The Cryosphere Discussions

The Cryosphere Discuss., referee comment RC1
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Comment on tc-2022-141

Anonymous Referee #1

Referee comment on "Timescales of outlet-glacier flow with negligible basal friction: theory, observations and modeling" by Johannes Feldmann and Anders Levermann, The Cryosphere Discuss., https://doi.org/10.5194/tc-2022-141-RC1, 2022

Review of Timescales of outlet-glacier flow with negligible basal friction: Theory, observations and modeling.

This paper uses the similarity principle applied to the SSA neglecting the basal friction with the goal to infer the time scale of marine ice stream retreats in Greenland and Antarctica. The paper considers idealized setup along with specifically chosen glaciers for Greenland and Antarctica and shows relatively good agreements with the theory.

I found the paper really well written and organized. I would like to thank the authors to have spent the time on both aspects. I enjoyed reading this manuscript. While working with 3-D complex models is becoming more of a norm, it is refreshing to see that simple mathematical arguments (derived from equations used in the 3-D models) remain useful to understand or give a sense on dynamical principals. While the manuscript is very mathematically driven, the authors carefully left the details in the appendix while leaving the basic understandings of the method in the main text. Doing so results in a relatively short manuscript with little dilution from the mathematical details and well suited for a quick read.

I would fully support the publication of this publication after minor revision. Main and minor comments are following.

Main Comments

- In comparing your similarity principle to Greenland glaciers, you set aside a couple of the glaciers and argued that physical properties of the glaciers break the similarity assumption. Did you check that it was simply the case that these glaciers behaved with respect to a similarity principal for which the main balance in the momentum equation is between the basal friction and the driving stress?

- Since you choose to neglect the basal friction term in your similarity discretization, why did you choose a Weertman-type sliding law as opposed to a Coulomb-derived sliding law (Schoof (2005), Leguy et al. (2014), Tsai et al. (2015)) in your idealized setup? A Coulomb sliding law has the advantage to go to zero at the groundline line by design. Please discuss this point in your manuscript.

- How can you compare your Antarctic theoretical computation with actual retreat rates? Could you compare them using the data from Rignot et al. 2019? You have found an elegant way in obtaining a retreat rate with a simple method, it would be super useful to show that the order of magnitude matches current observation in a way.

- While I understand that textbooks are a rich resource of information, using them for citations should be a last resort and when doing so, please mention the chapter and section or page number (Cuffey and Paterson 2010) is a rather large volume! You have used book references very often while papers would have been more appropriate. I will try to address a few of them bellow.

Figures

Figure 1, panel C: Please describe the meaning of each color shade. Also, are you using different values of A in order to obtain each profile starting from the most advanced profile? (I thought this was not very clear in the text or caption.)

Figure 4, panel B: I don't understand what the ice softness indication "A" is doing on the figure. Please clarify or remove it.

Figure 7: please give a reference value for the blue and red semi-circle for your reference glacier (PIG).

Minor comments:

Page 4, line 93: replace the citation “Greeve and Blatter, 2009” by Glen (1955).

Page 4, line107: The citations to reference the “Observations and laboratory studies” are wrong. Schoof 2007 and Haseloff 2015 use the value in their modeling effort. Instead, cite Duval (2013). Also, *n* cannot be observed directly as it is a parameter in a law which best fit data. Instead, I would replace “Observations and laboratory studies” by simply “Laboratory studies”.

Page 4 line 114: see remark above regarding Cuffey and Paterson.

Page 5 line 120: you can also cite Leguy (2015, chapter 7.1.5) who derived a relation for buttressing that is inversely proportional to the width of the bed. (Note that I do not expect people to read the dissertation of an author, I just happen to know his work having collaborated with him.)

Page 6, line 167: what did you modify in the MISMIP+ setup. Please add the relation you use in your bed topography derivation (in the appendix).

Page 8, line 216: Please remove the part of the sentence “might have been destabilized by recent oceanic warming.” It is highly speculative hence unnecessary here unless you can support the claim.

Page 10, line 278-279: for the reason you mention here, why not running the model using a Coulomb friction law?

Page 10, line 279: Replace the citation by (Schoof (2005), Martin et al. (2011), Leguy et al. (2014))

Page 11-12, *code and data availability*: The code, data and simulation setup should be available prior to the publication of the manuscript. Make sure that it is the case and replace the wording “will be” by “is”. At this point I could access your data.

Page 12, line 358: citation, see remark above.

Page 12, line 365: I don’t see the necessity in introducing the scalings Sx and Sy. Why not directly using L and W?

Page 12, line 366: Please, introduce the scaling x*=x/L and y*=y/W for clarity.

Page 13, line 381: Please define the O symbol as the Landau notation for non-mathematicians. And technically speaking, the leading order in Eq.(A3) is O(1/R) (if we account for the square root).

Page 14, line 399: citations, replace with Glen (1955) and Duval (2013).

Page 14, line 412: You argue that the velocity shape of the Rink Isbrae glacier near the terminus is ground to discard this glacier from your analysis. Why then keep Upernavik Isstrom N which exhibit a similar pattern?

Page 15, line 442: Please give the uniform rate of SMB you used in your simulations.

Page 15, line 444: replace citation with Glen (1955)

Page 15, line 449: Add chapter to citation.

References:

Rignot, E., Mouginot, J., Scheuchl, B., Van Den Broeke, M., Van Wessem, M. J., & Morlighem, M. (2019). Four decades of Antarctic Ice Sheet mass balance from 1979–2017. *Proceedings of the National Academy of Sciences*, *116*(4), 1095-1103.

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Leguy, Gunter. *The effect of a basal-friction parameterization on grounding-line dynamics in ice-sheet models*. New Mexico Institute of Mining and Technology, 2015.

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Martin, M. A., Winkelmann, R., Haseloff, M., Albrecht, T., Bueler, E., Khroulev, C., and Levermann, A.: The Potsdam Parallel Ice Sheet Model (PISM-PIK) – Part 2: Dynamic equilibrium simulation of the Antarctic ice sheet, The Cryosphere, 5, 727–740, doi:10.5194/tc-5-727-2011, 2011. 6

Leguy, G. R., Asay-Davis, X. S., & Lipscomb, W. H. (2014). Parameterization of basal friction near grounding lines in a one-dimensional ice sheet model. T*he Cryosphere*, *8*(4), 1239-1259.

Tsai, V. C., Stewart, A. L., Thompson, A. F.: Marine ice-sheet profiles and stability under Coulomb basal conditions, J. Glaciol., 61, 205–215, doi:10.3189/2015joG14j221, 2015. 28, 76, 77