The Cryosphere Discuss.,
https://doi.org/10.5194/tc-2019-325-AC2, 2020

The Cryosphere Discussions
Open Access
EGU

Interactive comment on "21st century estimates of mass loss rates from glaciers in the Gulf of Alaska and Canadian Archipelago using a GRACE constrained glacier model" *by* Lavanya Ashokkumar et al.

Lavanya Ashokkumar et al.

lashokkumar@email.arizona.edu

Received and published: 2 June 2020

We would like to thank the referee for detailed comments regarding the glacier model. In this short summary, we will discuss the major points addressed by the referee and revise them in our submission.

We are aware that our glacier model is not one of the sophicated or complex models as in GlacierMIP2. The primary objective of our model is to understand the present and future mass loss rates by model calibration using GRACE $monthly$ observations, in

Printer-friendly version

Discussion paper

contrast to single regional mass balance from geodetic observations. Also, we believe that the referee has not understood the concept of using GRACE $monthly$ observations in model calibration, instead the referee thinks that our model is calibrated with single mass balance estimate from gravimetry instead of geodetic observation as in the Huss and Hock, 2015 (Page C3 and C5 last paragraph). The major difference in our glacier model stems from the way in which the glacier area feedback is performed. While, we have used the volume area scaling compared to the advanced flowline or glacier thickness based area-evolution. It should be mentioned that 5 out of 6 models in GlacierMIP, 5 out of 11 models in GlacierMIP2 have used volume-area or volume-length or volume-area-length scaling to account for glacier geometry change.

We are planning to work on the model calibration and validation with suggestions from all reviewers, hence it is likely that some of the results and discussion will change in the revised submission. The minor comments from page C4-C10 will be addressed in the detailed submission.

1. **Use of terminologies and reference to tables/figures**: The term 'extrapolation' (instead of projection) has been used in the context of estimating the future mass loss and sea-level rates. We agree with the reviewer's comments that it is not a basic linear extrapolation, rather it is a temperature indexed glacier model constrained by GRACE monthly observations. We will revise the manuscript to read appropriate modeling terminologies, according to the standards of GlacierMIP and GlacierMIP2. We agree that the table 1 was incorrectly mentioned as table 5. And, the y-axis label in Figure 1 and Figure A5 has been corrected (comments from referee 1). In Figure 2, we have shown the temperature and precipitation after bias correction which are used as model inputs for future projections. As you may notice, there is large bias from precipitation (even after bias correction) from the GCM. This figure is similar to representation of temperature and precipitation from GCM in Figure 4 in Radic et al., 2014.

2. **Section 2.3: Inaccuracy of the modeling terminologies**: We agree that some of the formula used is confusing to understand the model setup and processing. We like to clarify that we followed the glacier mass terminologies and formula for model setup as in Wahr et al., 2016. The equation 8 and 9 represent the downscaled temperature and precitation at elevation bins, instead of temperature or precipitation at glacier. Further, it was a typo (L151) that we mentioned h and Δh as average elevation of glaciers. We are willing to address the terminology issue in the revised submission.

3. **Model validation** (Page C2): For model validation, our model was able to represent direct observations of mass balance from individual glaciers (Figure A4 - A6 in the supplementary). We would like to clarify that the L184 - 187 refer to model calibration step, where the glacier model is optimized with GRACE monthly observations. In the revised manuscript, we will be including a section on model validation as it was one of the suggestion by referee 3 (point 2b).

4. **Higher order dynamics** (Page C3, paragraph 1): We agree that we have not incorporated higher order of dynamics in our glacier models like some of the models in GlacierMIP and GlacierMIP2 (Hock et al., 2019; Marzeion et al., 2020). In the revised submission, we will make sure to exclude the term 'higher order of dynamics' and use approriate term for volume-area scaling feedback.

5. **Figure 2**: The precitation rates from different GCM are different (lower panel). We will analyse the GCM precipitation again and check if this is incorrect.

Conclusion a: The regional bias between the observed mass balance (GRACE) and modelled mass balance is shown in Figure 1. The comparsion is shown in the form of mass balance time series.

Conclusion b: The intension of this study is to calibrate glacier models with GRACE $monthly$ observations, in contrast to GlacierMIP where the model calibration was based on **single** regional estimate of mass balance. Here we are not trying to replace direct observations of mass balance, instead our model calibrated from GRACE monthly observations does not require any in-situ observations in model calibration. This is the very first attempt in glacier modelling community to test a model without inputs from direct observations. Figure A5 and A6 indicate the modelled rates of mass balance from individual glaciers and the agreement between modelled and measured direct mass balance.

Conclusion c: For the sentence "The Arctic Canada South has greater sensitivity of mass balance rates..". In the revised submission, we will be attempting the model calibration with inputs from ERA5 and optimization of parameters and we will revise the conclusions about the higher sensitivity in the ACS.

References

Hock, R., Bliss, A., Marzeion, B., Giesen, R.H., Hirabayashi, Y., Huss, M., Radić, V. and Slangen, A.B., 2019. GlacierMIP–A model intercomparison of global-scale glacier mass-balance models and projections. Journal of Glaciology, 65(251), pp.453-467.

Huss, M. and Hock, R., 2015. A new model for global glacier change and sea-level rise. Frontiers in Earth Science, 3, p.54.

Marzeion, B., Hock, R., Anderson, B., Bliss, A., Champollion, N., Fujita, K., Huss, M., Immerzeel, W., Kraaijenbrink, P., Malles, J.H. and Maussion, F., 2020. Partitioning the Uncertainty of Ensemble Projections of Global Glacier Mass Change. Earth's Future, p.e2019EF001470.

Radić, V., Bliss, A., Beedlow, A.C., Hock, R., Miles, E. and Cogley, J.G., 2014. Regional and global projections of twenty-first century glacier mass changes in response to climate scenarios from global climate models. Climate Dynamics, 42(1-2), pp.37-58.

Wahr, J., Burgess, E. and Swenson, S., 2016. Using GRACE and climate model simulations to predict mass loss of Alaskan glaciers through 2100. Journal of Glaciology, 62(234), pp.623-639.

Interactive comment on The Cryosphere Discuss., https://doi.org/10.5194/tc-2019-325, 2020.

Printer-friendly version

Discussion paper