**Reviewer 2**

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? In response to the question about the calving fronts, we prescribe a natural boundary condition and do not include calving: as the reviewer notes this is to separate out the impacts of SMB and sliding law and for computational efficiency. As noted by the reviewer, this does create a small floating section, but this section was always small and comparable to the width of HU / KG. In future work, we plan to quantify the relative impact of calving, implemented via a range of different laws. As noted by the reviewer, the Budd sliding law results in reduced mass losses compared to other sliding laws at KG. We note that the application of Budd sliding law, as used here and in several similar studies in that past, is somewhat questionable as it depends on the effective pressure changes throughout the whole computational domain, and not just in the vicinity of the grounding line. Despite our own reservations about this sliding law, we have nevertheless included it as it is a widely known sliding law and has been used in numerous studies in the past.

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)? There are 3 runs with NaN, which we realised just prior to submissions we needed to re-run. We will include these values in the updated version.

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? We used RACMO for the initialisation as we believed it was marginally better at representing contemporary Greenland surface mass balance and initially, we were only going to test the impact of sliding laws, not SMB forecasts, so there would have been no inconsistency. The downscaling of the CMIP5 and CMIP6 scenarios with MAR was done as part of another study (Hofer et al., 2020), and, importantly, was done for 13 different scenarios, which enabled us to test the impact of that range of SMB scenarios. Through the inversion and initialisation process, we ensured that our initial model state closely matched observed ice velocities and surface elevation change, so that we were confident our initial model set up matched well with observations at the start of the forward runs (i.e. 2015). Thus, any difference in initial model state due to the choice of SMB product is unlikely to have impacted our results and would be very much smaller than the differences we observed between the various SMB forecasts.

Line 214 “We subtracted the misfit between modelled and observed rates of thickness change ($\dot{h}$), 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? Yes, this is correct that we use a single timestamp of thickness change: the 2-year mean thickness change during 2014-2015 serves as a reference. However, the misfit between modelled and these observed rates of thickness change is calculated iteratively at every run step for a period of 5 years, nominally between 2010 and 2015. We will update the text to make this clearer to the reader.

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. Apologies, we will update this.

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? We selected BedMachine v3 because BedMachine 4 was not available at the time when we conducted the model runs. The topography for the study glaciers is similar between the versions and it would take months to re-run the experiments for BedMachine4, so this is unfortunately beyond the scope of this paper. In future work, it would be very interesting to assess the impact of different bed products and/or different versions of the bed. However, we are confident that the swap to BedMachine v4 alone is unlikely to result in major differences in our results.

Line 296 Please double-check to ensure figure references and subplot references correspond to the correct glacier. We will double check this in the revised manuscript.

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. We will change the line format for these figures, but the key message from these figures is actually that most of the lines do overlap, i.e. that sliding law makes little difference to the sea level rise contribution.

Minor Comments

Consider adding labels to subplots in Figure 3 if they are referenced by alphabetic notation in the text (“Figure 3c” for example). We will add these as requested.

Table 1 – Consider adding in paratheses what percentage of mean basin velocity is represented by the misfit value. We will add these as requested.

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. We will review the line styles and colours in this figure.