Author's response to Referee Comments

November 7, 2025

1 Author's response to the Editors Comment

[Thanks very much for your resubmission to The Cryosphere. As you'll see in reviews, Report #2 highlights a remaining issue with your estimation of prior probability for the Schoof C_max parameter – although the reviewer also notes that the overall message in the paper would be unchanged, even if it may impact the ranking of friction laws. I therefore wonder if a compromise could be reached here: is there any scope to at least consider the impact of a higher C_max parameter, as per the reviewer's suggestion? I'm not suggesting that models are run or revised in their entirety, but instead that a few lines of text are included to consider the impact of a different parameterisation.]
We thank the editor for their comment. We have revised the manuscript as outlined below; however, for the reasons discussed, we prefer to retain our original prior for the results presented in the main manuscript.

2 Author's response to Anonymous Referee 2 Comment 2

We thank the referee for their constructive comment. Our reply is reported below, with the referee comment in orange, our reply in black, and the revisions in light blue.

[However, there is still one important point on which I disagree. Since the mathematical formulations of the Schoof and Zoet-Iverson laws are similar, the ranking of these two laws is largely influenced by the choice of prior PDF for the model parameters. One could argue that this is justified because the parameters are associated with different physics and could thus have different priors, with which I agree. What I disagree with, is how the prior for C_max in the Schoof law is chosen based on irrelevant observations. Using different priors for μ and C_max favors the Zoet-Iverson law for an unjustified reason, in my opinion. This is evident in Figure S25, where the absence of a prior puts Coulomb and Schoof on a better score than Zoet-Iverson.]

[The claimed value of C_max = 0.2, as a maximum prior, is based on observations of bed topography that are not of a sufficiently high resolution to determine C_max. Furthermore, in three-dimensional geometries with a complete roughness spectrum, it is unclear how to relate bed slope and C_max because the relevant scale controlling friction is not known a priori and even associating a slope distribution with C_max is not straightforward. The authors answer that the one kilometer scale is relevant because of similar resolution of their independence data makes no sense to me. Even if the average friction at the kilometer scale is targeted, C_max can sill be controlled by smaller scale roughness and must be determined differently. An observational study such as that by Gimbert et al. (2019) suggests C_max = 0.4, which seems to me to be a more reliable estimation, even though it comes from a different glacier.]

[For all the above reasons and for a fair comparison between the different laws, I would suggest not providing any prior on μ and C_max. These parameters are simply not constrained well enough by external data to be associated with a prior PDF.]
We agree with the referee that it is not straightforward how to relate the bed slope and $C_{\max}$ given the

different scales in bed roughness. However, we want to emphasise that our $C_{\max}$ prior does consider high-resolution observations from autonomous underwater vehicles (AUVs; horizontal resolutions of 1.5 m and 2 m). We also agree with the referee that the resolution of our model inversion is not really relevant here and have updated the description of the $C_{\max}$ prior in the manuscript as follows: Due to the range of spatial scales in bed roughness that can affect basal drag, estimating $C_{\max}$ from observations of bed topography is not straightforward. We therefore base our $C_{\max}$ prior (Fig. 3d) on a combination of coarse-resolution bed topography beneath PIG retrieved from Bedmap2 data (Fig. S7 and S8; Fretwell et al., 2013), as well as high-resolution autonomous underwater vehicle (AUV) data collected downstream of Thwaites Glacier (1.5 m; Graham et al., 2022) and under the Thwaites Eastern Ice Shelf (2 m; Wåhlin, unpublished data; Fig. S9 and S10). Although shear resistance is most likely built at spatial scales smaller than the resolution of Bedmap2, these data provide a conservative lower bound on $C_{\max}$ (Sec. S6.2).

Similarly, Sec. S6.2 in the supplement was updated to The distribution of the up-slope angles of the bed in flow direction (β) and the corresponding Iken's bound ($C_{\max} = \tan\beta$; Fig. S7) is examined for the center part of Pine Island Glacier (PIG; magenta box in Fig. S8). As the horizontal grid resolution of Bedmap2 is 1 km (Fretwell et al., 2013), the maximum up-slope angle (and therefore $C_{\max}$) on smaller scales might be significantly steeper than suggested by the distribution in Fig. S7. For example, autonomous underwater vehicle (AUV) data collected downstream of Thwaites Glacier (1.5 m horizontal resolution; Graham et al., 2022) and under the Thwaites Eastern Ice Shelf (2 m horizontal resolution; Wåhlin, unpublished data) indicate that the maximum $C_{\max} > 0.7$ (largest value tested within this study; Fig. S9). As the bed roughness and therefore the actual relevant scale are unknown and likely vary spatially, the chosen $C_{\max}$ prior incorporates the coarse resolution Bedmap2 data as a conservative lower bound and accounts for the higher bed angles observed at smaller scales through a more gradual decline towards higher values.

Furthermore, we updated the discussion on the effect of prior distributions. It now states Even when using log-uniform prior distributions for scaling coefficients and uniform priors for other parameters – thus making no use of the Bedmap2 or AUV data to constrain the $C_{\max}$ prior – the sliding laws incorporating a Coulomb friction term still yield the highest probabilities, with the Coulomb and Schoof sliding law showing the greatest increase (26.3 % for both; Fig. S25).

Since our $C_{\max}$ prior assigns a relatively high probability to the $C_{\max} = 0.4$ suggested by Gimbert et al. (2021) and we show the results for (log-)uniform priors in the supplement, we refrain from adjusting the $C_{\max}$ prior used for the results presented in the main manuscript (as suggested by the referee). Prior distributions are inevitably somewhat subjective, and different authors are likely to adopt distinct priors depending on the prior information available to them. Furthermore, adjusting the prior distribution after conducting the experiments, analysing the results, and receiving reviewer feedback would no longer represent a true prior in the Bayesian sense, as it would inevitably be informed by the results rather than remain independent of it.

References

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