Referee #3: Lizz Ultee

General comments

Schlemm et al investigate the progression and sea-level contribution potential of two proposed ice sheet instabilities in Antarctica. They use the Parallel Ice Sheet Model to simulate the retreat of the Amundsen Sea sector of the West Antarctic Ice Sheet at centennial scale, first in a "reference" case and then in seven experimental cases. The authors then compare sea-level contributions from the Marine Ice Cliff Instability (MICI) with those from the Marine Ice Sheet Instability (MISI) alone.

Overall, the manuscript raises interesting questions and presents a great deal of work toward addressing them. However, I found the organization confusing. Many results appear together with uneven levels of detail in the discussion. One of the major conclusions seems to be about interpreting an upper bound on cliff calving rate; the framing of that analysis in particular confused me. I would encourage the authors to carefully consider what key points they wish to highlight, and to thoroughly rework the manuscript to focus on those points.

I have self-cited in my specific comments below; I would prefer to avoid that but feel the work is relevant. I am therefore signing my review in the interest of transparency.

All the best,

Lizz Ultee

Specific comments

1. The authors find that their results depend strongly on what value is imposed as an "upper bound" on calving rate. This result makes intuitive sense. The authors also describe the calving rate parametrization as "loosely constrained". Here I am confused. There are two possible interpretations:

- *Do the authors mean that the SLR contribution depends on the value of C_{max} they impose in their simulations? That is certainly true, but does not make sense as a main result, because the authors have the ability to compute an adaptive C_{max} that depends on local geometry. Results from an adaptive C_{max} experiment are presented in Figure 3 and 4.*
- *Do the authors mean that the parameters in Equation 1 are loosely constrained? I think this is the more interesting point, and it could be more prominent in the text. The authors briefly discuss the value of the exit velocity u_{ex} but do not further explore uncertainties in the adaptive calving rate. If related sensitivity studies have already been done, for example in Schlemm & Levermann 2021, it would be helpful to describe their key findings.*

Given that the authors have already derived the adaptive bound and implemented it in a PISM experiment, I do not understand their focus on the four constant-C_{max} experiments. Perhaps the constant-C_{max} experiments are intended to provide context for the range of possibilities of a poorly constrained adaptive C_{max}? If so, I need more framing from the authors to aid that interpretation.

The authors are right to point out the limitations in DeConto & Pollard's (2016) approach, which imposes a very fast cliff calving retreat rate. However, in my view, applying various constant cliff *calving rates as upper bounds is not much improvement on DeConto & Pollard (2016). For one thing, the theoretical upper bound on cliff calving rate depends on outlet glacier geometry, local climate, and the yield strength of ice (Bassis & Ultee 2019; implemented for all grounded GrIS outlets in Ultee & Bassis 2020). Secondly, the authors themselves have derived a parametrization for melange-buttressed cliff calving, which brings in more interesting physics than the constant rates.*

One way to reorganize might be to focus more directly on the adaptive calving rate experiment in the main text, and separate the constant-rate experiments into a supplement or even into their own "brief communication" style manuscript. I don't insist on this—simply a suggestion for how a more focused manuscript might read.

Reply: Thank you for the suggestion. In addition to the cliff calving experiments with different Cmax values (CC#), we performed a range of adaptive experiments with different uex values: 10 km/a (CCA10), 50 km/a (CCA50), 100 km/a as included in the original manuscript (CCA100), 200 km/a (CCA200), and 1000 km/a (CCA1000). The resulting Cmax for the initial ice geometry lie between 1.5 km/a for CCA10 and 150 km/a for CCA1000. Consequently CCA10 shows very little cliff calving and only little more ice retreat than FLK or BMT. The Cmax of CCA1000 is initially so much larger than the actual cliff calving rate that there is effectively no melange buttressing. As the calving front retreats, Cmax decreases significantly as in the CCA experiment included in the original manuscript. In contrast to the CC# experiments, where the upper bound Cmax was chosen adhoc, these experiments correlate an in principle observable parameter, the mélange exit velocity, to sea level rise. This does not actually constrain the uex value but gives a better understanding of its importance for the speed of MICI.

*2. I could use more explanation of the assumptions of the C_{max} bound. The authors write on p5, L22: "In order to estimate Cmax for a given grounding line configuration, we assume that the entire embayment is filled with mélange." I do not understand how this is an upper bound on calving rate. An embayment entirely filled with mélange would be the configuration that results in the most suppression of calving, but couldn't there be *more* calving if the embayment were not filled with mélange?*

Reply: Yes, there would be more calving, if the embayment was not filled with mélange. However the mélange parametrisation cannot evolve the mélange margin, we need to assume its position. Evolving mélange thickness can be modelled though: if the whole embayment is filled with very thin, spread-out mélange, the calving rate is large and many icebergs are produced. As a result the mélange thickness grows quickly and reaches its equilibrium thickness within a few years (see Schlemm&Levermann 2021). This has been added to the manuscript.

3. The experiments presented in Section 3.4 allow the ice divides and grounding lines of Thwaites and PIG to retreat all the way across WAIS to the Ross and Ronne-Filchner Ice Shelves. How realistic is this? In such cases, I'd expect some lateral motion of the ice divides and resulting adjustment in the grounding lines. It would be helpful to have more guidance from the authors in interpreting the real-world context of these results.

Reply: These are the same 2d-experiments discussed in the rest of the paper, just analysed along the trajectory of the flowlines. The ice divides are free to move. It may be that, due to movement of the ice divide, the actual flowline, aka main direction of the ice flow, changes. This has not been taken into account. This has been clarified in the manuscript.

4. The authors describe seasonal variations in the strength of mélange buttressing in Section 4.1.2. I have two concerns with this. First, the results are buried much later in the manuscript than other primary results of experiments. I was confused to see them there. Second, the title of the section reads "Mélange build-up can stop MICI under winter conditions", and p16, L16 indicates that result, but p18,L14 reads "…winter freezing of mélange is not sufficient to stop calving." I am left unsure whether frozen mélange inhibits MICI or not.

Reply: This section was split up and moved forwards, it is now included in the method section as well as in the results section. The title was corrected to "Winter freezing of mélange is not sufficient to stop MICI".

Technical corrections

P5, L8: "can lead to very large calving rates" - please clarify whether this refers to large calving rates in the model or in observations

Reply: It refers to the model, this has been clarified.

P10, L13-16: "Cliff calving with a small value of C_{max}…in this case." I do not understand this explanation. Consider rephrasing or elaborating.

Reply: This has been clarified.

P11, L3-4: "Because the embayment becomes wider…the upper bound on calving rate decreases with grounding line retreat into the Amundsen basin." This does not agree with the decline in buttressing that I interpret from Figure 2 and previous description. Please check this and/or clarify the explanation.

Reply: The distance between the calving front and the embayment exit increases. This has been corrected.

Figures 3 & 4: Please consider using thicker lines for the legend entries, or labelling C_{max} directly on the plot. I find the colors hard to distinguish with the thin lines currently in the legend.

Reply: Done.

Section 4.3: The official name of Greenland's fastest outlet, formerly called Jakobshavn Isbræ, is Sermeq Kujalleq (Bjørk, Kruse & Michaelsen 2015). Please update the nomenclature you use to discuss it.

Reply: Thanks for pointing this out, we corrected it.