The Cryosphere Discussions

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Comment on tc-2022-153

Anonymous Referee #2

Referee comment on "Seasonal variability in Antarctic ice shelf velocities forced by sea surface height variations" by Cyrille Mosbeux et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2022-153-RC2, 2022

This paper describes the effects of including annual sea-surface height changes when modelling the flow of ice shelves. By changing the height of the ice shelf, two changes to the flow are considered, firstly that raising the ice surface reduces the sea-ward driving stress and slows the flow, and secondly that raising the base of the ice causes the grounding line to retreat land-ward and reduces the basal drag, allowing the flow to accelerate. These contributions are quantified through the use of Elmer/Ice and the authors find that the change in grounding line position has a large impact on ice shelf velocity. It is a nice idea for a paper. But the models of grounding-line position are not correct for the timescales involved.

Looking at figure 2, the authors seem to be considering elastic flexure at the grounding line to be a major component of the ice shelf response, so that the direction of the surface perturbation close to the grounding line is opposite to that over the majority of the shelf (it is not clear what "relative uplift", l.307, actually means - relative to what? but I take it this is the effect being sketched). I cannot see any indication in figure 4 that this occurs - as the authors state, seasonal variations are much slower than the Maxwell timescale for ice, so the viscous relaxation should outweigh any elastic flexure, so the response of the shelf will primarily be that due to hydrostatic balance. In any case a rise in mean sea surface height should correspond to an inland migration of the grounding line (as stated in l.313); I should like to see figure 2 redrawn to remove the implication that the opposite occurs.

This brings me to my major concern - that the authors are using models for grounding line migration that were developed for a very different timescale, on which ice behaves primarily elastically. They attempt to justify this by reference to a paper that also uses this models for fortnightly behaviour - but that is an order of magnitude closer to the Maxwell timescale than the seasonal variations are. Elastic stresses within the ice will be negligible on seasonal timescales. I cannot really see why anything except hydrostatic balance would be appropriate here, and I cannot support publication of this paper while model (ii) is being given serious consideration.

A further concern regarding the model for hydrostatic grounding line position being used (since this is rather key to the remaining results) - the result of the Tsai and Gudmundsson paper, that downstream migration is 9 times less than upstream migration, assumes that the ice surface gradient is constant across the grounding line, while the gradient in ice thickness changes abruptly (by this factor of 9). If one makes the opposite assumption, that the ice thins uniformly through the grounding zone (e.g. Sayag and Worster 2011, Warburton et al. 2020), then the hydrostatic migration distance is completely symmetric. With access to all the data needed to test these assumptions, I would be more reassured if the authors calculated the hydrostatic migration distance "from scratch", rather than wholesale apply this massively idealised formula.

Smaller comments:

Given the inherent non-linearities of ice shelf dynamics (and indeed grounding line motion), to what extent is it valid to compare the average of a function (mean velocities over a month) to the function of an average (ice shelf model forced by mean SSH)? The authors could consider applying the same process with much more of the daily signal kept in the forcing, and then average the output over a month, to see if this differs from the model output from the monthly average.

For clarification, in figure 9, is this one set of simulations per month, with a continuous line drawn between these points, or is the model forced with daily values of a monthly running average?