Dear editors and reviewers:

On behalf of my co-authors, we thank you very much for giving us an opportunity to revise and modify our manuscript, we appreciate you and reviewers for their constructive comments and suggestions on our manuscript entitled “A tree-ring perspective on the past and future mass balance of a glacier in Tien Shan (Central Asia): an example from the Tuyuksu glacier, Kyrgyzstan” (Ms. No. hess-2022-329).

We have studied reviewer’s comments carefully and have made revision and modification. Please find below a detailed responses to all the raised points, which we would like to submit for your kind consideration.

We would like to express our great appreciation to you and reviewers for comments on our paper. Looking forward to hearing from you.

Thank you and best regards.

Yours sincerely,

Feng Chen

On behalf of all authors

Reviewer #2： : The authors presented interesting results for their study glacier. However, from my taste, novelty of the paper is far from acceptable in this journal. Seems the authors showed lots of trust on correlation analysis. They used correlation coefficient to evaluate their models, to explore the relevance between two variables, and to compare with other studies. I would say, correlation coefficient is useful for examining the change pace of two variables but can't tell the bias. Moreover, the authors used only simple linear models to reconstruct and predict the glacier mass balance, which I think is of highly uncertain. First, the training of linear models is heavily related to the collected data. There area inevitable uncertainty in the data collection, especially when only data from one glacier was collected in this study. Second, validation of the linear models is poor in this study, especially for the prediction models. Although the authors claimed that they validated the reconstruction model by a leave-one-out method, there were few details on how this was conducted in the paper. Last, the linear models typically ignored other contributing factors beyond the considered ones. Glacier mass balance is typically controlled by many factors, such as ice flowing, radiation, albedo, and even terrain, not simply by precipitation and temperature. Prediction of future glacier mass balance based on solely precipitation or temperature is highly uncertain.

Response: Yes, a large number of research reveals the relationship between glacier mass balance and climate change. Most studies are based on qualitative or semi-quantitative analysis. Although these studies have built a complete story framework (I also admit that our story is not very novel). But our study is the first to show high-resolution changes in the upper accumulation area of the Tuyuksu Glacier over the past 382 years and possible future changes. As you pointed out, we show interesting results from studying glaciers. In Central Asia and even globally, there are very few research results that combine dendrochronology with glaciers, but are more used to study changes in precipitation, temperature, and runoff, as we described in the introduction of the manuscript.

In constructing linear models of past glacier mass balance. We admit that there are some uncertainties in the constructed linear model of glacier mass balance. However, in previous studies based on tree-ring in Central Asia, linear models have been widely and successfully used to reconstruct past climate and hydrological changes, and many interesting research results have been obtained (Zhang et al.2015; Chen et al., 2017; Panyushkina et al., 2018). In our study, tree-ring were significantly positively correlated with precipitation from previous

July to June (r= 0.665, p < 0.01, 1969-2016). Referring to previous studies (Fritts, 1976; Zhang et al.2015), such a high correlation (r > 0.6) allows tree-ring to be used to reconstruct past precipitation changes. In addition, the mass balance of high-altitude glaciers is also significantly positively correlated with precipitation from April to September (r= 0.675, p < 0.01, 1969-2016). Therefore, on the basis that both tree-ring and high-altitude glacier mass balance are significantly related to precipitation, it is reasonable for us to use tree-ring to reconstruct glacier mass balance. In a similar way, Zhang et al. (2019) successfully reconstructed the changes of Tuyuksu Glacier based on tree-ring. On the other hand, as you said, after the linear model was established, we successfully used the leave-one-out method to verify the reliability of the model. As this method is a well-established method for verifying model reliability in dendrochronology (Michaelsen, 1987), we apologize for not detailing the process in the manuscript. In addition, we also acknowledge that there are uncertainties in estimating future changes in glaciers based on model simulation data from the Coupled Model Intercomparison Project 6 (CMIP6). However, previous studies have shown that the three models we selected can simulate climate change in Central Asia better than other models in CMIP6 (Guo et al., 2021). At the same time, we also use the method of multi-member ensemble averaging to eliminate the uncertainty of random coupling (33 ensemble members; Krishnamurti et al., 1999; Palmer al., 2000). In addition, previous similar studies have shown that data uncertainties in model simulations arise from internal variability in the climate system (Hessl et al., 2018 and Rao et al., 2020). On the other hand, there are relatively few research results on the combination of tree-ring data and model simulation data in the CMIP6. Our research is a useful attempt in this regard. In summary, although the linear model we constructed has certain uncertainties, it does not affect our understanding of past and future changes in the mass balance of the Tuyukesu Glacier.

Finally, we also acknowledge that, as you say, glacier mass balance is typically controlled by many factors, such as ice flowing, radiation, albedo, and even terrain, not simply by precipitation and temperature. However, it is undeniable that temperature and precipitation are the most important factors affecting the mass balance of glaciers (Sagredo et al., 2012; Cerrato et al., 2020). Low temperature and humid conditions are conducive to the accumulation of glaciers, while high temperature and drought conditions are conducive to the melting of

glaciers (Zhang et al., 2019). In other similar study, Cerrato et al. (2020) further used the tree-ring density to reconstruct the summer mass balance of the glacier based on the relationship between the tree ring density and the summer mass balance of the Careser Glacier, which were significantly correlated with the temperature from May to September.

By the way, I'm not familiar tree-ring. So I have a question for the authors, how did they have the tree-ring data for 1600s. Are there exactly trees so old in Central Asia? Regardingly, I would suggest the authors to provide more data (such as pictures) for the tree-ring collection. The simple statement of 'Data set available on request to corresponding authors' is unacceptable recently in HESS.

Response: Yes, there are many old trees in Central Asia. For example: Chen et al. (2022) collected tree-ring cores of *Larix sibirica* for nearly a millennial year in the Altay Mountains, and reconstructed the June-July temperature. Wang et al. (2021) collected tree-ring cores of *Picea schrenkiana* in the Tien Shan Mountains, and reconstructed the PDSI changes in the region over the past nearly 400 years. Davi et al. (2015) use an extensive collection of living and subfossil wood samples from temperature-sensitive trees to produce a millennial length, validated reconstruction of summer temperatures for Mongolia and Central Asia from 931 to 2005 CE. The following are some photos of our team collecting tree-ring cores in Central Asia:

Some small comments:

1. Seems the collection sites of tree-ring are far from the glacier. Do the authors have any comment on the representativeness of the tree-ring data?

Response: Yes, as you said, these sampling points are about 200 km away from the glacier. But as shown in Figure 8, we can see that the mass balance of glaciers and tree-ring is mainly affected by precipitation, and they are in the same high-correlation range. Therefore, we believe

that, using precipitation as a bridge, the tree-ring can represent changes in the mass balance of the accumulation zone above the glacier.

2. What is sample depth in Figure 2?

Response: "sample depth" refers to the number of samples, that is, the amount of tree sample cores collected.

3. Gridded data was derived from CRUs at a resolution of 0.5 degree, which is larger than the glaicer size. Do the authors have any comment of this uncertainty?

Response: Yes, it is undeniable that the accuracy of CRU grid meteorological data needs to be improved. However, as shown in the spatial correlation analysis of Fig. 8b, the gridded precipitation from April to September was significantly positively correlated with the glacier mass balance (r > 0.5), and this high correlation range included the entire glacier. Therefore, we think it is reasonable to use gridded CRU data for analysis.

4. Figure 3 different gradients should be different altitudes.

Response: Yes, thanks for the suggestion, we have corrected 'gradients' to 'elevations', including the same mistake in the title of Figure 4.

5. Leave more space between sub-panels in figure 4

Response: Yes, we have adjusted. The adjusted figure is as follows:

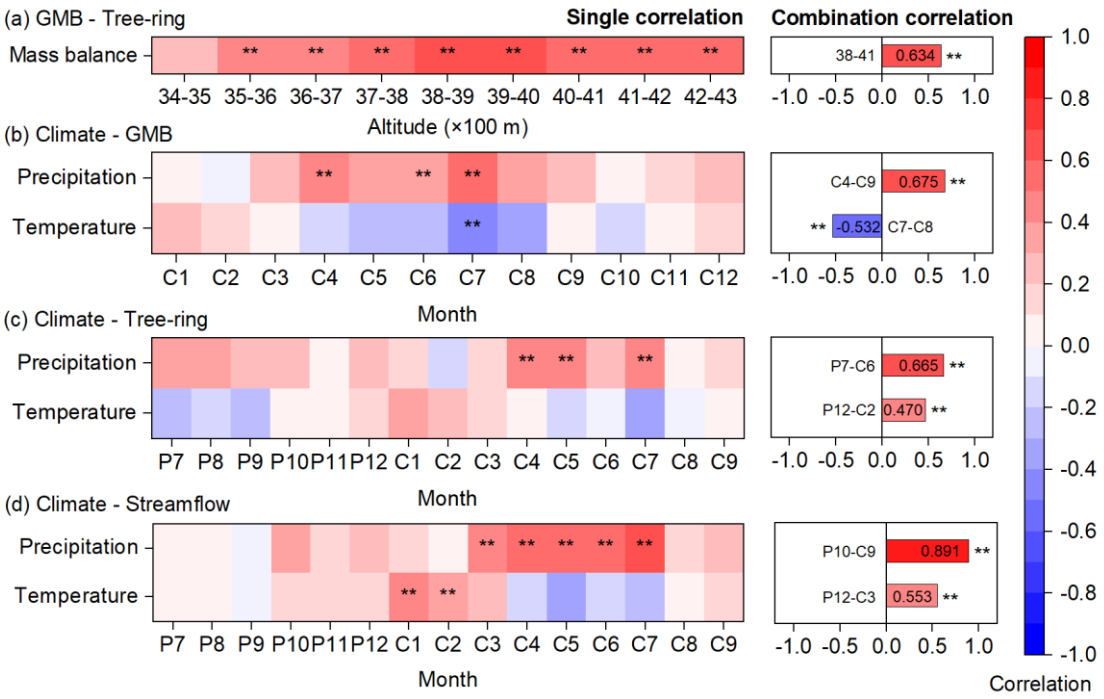

Figure 4: Correlations of regional chronology with annual mass balance of the Tuyuksu Glacier at different elevations (a). Correlations between monthly precipitation and mean temperature from the CRU TS4.05 with the glacial annual mass balance at 3800-4100 m a.s.l (b), regional chronology (c) and annual runoff of Talas River (d). "P", "C" and "" represent previous year, current year and 99% significant correlation, respectively**

6. What is growing season? From... to...

Response: The optimum photosynthetic temperature for evergreen conifers ranges from 10 to 25 ℃ and that photosynthesis may cease at temperatures below -5 to -3℃ or above 35 to 42 ℃ (Zhang et al., 2020). Figure 3b shows that the mean temperature in April and October was 4.7 ℃ and 3.7 ℃. Thus, the period from April to October was regarded as the growth season for spruce trees in the study area.

7. Figure 8 is unclear or even unnecessary, I think . Are they discussing the spatial representativeness of the glacier or the precipitation data?

Response: Such an analysis is necessary. As you suggested in points 1 and 3 above, such an analysis helps us understand how extensively precipitation drives changes in both tree-rings and the mass balance of the Tuyuksu Glacier.

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