 'written as'

l15: Surface ice flow velocities vary over several order of magnitudes between the interior of the ice sheet (slow flow) and the glacier outlets (fast flow). Therefore, Schaefer et al 2012 have shown that good convergence ...

p2800 l2: remove 'Here'

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p2801 l29: Similar to the velocity magnitude, ...

p2802 ll11: ... no guarantee that the actual ...

l17: Too coarse spatial resolution where the minimum ...

l19-20: rephrase

p203 l4-5: remove 'not shown here' and add (not shown) at the end of the sentence.

l6: insufficient

l11: at the margins

l11: unphysical very high: rephrase

l23: what is meant by 'fronts that open' Are these flux gates?

p2804 l12: After this, ice discharge increase ...

l17: Petermann

l18: imbalanced glaciers

p2805 The section on Setup should be rephrased somehow. Maybe it would be more clear to use a few baulated equations to show how the perturbation is done. It is not clear whether the whole spatially non-uniform friction field is subjected to the same perturbation, or whether this is scaled. Either write this better in the text or use a couple of equations to make your point.

p2806: l24: change 'retro-actions' into 'feedbacks'

l26: Without dynamic perturbation ...

l28: ... around zero and lacks a particular ...

p2807: l1: as a consequence, the total ice volume ...

l17: Due to this acceleration Bottom section of this papge: this is very novel and should

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be emphasized, by for instance bringing this into a separate paragraph

p2808: l6: discriminate between the ...

Bottom section: what happens when the ice sheet margins retreat further? Is there a remeshing? If yes, write why it is important; if no, explain in more detail the consequences for this.

p2809: l8: allows

l18: reference to Nick et al (2012) as well; modelling such processes on Petermann Glacier (J. Glac.)

Bottom section: rework the section on sea level rise, bring upfront the major conclusions of the work with respect to the innovations and importance of initialization through inversion and the way forward.

Interactive comment on The Cryosphere Discuss., 6, 2789, 2012.