Review 1 (reviewer comments in italic)

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.)

We appreciate the general endorsement of the work and the helpful suggestions below, which we have used to clarify and improve the paper.

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 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?

Thanks for the suggestion. We have changed the initial version of this question "Do local evaluations of ice shelf buttressing reflect how local perturbations in ice shelf thickness impact grounding line flux?" to "How do changes in ice-flux across the grounding line relate to local estimates of ice-shelf buttressing evaluated on 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.*

As suggested by the reviewer, throughout the revised manuscript we have attempted to (1) clarify that this is one of our primary conclusions, (2) more clearly tie together the various sections of the paper that need to be understood to support this conclusion, and (3) justify this conclusion based on the results and discussion presented in the paper.

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’?).

We have largely rewritten all of section 4.3 and attempted to clarify the main points therein and better connect them to the preceding and following sections, in order to better support the main findings of the paper. We also have removed most of the footnotes, either deleting them or incorporating them directly into the main text.

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.

A location figure for Larsen C has been added to Figure 1. We have also added several other new figures (mainly to the SI, in response to other reviewers). In general, the majority of figures and their captions have been updated and improved.

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

The brackets in Eq. (11) have been changed to parentheses.

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?

The reviewer is correct. We have added a new section up front (2.1.1) to clarify how the grounding line flux is calculated (along with additional discussion relating to the adjoint approach in Appendix C).

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?

The location of the grounding line in the model is defined at sub-grid resolution (i.e., "cut through") using a floating vs. grounded mask. Velocities and thickness are discretized as nodal finite element fields and are evaluated on the grounding line. This is now explained in detail in the new section 2.1.1.

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.

We have removed this discussion in the updated version of the manuscript so this is no longer relevant.

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.

The manuscript has been significantly revised since the initial submission and we believe that all of the reviewers concerns are adequately addressed.