General comments

This paper studies the impact of the recent large Larsen C 's calving event (iceberg A68) on the stability of the ice shelf and the ice velocity change both on the ice shelf and at the grounding line. This first simulation is followed by a series of synthetic perturbations of the ice shelf to study the potential effect of future calving event or large thinning.

The paper is well written and easy to read, with a sufficient amount of detail (generally). The paper is in line with a series of previous papers treating the buttressing effect of ice shelves: e.g., Fürst et al. (2016), Reese et al. (2018), Gudmundsson et al. (2019). In that sense, I think that the paper proposes a limited novelty in the field.

I think that the real case modeling of the A68 calving event and the comparison of the model velocity change with Sentinel-1 SAR observations is particularly well treated and gives a valuable and additional piece of information to the current literature on buttressing and the effect of calving events. Indeed, such processes are often treated only from an observation point of view or only from a model point of view. I really enjoyed the combination of the two here, although a previous and similar work has been conducted by Borstad et al. (2017), which is "acknowledged" by the authors.

However, I have some concerns about the significance of the instantaneous response of ice shelves and tributary glaciers to downstream ice mass loss. Since such steady modeling does not account for any transient, it seems only a good tool to simulate the effect of small variations for which the transients (ice thickness evolution, advection of the ice front post calving event, "degrounding" of grounding zones due to dynamic thinning, etc.) remain limited. I fear that the results obtained for the largest perturbations applied (thinning or calving of most of the ice shelf) are very theoretical (in the sense that they do not capture the entire physics of an ice-sheet evolution) and of limited value to assess the real effect of an entire (or substantial) collapse of the ice shelf. Also, community work such as the ABUMIP experiment (Sun et al., 2020) already focuses on the transient effects of similar events (ice shelf collapse).

I therefore think that some transient simulations, allowing the ice shelf and its tributary glaciers to evolve after a calving event would greatly improve this study, bringing more insights on the real impact of calving on Larsen C but also other ice shelves. It seems that the authors intend to do such work in the future (as they raise some questions at the end of the discussion) but maybe a part of this work should be included in the present publication.

I also have a few minor comments that are listed below.

Minor comments

Line 45: Similar work has also been conducted by the second author of (Gudmundsson et al., 2019) for the entire Antarctica. I would cite this work in the introduction. It would be interesting to make a few comparisons between this new study and Gudmundsson et al. (2019), to see if numbers agree.

Line 63: Could you refer to Figure 1 here, so that the reader directly looks at the map and locates the two IR.

Line 86: I'd specify that n=3 is a standard in ice modeling (rather than a choice from the authors).

Line 87: I'd delete the comma between "non-linear" and "Weertman".

Line 92: I am not well aware of the impact of the m exponent in Hill et al. (2018) but I think that Gudmundsson et al. (2019) show a substantial impact when changing m over some regions (up to 40% of GLF in their supplementary Figure S9). I agree that even such change would not affect the main conclusions of the study. However, in Gudmundsson et al. (2019), their perturbation of the ice shelf is not as extreme as the cases where your remove the most of the ice shelf or where you "thin" the ice shelf by more than 50%. I therefore think that applying their conclusion to this paper is a little too much. A little more detail on the effect of the m exponent, with an additional experiment testing this effect, would be useful to the paper.

Line 95: "The calving front location represents a pre-July 2017 state". Could you precise how the calving front was defined (?), as it supposedly does not come from Cook and Vaughan which was published in 2010.

Line 103: It is great that the authors tested the impact of resolution. As the impact seems negligible (conclusion of Appendix C), I'd suggest to specify the negligible effect in the main text too (avoiding to jump to the Appendix during a quick read).

Line 111: What is the impact of the density on the model results? Could you also add a map of the integrated density (maybe in a supplementary material)?

Line 113: What is the impact of using one velocity dataset (MEaSUREs) or the other (Sentinel-1)? I believe that the the MEaSUREs InSAR-based Antarctic Ice Velocity v2 data set (Rignot et al., 2011; Mouginot et al., 2012) is a "post-publication" version and that the data should be cited properly too. Instructions are provided at this NSIDC link: https://nsidc.org/data/NSIDC-0484/versions/2. Could you also give a reference for the ENVEO data?

Equation 6, Line 123–127, and Appendix A:

- I understand that you use the same regularization parameter for both the A and C regularization. What is the order of magnitude of A and C (or their gradient), there must be a risk to over or under regularize one of these parameters if they have a different order of magnitude.
- Would the method beneficiate from a proper 3D treatment of the L-curve (e.g., Fürst et al., 2015) where both regularization parameters are varied together? I think that would allow a

better optimization of the model (even if your velocity misfit is relatively low). Again, considering different regularization parameters for functions of A and C could be useful.

- What are these priors? You should state these since the choice of prior can affect the optimization.

Section 2.5: I have one concern about the effect of the spatially varying ice density when instantaneously thinning the ice shelf. I expect the vertically averaged density to vary as the ice thin. Also, thinning by surface ablation/melting will have a different impact on the averaged density than basal melting. I think that since you use a spatially varying vertically integrated density, the density change with thinning should be investigated. If density has no significant effect, maybe mention that despite the model accounts for a varying density, its effect is not important to this study.

Figure 4: please specify that the red line in (c) is the grounding line.

Line 201: Please refer here to Sec. 2.5 that explains the two types of thinning (also use the same wording to define them along the paper).

Line 225: You mention that the velocity decrease is likely an artefact in the model due to the timing of the velocity you assimilated for initializing the model. I believe that the negative response could also be partially due to a change of stress state and that acceleration in a region can lead to a deceleration in another one, although such behavior might be only possible when considering a transient model.

Line 280: I would change “dynamic response” for “instantaneous response” as there is no dynamical/transient effect in this study.

Line 286: The (instantaneous) buttressing effect of the ice rises is indeed relatively small but if the ice rises had to disappear, the dynamical effect might be more important than a 2.2% change in grounding line flux. In my opinion, this is where a transient experiment would bring very valuable insights.

Section 5 (Conclusions): Following my comments on the importance of considering the dynamics of the system and not only the instantons buttressing effect, I think that some of the results, such as the minor contribution of most of the ice shelf (e.g., up to 5 km from the grounding line) should be tempered.

References

Fürst, J. J., Durand, G., Gillet-Chaulet, F., Merino, N., Tavard, L., Mouginot, J., Gourmelen, N., and Gagliardini, O.: Assimilation of Antarctic velocity observations provides evidence for uncharted pinning points, The Cryosphere, 9, 1427–1443, https://doi.org/10.5194/tc-9-1427-2015, 2015.

Sun S. et al. (2020). Antarctic ice sheet response to sudden and sustained ice-shelf collapse (ABUMIP). Journal of Glaciology 66(260), 891–904. https://doi.org/ 10.1017/jog.2020.67