Reviewer 1:

This study presents a tree-ring based reconstruction of annual precipitation (previous July to current June) for the eastern Tianshan Mountains spanning 1830–2020. However, the explained variance of the reconstruction is only 37.6%, which falls below the generally accepted threshold of >40% reported in most dendroclimatological publications. Given the extensive body of dendroclimatological research already conducted in the Tianshan Mountains, including the eastern region, for example, Zhang et al. (2015) reconstructed precipitation variations for the Mulei region over the past 281 years, this work offers limited novelty in terms of both reconstruction length and temporal coverage. Furthermore, the discussion remains superficial and fails to generate new insights into climate change in the eastern Tianshan Mountains. Therefore, the manuscript is not suitable for publication in Climate of the Past in its current form.

Author response:

First of all, we acknowledge that the Tianshan Mountains have been extensively investigated through previous tree-ring studies, including Zhang et al. (2015) for the eastern sector. Nevertheless, our study differs from these earlier efforts in several critical respects:

First, while most prior dendroclimatic research in this region has focused on reconstructing drought severity (e.g., via PDSI or SPEI), direct precipitation reconstructions have been exceptionally rare. This is not a trivial distinction: drought indices are tightly coupled to evapotranspiration, which is highly sensitive to temperature and introduces a warming-driven bias into the reconstructed signal. Direct reconstructing precipitation is more important providing explicit hydrological information which is a fundamental baseline for understanding water resource dynamics. Second, regarding precipitation reconstruction specifically, our study is distinguished by a substantially larger and more comprehensive dataset—comprising 161 tree-ring samples collected from five 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.

Specific Comments

Table 2: Is "S" intended to denote the Sign Test (ST)? I question whether the authors fully understand what ST represents and how it is calculated. For the period 1961–1990, N = 30, yet the reported ST is 27+/11−; similarly, for 1991–2020, N = 30 but ST is reported as 30+/7−. These values are inconsistent with the sample sizes and require clarification.

Author response:

Thank you for pointing out this critical mistake. Yes, we intended to denote the Sign Test. We apologize for the typographical errors in the original submission and have now replaced the incorrect values with the corrected Sign Test results. Following is the table showing the calibration and verification (including the reverse calibration and verification) results to the climate reconstruction model that we will incorporate in this revised manuscript:

Table 2 Calibration and verification statistics for the precipitation reconstruction model (split-sample method)

Period	*r*	R^2	*F*	*RE*	*CE*	*ST*
Calibration (1961-1990)	0.56	0.31				/
Verification (1991-2020)	0.65	0.423	19.0	0.39	0.11	23+/7-
Calibration (1991-2020)	0.59	0.34				/
Verification (1961-1990)	0.68	0.46	18.5	0.31	0.21	19+/11-
Full calibration (1961-2020)	0.62	0.382	35.9	—	—	—

Line 215–225: This section should characterize the temporal patterns of precipitation variability, rather than merely listing dry and wet years. A more systematic analysis of decadal to centennial trends, periodicities, or regime shifts is needed. Moreover, regarding the statement "although some discrepancies are evident", what specific discrepancies are being referred to?

Author response:

Thanks. We have carried out multi-taper-spectrum analysis to demonstrate the periodicities of the historical precipitation variability, and we are going to insert the following figure and relevant findings in the results section:

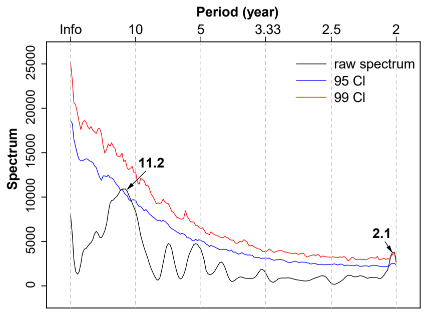

Fig. 9 Multi-taper spectrum analysis of the reconstructed July – June precipitation. Blue and red lines denote the 95% and 99% confidence levels (CI confidence intervals), respectively. Significant periods at the 95% confidence level are marked.

"According to the results of the multi-taper-spectrum analysis, the 191-year precipitation reconstruction (Fig. 8) exhibits short-period (2.1-year) and long-period (11.2-year) cycles of variability. This suggests that the El Niño–Southern Oscillation (ENSO) and solar activity exerted a considerable influence on precipitation variability in the eastern Tianshan."

Also, we are going to use the following content to interpretate the discrepancies between precipitation reconstruction in our study with nearby climate reconstructions, and we will add this to the discussion section:

"Despite this general consistency, several disagreements merit attention. First, our reconstruction indicates only modest wetness during 1960s, whereas Jiang et al. (2017) shows a pronounced wet phase for the same period. This discrepancy is likely attributable to the different reconstructed

variables—our study focuses on annual precipitation, while Jiang et al. (2017) reconstructed PDSI, which integrates both temperature and moisture balance. Second, the wet period during 1930s in our reconstruction was appeared to be as dry in Zhang et al. (2017). This mismatch may reflect differences in the seasonal window of the reconstructed climate variable (annual precipitation in our study vs. spring drought in Zhang et al. 2017)".

Line 28–30: It is inappropriate to state that "The validity of our reconstruction is further supported by its strong agreement with other precipitation and drought reconstructions from nearby regions." The validity of a reconstruction should be established primarily on the strength of the tree-ring width–precipitation relationship and the robust statistical characteristics of the regression model. Agreement with independent records can only demonstrate spatial coherence of hydroclimatic conditions to a limited extent. Please revise all related statements throughout the manuscript accordingly.

Author response:

Thanks for pointing out the inappropriate point. We are going to revise the original statements as follows:

"*The validity of our reconstruction is assessed and confirmed by the calibration/validation statistics of the climate reconstruction model. The consistency with existing precipitation and drought reconstructions from nearby regions supported that the observed patterns reflect regional hydroclimatic variability*".

Line 101–104: The spatial distribution of the five sampling sites (longitude, latitude) and the 180 sampled trees is unclear. What is the distance between sites? What is the rationale for combining 161 samples from five distinct sites into a single tree-ring chronology? The sampling environment, including associated tree species, soil conditions, and inter-tree distances, should be described in detail to allow readers to assess sampling conditions and interpret the tree growth–climate relationship appropriately.

Author response:

Thanks for the suggestion. In order to develop a robust, regional-scale reconstruction of precipitation for the eastern Tianshan, a multi-site composite chronology was developed from five spatially distinct sampling sites. Out of 180 tree ring samples 161 samples passed the cross-dating, and accordingly we established a composite chronology. In the revised manuscript, we will provide the geographical coordinates of all the sampling sites as well as the soil conditions. We are going to insert the following table which includes the coordinates of the sampling sites into the manuscript:

Table 1 Site information of the tree ring sampling sites

Sites	Latitude	Longitude	Elevation (m)	Number of cores	Slope
1	43.66	90.15	2265	32	30°
2	43.64	90.14	2279	28	34°
3	43.65	90.15	2312	30	33°
4	43.64	90.16	2288	29	36°
5	43.66	90.18	2295	31	32°

The soil conditions of the sampling region as follows and we will incorporate this information in the corresponding position within the text of revised manuscript:

"The soil in the sampled region consists of Leptosols, which are shallow soils characterized by limited depth and high rock fragment content."

During the revision, we will also insert following revised map illustrating the location of study area and the sampling sites:

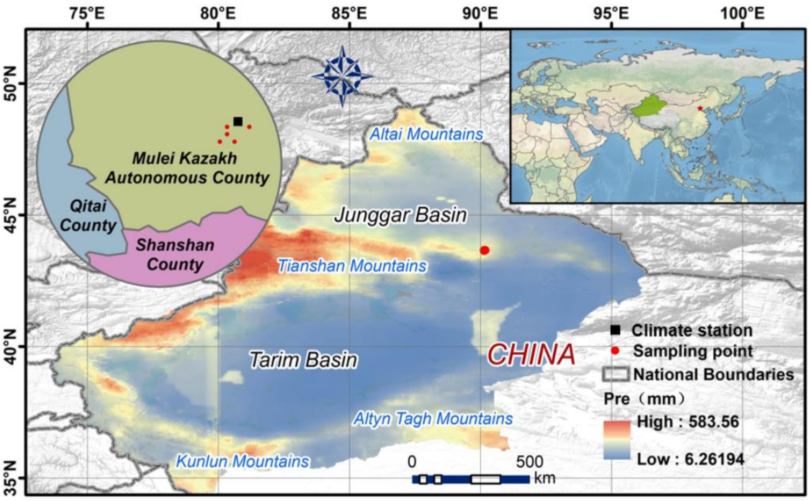

Fig. 1 Location map of the study area showing the tree ring sampling sites and climate station.

Fig. 1: The map scale is too large to clearly display the five sampling sites. Please rescale the map or provide an enlarged inset showing the sampling locations and meteorological station. The geographic coordinates (longitude, latitude) and elevation of the Mulei meteorological station should be reported.

Author response:

Thanks for the suggestion. According to the reviewer, we have re-created the map of the study area, in the new map, the location of the sampling sites and the Mulei climate station is marked clearly. We are going to insert updated location map (please refer to previous response) into the manuscript.

Line 122–126 and Table 1: The reported Rbar and EPS values appear to derive from a common period analysis rather than the full chronology length (1830–2020). Please specify the common period used. Generally, running Rbar and EPS statistics are more informative for evaluating chronology quality and should be provided.

Author response:

Thanks for the important suggestion. We have calculated the running Rbar and EPS using 30 – year window. We have updated the Fig. 3 in the original manuscript, and will insert following new figure which is illustrating the running Rbar and EPS in the revised manuscript:

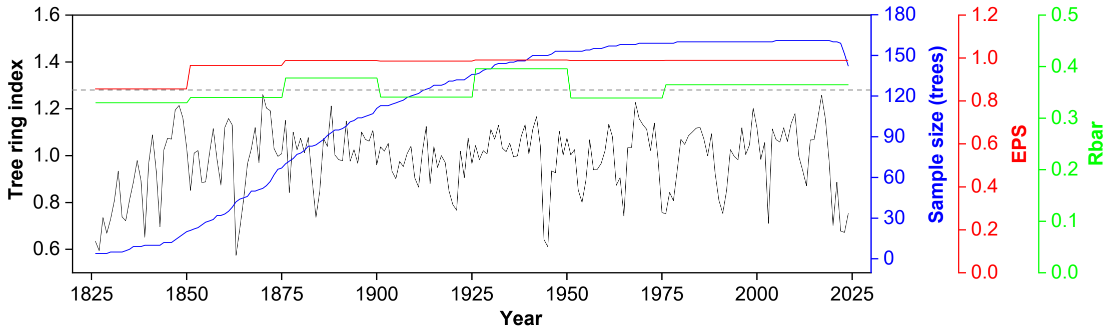

Fig. 3 Standard TRW chronology and sample size for Schrenk spruce in the eastern Tianshan

Mountains (chronology: black line; sample size: blue line; running Rbar: green line; running EPS: red line; grey line is the threshold of EPS 0.85).

Line 203: The text states RE = 0.18 and CE = 0.15, but these values do not match those in Table 2. Please clarify this discrepancy.

Author response:

Thanks a lot for pointing it out. We will correct it in the revised manuscript and keep consistency.

Table 2:

1. The calibration–verification scheme uses 1961–1990 for calibration and 1991–2020 for verification. Have the authors performed the reverse calibration–verification test (i.e., calibration on 1991–2020 and verification on 1961–1990)?

   Author response:

   We thank the reviewer for this constructive suggestion. We agree that performing the reverse calibration–verification test helps to further validate the stability of our reconstruction model. Following the reviewer's advice, we have now conducted the reverse split-sample validation. Both the RE and CE values are positive, and the sign test is statistically significant ($p < 0.05$), indicating that the regression model maintains robust predictive skill even when the calibration and verification periods are exchanged, further confirming the reliability of our reconstruction model. Following is the specific results, and we will incorporate these new results into the revised manuscript:

Period	*r*	r^2	*F*	*RE*	*CE*	*ST*
Calibration (1961-1990)	0.56	0.31				/
Verification (1991-2020)	0.65	0.423	19.0	0.39	0.11	23+/7-
Calibration (1991-2020)	0.59	0.34				/
Verification (1961-1990)	0.68	0.46	18.5	0.31	0.21	19+/11-
Full calibration (1961-2020)	0.62	0.382	35.9	—	—	—

2. How is the statistical significance of F, RE, CE, and ST evaluated? Please also cite relevant standards or references.

   Author response:

   Thanks for this constructive comment. We have prepared relative information to evaluate the statistical significance of F, RE, CE, and ST, and we will insert following content and references in the method section:

   "*Positive values of RE and CE demonstrate that the model's predictive skill surpasses the climatological reference, thereby supporting the robustness of the reconstruction. In addition, the significance of both the sign test (ST) and the F-test at p<0.05 level provides statistical evidence for the model's performance, validating its ability to accurately capture inter-annual variability (Cook et al., 1990, 1999)*".

Cook, E. R., & Kairiukstis, L. A. (Eds.). (1990). Methods of Dendrochronology: Applications in the Environmental Sciences. Springer.

Cook, E. R., Meko, D. M., Stahle, D. W., & Cleaveland, M. K. (1999). Drought reconstructions for the continental United States. Journal of Climate, 12(4), 1145-1162.

Line 217–219: Please provide references for the criteria used to define dry (extremely dry) and wet (extremely wet) years.

Author response:

In many dendroclimatic reconstruction studies, the classification of dry and wet years is typically based on the deviation of precipitation or drought indices from their long-term mean, measured in units of standard deviation (σ). Specifically, years with a positive deviation exceeding one standard deviation (i.e., > +1σ) are conventionally defined as wet years, whereas those with a negative deviation exceeding one standard deviation (i.e., < –1σ) are defined as dry years. Furthermore, years with deviations exceeding two standard deviations (> +2σ or < –2σ) are respectively categorized as extreme wet or extreme dry years. We will provide the relevant methodological details in the corresponding section of the revised manuscript and will incorporate the following references:

Keyimu, M., Li, Z., Fu, B., Liu, G., Zeng, F., Chen, W., Fan, Z., Fang, K., Wu, X., & Wang, X. (2021). A 406-year non-growing-season precipitation reconstruction in the southeastern Tibetan Plateau. Climate of the Past, 17(6), 2381–2392. https://doi.org/10.5194/cp-17-2381-2021

Ahmad, S., Zhu, L., Yasmeen, S., Zhang, Y., Li, Z., Ullah, S., Han, S., & Wang, X. (2020). A 424-year tree-ring-based Palmer Drought Severity Index reconstruction of Cedrus deodara D. Don from the Hindu Kush range of Pakistan: Linkages to ocean oscillations. Climate of the Past, 16(2), 783–798. https://doi.org/10.5194/cp-16-783-2020

Fig. 8 and Line 315: What does "11-year loess smoothed trend" mean? Please clarify the smoothing parameters and methodology. Additionally, the "11-year loess smoothed trend" in this figure does not match that in Fig. 9a. Please clarify this difference.

Author response:

We thank the reviewer for pointing out the need to clarify the smoothing methodology.

Part 1: The "11-year loess smoothed trend" refers to the application of the Locally Weighted Regression (LOESS), a non-parametric smoothing method introduced by Cleveland (1979), to extract the low-frequency (in our study it is 11 years) variability from our reconstructed precipitation series, while suppressing interannual fluctuations. We used R program to smooth the original precipitation series, following is the R code, and we will provide this R code in the supplementary file so that this method can be reproducible:

```
“library(dplR)
library(graphics)
library(utils)
dat=read.csv('dat-series.comparison.csv')
par(mfrow = c(3,2))
par(mar=c(1,3,1,2))
par(tcl=0.3,mgp=c(1.5,0.2,0),cex=0.8)
n=length(dat[1,])
for(i in 2:n)
{
x=dat[,1]
y=dat[,i]
not.na <- !is.na(y)
x <- x[not.na]
```

```
y <- y[not.na]
y2=ffcsaps(y,nyrs=11)
plot(x,y,type='n',xlab="Year",ylab=expression(mm^2))
lines(x,y,col="grey",lty='dashed')
lines(x,y2,col='red',lwd=2)
out.cell=cbind(x,y2)
colnames(out.cell)=c('year',colnames(dat)[i])
write.csv(out.cell,paste('result_',colnames(dat)[i],'.csv',sep=''))
}”
```

Part 2: We Z-scored the reconstructed precipitation series to create the figure 9a. The reason why the figure 8 and figure 9a looked different maybe because of the different height of these two figures, height of the figure 8 is larger than the figure 9a, we have double checked the two series during the revision, and they are confirmed to be the same.

Line 222–224: The results presented in Fig. 10 are not sufficiently convincing to support the claim that precipitation in the study area captures climatic variability across the broader eastern Tianshan region.

Author response:

We sincerely thank the reviewer for the constructive comment and suggestion on spatial representativeness. In the original manuscript, we used CRU based precipitation data to carry out spatial correlation analysis, apparently the results were not good enough. During the 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 figure caption. We will insert the updated figure in the manuscript and make corresponding revision to the text accordingly.

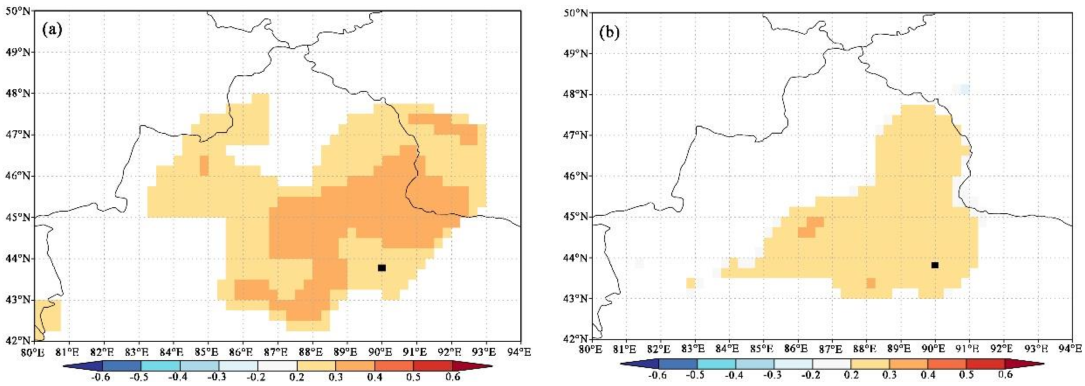

Fig. 10 Spatial correlations of actual (a) and reconstructed (b) precipitation with a gridded precipitation dataset during their overlapping periods (1961–2020). The black square indicates the location of the study site.

Line 312–328: The comparison with other records should explicitly address similarities and differences, rather than offering general and vague statements. A more critical and structured synthesis is required.

Author response:

We thank the reviewer for this critical and constructive comment. We have revised this section to provide a more rigorous and structural comparison.

Specifically, we have restructured the comparison into three parts: (1) common dry and wet episodes that are consistently identified across multiple records, with explicit mention of specific periods and the studies that support them; (2) notable discrepancies, where we now pinpoint the exact periods of disagreement and provide targeted explanations based on differences in reconstructed variables, seasonal windows, species sensitivity, and site geography; and (3) correlation patterns, where we rank the correlation coefficients and interpret them in terms of spatial proximity and methodological similarity. We have also added a concluding synthesis that clearly states the incremental value of our reconstruction, that it provides an independent, annually resolved precipitation record that complements existing PDSI-based reconstructions and extends the spatial coverage for the eastern Tianshan. We have modified the original line "312-328" and we will incorporate following updated discussion into the corresponding position of the manuscript:

"*To evaluate the reliability and spatial coherence of our precipitation reconstruction, we compared it with six hydroclimatic reconstructions from the eastern Tianshan and adjacent regions (Zhang et al., 2015; Jiang et al., 2017; Zhang et al., 2017; Ma et al., 2017; Wang et al., 2021; Xu et al., 2014). All series were smoothed with an 11-year LOESS filter to highlight decadal-to-multidecadal variability (Fig. 10).*

Our reconstruction and the six comparative records show consistent identification of several major dry periods, including the severe droughts of the 1880s–1885s and 1940s–1950s. The latter dry episode, in particular, is documented by Xu et al. (2018) and Zhang et al. (2015) as a regionally extensive event affecting the entire Tianshan region. Similarly, wet phases during the 1850s and 1960s are apparent in all comparable records, pointing to a broad-scale moisture increase potentially driven by large-scale atmospheric circulation patterns.

Despite this general consistency, several disagreements merit attention. First, our reconstruction indicates only modest wetness during 1960s, whereas Jiang et al. (2017) shows a pronounced wet phase for the same period. This discrepancy is likely attributable to the different reconstructed variables—our study focuses on annual precipitation, while Jiang et al. (2017) reconstructed PDSI, which integrates both temperature and moisture balance. Second, the wet period during 1930s in our reconstruction was appeared to be as dry in Zhang et al. (2017). This mismatch may reflect differences in the seasonal window of the reconstructed climate variable (annual precipitation in our study vs. spring drought in Zhang et al. 2017).

Correlation strength between our reconstruction and comparable records from surrounding regions (Zhang et al., 2015; Jiang et al., 2017; Zhang et al., 2017; Ma et al., 2017; Wang et al., 2021; Xu et al., 2014) is not uniform. These differential correlations may be partially explained by geographical proximity between study sites. The highest correlation (R = 0.53) is observed with Zhang et al (2015), which shares the closest geographical proximity to our study site and reconstructs a similar hydroclimatic variable. Conversely, the weaker correlation (R = 0.14) with Xu et al., 2014 may be explained by the greater distance between sites and the different seasonal window of reconstruction".

Line 219–220: The statement "A complete listing of these years is provided in Table 3" suggests that individual dry/wet years are tabulated. However, Table 3 presents dry and wet *periods*, not specific years. Please revise the text or the table to ensure consistency.

Author response:

Thanks. According to the suggestion, we have altered the interpretation in the text, and now it is in consistent with the table.

Fig. 5:

1. Explain the meaning of the light blue shaded band.

   Author response: We thank the reviewer for pointing out this omission. The light blue shaded band represents the 95% confidence interval for the correlation coefficients. We are going to add this information into the caption of Fig. 5.
2. The unit for precipitation should be "mm".

   Author response: Done.
3. The standard symbol for the correlation coefficient is lowercase "*r*", as that in Table 2. Please replace "R" with "*r*" for consistency (also for Fig. 7).

   Author response: Done
4. Ensure consistency throughout the manuscript in referring to the target variable: use either "July–June precipitation," "annual precipitation," or "precipitation from the previous July through the current June" uniformly.

   Author response: Thanks. According to the suggestion, we will use July – June precipitation throughout the manuscript.

Line 151-154: Classic reference(s) for the split-sample calibration–verification procedure should be provided.

Author response:

We will insert following references for the split-sample calibration–verification procedure and insert them in the revised manuscript:

Fritts, H. C., Guiot, J., Gordon, G. A., & Schweingruber, F. (1990). Methods of calibration, verification, and reconstruction. In Methods of Dendrochronology (pp. 163–217). Springer, Dordrecht.

Cook, E. R., & Kairiukstis, L. A. (Eds.). (1990). Methods of Dendrochronology: Applications in the Environmental Sciences. Springer, Dordrecht.