2nd review of Moreno-Parada et al.

By Tijn Berends

After the first round of reviews, the authors have added references to earlier studies involving flowline models, in order to demonstrate the practical applicability of the Nix model. They have added extra information about their discretisation and included some extra text discussing the relevance of their results in the thermomechanically coupled experiments. This has generally improved the quality of the manuscript. However, I still have a few concerns which I believe should be addressed before publication.

Major comments

1. Applicability

I think you could still do a better job of convincing the reader of the practical value of the Nix model. The experiments presented in the manuscript used "a horizontal resolution of $\Delta x = 2$ km and 35 vertical layers". These numbers would not pose any difficulty in terms of performance for existing 3-D models (PISM, CISM, Elmer, UFEMISM, etc.) when using a flow-band set-up, so the added value of Nix in this application does not really stand out. However, in your rebuttal, you state that "For wall-clock times of the order of minutes, Nix allows for resolutions of $\Delta x = 0.1$ km … and simulated times of order $t \sim 10^3$ kyr.". This resolution is 20 times higher than what is used in your experiments. Such a high resolution likely cannot be easily matched by existing 3-D models (at least, not without using really large numbers of CPU cores), and so there the added value of Nix would be much more noticeable. I think that providing some numbers to demonstrate Nix's performance at such high resolutions, including some (hypothetical) examples of experiments where such a high resolution would be necessary, would help convince the reader of why (as I asked in my first review), they should use Nix instead of any of the already existing ice-sheet models.

2. Discrepancies in new results

The results of the thermomechanically coupled experiments in the current version of the manuscript are quite different from those in the previous version. It is not entirely clear to me exactly what has changed that could cause these differences, nor why these changes were made. There are also a few discrepancies in the new results which need to be explained.

In Sect. 6.2.,1 I see that you added an altitude dependency to the surface temperature forcing, why was this done? Also, in the authors' response, you mention "both adiabatic and moist lapse rates", but only one value of 9.8 K/km is given in the manuscript. Also, in the previous version, you needed to reduce the surface temperature by about 80 K to cause the ice sheet to advance, whereas now you only need a 30 K change. Can you explain this difference?

In the new version of Fig. 5, large parts of the ice in panel E (the lower left, near the bedrock and near the ice divide) seem to be about 20 to 30 K colder than in panel A. In the text, you

claim that the 30 kyr steps are long enough to “ensure thermal quasi-equilibrium”, and since the geometries in these two panels are identical, the temperature profiles should be identical too. Can you explain where these substantial temperature differences come from?

Minor comments

L76-77 “…though differences are particularly notable for resolutions below 20 km.” The differences between the DIVA and the BPA arise when the scale of subglacial bedrock topography is smaller than ~20 km (in the ISMIP-HOM experiments). This has nothing to do with resolution, nor with any other numerical model parameter. It is a consequence of the neglected strain rates in the DIVA, making the velocity errors increase faster with the aspect ratio of the ice than they do in the BPA.

L87 “…ice high-quality spatially distributed observations…” unclear what you mean by this.

L307 “This melt rate is included as an additional term in the ice flux computation (Eq. 7 and 18)” Please provide the modified versions of these two equations including M.

L397 “…(Fig. 3c and 3c)…” I think these are 3c and 3d.

L439 “…panels 5a, 5b 5e…” I think these are 5a, 5c, and 5e.

L550 “…the required calving at the grounding line…” I thought M was supposed to represent some sort of melt?