In this document, we respond to the comments of reviewer 1 one by one. Whenever some entirely new text has been added to the manuscript, it has been added in italics and in red.

The proposed revised with and without track changes is added as a supplementary .pdf file.

Reviewer 1

This study analyses the past and future evolution, from the Little Ice Age to 2100, of 6 ice masses localized in Kyrgyzstan. It provides detailed future changes in glacier geometry, volume and runoff under different climate scenarios highlighting significantly different responses between the studied glaciers depending on their climatology and geometry. The authors use a model of intermediate complexity based on high-order approximation of the Stokes equation to model the ice dynamics while solving for heat advection and diffusion in the ice body. The flow model is coupled to a “degree-day”-type mass balance model including the influence of incoming potential radiation and albedo difference between snow and ice. The main strength and originality of the study is the attempt to correctly represent the surface boundary condition of the temperature field to properly model the evolution of the glacier thermal regime, and also to start the simulation from the Little Ice Age using long term reconstructed meteorological data. I also appreciate that the author combines thickness, velocity and mass balance measurements to constrain the model in order to provide, most likely, reliable estimation of the future evolution of those ice masses. The paper is well written and organized and I think it deserves publication in The Cryosphere after addressing the points below that would be rather in the major revision category.
We would like to thank the reviewer for the useful review which helped us to improve the quality of the manuscript.

General comments

<table>
<tr><td>[RGC1.1] Downscaling of GCM data.
1. Applying a monthly bias correction to the GCM data is a necessary step to perform the future simulation. However, this may result in a change in the long-term trend of precipitation and temperature contained in the original GCM output. The trend preservation should be checked after applying the downscaling procedure. If the trend is modified, some methods have been proposed to preserve it and should be applied (e.g. Cannon et al., 2015).
2. Also, since you are using a temperature threshold to determine solid precipitation, a different precipitation distribution as a function of temperature in the GCM and in the local data may cause a bias in the modelled snow accumulation. This should be checked by plotting the precipitation distribution as a function of temperature for the GCM and for the data over the calibration period (1984-2014). This should be corrected, if necessary, by applying a precipitation correction per quantile of temperature.</td></tr>
<tr><td>1. We use monthly GCM data for total precipitation and average temperature, employing a debiasing procedure based on the delta-method. To achieve this, we calculate monthly anomalies (for temperature) and ratios (for precipitation) for each GCM, relative to a common period (1984-2014) shared by both the GCMs and historical data. The derived anomalies and ratios are subsequently rescaled to align with the standard deviation of the historical data, ensuring consistent interannual variability. Next, we use the obtained (average) anomalies of all GCMs and the average (ratios) of all GCMs to extent the 1984-2014 period from the measured time series into the future. With regards to the precipitation distribution, we use the monthly data of the GCM and an historical sequence which is repeated in the future, matched to obtain the total precipitation sums of the GCMs. In doing this, we ensured that the trend was preserved.

2. We thank the reviewer for the valuable comment, which we thoroughly analysed. Specifically, we conducted a comprehensive comparison of the precipitation distribution as it relates to temperature for both the observed data and our multi-model mean GCM for the period of 1984-2014. We found</td></tr>
</table>

no discernible disparity in the precipitation distribution between the two datasets. Consequently, we concluded that a precipitation correction was unnecessary.

[RGC1.2] Initial steady state condition
Finding a steady-state glacier to match the Little Ice Age moraines is a good approach to get the initial state, but this should be done by perturbing the climate and not directly the surface mass balance (especially in a uniform way). The surface mass balance response to climate perturbation is elevation dependent and shifting the average (1820-1850) temperature (or precipitation) rather than introducing a mass balance bias would capture this easily. The introduction of a uniform mass balance bias also incorrectly affects the surface temperatures which set the boundary condition of the steady temperature field.

We acknowledge the reviewer's concerns regarding the use of constant mass balance perturbations, recognizing that it may not be the optimal approach. Consequently, as recommended, we have explored an alternative method to achieve a glacier state that closely aligns with the desired conditions by considering temperature and/or precipitation biases. Although this adjustment had minimal impact on our overall findings, some minor variations in modelled thicknesses were observed. All figures were adjusted.

To address this matter, we have included additional information throughout the manuscript.

For instance, on line 384, we have explicitly stated, "Based on this comparison, a *temperature and/or precipitation bias is searched* and applied to acquire the LIA geometry of all ice masses."

[RGC1.3] Historical simulation
1. The same comment applies here. Instead of quantifying the uniform mass balance bias needed to reproduce the length change, one should quantify a precipitation or temperature bias needed to reproduce the length change. This would allow a better assessment of the model performance and can even be used to propose a correction to the reconstructed climate data in the region.
2. I would like to see the evolution of the temperature field from the Little Ice Age steady state to the present. This would help to assess whether the surface temperature parameterization holds on long time scales.
3. To validate the model, you should compare the modelled thickness at different times using different surface DEMs (if possible). Here you show a good agreement with the data set you actually use to tune the flow parameters (unless I am wrong?). In this case, this is not a validation that the model actually captures the physics, but just a confirmation that your parameters are well tuned...

1. See our answer in RGC1.2. We use in the revised version a temperature and/or precipitation bias to match the modelled extents with the observations.

On line X, we wrote: "By comparing with the intermediate extents, *a temperature and/or precipitation bias is searched and used* to match the historical modelled extents optimally with the observed extents."

2) We acknowledge the reviewer's suggestion regarding a comprehensive analysis of the temperature field evolution, which would provide valuable insights. However, we must clarify that providing an extensive description of the ice temperature field evolution falls outside the scope of this particular study. Nonetheless, to address this briefly, we have included a dedicated section in 6.2 that showcases the evolution of the percentage of temperate ice and offers a discussion on the modelled evolution. This addition allows us to explore the evolving nature of the ice temperature field within the context of our study. See also our answer in RGC1.5.

3) As suggested, we validate the obtained ice thickness with the ice thickness derived using the SRTM DEM and the bedrock DEM. Unfortunately, we have no access to older DEMs. This would certainly be interesting to compare to in future work.

[RGC1.4] Future simulation 1. It would be good to see and comment the evolution of the temperature field.
See our answer in RGC1.3 point 2.

[RGC1.5] Sensitivity test 1. Your study is one of the few to consider the structure and evolution of the thermal regime on long-term glacier evolution. You should take advantage of this to quantify the influence of the temperature-dependent ice viscosity on the modelled glacier and ice cap evolution. It would be interesting to run all simulations with a uniform and constant flow factor to see the difference and to discuss the necessity (or not) to model the thermal regime in future simulations (for volume/area changes assessment).
The study is already rather extensive, preventing us from delving into this topic further, as it falls outside the scope of the current research. Nevertheless, we acknowledge its potential significance and note it for consideration in future investigations, as highlighted in the manuscript at line 690.

Specific comments:

The specific comments are directly incorporated in the text, as the reviewer provided track changes.