

Hydrol. Earth Syst. Sci. Discuss., referee comment RC1
<https://doi.org/10.5194/hess-2022-329-RC1>, 2022
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Comment on hess-2022-329

Anonymous Referee #1

Referee comment on "A tree-ring perspective on the past and future mass balance of a glacier in Tien Shan (Central Asia): an example from the accumulation area of Tuyuksu Glacier, Kyrgyzstan" by Youping Chen et al., Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2022-329-RC1>, 2022

General comments

The paper by Chen et al. is interesting and worth of publication in my opinion, however it require a major review devoted mainly in formal improvements. Indeed, several parts are poorly written and unclear. I have reported some examples of possible improvements in the Specific comments, and I have highlighted the parts that are more problematic.

From a methodological point of view the paper is rather good, even though it requires a change in the approach used for projecting future glacier scenarios. Details are reported in the Specific comments.

In general, the authors should pay attention at not generalizing too much their result, because they analyse only the response of the upper part of the glacier, which is half of the story...

A possible alternative would be to perform their analysis considering the entire glacier, or maybe better 2-3 elevation bands representative of the ablation and accumulation area, as well as the zero-balance ELA.

Specific comments

L 32: 'geosphere layers' is not clear, please clarify the meaning

L 45: what is the meaning of 'comprehensive'? Worldwide? Century-long? Others? Please clarify

L 52: finding that the loss of mass (remove 'balance')

L 57: huge = large glaciers? Or maybe long series of mass balance? Please clarify

L 58: Two long-term mass balance programs exist (where?): one at the Urumqi..... It is not clear if these series are ongoing or have been demised

L 60: ...for reconstructing past changes

L61: The mass balance of the Tuyuksu Glacier was analysed by Zhang et al. (2019), who employed..... (remove the first sentence)

L 69: and to compare the spatial and temporal characteristics of our reconstruction with other glacier mass balance and runoff reconstructions based on tree ring

L71: predictions are always hard to do, especially of the future! Please replace with 'project', or 'try to understand the possible future evolution'

L 74: long-term time scales? Long -term variations?

L 89: coring sites are 100 km west of the glacier, not really 'around' it

L 90: human 'agencies'? Please clarify

L 107: maybe better 'Based on the threshold values, the RC starts in 1635 CE (figure 2).'

L 111: we retrieved annual balance data from the WGMS database..... The data are average annual values at 100 m elevation bands comprised between 3400 and 4200 m, and cover the period between 1969 and 2016.

L 133: I do not understand the meaning of the sentence 'Calculations show that fluctuations in the glacier mass balance at various elevations are quite constant'

L 115: what are 'simulation parameters'? Simulated/reconstructed (or maybe measured?) meteorological variables? Air temperature and precipitation? In addition, it is unclear whether the authors simulated the mass balance of the glacier in the past/future with these meteorological data, or maybe they only did statistical analyses...

L 125 and following: please make more explicit which period these statistics are referred to

L 128: please do not mix annual with monthly data.

L 137-140: this part is poorly written, please rephrase. In addition, why Pearson and not e.g. Spearman correlation analyses? Are the frequency distributions of analysed variables normal? Are the relationships linear and outliers absent? And what about the sample size? Please check e.g. <https://doi.org/10.2307/2346598> and justify the choice of Pearson vs. Spearman correlations.

What is the 'altitude combination of glacier mass balance'? Is it the mass balance averaged for different elevation bands?

L 141: bases on the correlation analysis in the period between (1969 to 2016 I guess...), a linear.....employed in the period between (1635 and 1969?) to reconstruct..... mass balance based on tree-ring (and/or meteorological data?). Hard to follow here...

L 145: why 31-year and not other lengths? Following period requires rewriting because it is poorly written.

L 152: why is Oscillation Period uppercase?

L 153: why 'meanwhile'? Please remove it.

L 160-167: it would be interesting to know whether the maximum correlation matches with the zero-balance ELA or is just above it, as it looks like in Fig. 4.8.4 page 77 in:

WGMS 2021. Global Glacier Change Bulletin No. 4 (2018–2019). Zemp, M., Nussbaumer, S.U., Gärtner-Roer, I., Bannwart, J., Paul, F., and Hoelzle, M. (eds.), ISC(WDS)/IUGG(IACS)/UNEP/UNESCO/WMO, World Glacier Monitoring Service, Zurich, Switzerland, 278 pp., publication based on database version: doi:10.5904/wgms-fog-2021-05.

In the following, the authors work mainly with mass balance data above 3800 m, which mean they reconstruct the mass balance in the accumulation area of the glacier. This should be state more explicitly in the manuscript.

L 168: aided -> positively correlated?

L 176: I suggest being less categorical, e.g. 'Overall, our findings indicate that fluctuations in the Tuyuksu Glacier's high-altitude mass balance are influenced by meteorological conditions during spring and summer. In particular, precipitation during spring and summer looks comparatively more important than air temperature in the same period of the year.

L 184: it is unclear from the text and the figure whether the correlation for precipitation is highest for the period going from the previous July to the current June (as I understand). Please report always the same number of decimals (2 or 3), both in figures and text.

L 186: Figure 4 presents also correlations with runoff, which are not reported in the text. In my opinion it should be also interesting to see the relationship between precipitation and temperature, because from the Figure 4 it looks like they are negatively correlated, i.e. high runoff corresponds with low temperature and high precipitation in spring and summer. This could suggest that anticyclonic weather is associated with high temperature and low precipitation, and vice versa....

L200: please specify that these statistics are related to the leave-one-out validation. These statistics are ok, but I would suggest using RMSE (expressed in mm or m water equivalent) and/or the Nash and Sutcliffe index, which are more commonly used in the scientific literature (and therefore ease comparisons with it).

L 218: a significant 'mass loss' trend during... Again, the authors should stress that they

are dealing with the accumulation area of the glacier, which is only half of the story (the glacier had prevailing negative mass balance since the late 1970s, WGMS (2021)).

L 221: what is MTM? Please introduce acronyms

L 226: remove 'highly'

L 229: correspond to SST (introduce acronym) anomalies linked to NAO and ENSO occurrences. Please state more explicitly what is the relationship and what are the SST anomalies linked to positive/negative ENSO and NAO phases (for the non-specialist readers).

L 241: what are the 'regional climatic inputs'? Please explain

L 244: I suggest removing the sentence 'which contributes to the build-up of the mass balance of high-altitude glaciers'

L 246-247: poorly written and hard to understand, please rephrase.

L 250-267: I am a non-specialist of these arguments and had to read three times this part to grasp what the authors mean. This means that, probably, the authors should clarify this part of the paper. Moreover, I suggest a more consistent use of verb tense, probably present is more suitable to describe the growth behaviour of analysed tree species.

L 269: this is the first time such a high correlation coefficient is presented. Among which variables is it calculated? Not clear

L 282: I agree with these considerations but I wonder why there is a significant positive correlation with temperature in the winter months. It would be interesting to read what the authors think (or better, propose as possible explanation) about that.

L 286-290: poorly written, please rewrite e.g. 'Since precipitation has a strong link with RC and GMB3800-4100, we investigated the spatial correlation between GMB3800-4100 (RC is not presented....) and gridded precipitation from 1969 to 2016. A large geographic area showing significant correlation up to (up to....?) was found, encompassing eastern Kyrgyzstan and south-eastern Kazakhstan (figure 8).'

L294: our reconstruction of what?

L 296: were matched to a high degree -> correlates well (or are highly correlated)

L 298: were relatively negative -> were characterised by negative mass balance.

L 299: confirm the robustness of our model approach (is this the intended meaning?)

L 302: I suggest writing explicitly that the paper presents results for the accumulation area of the glacier. Is it the same in the paper of Zhang et al., (2019)? Measurements clearly show that the mass balance of the glacier, in its entirety, was negative in the last decades (WGMS, 2021) and these considerations are important while discussing the results. I suggest linking better the sentence 'We extended the reconstruction of this glacier's mass balance sequence back to 1635, which is 216 years longer (than what?)'. E.g. 'even if our reconstruction regards only the accumulation area of Tuyuksu Glacier, the added value of our work is that we reconstructed mass balance in a longer period etc...'

L 304: compared is actually better than 'contrasted' (in my opinion)

L 312: our glacier reconstruction sequence were negative -> our glacier reconstruction show negative mass balance between 1760 and 1779 (this is an example; I suggest rephrasing accordingly, or similarly, the rest of the paper). Sequence should be replaced with 'time series' in my opinion

L 322: here the authors present the periods when their model agree with other reconstructions. Are there only agreement period or also disagreement periods? The second ones are interesting as well!

L 328: How were they scaled to zero?

L 335: in Figure 9 there are also periods with disagreement, see comment L 322

L 350: it would be nice to see a figure depicting mean geopotential height anomalies (and dominant winds/storm tracks) associated to the positive/negative NAO phases in this

geographic area (or northern hemisphere), and positive/negative ENSO as well

L 376-405: this is an appreciable attempt to model the future response of the (accumulation area of the) glacier. However in my opinion this approach should be improved because it is clear that it is unable to reproduce historical mass balance variations (Figure a) and therefore there is low confidence on its skills in future projections. In particular, I suggest i) checking the model accuracy (comparing modelled and measured temperature and precipitation in the 1850-present period) and if necessary correct model outputs, ii) trying a multiple correlation analysis between reconstructed mass balance (from tree ring) and CMIP6 temperature and precipitation (corrected if necessary). This approach should better account for mass balance variability, which is influenced by precipitation and temperature (the second governs ablation but also accumulation through rain/snow partitioning).

L 425-426: this sentence is misleading and generalizes too much. See previous comments concerning the analyses focused only in the accumulation area.

L 430: intricate? I suggest removing or replacing with 'complex'

Figure 1: this figure could be improved e.g. making text and symbols more visible, adding political boundaries and nations names

Figure 3: caption: at different 'elevations' (also in the following e.g. Figure 4 caption...). Monthly mean temperature and precipitation in the period from 1969 to 2016 from.....

Figure 8: it is unclear whether the colored areas represent statistically significant (at which p level?) correlations or not. 'The yellow and blue triangles represent the TREE-RING sampling point and the location of the Tuyuksu Glacier.'

Figure 10: yellow lines are almost invisible