

The Cryosphere Discuss., referee comment RC1  
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## Comment on tc-2021-238

Anonymous Referee #1

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Referee comment on "Stabilizing effect of mélange buttressing on the marine ice-cliff instability of the West Antarctic Ice Sheet" by Tanja Schlemm et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2021-238-RC1>, 2021

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### General comments

This paper investigates the possible consequences of two main instabilities mechanisms (MISI and MICI) for the Amundsen region of the Antarctic Ice Sheet (AIS) using the Parallel Ice Sheet Model (PISM). The authors use a simple cliff-calving parameterization and a mélange buttressing model that were proposed and tested on idealized cases in their previous papers and apply them to real glacier cases in this paper. MICI is an important mechanism that could lead to large uncertainties in modeling the physics of the ice sheets. Recent theoretical and modeling studies (Ma et al., 2017, Bassis et al., 2017, Mercenier et al., 2018) have investigated and analyzed mechanisms for MICI. Applying a more physically based cliff-calving law on real glaciers setting is the timely step to makes an important contribution to the MICI hypothesis. However, I have several concerns described below that need to be addressed before publication. The impact and usefulness of the paper could be improved further if it were expanded to clarify some fundamental issues associated with constraining the idealized mélange buttressing parameterizations. Without observationally constrained models, the results would be over/under- estimating sea level contribution as other papers the authors mention in the manuscript.

#### 1. Constraining the idealized mélange buttressing parameterization

The authors of course acknowledge and raise this issue in the manuscript. However, the application of the mélange buttressing parameterization is still limited because the model parameters are not observationally constrained. For example, the authors choose  $u_{ex}=100$  km/a that falls between mélange flow speed (10-18 km/a) and iceberg drift velocity (3000-5500 km/a) but it's a quite large range (10~1000 km/a) and I think the authors arbitrarily choose this value (If I understand correctly). It seems that the results

heavily depend on this  $u_{ex}$  value because it determines the upper bound of the calving rate ( $C_{max}$ ) so constraining  $u_{ex}$  based on observations (e.g., observational calving rate) is key to applying the parameterization to real glacier cases. Please elaborate on how this  $u_{ex}$  is chosen and I suggest some sensitivity tests if needed.

Also, please elaborate on how other parameters for the cliff-calving law and mélange model are chosen or constrained with observations.

## 2. Model description

I think the methods section is a little scant on details on model description. See below for more details.

P2L10: "This is referred to as Marine Ice Cliff Instability (MICI)": add references.

P4L6: "... at a horizontal resolution at 4 km". I think it would be beneficial if the authors could state the spatial and temporal resolution in a few sentences to make sure that results are numerically converged (i.e., independent of resolution) or the impact of resolution on the results.

P4L12: "The till friction angle is parameterized with bed elevation"

How is it parameterized? Please include details and references.

P6L4: "The ice sheet was spun up into thermal equilibrium with fixed bed and ice geometry"

Please include details on how the model is initialized, for example, how long was the model spun up? What data (SMB, temperature) were used for this procedure? Also, include references if there are any.

P6L9: "REF: a reference simulation with current day atmosphere and ocean conditions held constant"

What are the current day conditions for the atmosphere and ocean? Include details and references.

P7L1: "BMT: the 'basal melt experiment...200 m/a"

Why 200 m/a? any reference? Consider moving sentences from P8L18-L20 to this section.

What about the ice front? I think there is no calving in this experiment. Although it is explained later in the Results, please add how the ice front is dealt with (fixed or move) for this experiment.

P7L3: "FLK: the 'floatkill' ... removed"

Again, please add how the ice front is dealt with (fixed or move) for this experiment.

P8L2: "the three cliff calving experiments with small  $C_{max}$ ".

Specify "small  $C_{max}$ ". 2, 5, 10 km/a for  $C_{max}$ ?

P8L1-3: "The 'floatkill' -parameterization... with  $C_{max}=20$  km/a"

Where are the results of the extended simulations?

P8L31: "...reached the boundary of the inner WAIS region where cliff calving and the 'floatkill' parameterization are applied" -> floatkill parameterization are "not" applied.

P10L2: "see fig3c" -> Figure 6?

P10L14: "This results in a slightly lower overall calving discharge"

What is that compared to?  $C_{max}=2$  m/a without floatkill parameterization?

Does this issue with partially filled cells only show up when  $C_{max}=2$  m/a? or also with  $C_{max}=5$  m/a? Does this issue depend on the resolution of the domain? Please elaborate.

P11L7: "...is shown in fig 3c." -> Fig. 6

P13L7: "...with the FLK experiment being the slowest, arriving there after 150a"

I don't see the results with extended time in the manuscript. Consider putting the results in the manuscript or appendix, or put "not shown here" in the text.

P16L7: "we use an estimate of  $u_{ex}=100$  km/a. However, smaller or larger values would also be consistent with observations"

Why do you choose this value? Is the model calibrated against observation with this value? Please clarify what's consistent with observations. Have you done the sensitivity tests with  $u_{ex}$  values?

P16L15: "4.1.2 Melange build-up can stop MICI under winter conditions"

The title of this section could be misleading since the results show that mélangé can stop MICI only if the winter condition ( $u_{ex}=0$ ) lasts for several years, which is unlikely in real climate conditions.

P18L6: "This seasonality can be modelled with a time-dependent ..."

Does this experiment include melting/freezing of mélange? How are the results affected with melting/freezing of mélange?

P18L26: "The mélange parameterization assumes a constant calving rate..."

Do you mean "the upper bound on calving rates ( $C_{max}$ )?"

P20L2: "The processes by which ice shelves fracture... in an ice sheet model"

Add references.

P22L14: "...but it could provide enough buttressing to enable ice shelf regrowth, which would then stop further MICI progress."

Is the ice shelf regrowth shown in model results or just from observations of Jakobshavn glacier?

Figure 4a: How is "calving discharge" calculated? Is this "(calving rate) x (area)" or ice discharge, that is "(velocity) X (area)"? If "calving discharge" is (calving rate) x (area), how is that calculated from the floatkill experiment which does not have calving? If calving discharge is ice discharge, the term "calving discharge" could be confusing.

Figure 4b: The calving amplification value for  $C_{\max}$  20 km/a experiment seems larger than 6 but it's cut off. Please consider including the full extent if possible. Also, I am wondering why it suddenly increases toward the end of the simulation. From Figure 4a, the overall calving discharge for  $C_{\max}$  20 km/a looks highest near  $t=60a$  and decreases towards the end of the simulation.

Figure 5: Why do authors prohibit calving for the shaded area? Is it because of the bed topography  $>0$  for that area? Include 0 m contour of bed topography since it's hard to see in the grey scale.