Title: Assessing the sensitivity of the Vanderford Glacier, East Antarctica, to basal melt and calving
Authors: Bird et al. (2024)
Journal: The-Cryosphere
Reviewer: T. Pelle (tpelle@ucsd.edu)

Overview:
In this manuscript, Bird et al. present an ice sheet modeling study that investigates the role of ice shelf basal melting and ice shelf calving in driving observed retreat of Vanderford Glacier in East Antarctica. The author's primary conclusions are that ice shelf basal melting (>50 m/yr) is the primary forcer of this observed retreat and that currently available satellite estimates of basal melting are insufficient to drive the magnitude of retreat observed over the past ~25 years. On the other hand, ice shelf calving had minimal impact on the dynamic retreat of Vanderford Glacier. Overall, I found this paper to be a pleasure to read! The ice sheet model and experimental set-up are meticulously described and the writing is free from any grammatical errors. Furthermore, I find that the conclusions are generally well supported by the results and that the authors make sure to highlight major sources of uncertainty. I also believe that the results of the paper will be important for future ice sheet modeling studies in this region, as this paper presents important constraints on the choice of ice sheet friction law as well as which forcing mechanisms to prioritize in the modeling of Vanderford Glacier. Below, I include suggestions that could improve the presentation and quality of the manuscript, but they are generally minor and should be relatively easy for the authors to address. Once this is done, I would be very supportive of this manuscript's publication in *The-Cryosphere*.

General Comments:

- **Ice sheet model spin-up**: In the manuscript, you describe a 500 year spinup of the ice sheet model so that it relaxes to a pseudo steady state. I wonder about the implications of running the model to steady state given that you are trying to match observed patterns of grounding line retreat. If Vanderford Glacier was not in steady state prior to the 18.6 km grounding line retreat, is this spinup to steady state really necessary (or appropriate)? Have you checked that the rate of ice mass change of Vanderford Glacier at the end of your spin-up is in somewhat of agreement with observations? How about the simulated velocities? You could test the impact of this steady state by perhaps performing an additional experiment that starts directly after the 2 year relaxation period and comparing the results to the corresponding experiment that started from steady state. Overall, I think that some justification of this spinup, discussion of its impacts on your results (possibly highlighted as an uncertainty in the later stages of the Discussion section), and a comparison of your steady-state model to present day observations (velocity and mass loss) would be very helpful.
- **Reversibility of retreat**: I was happy (possibly relieved) to see that in all of your experiments, simulated retreat and the grounding line flux stabilized back to conditions at the start of the simulation once the forcing was reverted back to what was applied in the spinup. I think that this is an important result and is worthy of being highlighted in the text! In your simulations, you show that retreat of Vanderford Glacier is not irreversible and that, in its current configuration, Vanderford is not undergoing MISI.

- **Figure references**: I noticed a couple of incorrect figure references. I tried to catch as many of them as possible in the line comments below, but also wanted to highlight it here in case I missed any. It would be great to double check these.

Line Comments:

- L57-60: How do these satellite estimates perform over heavily crevassed ice shelves? Would this be a factor as well? Also, what are their resolutions?
- L78-80: This might be a good place to point to figure-1, which shows the model domain.
- L146: In your steady-state runs, do you also check that mass loss is steady as well? Is the steady state the same for all friction laws? How does the steady state geometry and ice velocity compare to the initial model state? Have you tested the impact of starting your perturbation experiments directly after the 2-year relaxation period (since Vanderford likely has not been in steady state). I'm wondering if this choice to spin up your model for such a long time feeds back on your results in some way?
- L150: Change "simulate" to "perform"
- L151: Perhaps it might be clearer to say "we simulate a series of perturbation experiments for each of the three friction laws that run for 100 years."
- If the model is spun-up for 500 years, why do you need to further spin up each experiment for another 5 years?
- L158-159: What does it mean to remove the response of the control experiment from each perturbation experiment? Can you be more specific here? Is this specific to the grounding line flux, or does this also include the response of the grounding line as well?
- L230: Does this point to the fact that MISI is not in play here and that retreat of Vanderford is reversible if forcing decreases?
- Sec. 3.1: Also, do you know what caused this large jump in grounding line retreat in the Weertman M_{Davidson} simulation (yellow dotted line in figure 6b)? It is odd that you see this spike in grounding line retreat, but do not see a corresponding jump in Delta-VAF or Delta-ice volume.
- L242: Figure pointer to 5c seems incorrect(this figure shows grounding line retreat in the linear calving experiments). Did you mean 5b? Same with pointer on L271 to fig. 7j (should this be 7i?)
- L286: Fig. 7j references the basal melt perturbation experiments, do you mean fig. 7l? Same for figure reference in L294.
- L363: In addition to in situ measurements, what about the opportunity to back out high resolution ice shelf melt rate maps using techniques such as the one described in Zinck et al. (2023); https://tc.copernicus.org/articles/17/3785/2023/? Given that direct observations of ice shelf melt are difficult/costly to obtain, it might be worth discussing other avenues.

Figure Comments:

- Fig. 2: In the caption, you say "current mass loss estimates for Vincennes Bay", but is this accurate since you are showing ice shelf melt rates and calving rates? Might consider removing this qualifying sentence.
- Fig. 3: It is difficult to tell which experiments are bolded (I did not realize any were bold until I read the caption). Can you make this stick out more?

- Fig. 6: Is panel-b showing the location of the grounding line along the flowline (e.g., in the Weertman M_{Davidson} experiment, the grounding line was ~2.5 km retreated inland from year 20-25, but then advanced back to its present day position at year 30), or is this the retreat rate? It might be nice to briefly mention this in the figure caption or corresponding section of the paper.
- Fig. 7: In the caption, I am a bit confused at your description of what the purple line is in panels d-f. Is the purple line the location of the 2020 grounding line along the flowline?
- Fig. 10: The orange line is a bit difficult to see given the colormap used. Can you try to make these stand out a bit more?