Review of ”Modelling the historical and future evolution of multiple ice masses in the western Tien Shan, Central Asia, using a 3D ice-flow model”, Lander Van Tricht, Philippe Huybrechts

The paper provides past and future glacier mass balance projections for 6 Central Asian ice masses, as well as estimates of changes in discharge. The methodology is appropriate and the results are useful for understanding the response of glaciers in the region to climate change. I believe that the paper is worth publishing after taking into account some comments listed below. As I am not an expert on dynamic flow models and climate model data, I rely on the other reviewers to review this section and to address the presented results on mass balance and data presentation in my review.

1. In general **referencing** could be improved. Certain relevant literature for this region has not been referenced in the introduction, study area and description of the climatic setting and drainage. For example, p.130 Kutuzov et al 2009 have already published annual precipitation totals for the region. For example, p. 38ff: Sorg et al, 2012 is a review going back 10 years. There is much more recent literature showing the heterogeneous mass balance response for the region that is worth citing: Hoelzle et al., 2019; Brun et al., 2017 or 2019, Shean et al. 2020; Barandun et al., 2020 or 2021. Or, for example, l.490 also suitable is Kronenberg et al., 2016. In general, self-citation is quite prominent in the article.

2. **Introduction paragraph 2**, concerning the heterogeneity of the mass balance in the region: This paragraph is too superficial and not well substantiated by literature or own research. Many buzzwords are used without proper context and references are missing. This paragraph needs to be improved. In terms of the results of the paper, this paragraph should be restated in the discussion and better contextualised: do the results of this paper reflect the heterogeneity of glacier response or not? Are the ice masses chosen representative of the heterogeneity? And what role plays the uncertainty --> see also comments #6 & 7.

3. **Location and climate**: please restructure to show the geographical order (heterogeneous settings): West to East, lower elevation to higher elevation, increasing continentality etc. I would also prefer a more structured and systematic description and suggest a separate data section --> see comment #4

4. For me a **data section** is missing. I would like to see a more structured description of the data. At the moment it is difficult to understand the origin of the different data sets used. It is also not entirely clear which data have been used for calibration, validation or both. There should also be a better description of what is measured data and what is modelled / interpolated data. As far as I understand, ice thickness measurements are only/mostly done on the frontal part of these glaciers? Where are the meteorological stations located? For what time period was the meteorological / precipitation data available for each station? Are the data filtered and gap filled and how representative are the data for each glacier? See also comment #5.

   Golubin Glacier is located in the Western Tien Shan and has a significantly different regime (temperate vs polythermal), the glacier is located in a different climatological setting, much more precipitation than in the Central Tien Shan, lower elevation etc. The author announces to consider different climatological setting, but in my point of view, the authors do not pay sufficient attention to these differences in their calibration and interpretation in the discussion. For example, I am surprised that the basal sliding parameters are similar for Golubin (temperate glacier) and glaciers in the central Tien Shan (e.g. Bordu, Sary Tor,

Greogoriev: polythermal glaciers). I am not convinced by the authors' suggestion that the sliding behaviour is regionally uniform because of the calibration results of similar basal sliding parameters. This needs some clarification. See also comment 6.

5. **Climatological settings**: there is a large west to east gradient in continentality for the Tien Shan. Glacier regimes and the importance of summer precipitation events is changing from west to east (central part). This could be better described here.

6. **Meteorological input data**: Precipitation data for the Tien Shan are critical and there is little high altitude precipitation data available. While the Tien Shan station may be representative of the glacier in the central Tien Shan, Ala Archa and Chon Kyzyl Suu are located much lower than Golubin and Kara-batkak glacier respectively. While a relatively detailed description of the extrapolation of the Ala Archa data is given for Golubin, it is completely lacking for Chon Kyzyl Su. Considering the less good result for Kara-batkak in calibration and validation, the representativeness and uncertainty of the precipitation data deserve at least a bit more discussion → see also comment 8

7. **Discussion of limitation**: I believe that the representativeness of the meteorological forcing, in particular the precipitation input over the past 100 and future 100 years, is not sufficient. Looking at Figure 2, the variability of the precipitation data, especially for Golubin and Chon Kyzyl Su, does not seem to be well represented. How does this affect the model results? Unfortunately, it is also not clear for which period measurements are available, but it also seems that the precipitation variability changes between 1960-1980 (depending on the station). Any explanation for this? Could it be due to the availability of direct measurements? How does this affect the results?

8. **Surface mass balance model parameters**: What does the hcrit parameter mean? It is not explained in the paper. If it is the height at which precipitation decreases, I think it is relatively low. Why is there no value for Ashu Tor and Gregoriev (and no second precipitation gradient)? Not all glaciers were modelled in Van Tricht et al 2021b. In addition to hcrit, the two precipitation gradients should also be explained.

9. **Comparison with observed ice thickness and surface velocity**: It is not clear what was used for validation and calibration.
   I don't think the mismatch of velocity data for Kara-batkak is explained by the higher velocities in general. Golubin has similar velocities, but the results are much better. This glacier is not easy to model, very steep topography and a very thin glacier. Perhaps the model simply does not work as well for this glacier? Also looking at Figure 8, I am not sure how plausible the AAR evolution shown for Kara-batkak is. In general, the AAR seems to be overestimated for the present, later remaining fairly constant for the next 30 years and suddenly dropping to almost zero, I would expect a more gradual decrease? Any explanation for this?

10. Following comment 9, for Kara-Batkak, the AAR basically does not change at all from roughly today to 2100. Only the ablation area decreases. I am not sure how plausible this is, given the high uncertainty and reduced performance of the model for this glacier.

Considering the geodetic mass balance shown later in the manuscript that is unfortunately highly inhomogeneous does not help to evaluate the model performance very well. Looking at the measured data provided by WGMS, the -0.5m w.e. seems more likely, which would then also challenge the large AAR. I would appreciate a discussion showing the possible limitations of the model, especially in the case of Kara-batkak and the results provided.

11. **Discussion**, **uncertainties**: l 559: I am not sure how meaningful it is to compare precipitation importance for future modelling in comparison to uncertainties in calibration for Iceland and the Tien Shan. Tien Shan is a very large mountain range with heterogeneous topography and heterogeneous climatological settings that is largely under-measured at high altitude. You might consider De Kok et al., 2020 or Barandun and Pohl, 2023, which highlight the uncertainties in precipitation datasets for the region. I agree that the uncertainties introduced by model calibration, especially for region-wide applications, especially are large for the Tien Shan due to the lack of good validation datasets. However, without a proper uncertainty analysis, it is hard to say which is more important, the uncertainty introduced by the input or the calibration datasets. I would rather point out the unknowns that make it difficult to quantify the uncertainties in such a study. This is also true for the runoff estimate, which is highly dependent on the available precipitation data.

12. **Discussion, uncertainties**: Englacial temperature might be very different for Golubin and probably also for Kara-batkak in comparison to Gregoriev. This should also be discussed here.

13. **Comparison with geodetic mass balance**: This chapter is the only independent validation, if I am not mistaken. I576: I believe that the problem is not only with the geodetic mass balance, but might also relate to the model performance for Kara-batkak. L.580: Large discrepancies in the region-wide geodetic estimates do not necessarily make it easy to use these values for validation. I would have more confidence in the glacier-specific, high-resolution estimates.

    For Kara-Batkak: I can only strongly recommend the authors to produce a high-resolution based geod. mass balance, which is so far missing for this glacier. I can understand if it is not in the scope of the study but it is unfortunate that this is not available yet, especially since this glacier was the focus of the authors' previous work and the lack of validation data might have been a limitation before. A number of high resolution sensors are now freely available (Pleiades? SPOT?) and I am convinced that this would be of great value as an independent validation dataset for various modelling studies carried out by the authors (maybe also in the future?).

14. I miss a more detailed **discussion** about the heterogeneous response of the different glaciers in the different climatological settings as promised in the abstract and introduction.

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