Author response to Anonymous Referee #2

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General comments:

I believe high-resolution hydroclimatic records during the last millennium in Tienshan Mts will be welcomed by both paleoclimatologists and archeologists. This study made a good attempt. In general, the manuscript is properly organized and well written. The scientific topic is significant and main conclusions are convincing. It is suitable for the scope of this journal. Therefore, I recommend acceptance of the manuscript for publication after some minor revisions.

We thank the reviewer very much for reviewing the manuscript. All suggestions are careful and insightful, which will help us improve the manuscript. Accordingly, we have prepared detailed point-by-point responses below. Our responses to the comments have been made in *blue*. Line numbers that refer to the changes in the revised manuscript version have been marked in *red*.

1. There are still some records suggesting a humid MWP around Tianshan Mts (e.g., Zhang et al., 2009[doi: 10.1029/2009gl037375]). Could you please provide some discussions?

Thanks for the comment. Yes, a humid climate during the MWP was documented by the tree ring of Sabina przewalskii Kom, the Lop Nur, and the Daxigou profile in the Tianshan Mountains, etc. in the earlier studies (Zhang et al., 2009; Ma et al., 2008; Zhang et al., 2003). However, a growing body of studies based on the variety of paleoclimate records show a general climate pattern of a relatively dry MWP and a wet LIA (Chen et al., 2006; Song et al., 2015; Lan et al., 2018; Lan et al., 2019; Zhao et al., 2009; He et al., 2013; Ma and Edmunds, 2006; Gates et al., 2008; Rousseau et al., 2020; Chen et al., 2015; Chen et al., 2010; Chen et al., 2019). We have provided relevant discussions in sections of “Introduction” and “Discussion” according to the above two respects. (Lines 49-58, 207-212)

2. Previous studies have already proposed "an unstable hydroclimate during the LIA over the ACA" (e.g., Chen et al., 2009 [doi: 10.1007/s11434-009-0201-8], 2019[doi: 10.1007/s00382-019-04685-5]) on multi-decadal to centennial timescales, which should not be neglected in the relevant discussion part.

Good suggestion! The research of the unstable hydroclimate during the LIA is an important reference, but it is not clear how the specific unstable wet and dry climate

fluctuated during the LIA. Our reconstruction provides new evidence for the unstable hydroclimate variability during the LIA. More relevant discussions have been added in "section 5.2". (Lines 220-232)

3. In "5.3 Linkage to ENSO", the significance of ENSO variance for hydroclimate in ACA, or Asia, should be firstly pointed out. It is also notable that the referred work (Huang et al., 2017) could not be used as evidence for the influence of ENSO variance on extreme rainfall events in this region - It focuses on ENSO itself rather than ENSO variance.

Thanks for the comment. The significance of ENSO variance for hydroclimate in ACA has been added in the discussion in "section 5.3.3 Linkage to ENSO" of the revision. The influence of ENSO on the extratropical climate has been shown to be modulated by ENSO variance at multidecadal timescales, and the calculated 31-year running correlations between the reconstructed ENSO variance and other records of ENSO teleconnections shows that the ENSO teleconnection is robust over Central Asia during the past seven centuries only except for the Maunder minimum (Li et al., 2013). (Lines 338-339, 360-366)
Moreover, the ENSO variance is the calculated 21-yr running biweight variance derived by the ENSO variability, reflecting changes in ENSO itself (Li et al., 2011). In other words, the changes of ENSO itself contribute to the multidecadal-timescale ENSO variance. In the manuscript, we suggest that the ENSO variance effect on the hydroclimate changes in ACA might be through modulating the extreme precipitation. Previous studies indicate that the water vapor from the Arabian Sea may be transported to the Xinjiang region and cause heavy precipitation, although the water vapor fluxes mostly come from the west transported by the prevailing westerlies (Huang et al., 2015; Huang et al., 2013). Observational reanalysis data show that water vapor in ACA also comes from the Indian Ocean and cause heavy precipitation, which gives us a good theoretical and data support, although the driving mechanisms of ENSO variance for the hydroclimate changes in ACA require further exploration through high-resolution records and simulation experiments. We have added more relevant discussions in the section "Linkage to ENSO" of the revised manuscript. (Lines 364-377)

Technical comments:

1. The contour lines should be further smoothed in Figure 1c.

Thank you. We have further smoothed the contour lines in Figure 1c.

2. In Figure 3b, I know what you mean, but where are the "black dots"?

Thanks for this comment. We have revised “black dots” to “Black dotted lines”.

3. It would be better to use "centennial" timescale when "multi-decadal" timescale was used.

Thanks for the comment. Yes, the "centennial" is a good choice, but it was also usually referred to as “multi-centennial”. The aim we used “century” in this manuscript is to correspond to cycles of solar activity from 88 to 146 years because the Glasberg cycle is also known as the century-type cycle (Gleissberg, 1958; Ogurtsov et al., 2002). Thus, the “multi-decadal, century, and multi-centennial” were used to correspond different forcing at different timescales.

4. P5L140, "Positive and negative Z-scores indicate dry and wet climatic conditions". It seems to me that positive Z-scores indicate dry conditions, and vice versa. Please revise it.

Thanks! We have revised the manuscript accordingly. (Line 198)

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