SUMMARY

In this study the authors use a glacier flow model to investigate the impact of tides on iceberg calving. The model is designed to mimic the geometry and stress state of Kronebreen, a well-studied glacier in Svalbard. The authors conclude that tides affect the timing of calving events when submarine melt rates are low, but as the submarine melt rate is increased calving becomes driven by undercutting; the impact of tides is either diminished or is masked by the impacts of submarine melting. If correct, this is a really interesting result that provides insights into the processes governing iceberg calving.

I have two major concerns about the model set-up and several overarching comments that I think could help to improve readability and impact.

1. Basal friction

My major concern with the paper is the choice of using a linear friction law, which as I understand does not include effective pressure. Tidewater glaciers are typically close to flotation and therefore the basal shear stress is sensitive to small changes in thickness. Other modeling studies have suggested that tidal response should depend on effective pressure (e.g., Walters, 1989; see also Amundson et al., 2022). The closer a glacier is to flotation, the farther upstream a perturbation will be felt. It's possible that the modeled glacier is in a regime where that effect is small (compare to Fig. 6a in Amundson et al., 2022), but it will likely still affect the near-terminus stresses and the timing and magnitude of calving events.

Effective pressure appears in the analysis of Amundson et al., which focused on nearly instantaneous stress changes from calving events, because of how changes in ice thickness propagate upstream. There is another effect that the authors don't consider which is that changes in sea level must affect the near-terminus subglacial water pressure. If the tides go up, the piezometric surface must adjust in order to continue to drive water out of the subglacial system and into the water. Thus, a rise in sea level results in a reduction in basal friction.

I feel that an analysis of how tides affect flow and calving must take these things into consideration, which requires a friction law that depends on effective pressure.

2. Undercut geometry

My understanding is that the melt parameterization that the authors use will essentially erode a "box" into the glacier with vary sharp corners. It at least produces a sharp overhang, as shown in the Figure 7, that appears sharper than observations presented in the paper and in other previous studies (e.g., Fried et al., 2015 and Sutherland et al., 2019). I worry that the sharp corners are producing especially high stresses and biasing the model results such that the undercutting appears to have a larger impact on calving than it might otherwise. One solution might be to test what happens when the boundaries of the plume are not so sharp — perhaps using some sort of gaussian melt profile, for example.

3. Message

Maybe I was thrown off by the title, which suggests that this paper is investigating the impact of submarine melting on calving in general (like Mercenier et al., 2018 and Ma and Bassis, 2019), but it wasn't until I was pretty far into the paper that I realized that this paper is really primarily about the impact of tides on the timing of calving events. Submarine melting only really comes into the analysis because it acts to diminish the impacts of tides (at least according to the model). I suggest focusing the message of the paper more on tides, starting with the title.

4. Structure

I felt that the paper jumped back and forth between the model and observations too frequently, especially in Section 3. The paper is guided by observations, particularly glacier geometry and flow, which I appreciate. However, the authors are unable to make really detailed comparisons of the model output and data due to the nature of the modeling, and so the jumping back and forth just makes things a little confusing. Personally, I think a better approach would be to lay out the data, say that you are using it to motivate a modeling study, and then describe the model and model output. At a minimum, it would be worth considering how sections 3.2 and 3.4 are structured. Both include observational data.

5. Model details

I think the model description needs more details. For example:

- How was the ice-ice boundary at the confluence of Kronebreen and Kongsvegen handled?
- Was the ice-rock boundary a no slip boundary?
- Did the friction law depend on effective pressure? (I think not; see comment above.)
- What was the width of the melt plume / region of submarine melting?
- Was there no ambient melting outside of that region?

The authors state that they are investigating several different tidal impacts in their, but the connection between tides and the impacts is not made clear. I would like to see them clarified. As I understand, the impacts they include are:

- sea pressure: this just relates to the stress on the glacier face, which has a direct impact on ice flow
- crevasse depth: Are you just saying that crevasses don't have to penetrate as deep (in the crevasse-depth model) to produce a calving event when the water level is high?
- frontal melt: Is there more frontal melt when the water is high because more water is in contact with the face? I think you need to be careful here because tides could also affect ocean heat transport toward and away from the glacier, which you are not modeling.

6. Implications

I'm wondering if the authors can go farther with their discussion of the impact of tides on calving. Most of the focus is on the timing and location of calving events—which is itself interesting. But can the authors also say something about fluxes? For example, in the absence of submarine melting, how does the calving flux change if you turn the tides on or off? Is it important to include tides if you want to get the fluxes correct over longer time scales?