

Interactive comment on “Hydrostatic grounding line parameterization in ice sheet models” by H. Seroussi et al.

F. Pattyn (Referee)

fpattyn@ulb.ac.be

Received and published: 23 July 2014

General appreciation

This is a timely paper that investigates how numerical models can be improved to capture grounding line migration based on the intercomparison work of MIS-MIP and MIS-MIP3d. The participating model HSE1 in the latter intercomparison (Pattyn et al. 2013) did show a behaviour that was not possible to explain at that time, and the work presented by Seroussi et al. gives (i) a clarification on this and - more importantly - some solutions as how to improve its accuracy and performance. Since the MIS-MIP3d intercomparison other people have investigated the possibility to improve both accuracy and performance. One of these is due to Feldmann et al (2014) - Journal of Glaciology, a paper that not only should be referred to, but also needs closer attention

C1383

to put the results of Seroussi et al in a wider context, since it is not the first paper that explores grounding line interpolations in planview (vertically integrated) models. At the time of MIS-MIP3d very few (if not only one) model(s) used grounding line interpolations, which limited conclusions beyond recommendations of grid resolution. The advent of interpolation studies show that alternative techniques may aid at obtaining solutions for coarser resolutions. However, in this sense, and interpolation can be regarded as locally increasing spatial resolution by subdividing a mesh into sub-elements.

I was quite intrigued by this paper, and more so by its promises. The abstract clearly mentions that "Our simulations explain why some vertically depth-averaged model simulations exhibited behaviors similar to full-Stokes models in the MIS-MIP3D benchmark". However I did not find any clarification beyond the fact that we are dealing with a numerical artifact. Moreover, it fortifies my belief that this is pure coincidence.

This brings me to another point that is stated in the abstract: "The results reveal that differences between simulations performed with and without sub-element parameterization are as large as those performed with different approximations of the stress balance equations and that the reversibility test can be passed at much lower resolutions than the steady-state grounding line position." This statement argues that numerical noise is of the order of magnitude as the effect of stress approximations and that the difference can only be reduced by making use of sub-element parameterization. Here we need to make a clear difference between approximating a physical process and the way it is numerically approximated. Both are two different types of approximations: the goal of a numerical model is to be free of numerical bias and to demonstrate that the physical model (represented by full Stokes or any of the approximations to this system) is accurately represented/captured. This was the focus of the Pattyn and Durand paper (2013): by only selecting models that were free of numerical biases, i.e., that not only showed reversibility but also took the finest spatial resolution computationally possible resulting in smooth grounding lines (void of numerical noise - see the selection criteria in the Supplementary Material of that paper), it was clear that a distinction between

C1384

physical approximations could easily be made. Therefore it was possible to investigate what the impact of physics is on grounding line migration. So, it is not only a question of spatial resolution, it is also question of having a stable numerical solution.

In this respect, the authors should reformulate their abstract/discussion/conclusions and make numerical noise reduction their ultimate goal. The reversibility test is only a parameter amongst so many that helps at improving our understanding of grounding line migration. It should be clear that 'passing the reversibility test' does not make your model correct. Furthermore, the conclusions should be put in the light of 'this particular experimental setup'. Since other setups are not tested, we don't know whether the slightly convex grounding lines are representative of capturing grounding lines in Antarctica (nevertheless, Favier et al (2014) have shown that model numerics did have a minor effect compared to model physics in their simulation of Pine Island Glacier with three different approximations to the Stokes equations). One should remain very careful.

Detailed remarks

Page 3341: "... in the reset of the manuscript": remainder of the manuscript.

Page 3343, last line: I wouldn't state 'usually associated with". Only the MISMIP papers put spatial resolution forward as a solution due to the lack of other measures. You could be precise and specifically mention that those papers demonstrate that increase in spatial resolution improved the accuracy of the solution.

Page 3344: Results section, first sentence: add ', respectively' at the end of this sentence

Page 3350: line 17-20: this is only valid for this particular setup of the experiment and cannot be generalized.

Figures 3 and 4: make coloured lines thicker

C1385

Interactive comment on The Cryosphere Discuss., 8, 3335, 2014.

C1386