Review of *'Uncertainties in forecast surface mass balance outweigh uncertainties in basal sliding descriptions for 21st Century mass loss from three major Greenland outlet glaciers.'*
By Carr et al., 2023

Summary

This modeling study investigates the relative impact of a combination of four sliding laws and 12 future surface mass balance scenarios on mass loss from three major Greenland outlet glaciers through 2100. The four sliding laws are selected to include a variety of common modeling applications — these include sliding laws that prescribe the relationship between basal drag and sliding (Weertman and Budd), one where basal drag is directly prescribed (Tsai, in the manuscript), and a combination of the two (Cornford). The three glacier experiments are initialized with the same input data and model parameters. The authors find that the choice of SMB scenario imparts far greater variability on projected mass loss than choice of sliding law for all three study glaciers. By contrast, the SMB scenario used had minimal impact on the magnitude of grounding line retreat, which occurred for all three glaciers in the study. The authors note similar behavior from the two northern outlets, Petermann and Humboldt, with greatest mass losses projected using the Budd sliding law. Interestingly, Kangerdlugssuaq (SE Greenland) exhibited, on average, the smallest net mass losses, which were greatest when implementing the Weertman sliding law and an RCP 2.6 SMB scenario. In addition to suggesting a relatively minimized impact of sliding law choice compared to future SMB scenario, study results also emphasize the likely future importance of Humboldt for Greenland wide mass loss, as this catchment showed the highest SLR contribution of nearly 8mm, without considering additional mass losses from elevation feedbacks or dynamic thinning and terminus change.

This manuscript is clearly written and presents important glaciological work, as the impact of sliding choice is quite understudied for Greenland outlet glaciers. The results will add value to the community and add insight to the relative importance of remaining unknowns to future mass loss scenarios. The methods are overall sound and well justified, and clearly described in the main text and supplement. With minor revisions, this manuscript will be suitable for publication in TC. Some figures may be condensed or combined if manuscript length is of concern. I have included my main comments and requests for clarification first, followed by a few minor comments and edits.

Comments and requests for clarification

I understand the motivation for holding terminus fronts static and neglecting elevation/dynamic thinning feedbacks for these experiments, given the focus on SMB+sliding law and high computational load. However, I wonder how these exclusions impact the interpretation of grounding line retreat, given that HU and KG, assumed to terminate at the grounding line (no or negligible floating extensions), both show retreated grounding lines while holding initial 2015 fronts stationary. Wouldn't this create an artificial floating ice tongue by the end of the simulations?

In the discussion, reduced SLR projections stemming from the Budd sliding law at KG s attributed to enhanced sensitivity to changing ice thickness. This is suggested to indicate that the use of the Budd sliding law results in unrealistic SLR projections. Given the sensitivity to effective pressures and related basal shear stress in implementing Budd sliding law, does it not also seem reasonable that for KG, where some SMB scenarios resulting in net thickening (SMB gains), this would then manifest in reduced mass losses in Budd sliding law relative to the other sliding laws?

I may have missed this reference in the text, but what is the cause of NaN values for several Weertman SMB runs for Humboldt Glacier (see Figure 3)?

Line 170
"Annual surface mass balance (SMB) was used to initialise the transient runs and was sourced from RACMO v2.3 (Noël et al., 2016). We used the average SMB for the years 2013-2017…"

Can you please explain the use of RACMO for initialization, but use of MAR for downscaling CMIP5 and CMIP6 for the SMB scenarios?

Line 214
"We subtracted the misfit between modelled and observed rates of thickness change (˙h), determined from Cryosat-2 two-year mean data for 2014-2015 (Simonsen and Sørensen, 2017)…"

Does this indicate that the misfit was computed only at a single time step (here the 2 year mean thickness change during 2014-2015)? Or that this 2-year period serves as a reference elevation for deriving thickness changes? If the latter, can you clarify the period over which dh/dt relative to the reference period were computed? 2010-2015?

Line 252 through 255
Figure references indicate 3b showing Pg results, and Figure 3c showing results from KG. I believe these need to be swapped.

On BedMachine v3
Why do the authors elect to use BedMachine version 3 over a newer version? Is the topography similar at the three study catchments for version 3 and the newer version of BedMachine?

Line 296
Please double-check to ensure figure references and subplot references correspond to the correct glacier.

Suggestions for Figures 6—8
Consider using a combination of solid, dotted, and dashed lines for figures that are stacked in a way that all curves appear in the figure. As shown, only W-N0 and rCW-N0 are readable in many subplots, and it is unclear which of these scenarios are overlapping the other two.

<u>Minor Comments</u>

Consider adding labels to subplots in Figure 3 if they are referenced by alphabetic notation in the text ("Figure 3c" for example).

Table 1 – Consider adding in paratheses what percentage of mean basin velocity is represented by the misfit value.

Figure 4 – consider an alternate color ramp or alternating line styles and thicknesses. The yellow and light green colors are challenging to see and discern from one another in the figures.