Review of Mitcham et al. "The impact of calving and ice-shelf thinning on the Larsen C Ice Shelf"

November 11, 2021

General comments:

The manuscript by Mitcham et al. presents a very thorough and detailed numerical study of the instantaneous effect to a number of idealised ice-shelf thinning and calving perturbations to Larsen C Ice Shelf. For the calving perturbation, they find that most of the buttressing is exerted by floating ice within 5 km downstream of the present-day grounding line position. For the ice-shelf thinning experiments, the authors show that a significant thinning (ca. 200 m) is necessary to get a doubling of ice flux across the grounding line. Overall, I find the manuscript very well written and easy to follow. The provided Figures are appropriate and of high quality. The main criticism in the first round of reviews was about the novelty of the study, as a number of previous studies exist that have investigated the instantaneous response of Larsen C Ice Shelf already, albeit with slightly different foci. I should mention that I was not a reviewer in the first round of reviews.
My opinion is that the depth of experiments including additional sensitivity simulations are just enough to warrant publication as a full research article in TC, without having to undertake transient perturbation simulations. However, I think the fact that this is the instantaneous response should be highlighted throughout. To be fair the authors already do acknowledge this in several places throughout the manuscript. I think that drawing any conclusions about the future should be avoided in the manuscript (e.g. L313-317). In the following I outline my list of minor suggestions below and hope the authors find my comments helpful.

Specific comments:

- I think the title should already convey the information that this paper is looking at the instantaneous response. Since the paper is also focusing on ice flux across the grounding line, my suggestion would be to also include this in the title. So maybe something along

the lines of : "The instantaneous response of Larsen C Ice Shelf grounding line flux to calving and ice-shelf thinning perturbations."

- Just a comment to line 33-35. It reads like there are no studies on the transient upstream response to changes in Larsen C ice shelf thickness and extent. I would just like to point out that at least for the extreme scenario of complete ice shelf removal, we published a paper in TC in 2018 (Schannwell et al. 2018) about this. We basically find that the sea-level contribution and upstream thinning decay very rapidly (<50 years) after the perturbation.

- In section 2.1., can you please mention if you assume isothermal ice and if so what temperature and why?

- In section 2.2 L107-108, this reads like Gmsh is creating linear finite elements. As far as I know, Gmsh simply creates the triangulation or mesh, but you can use any finite element type on this mesh. Does this mean that you are using linear Lagrange elements? Would be nice to spell this out more explicitly.

- L305-307, I find the result that a 1 m or even 0.001 m thick ice shelf vs. no ice shelf gives a difference of ∼100% in ice flux across the grounding line surprising. This warrants a discussion why there is such a large discrepancy.

- L313-316 I find this scenario to be a bit too far fetched and recommend deleting this paragraph.

- Appendix E: I do not know if Ua has pressure-limited sliding laws implemented (Tsai, Budd, or Schoof sliding relation), but I think as a community we are moving towards pressure-limited sliding relations, so it would be interesting to see if the effect between these two relations is already large in the instantaneous response or only in transient simulations.

- Appendix E: Why did you rerun the inversion for different sliding law exponents? In theory you should be able to use one inversion for all different exponents because they must satisfy $C_2|u|^{m2} = C_1|u|^{m1}$, where $m1 = 1$ and $m2 = 2$ for example. You could then rearrange that for C_2. Maybe you can comment on that?

Technical corrections:

L69 outlined and labelled

L86 I think this should be reworded. The stress balance equation is always solved diagnostically. There is no time-dependence in Eq. 1. Only when you couple the stress

equation to a transport equation (e.g. ice-thickness evolution equation) does it become transient (time dependent).

L430 Whilst

Figures:

Fig. 1: Does the ps in the axes label stand for polar stereographic? I would consider scratching this.

Fig. 5: Is there really only speed-up in panels a-c?

Fig. C1: sizes were half

Fig. E1: (Eq.5).

Sincerely,
Clemens Schannwell

References

Schannwell, C., Cornford, S., Pollard, D., and Barrand, N. E.: Dynamic response of Antarctic Peninsula Ice Sheet to potential collapse of Larsen C and George VI ice shelves, The Cryosphere, 12, 2307–2326, https://doi.org/10.5194/tc-12-2307-2018, 2018.