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Interactive
Comment

Interactive comment on "Description of a hybrid ice sheet-shelf model, and application to Antarctica" *by* D. Pollard and R. M. DeConto

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We thank both reviewers for their careful and helpful reviews, and are in accord with almost all points, which we plan to implement in a revised version. The first comment of both reviewers is well taken, and we will add one or two introductory paragraphs on numerical ice dynamical modeling from SIA to full Stokes, and how this model fits in. Other points include:

R. Greve comments:

The enhancement factor for SIA flow (E_{sia}) is the subject of a section in a companion paper in The Cryosphere Discussion which describes how its value is qualitatively constrained along with basal sliding coefficients. The individual magnitudes of the enhancement factors reflect our choice of the rheological coefficient A (Eq. 16) and are not directly comparable with those in other papers. The ratio of enhancement coefficients for SIA and SSA flow is 3.3 (E_{sia} = 1, E_{ssa} = 0.3), which is slightly lower than the range 5 to 10 in Ma et al. (J. Glac. 2010), as mentioned in section 2.7. We do not know why this differs from Ma et al., but perhaps in future work we can decrease E_{ssa} and compensate for the reduced shelf flow by also decreasing the sub-grid pinning factor (section 2.5, and below).

2nd post, 27 July: An N_b^q term could readily be added in the denominator of the basal sliding law (Eq. 10). Some algebra and coding would be required to include linearized Newton-Raphson terms accounting for time-implicit variations of ice thickness h within a timestep (since N_b^q depends on h), in the same way as currently done for the h and ∇h terms in τ_b, but that would be quite do-able. However, the addition of an N_b^q term in Schoof's grounding-line flux parameterization (Eq. 8) would be more questionable. Pragmatically one could include it simply as a modification to the factor C_s; however, the derivation of (8) in Schoof (JGR 2007; JFM 2007) is based on a sliding law without N_b^q (the same form as ours in Eq. 10), and it is questionable whether his derivation with an N_b^q term would still be possible.

F. Pattyn comments:

We will implement the various suggestions to clarify the hybrid dynamics formulation in section 2.2.

We agree that the strength of sub-grid pinning of ice shelves (section 2.5) is somewhat speculative and deserves more study, modeling and observational. The implementation here is logical, and simply quantifies the fractional area of ice-bed contact given the sub-grid standard deviation of bed topography and the grid-average water-column thickness. The main question is: what is the actual sub-grid bed relief in various embayments? We will add references to Favier et al. (The Cryo. 2012) and Fricker et al. (Ant. Sci. 2009) as examples of modeling and observational studies, respectively.

The sub-grid pinning process does not compete with Eq. (8) in our view, but does interact with it as follows. It augments the overall drag on the entire ice shelf, like side drag. The aggregate drag is transmitted upstream to the grounding line self consistently within the model's SSA solution, increasing the back stress at the grounding line, i.e., making τ_{xx} less positive in (8) relative to the free-floating value, and so reducing the ice flux across the grounding line. A sentence addressing this will be added.

We agree that the current line 8, pg. 1106, and line 6, pg. 1109, give the misleading impression that uncertainties in geothermal heat flux (GHF) are not significant. We plan to add a figure showing ice thicknesses and basal temperatures using several available GHF maps (including Pollard et al. GPC 2005), which will show regional-scale differences of a few 100's m, much like Rogozhina et al. (JGR 2012) for Greenland. The new text will say only that some aspects on the largest scales do not strongly depend on the choice of GHF map.

Interactive comment on Geosci. Model Dev. Discuss., 5, 1077, 2012.