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Interactive comment on "Diagnosing the sensitivity of grounding line flux to changes in sub-ice shelf melting" *by* Tong Zhang et al.

G. Hilmar Gudmundsson (Referee)

hilmar.gudmundsson@northumbria.ac.uk

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This is a very nice piece of work!

The authors present some important methodological advances. The use of the adjoint-method to calculate the grounding-line flux is very nice, and of course far better than the approach used in Reese et al (full disclosure, I was one of the authors of the paper, and it should have been my job to implement the adjoint approach myself for that work, but I was too busy with other things. . .So I'm, very glad that someone has now done what I myself should have done some time ago.)

I like the three research questions and I think the authors provide very satisfying answers to all of them in the paper. I wonder if the research question (1) could not be

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formulated a bit better? Maybe: How do changes in ice-flux across grounding line, relate to estimates of ice-shelf buttressing evaluated at locations within the ice-shelf?

Must confess that I have never myself fully understood the usefulness of quantifying buttressing at some location within an ice shelf. What makes sense to me is to quantify the grounding-line buttressing provided by an ice shelf, and the changes in GL buttressing and GL ice flux as a function of thickness-perturbation across the ice shelf. I guess in some way the authors also address this issue when they conclude that the buttressing at a given location within an ice shelf depend critically on the normal direction chosen. (Possibly it might be better just to look at, in a general sense, how stresses within an ice shelf differ from the unconfined case, but again this will depend on the particular question being addressed.)

The authors investigate the possibly that perturbations in ground-line flux due to local changes in ice-shelf thickness, are linearly related to ice-shelf buttressing values calculated at those same locations within the ice shelf. This is an important point that needs to be investigated, and I guess it could be argued that Fuerst et al implicitly assumed this to be the case. (As mentioned above, I personally have never understood why one would expect there to be a simple correlation between these two quantities, except possibly in some general qualitative sense.) But this has been implicitly assumed in some previous work, and the authors are the first ones to actually look into this in any detail. They provide a detailed but arguably also a too long and somewhat confusing answer, but essentially I think they conclude that there is not simple relationship between these two. If I have correctly understood their conclusion, I would recommend stating more clearly this key finding and basically just write that there is no theoretical reason to expect GLF to scale in a simple way with buttressing numbers evaluated at a given location within the ice shelf, and that the numerical experiments show that no such simple relationship exists for the cases considered.

I had some difficulties following the discussion in 4.3.2. Not sure if this is really relevant, but a reduction in ice thickness change at any location within an ice shelf will generally

have two opposing effects on ice-shelf flow: 1) the spreading rate goes down and with it the speed further downstream 2) buttressing (as measured along the grounding lines upstream) will generally decrease and therefore speed increase. So there are two exactly opposing effects involved. Usually, reduction in ice-shelf thickness leads to an increase speed close to the grounding line, and decrease further downstream (provided the ice-shelf is long enough for the integrated effect of ice-shelf thinning to outweigh the effect on increased GL speed.)

The manuscript is still in a bit rough state. In fact, I find it to be in an unusually rough state compared to a typical TC submission. There are number of footnotes, and these seem to be mostly some comments aimed at the authors themselves. This needs to be sorted out and the presentation of the material needs to be sharpened up a bit (what are 'distal changes'?).

The figures are also some of rather poor quality. I guess most TC readers will know where the Larsen C is, but it might nevertheless be good to have some map showing the location of Larsen C.

It's a bit unusual to use curly brackets around a tensor as done in Eq, (11).

I missed an exact definition of the grounding-line flux and the GLF used in the adjoint method. Is it a line integral over all the grounding lines? How is the grounding-line defined at a local element level? Do you use the edges of the grounded elements, or do you cut through elements based on the flotation/grounding mask? If so, how do you interpolate velocities and ice thickness from the nodal points? Line 193-194: Not sure if I actually showed this. At least I don't think I used the concept of 'group velocity' in this context.

I would generally have recommended a minor revision to such an excellent work. But the presentation is still too poor, and for that reason I suggest a revision following a re-review.

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