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The Cryosphere Discussions

Interactive comment on "Basal traction mainly dictated by hard-bed physics over grounded regions of Greenland" *by* Nathan Maier et al.

Anonymous Referee #2

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This is a well-written manuscript that reflects a lot of hard work by the authors. It sets up an interesting and thoughtful experiment, assessing basal traction with three different model hierarchies.

Main Concerns: - A large basis of the conclusion relies on the relationships in the scatter plots in Figure 4. These are on a log-log scale and even then the scatter is so great that I am skeptical any credible conclusion can be drawn from these graphs. Binning the velocities and taking the median, especially in log-log space looks better, but does seem kind of sneaky. I am particularly nervous about the unequal distribution of velocities, since fewer data points exist in the faster flowing regions in making the bins. So, while 'fitting the binned data gives equal weights to fast flowing and slow-flowing regions of each catchment" (line 247), many of the faster flowing bins only

have a handful of data points, so the fit is biased by the slower regions.

I am sympathetic that these 'tricks' are needed in order to get the clean-looking relationships that are distilled in Figure 5. However, Figure 4 really highlights the incredible complexity of this relationship that gets glossed over in the subsequent discussion and conclusions. Instead, every kink in the fitted curve is analyzed in great detail. Figure 8, which shows a map of strong vs weak bed grid cells, takes this (in my opinion) messy relationship and derives some binary conclusions about the preponderance of hard-bedded rheology. At 6 km data points, then binned to derive the traction-velocity relationship, the impact of the fastest flowing regions is muted.

- The assumption (section 2.2.1) that basal drag can be approximated by the driving stress works for the interior but really falls apart near the margins. As a result, I think the limit of this analysis precludes a lot of the faster flowing regions. Given that shortcoming, the overall conclusions are weaker.

- While it is done frequently, it is incredibly circular to prescribe a sliding relation to estimate basal drag and then use the calculated basal drag to show a correlation with velocity (section 2.2.2 and 2.2.3). The whole justification for this is described in line 137: While a linear sliding law is used for the inversion, the traction field is shown to have little sensitivity to the choice of sliding law (Joughin et al., 2004)." This paper uses the control method exclusively for the Ross Ice Streams (no basal drag and high velocity), which is opposite to how it's being used here.

Other comments:

Line 10: "three different methods" but with the same assumptions and workflow. It would be clearer to say models with three different levels of complexity. This comes up again in line 83ish. Having three models that are based on the same assumptions converge does not necessarily yield confidence in the velocity-traction relationship – just highlights where the complexity is unimportant.

Line 46: “bypassing” is too strong a word. We have some models that can be used to infer basal processes, but they are really far from capturing details from localized observations at the ice bed interface.

Line 76: How can rheology have impacted the findings of Stearns and van der Veen? This is a fairly bold statement; if you keep it in it needs justification. I think it’s ok to say it’s still under debate and leave it there.

Line 254: What is meant by “visually well defined” and “show good agreement with the model fit at both high and low velocities”. I thought the model was fit to these binned points.

Line 255: High R2 (.22 -.99)? It’s more representative to specify where it’s high and where it isn’t - especially since it’s closer to .99 in most places. Also specify what the R2 value refers to (binned or raw data).

Figure 5: Add labels of catchment to each subplot for color-blind folks. Is the grey line the cdf of the binned velocity data or the input data? I’m guessing the latter, which is misleading because the velocity-traction curves are based on the binned data. Don’t these graphs also show that the models diverge at fast flow (I didn’t like framing the models this way at the start, but since you did it tshould be revisited).

Figure 8: Doesn’t the fact that strong and weak beds exist roughly equally in slow and fast flow regions show that bed strength is not related to velocity? If so, then a sliding relation that equates the two falls apart.

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