Comment on tc-2021-81

Anonymous Referee #2

Referee comment on "Geometric controls of tidewater glacier dynamics" by Thomas Frank et al., The Cryosphere Discuss., https://doi.org/10.5194/tc-2021-81-RC2, 2021

The paper "Geometric Controls of Tidewater Glacier Dynamics" studies ocean-induced tidewater glacier retreat for different geometric configurations. The idea is interesting and has the potential to lead to publishable results, but some assumptions in the design of this study are not ideal, and the analysis of the results needs to be improved (figure 6 & 7 in particular). Moreover, often statements about stability are included when discussing transient model results, which is a wrong and confusing use of terminology.

Design of the study: Some of the modelling choices are not ideal and lead to ambiguous results.

- Why include an elevation-dependence for the flux at the inflow boundary and why have accumulation only in a small area upstream rather than a constant accumulation rate on the entire geometry as is typical in idealised modelling studies? Including the elevation dependence adds an unnecessary complexity that does not provide any additional insights.
- Why use the Budd-sliding law? This sliding law includes the dependence on bed elevation below sea level, which introduces additional complexity that can obscure the results (see also Brondex et al., 2017, for a study of the sensitivity of grounding line dynamics to the choice of the friction law). Where there are bedrock bumps or dips, this changes the basal resistance to flow.
- Use of different forcings to trigger retreat: again, this makes it difficult to compare different results. Why not use one (strong) melt forcing for all cases?
- Lines 160-163 mentioning that doubling the melt rate leads to a reduction in calving and the grounding line is mostly stable. Again, such a choice of calving law is unfortunate, as it is not clear which dynamics are due to the topographic controls and which are due to feedbacks between melting and calving (see also Schoof et al.; 2017 and Haseloff & Sergienko; 2018 for discussions about how the choice of the calving law can alter grounding line dynamics).
- Use of wetted area: I've never come across this term before and have difficulties

subscribing to its usefulness (its application in figures 6 & 7 is highly doubtful, see below). What is wrong with just using the amplitude of the perturbation?

Results:

- Line 203 onwards: The terms "stable" and "unstable" refer to steady states, not transients, and are incorrect in this context as steady states are only attained at the beginning and the end of the simulation (see e.g., Strogatz, 2018). This needs to be rewritten to use appropriate terminology.
- The presentation of retreat-results in figure 3 is not ideal as it is difficult to identify the important information from this plot. Better plot grounding line position in the center of the geometry vs. time and include both the results for the reference plot with forcing and the small, medium, and large perturbations. This should make it much easier to see where the retreat is fast and where it is slow and how patterns change with different topographic perturbations.
- Some of the transient results are interesting and maybe counter-intuitive, but the presentation of the results and the unnecessarily complicated model assumptions make it difficult to trust those to be robust.
- Figure 6 & 7 and related discussion: Isn't this simply showing mass conservation? For lateral variations, plotting Q/S is a proxy for the width-averaged velocity, which must increase where the geometry narrows simply due to mass conservation arguments.

  As correctly stated in equation (3), with this choice the integrated accumulation at the grounding line depends on the ice thickness at the inflow and the prescribed parameters only, i.e., is constant over most of the domain. The width-averaged ice flux at the grounding line at the beginning and the end of the transient (when presumably a steady state is attained) should thus only differ due to differences in ice thickness at the inflow boundary. For transient model results the picture is less clear, but the dynamically interesting quantity is the *width-integrated grounding line flux*. Does that show deviations from expected steady-state results (ideally in simulations without the elevation-accumulation feedback)?
- Figure 8 & discussion: need to plot Q/S against dS to show that relationship still holds.

References:

Brondex, O. Gagliardini, F. Gillet-Chaulet, and G. Durand, 2017. Sensitivity of grounding line dynamics to the choice of the friction law. Journal of Glaciology, 63(241):854_866, 2017. doi: 10.1017/jog.2017.51.

Haseloff, M. and Sergienko, O.V., 2018. The effect of buttressing on grounding line dynamics. Journal of Glaciology, 64(245), pp.417-431.

Schoof, C., Davis, A.D. and Popa, T.V., 2017. Boundary layer models for calving marine

outlet glaciers. The Cryosphere, 11(5), pp.2283-2303.

Strogatz, S.H., 2018. Nonlinear dynamics and chaos: With applications to physics, biology, chemistry, and engineering. CRC press.