Reviewer 2

This study aims to reconstruct annual precipitation for the eastern Tianshan Mountains from 1830 to 2020 using tree-ring widths of *Picea schrenkiana*. The authors identify that while much dendroclimatological work has been done in the Tianshan Mountains, it has primarily focused on drought indices rather than direct high-resolution precipitation reconstructions. However, the results show that the tree-ring width series also exhibits a strong correlation with scPDSI, which is only slightly lower than its correlation with precipitation. Therefore, the novelty of this study is still challenged by existing high-quality, longer reconstructions in the same region, most notably Xu et al. (2018, Climate Dynamics). The authors must explicitly justify the necessity of this new 191-year chronology. Specifically, does it provide higher spatial resolution, stronger statistical reliability, or new insights into the last decade (2011–2020) that are absent in previous longer records? Without a rigorous comparative analysis and a clear statement of incremental value, the manuscript's contribution to the field appears limited.

Author response:

First of all, we sincerely deliver our gratitude for the reviewer's careful evaluation on our work, and also for the important suggestions to improve our work. We acknowledge that the Tianshan Mountains have been extensively investigated through previous tree-ring studies, including Xu et al. (2018). Nevertheless, our study differs from these earlier efforts and we are going to justify the necessity of our work from following several critical respects:

First, while most prior dendroclimatic research in this region has focused on reconstructing drought indices (e.g., via PDSI or SPEI), direct precipitation reconstructions have been exceptionally rare. Indeed, the correlation of tree growth with drought index is also high in our investigation, however, drought indices are coupled to evapotranspiration, which is highly sensitive to temperature and introduces a warming-driven bias into the reconstructed signal. Therefore, we believe that direct reconstructing precipitation is important which provide more explicit hydrological information and fundamental baseline for understanding water resource dynamics in the eastern Tianshan Mountains.

Second, regarding precipitation reconstruction specifically, our study is distinguished by a substantially larger and more comprehensive dataset—comprising 276 tree-ring core samples collected from nine spatially distributed sampling sites. This multi-site, high-replication design effectively suppresses local non-climatic noise arising from micro-site effects. This substantially enhances the statistical robustness and signal-to-noise ratio of our reconstructed precipitation series and ensures that our record captures the dominant regional-scale precipitation variability, rather than localized hydrological anomalies confined to a single valley or slope aspect.

Third, we have explicitly extended the temporal coverage of our reconstruction into the most recent decade—a period that falls outside the time horizon of many prior proxy records. This extension allows us to capture contemporary hydroclimatic variability that has not yet been fully addressed in existing regional chronologies.

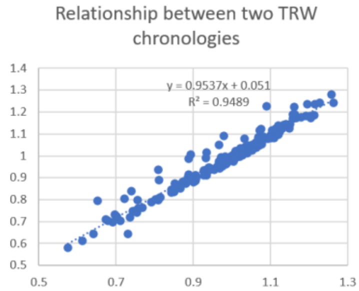
Taken together, these methodological and chronological advances ensure that our precipitation record is not merely a redundant update, but rather a genuinely independent and up-to-date dataset for the eastern Tianshan Mountains. By providing this refined, high-resolution reconstruction, we effectively address a pressing gap in the region's hydroclimatic history during the recent period. Consequently, we contend that our work does not simply repeat previous investigations; instead, it serves as a meaningful supplement, a targeted refinement, and a timely extension of the existing body of knowledge. We will incorporate the above-mentioned aspects in the revised manuscript.

Major comments:

1. Given the relatively short length of the tree-ring width chronology, relying solely on a negative exponential curve for detrending may be insufficient. The authors should consider employing smoothing spline functions with various stiffness levels to verify if the reconstructed precipitation trends remain consistent across different standardization methods. In addition, the divergence problem has been proposed by many studies, will it affect trees width in eastern Tianshan?

Author response:

Part 1: We thank the reviewer for this constructive and important comment. In response, we applied a cubic smoothing spline function for detrending and chronology establishment during the revision. The reconstructed precipitation series based on this method closely resembles the original reconstruction derived from the negative exponential curve. The following figure compares the two series (note: this figure is provided exclusively for this response letter and will not be included in the revised manuscript or Supplementary files):



Therefore, we are going to keep the original TRW chronology and precipitation reconstruction series in the revised manuscript.

Part 2: We have conducted moving correlation analysis between the tree ring width chronology and the July – June precipitation to observe is there any non-stationary relationship existed, according to the results the relationship was strong and stable overtime, indicating that there was no diverging phenomenon between the tree ring growth and the July – June precipitation. Following is the results of moving correlation analysis:

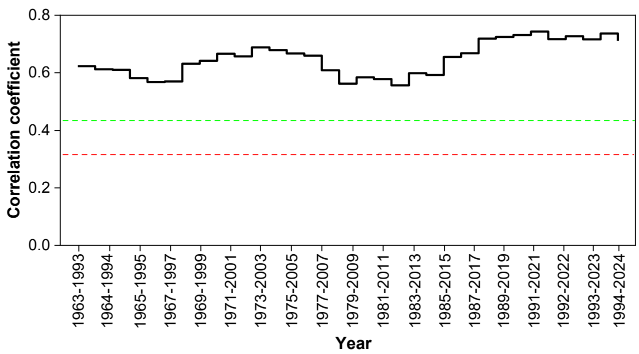


Fig. 6 The moving correlation between the TRW chronology and July – June precipitation over the period 1963–2024. The horizontal red and dashed green lines represent the 0.05 and 0.01 significance levels, respectively.

But the reviewer's suggestion provided us with an excellent research idea for our future work (divergent problem may be existed at the lower elevation), and we will definitely work on it in our later research, and we really appreciate the reviewer.

2. In the Discussion section, the authors should discuss the influence of temperature and PDSI. Especially, why there are strong correlations between tree ring width and temperature in previous July, rather than current spring or summer? It is also strange that there is only significant correlation between current May precipitation and tree ring width.

Author response:

Our analysis of tree growth–climate relationships revealed that correlations with temperature were either negative or statistically insignificant across most monthly windows. Moreover, the highest correlation coefficient was observed between the tree-ring chronology and July–June precipitation, which we consequently selected as the reconstruction target. Given these findings, we consider that a detailed discussion of other climatic factors would be of limited relevance and would not provide substantial additional value to readers. We therefore chose to keep the discussion focused on precipitation, which clearly emerges as the primary climatic driver in this analysis.

In our revised work, the correlation between precipitation of April, May, and June showed significant correlations with tree growth. More importantly, when precipitation was aggregated into seasonalized (multi-month) timescales, the correlations became substantially stronger and statistically significant. As observed in many other dendroclimatic investigations, the aggregation of climatic factors exerts a more effective influence on tree growth than single-month values alone. The results of the correlation analysis between tree growth and seasonalized climatic factors are presented in the figure below (this figure will be included in the Supplementary file of the manuscript):

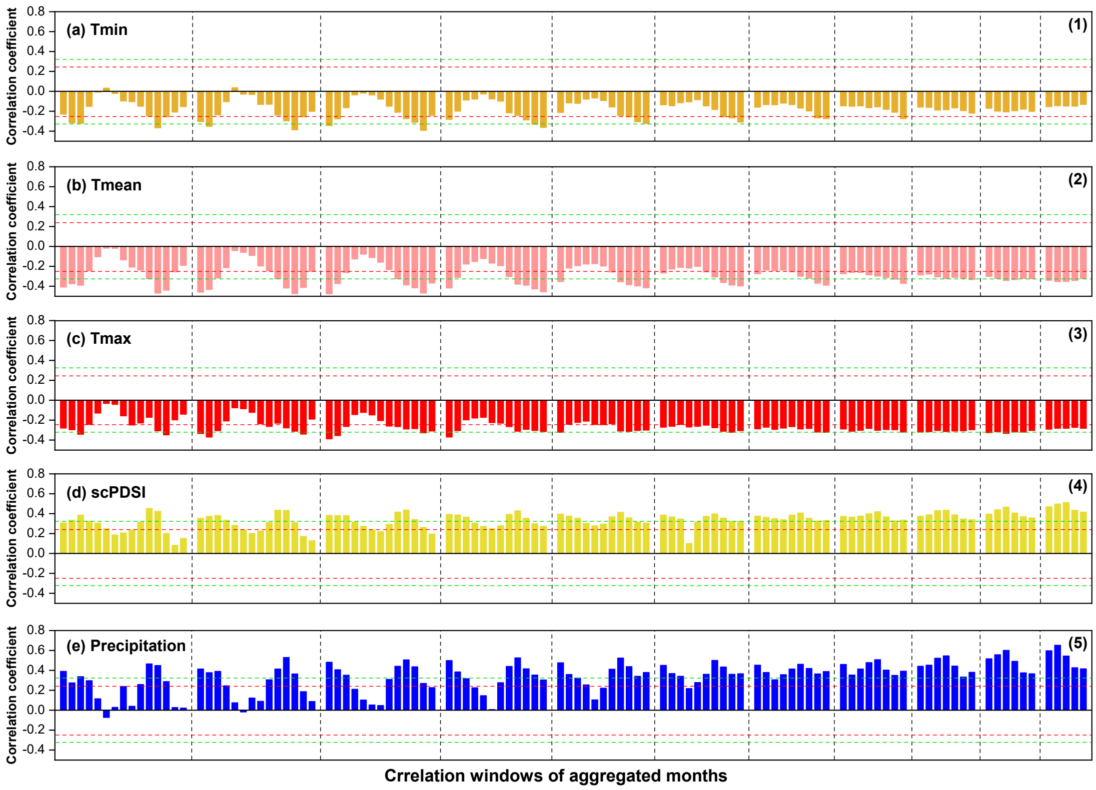


Fig. S1 Correlations between the tree-ring width chronology and aggregated monthly climate variables (temperature, precipitation, and scPDSI) were examined over windows of 2 to 12 consecutive months. Horizontal dashed lines indicate the 95% and 99% confidence levels for correlation significance.

3. The current study employs a purely traditional dendroclimatological methodology and appears largely redundant given existing research, offering minimal advancement in our understanding of the regional water cycle. To significantly elevate the quality of the manuscript, I suggest the authors integrate comparisons with simulated precipitation data to disentangle the impacts of anthropogenic forcing and natural variability. Furthermore, the discussion should be expanded to address regional moisture sources, particularly by investigating water vapor transport patterns during extreme climate events.

Author response:

We sincerely thank the reviewer for providing us constructive comments and suggestions. Following are our detailed responses:

Part 1: As detailed at the beginning of this response, our study offers a distinct and significant contribution. Our precipitation record constitutes a genuinely independent, contemporary, and largest scale (by far) dataset for the eastern Tianshan Mountains—not merely an incremental update. Hence, rather than recapitulating previous investigations, our work provides a meaningful supplement, a targeted refinement, and a timely extension of the existing body of knowledge.

Part 2: We greatly appreciate the reviewer for the suggestion to disentangle the effects of anthropogenic forcing and natural variability. In response, we correlated our reconstructed precipitation series with the CO_2 trend and found no significant correlation. Furthermore, we identified periodicities of 2.1 and 11.2 years in our reconstruction, which reflect the influences of ENSO and solar activity, respectively. Collectively, these findings indicate that the long-term precipitation variability over the eastern Tianshan Mountains is primarily governed by natural climatic drivers.

Part 3: We sincerely thank the reviewer for this valuable suggestion. Although our core research focus is tree-ring-based climate reconstruction, we have tried to make a concerted effort to explore the large-scale atmospheric drivers of moisture supply. Accordingly, we performed a correlation analysis between our precipitation series and six major atmospheric circulation indices. The resulting **Fig. S2** is shown below (to be added to the supplementary file):

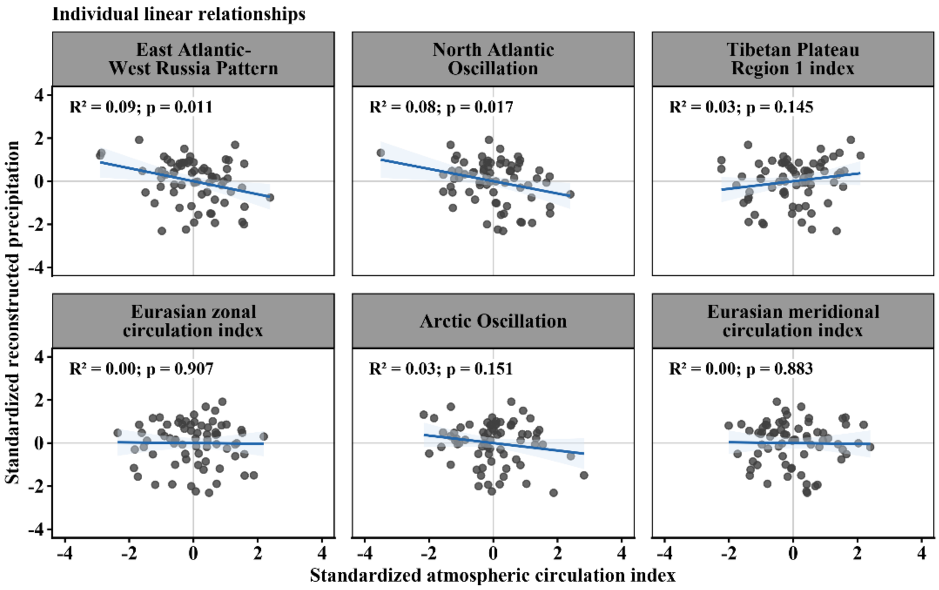


Fig. S2 Relationship between reconstructed precipitation and atmospheric circulation indices

Our results indicate that the East Atlantic-West Russia Pattern (EAWR; r=0.09, p=0.011) and the North Atlantic Oscillation (NAO; r=0.08, p=0.017) achieve statistical significance. Conversely, the Tibetan Plateau Index, Arctic Oscillation, and Eurasian zonal/meridional indices exhibit no statistically significant relationship with our reconstruction. This suggests that these broad-scale hemispheric indices are not the primary drivers of interannual precipitation variability at our specific eastern Tianshan area. We will add this information into the discussion of the revised manuscript.

Minor comments:

Fig. 10: The confidence intervals or significance levels (e.g., p < 0.05 or p < 0.01) must be provided in Figure 10 to validate the results. The spatial representativeness is not good, have you tried other precipitation dataset, such as ERA?

Author response:

We sincerely thank the reviewer for the constructive comment and suggestion on spatial representativeness. We acknowledge that the original CRU-based correlation was suboptimal. During revision, we have replaced CRU with the GPCC dataset, which has resulted in substantially improved spatial coherence. The updated Figure 10 (shown below) now incorporates these new results, along with 95% confidence intervals in the caption. We will insert the updated figure in the manuscript and make corresponding revision to the text accordingly.

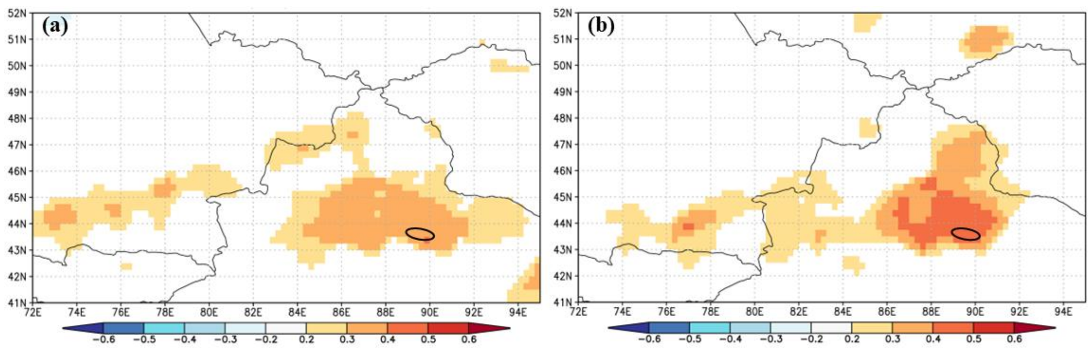


Fig. 10 Spatial correlations of observed (a) and reconstructed (b) precipitation with the gridded dataset over the common period 1963–2020. The black circle indicates the study area. Only grid cells with correlations significant at the 95% confidence level ($p < 0.05$) are colored.

Line 263: what is the growth season?

Author response:

Growth season refers to the period when cambial activity occurs, resulting in the formation of new xylem cells (tree rings) — essentially, the period when the tree undergoes radial growth. In our case, the growth season of *Picea schrenkiana* is from April – October. We will also provide following reference to show the growth period of *Picea schrenkiana* in the revised manuscript.

Wu, Y. L., Gan, M., Yu, R. D., Yang, M. L., Guo, Y. F., & Zhao, P. (2020). Process-based modeling radial growth of Picea schrenkiana in the eastern Tianshan Mountains. Arid Land Geography, *43*(1), 64-71, 8. https://doi.org/10.12118/j.issn.1000-6060.2020.01.08

Line 329: you should put these historical archives documenting climatic extremes in the Fig. 9 or in a table combined with reconstructed precipitation amount.

Author response:

Thanks for the suggestion. According to the reviewer, we have incorporated the historical archives of climate events in the Fig. 9, and we will insert it in the revised manuscript. Below is updated Fig. 9:

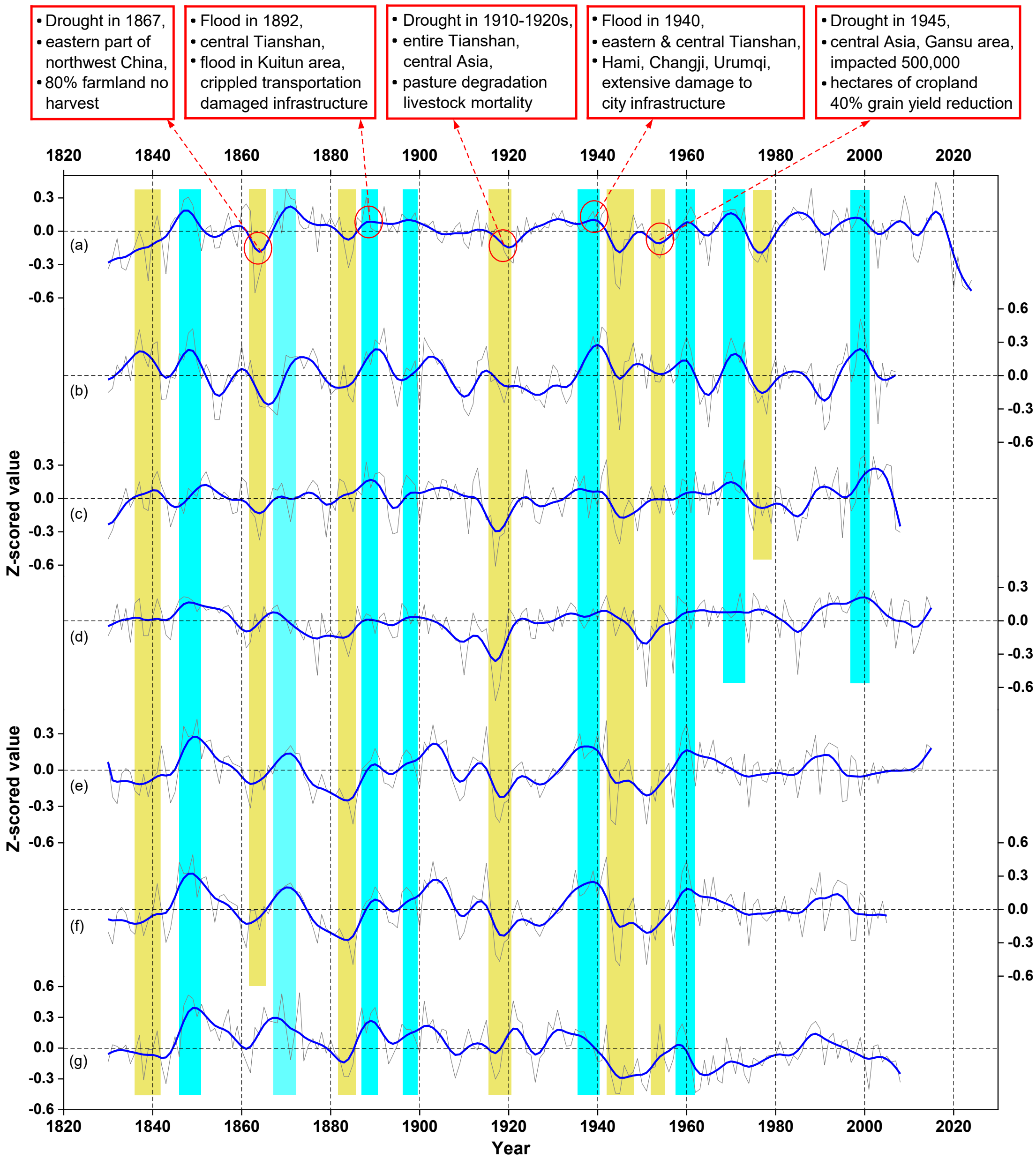


Fig. 10 Comparison of multiple hydroclimatic reconstructions across the Tianshan Mountains from different studies: (a) precipitation reconstruction from this study; (b) precipitation reconstruction for the eastern Tianshan Mountains (Zhang et al., 2015); (c) PDSI drought reconstruction for the inner Tianshan Mountains (Zhang et al., 2017); (d) SPEI drought reconstruction for the central Tianshan Mountains (Ma et al., 2025); (e) PDSI drought reconstruction for the Tianshan Mountains (Wang et al., 2021); (f) SPEI drought reconstruction for the central Tianshan Mountains (Jiang et al., 2017); and (g) SPEI drought reconstruction for the central Tianshan Mountains (Xu et al., 2014). The historical archives of climate events are shown in the red boxes on the top.