Second Review of “Sensitivity of the Ross Ice Shelf to environmental and glaciological controls”, by Baldacchino et al.

Major Comment

In the first round of reviews for this manuscript, I expressed a concern about the use of a linear sliding law, and I suggested that the authors needed to perform additional analysis to demonstrate that their results are robust to the choice of sliding law prior to publication. The authors responded to my concern by repeating their experiment with a Weertman sliding law in addition to the Budd law that they originally used. I appreciate the effort that the authors have gone through to run an additional set of sensitivity experiments, which is more than the extra analysis that I requested originally. However, the new experiment doesn’t actually address my concern.

My concern was specifically with respect to the nonlinearity of the sliding law. That is, I was concerned that they were using a value of the sliding exponent of m=1. Perhaps I was not clear enough in my original review. If that is the case, I apologize. Thus, I would like to emphasize here what exactly I was concerned about.

In their original experiment, the authors used a Budd sliding law, which has the following form:

$$\tau_b = C_b N v_b^{1/m} \qquad \text{eq. 1}$$

where τ_b represents the basal shear stress, C_b represents the drag coefficient, N represents effective pressure, v_b represents the basal shear stress, and m represents the slip exponent. A Weertman law is identical to a Budd law except that it omits any dependence on effective pressure, like so:

$$\tau_b = C_b v_b^{1/m} \quad . \qquad \text{eq. 2}$$

However, the Budd law and the Weertman law are identical in the sense that they both contain a power-law relationship between basal drag and basal sliding velocity. In the authors’ original experiment, they set m=1, creating a linear relationship between slip and drag. However, there is a large body of work, including observational evidence, theoretical derivations, and numerical modeling results, indicating that a linear relationship between slip and drag is unrealistic. I cited a few papers making this case in my original review.

Thus, replacing the Budd law with a Weertman law does not, in itself, address my concern. My concern was that, in their original paper, the authors used a value of m=1 for the exponent in their sliding law, in contradiction to well-founded work which indicates that the relationship between slip velocity and shear stress ought to be highly nonlinear. Replacing a linear Budd law with a linear Weertman law does nothing to address this concern. What I wanted was some exploration of whether their results and interpretation would be robust if the linear sliding law they used was replaced with a nonlinear one.

To be fair, the authors do not state what value of the slip exponent they used for their Weertman experiment. The units of subplot (a) in figure A3 imply that they used a value of m=3, which would satisfy my concern as it means that they have tried a value of the exponent other than 1. If that is in fact the case, then all the authors need to do is to explicitly state what value of the slip exponent they used in the Weertman law, and my concern would be satisfied.

However, I cannot be sure what value of the slip exponent the authors have used simply from the units in the plot label, as the units could be mislabeled (as I mention in a minor comment below, the units are also mislabeled in other subplots of that figure). If, however, the authors have used a linear Weertman sliding law, then I must reluctantly insist that they have **not** addressed my major concern from the first round of review. When I expressed concern about the sensitivity of their results to the choice of sliding law, I was specifically concerned about the fact that they used a linear relationship between basal shear stress and basal sliding velocity. Simply replacing a linear Budd law with a linear Weertman law does not address this concern.

If it is the case that the new sensitivity test used a linear Weertman sliding law, then I would suggest one of the following two strategies to address my concern: 1) since the authors are willing to perform additional sensitivity experiments, they could perform a test using a nonlinear Weertman or nonlinear Budd law, with a slip exponent of at least m=3; or, 2) they could analyze their existing results in the manner I suggested in the first review, and present the results of that analysis in additional supplemental figures.

Minor Comments

Figure 1:
"ice surface thickness"
"Ice surface thickness" sounds weird. After all, the thickness is computed from both the surface and the base, not the surface alone. Just plain "ice thickness" makes more sense.
"polarstereographic" → "polar sterographic"
In addition, the formatting of the degree symbol in -71º needs to be fixed.

L70-73: "The basal friction is based on a Budd friction law (Budd et al., 1979), in which basal drag is directly proportional to sliding velocity. This friction law may not be valid under some sectors of ourmodel domain such as the Siple Coast. Therefore, we performed additional experiments to test the sensitivity of our results to the Budd friction law (Figure A3) by using a Weertman friction law instead."
As I stated in my major comment, this is where you need to state what value of the sliding exponent you used in the Weertman law. Replacing a linear Budd law with a linear Weertman law does not change the fact that "basal drag is directly proportional to sliding velocity". If you did, in fact, use a nonlinear Weertman law, then my major concern could be satisfied by simply stating the value of the slip exponent here.

Figure 5:
I believe that the units are wrong in the caption. Sensitivity should be m/(parameter units), which in the case of surface and basal mass balance would be m/(m/s).

Section 4.4 Limitations
Again, the Weertman law does not really present anything independent of the Budd law if the Weertman law also used a linear relationship between basal stress and basal slip. If the Weertman law used a value of the exponent other than m=1 then that fact needs to be stated here.

Figure A1.
Thanks for including these maps, they are helpful for putting the results in context.

Figure A2.
Thanks for including this figure as well. However, I think you should double-check the units of the plot. You have a color scale from 0 to 1000, with no units labeled. If this is supposed to be units of Pa, then the maximum is way too low, but if this is supposed to be kPa, then the maximum is way too high. The spatial pattern in the map looks reasonable but you should really double-check the units and the magnitudes here.

Figure A3.
The units label for plot (a) implies that you used a value of m=3 in the Weertman law, which would satisfy my major concern described above. However, I can't be sure that you have labeled them

correctly, because the units labels for plots (c) and (d) are wrong. Those labels should be m/(m/s) rather than $m/(m/s)^{1/3}$.