Review of the article entitled "Glacier geometry and flow speed determine how Arctic marine-terminating glaciers respond to lubricated beds"

1 General comments

This manuscript presents further development on the precedingly applied perturbation theory. Rather than using a perturbation in elevation, the author is introducing a basal friction term which will be the source of the perturbation. The development of the model leads to the definition of two key parameters, J_0 represent the strength of the initial response to basal lubrication and P_e gives insight on the longer term mode of mass transport. The author used multi-sourced data from 1996-1998 from glaciers in Greenland and Austfonna ice cap to compute P_0 and J_e and compare those to the observe velocity changes in the following twenty years. The application of this 1D model allows to highlight glaciers for which a combination of thickness and initial velocity will render said glacier vulnerable to a lubrication of its bed. The study indicates that for some ocean terminating glaciers in the Greenland ice sheet, multiple feedbacks could make glaciers more sensitive to changing basal condition.

The introduction of basal friction in the perturbation theory model allows to introduce a more realistic way to perturb the model and observe its evolution. This improvement allows to draw conclusions on the stability of glaciers to a lubrication event with respect to its P_0 and J_e which ultimately are based on its geometry and velocity before the perturbation. The result unfortunately show that there is quite a large area of the J_0 against $\frac{P_e}{l}$ graph in which the behaviour of the glaciers is uncertain and their classification as vulnerable or not to basal lubrication is not clear. The author propose two hypothesis that would explain this clustering on the graph with quite different effect in term of acceleration. Finally, the author presents some characteristics which would render a glacier vulnerable to lubrication and the potential feedback due to said lubrication.

The description of the model, and development of its equations is clear and well described but some of the figures could be clarified for better readability. As a colourblind reader I have a hard time with the colour choice of Figures 5 and 7. This is not vital to the understanding of the paper as the difference between pale and other colours is still readable but it will help to control the colourscale and/or add a colourbar to help with readability. On panel (B) of these figures, it might also be better to use a smaller marker than the dot to allow a better readability of the lines themselves.

There are a few more points that might need clarification in the paper as those were not completely clear to me.

- In the description of the data treatment, it is stated that the velocities are interpolated on NoData points and afterwards that a valid vertex should not contain any NoData Values, I expect that at this point the interpolated velocities are not considered as NoData anymore, is that right?

- It is clear particularly on the Austfonna example that the flowlines are displaced due to the changes in velocity, I wonder how these changes affect the model result and why the flowlines were computed from the 2018 dataset and not from the ITMIX one.

- Only marine terminating glacier are investigated here, is there any limitation of the model that prevents to study land terminating glaciers, or was it a choice of the author?

- Ultimately, most of the study investigates J_0 as close to the front as possible, it would be interested on the reasons behind that choice in the paper.

- On figure 6, I noted that the spread of the Gaussian kernels is different for both classes of glacier, more spread on J_0 and more defined peak on $\frac{P_e}{l}$ for glaciers with high acceleration and the other way around for the more stable glaciers. Can that be explained by the model? If yes it would probably be worth discussing that pattern.

- Line 285, it is stated that GrIS land terminating glaciers are insensitive to meltwater forcing. However there are some modelling study that seem to disagree with that statement [e.g. Gagliardini and Werder, 2018]

2 Specific comments

Bellow is a list of more specific comments throughout the manuscript given with line numbers:

- Line 1: “flow” seems misplaced here, isn’t “discharge of ice” sufficient?

- Line 11: I do not completely understand the usage of “forms” here.

- Line 16: I am not sure of the meaning of “where a good portion” is it for most of Greenland glaciers, or most of the marine terminating glaciers?

- Line 23: Should "subsurface ocean water" be specified here?
- Line 28: Sentence on this line is unclear and could be rephrased.
- Table 1: K_1 here is a function of x and t but it is stated in the text that it is a constant, perhaps the notation in the table should reflect that.
- Table 1: The primes (') are not defined here perhaps it would be worth defining them as x derivative here.
- Line 86: I suspect that $fracdhdt$ stands for $fracdH_1dt$
- Figure 3: In this figure and the following, the panel lettering is missing in the figure.
- Line 207: I would prefer the "J_0 against $\frac{P_e}{l}$"notation than the one used here and further down (line 233, 239).
- Line 210: It seems that a zero is missing in the value of P_e/l.
- Figure 5: In this figure and following the units should be changed to be consistent with the text.
- Line 292: I am not sure of the meaning of status here.
- Line 306: Isn't "and" missing, "and create an other feedback..."

References

Olivier Gagliardini and M. A. Werder. Influence of increasing surface melt over decadal timescales on land-terminating greenland-type outlet glaciers. *J. Glaciol.*, 64(247):1–11, aug 2018. doi: 10.1017/jog.2018.59.