Response to comments by Jeremy Bassis

A theme that has been helpful for many of these past debates about physical processes, rests in asking what observations can be used to test the model or better constrain the parameters? I personally think that this link back to existing or needed observations is a useful question to expound upon in the manuscript. How do we know the model (or certain parameter combinations) are capturing some of the relevant physics. Are there specific predictions that the model can make that can be tested to (in)validate any of the model hypotheses?

Reply: We agree that this is an important point. How might the predictions of the mélange-buttressed cliff-calving parametrisation be tested against observations? There is limited data on Antarctic glaciers and most of them still have shelves, so they are not currently in a cliff-calving regime. In Greenland, however, most glaciers terminate in narrow fjords filled with mélange and many have no floating tongue – they may therefore be subject to cliff calving. The cliff calving parametrization was confirmed as a lower limit on calving rates for Sermeq Kujalleq (Jakobshavn glacier) in Schlemm & Levermann (2019). This is because the cliff-calving parametrisation used here underestimates calving rates, if the glacier is just at the beginning of the cliff-calving regime. This is in contrast to Ultee & Bassis (2020), where a calving model based on a thin film viscoplastic theory was shown to provide an upper limit for calving rates of Greenland glaciers. Since the cliff-calving parametrisation underestimates calving rates of current glaciers, another calving parametrisation would need to be used in order to test the mélange buttressing parametrisations against observations. However, then it would be unclear how to differentiate between fitting the calving model and fitting the mélange model.

Ultee & Bassis (2020). SERMeQ model produces a realistic upper bound on calving retreat for 155 Greenland outlet glaciers. *Geophysical Research Letters, 47*(21): e2020GL090213. https://doi.org/10.1029/2020GL090213

Schlemm, T. & Levermann, A (2019). A simple stress-based cliff-calving law. *The Cryosphere,* 13, 2475-2488

Another important issue is one of numerical convergence. My view has long been that modelers (I include myself in this) need to more systematically demonstrate numerical convergence of models, but we often forget or assume that because it was done for a previous study that it doesn't need to be repeated. I do think that a numerical convergence study, even if it is for a shorter period of time or limited portion of the domain would better allow the authors to demonstrate how robust the results are to numerical parameters.

Reply: We agree. We know that the model is not converged at a resolution of 4km. However using the subgrid scheme at the grounding line, the reversibility of the grounding line is captured well as shown in Feldmann et. al. (2014).

Feldmann, J.; Albrecht, T.; Khroulev, C.; Pattyn, F. & Levermann, A. (2014). Resolution-dependent performance of grounding line motion in a shallow model compared with a full-Stokes model according to the MISMIP3d intercomparison. *Journal of Glaciology, Cambridge University Press,* 2014, 60, 353–360