Review of:
“Evaluation of four calving laws for Antarctic ice shelves” by Wilner et al

Wilner and colleagues assess how accurately four calving laws represent ten Antarctic ice shelves under the assumption that the ice front of these ice shelves are in steady state. For this purpose, they use a state-of-the art ice sheet model run at high resolution in constrained Antarctic domains. The metric they use to quantify the realism of the calving laws is based on the areal mismatch. Their results show that the eigencalving law (EC) and the von Mises law (VM) are the ones which best reproduce the calving front position. A further analysis based on the passive shelf ice (PSI) suggests that the VM law represents more accurately the observed PSI computed by Fürst et al., (2016).

This manuscript is very well written and illustrated and it is very well suited for the scope of The Cryosphere. I do not have major concerns but I think some initialisation steps should be clarified for the reader. I also have some questions and suggestions for the authors which they may consider or not.

<u>General comments:</u>

Initialization

I agree with the other reviewer that some important information is lacking in the methodology, mainly if basal melting is considered and how you treat grounded ice in your ice-sheet model. Is the grounding line fixed or is it allowed to evolve?

Ice shelf rigidity

You say that you invert for rigidity in ice shelves. Which parameter are you tuning there? The ice viscosity parameter B? A viscosity enhancement factor for ice shelves?

Stationary calving front position

As suggested by the other reviewer you could do an additional equilibration simulation with a stationary calving front position fixed to observations. You could compare there for instance the calving rate at the ice front for different calving laws with Rignot et al., (2013).

von Mises calving law

One of the key messages of this manuscript is that the VM law best reproduces the observed calving front positions. However, as you state in the manuscript, this result can be partially explained by the fact that you invert for rigidity which is explicitly considered in the VM computation (Eq. 3). There exist other approaches in the literature for tuning ice shelves, for instance through enhancement factor (Surawy-Stepney, 2023) or basal-melting rates (Lipscomb et al., 2021), though the latter are applied to match observed ice thickness rather than velocities. Do you think that if you would have adopted another inversion method you would still have such a good ice front position with VM?

Calibration parameter of von Mises calving law

You calibration parameter in the VM calving law is the tensile stress threshold σ_{max}. This threshold should represent a physical property of the ice, mainly the ice tensile strength (~0.7 MPa; Morlighem et al., 2016, Bassis et al., 2021). Your obtained calibration values are lower, but in the same order of magnitude. Do you have an explanation or interpretation for this?

Technical questions:

- It is not clear to me how you apply calving in your ice-sheet model. Is the calving rate a thinning rate applied to the ice front or do you trace the ice front position via a level-set method?

- The crevasse depth law (CD) is only computed at the ice front or are crevasses computed over the whole ice shelf? Do crevasses affect your ice dynamics?

- How well do you simulate ice thickness with observations?

References:

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- Lipscomb, William H., et al. "ISMIP6-based projections of ocean-forced Antarctic Ice Sheet evolution using the Community Ice Sheet Model." *The Cryosphere* 15.2 (2021): 633-661, DOI: 10.5194/tc-15-633-2021.

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