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The Cryosphere Discussions

# *Interactive comment on* "Sensitivity of centennial mass loss projections of the Amundsen basin to the friction law" *by* Julien Brondex et al.

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The paper entitled "Sensitivity of centennial mass loss projections of the Amundsen basin to the friction law" by Julien Brondex, Fabien Gillet-Chaulet, and Olivier Gagliardini investigates the effect of 3 different basal friction laws (using different parameters) on projections of the Amundsen sea embayment over the next hundred years. The authors conducted a similar study last year but based on idealized geometry. They concluded that the evolution of the grounding line and volume above floatation over a 100-year simulation varies significantly depending on the choice of friction law used (Weertman, Budd or Schoof). Here, the authors conduct a similar investigation but applied to a real system, and extending this analysis to the Amundsen sea sector proved to be more difficult than with an idealized setting. It is shown that, for similar initial



states, the Weertman friction law systematically predicts less mass loss than any other law. The Budd friction law, on the other hand, induces more grounding line retreat and mass loss than the Schoof sliding law. The authors do not make recommendation on what friction law to use but put the finger on an important problem: ice sheet projections are strongly dependent on the choice of basal friction law and more research is necessary to better constrain basal friction.

## 1 General Comments

This is a very important topic that has not received a lot of attention so far. The paper is well written and easy to follow. I don't have any major comment but a few suggestions outlined below.

First, three friction laws are used:

- Linear Weertman ($m = 1$)
- Nonlinear Weertman ($m = 1/3$)
- Nonlinear Budd ($m = 1/3$)
- Nonlinear Schoof ($m = 1/3$ and $C_{max} = 0.4$)
- Nonlinear Schoof ($m = 1/3$ and $C_{max} = 0.6$)

I understand that the authors cannot run every possible combination, but it would be great if they could include the friction laws that are commonly used in the ice sheet modeling community. The linear Budd law ($m = 1$), for example, is extensively used by multiple groups (ISSM, UW, etc), much more than the nonlinear Budd law. It would be great to see how it compares with respect to other laws. These experiments could also

be useful for intercomparison projects such as ISMIP6 in order to better understand the differences in model projections, but this would only be possible if common laws are tested.

Also, why is the Budd sliding law only tested with one of the inferred initial states? Is it a problem of computational resources? It feels like the analysis is incomplete.

## 2 Specific comments

Lots of comma missing before “which” and “where”.

- p1 l3: to a schematic perturbation → to a prescribed perturbation
- p1 l11: much higher → significantly higher
- p1 l21: trustworthy → reliable
- p1 l21: modelling of GL dynamics ...
- p1 l22: as close as possible to observations.
- p2 l1: have come up → have been developed
- p2 l7: have shown that, at large strain, the till ...
- p2 l13: behaves very similarly → behave similarly
- p2 l27: schematic perturbation → prescribed perturbation
- p2 l28: consider removing “To reach our goal,”
- p2 l33: we apply a synthetic perturbation to the basal melting rate under floating ice, to the different...



- p3 Figure 1: label Cosgrove ice shelf on the figure (in green)
- p3 eq 1: double check but given your definition of $\tau_b$, the sign in front of $\tau_{b,x}$ and $\tau_{b,y}$ should be $+$.
- p3 eq 2: Did you forget to divide the integral by the ice thickness $H$?
- p5 l6: I think $a_s$ should be defined as the surface mass balance instead of just the accumulation rate (it may be negative in some places). That’s how it is defined in p6 l9
- p6 l12: these two pinning points ... to be critical because of the ...
- p6 l27: being submitted → undergoing
- p7 l18: impurity content
- p7 l18: the question is whether
- p9 l22: initializing the friction based on driving stress was first proposed by Morlighem et al. 2013 :)
- p10 l11: the coefficient of other laws, which ...
- p10 l30: all over the model domain
- p11 l14: rephrase “are submitted to”, maybe “the 13 initial states are then run for 105 years under two different scenarios: (1) ...”
- p13 l17 seldom exceeds 10 % → rarely exceeds 10% (no space between before a percentage sign)
- p13 l24 significative → significant

- p13 l32: focus on → focuses on
- p14 l11: Independently → Irrespective
- p14 l16: all over the 105 a → over the entire 105 a
- p15 l32: as going further → as we go further
- p17 l10: the lower ... the higher
- p17 l18: an increase in ice velocities
- p17 l23: as going further → as we go further
- p17 l32: as Thwaites glacier is *mostly* unconfined
- p17 l35: a MISI likely *initiates*
- p19 l4: The perturbation experiments
- p19 l16: You have not really shown that a subglacial hydrology model is needed here, maybe rephrase the sentence
- p17 figure 8: increase the width of the grounding lines

## 3 References

M. Morlighem, H. Seroussi, E. Larour and E. Rignot, Inversion of basal friction in Antarctica using exact and incomplete adjoints of a higher-order model, Journal of Geophysical Research: Earth Surface 118 (2013) 1746–1753

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