

The Cryosphere Discuss., referee comment RC2  
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## Comment on tc-2022-114

Lizz Ultee (Referee)

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Referee comment on "Observed mechanism for sustained glacier retreat and acceleration in response to ocean warming around Greenland" by Evan Carnahan et al., The Cryosphere Discuss., <https://doi.org/10.5194/tc-2022-114-RC2>, 2022

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### General comments

Carnahan, Catania & Bartholomaeus present a stress-balance analysis of three neighboring outlet glaciers in Greenland: Ingia Isbrae, Umiamako Isbrae, and Rink Isbrae. Despite their proximity, the three outlets showed a variety of retreat histories in recent decades, making them a useful site for comparative analysis. The study is interesting and relevant, certainly worth publishing in *The Cryosphere*. In some places, I suggest revising to make the text more precise. The discussion should also be strengthened, especially with regard to the Greenland-wide implications of the work. Finally, I suggest the authors take another editing pass through the text to simplify the language.

### Specific comments

- L58: would it be accurate to say simply "no secular trend emerges from seasonal fluctuations"?
- L62-65: Please revise here to describe why the force balance method is suitable for your study. Stating which studies have used it before does not provide your scientific motivation for using it here.
- L84: I would not cite the Minchew et al. 2019 comment as evidence of "uncertainty" in the basal sliding relation. Minchew et al. 2019 do not advocate for or provide evidence supporting any sliding relation different from the one tested by Stearns and van der Veen 2018. If the authors wish to highlight the longstanding debate about an appropriate form of the sliding relation, I suggest older (classic) references: Kamb 1970; Budd et al 1979; Weertman 1957, 1964, 1972; Lliboutry 1968, 1975, 1979; Nye 1969, 1970, etc. No need to cite them all, of course, but to me the longstanding and

ongoing debate is more compelling than the “present uncertainty”.

- L129-130: Please describe how you calculated the stress coupling length, for readers who are not familiar with it.
- L137: “Average absolute changes in inferred basal drag...” - What does this average mean? Is it the average of per-point change from one time step to the next, at each point along the flowline? Or is it averaged in some other way?
- L142-143: “...implies that in the absence of terminus retreat glacier dynamics are largely invariant” can you be more specific? Invariant in what way? Which observable variables would you expect not to change, and over which time scales?
- L154-155: “The climate system can also force retreat through processes at the ice-ocean boundary (Motyka et al., 2011).” Is the backstress example (3) from Nick et al. 2009 in the preceding sentence not an example of forcing at the ice-ocean boundary? Please clarify wording in these sentences.
- L202-203: would it be more accurate to say “Ingia experienced an acceleration in ice flow velocity and associated two-fold temporal increase in lateral drag”?
- L234-236: “If these observations are representative of the ice sheet as a whole...” is a big assumption. Greenland has more than 200 outlet glaciers, and they are quite heterogeneous in terms of geometry, surface climate, ocean access, etc.—and I don’t mean to lecture the authors on this, as I know they have published papers on the heterogeneity of Greenland outlet glaciers. Anyway, I suggest toning down this generalization, or else including several more sentences of interpretation.
- L239: can you specify \*what\* about the fjord geometry permits low basal drag extending inland?
- L261-262: please look for a few more references to support the claim that low basal drag conditions “are not restricted to these well-studied glaciers, but occur around Greenland”. Shapero et al (2016) considers only the three outlet glaciers that I would argue are the most well-studied: Kangerlussuaq, Helheim, and Sermeq Kujalleq. That is not sufficient support for the more general statement that follows in L262-264. It would be very interesting to know how generalizable your findings are to other outlets, but we need evidence from more outlets than the “Big Three” for that generalization.
- Abstract lines 9-11: This claim is related to the manuscript, but not supported by the evidence you present. See above. Please remove, rephrase, or provide more evidence in the main text.
- I was surprised not to see any discussion of this manuscript’s findings in context with those of Felikson et al. (2017, 2021), especially given the overlap in authorship. It would be helpful to me as a reader if the authors would discuss those works.

## Technical corrections

- L24-25: “heterogeneous changes in elevation (Csatho et al., 2014; Felikson et al., 2017) and velocity (Moon et al., 2020).”
- L25: “This means...” - what is “this”?
- L37: “circumnavigate elevation data scarcity” —> “circumvent scarce elevation data”
- L61 replace parenthetical citation with in-text citation
- L78-80: “Such observations...(Shapero et al 2016)” — I suggest removing this sentence. I want to know more about what you did, not necessarily what others have done before.

- L84: "Zoet and Science, 2020" → "Zoet and Iverson, 2020"
- L103: "two additional data products are necessary..." should have a colon rather than a comma
- L116: "model's" missing apostrophe
- L138: why not reference the relevant figure directly after mentioning each glacier? That is, "16 kPa for Rink (Fig. 4); 25 kPa for Umiyamako (Fig. 3); and 11 kPa for Ingia (Fig. 2)"
- L147: "buoyant"-> "buoyancy"
- L150: remove semicolon
- Sections 3.2-3.4: check verb tenses. "We observe" in the present tense makes sense to me, but in describing the results you use both past and present tense. For example, "Umiyamako experiences...driving stress substantially increased" appear together in one sentence.
- L184: consider "not only lateral drag" rather than "just"
- L244: "maxima" is plural. Try "A maximum...is" or "Maxima...are".
- L250: colon rather than comma when starting the list of glaciers with observed or modeled stress fields
- L251-254: please use the official name of Greenland's largest outlet: Sermeq Kujalleq. For clarity, you might consider "Sermeq Kujalleq (also called Jakobshavn Isbrae)" or similar. See Bjørk, Kruse & Michaelsen (2015).
- L269: "dictates"-> "determines"
- Figure 1: Please annotate a bit more and/or include more description in the caption. For example, what do the green and white regions indicate on each plot? Can you include arrows to show the direction of ice flow on one of the plots? I suggest glossing the abbreviations you use (e.g. "Ingia (Ing)") in the caption, even if you think they are obvious.

## References in this review

Felikson, D., Bartholomaus, T., Catania, G. *et al.* Inland thinning on the Greenland ice sheet controlled by outlet glacier geometry. *Nature Geosci* **10**, 366–369 (2017). <https://doi.org/10.1038/ngeo2934>

Felikson, D., Catania, G. A., Bartholomaus, T. C., Morlighem, M., & Noël, B. P. Y. (2021). Steep glacier bed knickpoints mitigate inland thinning in Greenland. *Geophysical Research Letters*, 48, e2020GL090112. <https://doi.org/10.1029/2020GL090112>

Bjørk, A. A., Kruse, L. M., and Michaelsen, P. B.: Brief communication: Getting Greenland's glaciers right – a new data set of all official Greenlandic glacier names, *The Cryosphere*, 9, 2215–2218, <https://doi.org/10.5194/tc-9-2215-2015>, 2015.