# Author response to Anonymous Referee #1

## Article ID: cp-2021-137

**General comments:**

The instability of humidity variation, especially on decadal to multi-decadal timescales, has a profound impact on human welfare in arid central Asia (ACA). However, it is still uncertain whether the regional hydrological evolution was controlled by external driving or internal driving. In this study, the authors provided a ~1.8-year high-resolution humidity record spinning the past 840 years from Lake Dalongchi. Based on this record, a dry Medieval Warm Period (MWP) and a wet, unstable Little Ice Age (LIA) was determined. Moreover, they suggested that the climate instability during the LIA was controlled by Gleissberg solar cycle and ENSO on centennial and multi-decadal timescales, respectively. Such high-resolution record is very rare in the ACA. This manuscript provides critical insights into regional climate change history, although the results still need to be further corroborated. Therefore, I suggest that the manuscript can be accepted for publication after a minor revision.

We are very grateful to the reviewer for your careful review and helpful comments on this paper. These suggestions are conductive to revise and improve our manuscript. Accordingly, we have prepared detailed point-by-point responses below. Our responses to the comments have been made in *blue*. Line numbers and revised figure numbers that refer to the changes in the revised manuscript have been marked in *red*.

**Major comments:**

1. A previous study discussed climate instability in Northwestern China during the LIA, which proposed that the instability of North Atlantic Oscillation (NAO) was a major driving factor (Chen et al., 2019). In this manuscript, the authors emphasized the influences of solar forcing and ENSO on climate instability during the LIA, but neglected the influences of NAO. It would make the conclusions more complete by adding the related discussion in the manuscript.
Chen, J., Liu, J., Zhang, X., Chen, S., Huang, W., Chen, J., Zhang, S., Zhou, A., and Chen, F. Unstable Little Ice Age climate revealed by high-resolution proxy records from northwestern China, Climate Dynamics, 2019, 53, 1-10.

Good points. Thanks for the comment. NAO and AMO are important factors in influencing the hydroclimate changes of ACA during the past millennium. As suggested, we have added a section "5.3.1 The influence of NAO and AMO" to provide more

corresponding discussion through comparing our reconstruction with the reconstructed NAO and AMO (Ortega et al., 2015; Wang et al., 2017). The results show that the relationship between HI and NAO, and AMO is ambiguous on multidecadal timescales, and the Wavelet Coherence (WTC) results also show their relationships are nonpersistent. But on the multi-centennial timescales, our reconstruction reveals the dominant dry climate conditions during the Medieval Warm Period (MWP) and humid climate conditions during the Little Ice Age (LIA), which is related to the generally positive and negative phases exhibited in the NAO and AMO. This is in agreement with the previous studies (Chen et al., 2006; Lan et al., 2018; Chen et al., 2019b; Chen et al., 2019a). The relevant discussions added in the manuscript make the conclusions more complete. (Lines 237-264, Fig. 6 and Fig. S2 in the Supplement)

2. During 1400-1800 CE, the variation of humidity index was negatively correlated with that of ENSO variance (Fig. 7d). However, the humidity index showed consistent variation with ENSO variance during 1800-1950 CE. How to explain the complicated relationship between humidity index and ENSO variance? More discussion is needed in here.

Thanks for the comment. There is a negative phase relationship between the HI and ENSO variance at multidecadal timescales. However, this relationship can only be revealed by the WTC results, rather than the two datasets, because the original HI contains a variety of signals at different timescales. To solve such a problem, we further performed the ensemble empirical mode decomposition (EEMD), a new noise-assisted data analysis method (Huang et al., 1998; Wu and Huang, 2009), to extract the multidecadal signals of the HI. Interestingly, the extracted multidecadal component of the HI exhibits better inverse relationship with the ENSO variance almost throughout the entire time series (*please see the following Figure 1*), which is in line with the WTC results. More discussions were added in the revised manuscript. (Lines 358-377, Fig. 7g and Fig. S3b in the Supplement)
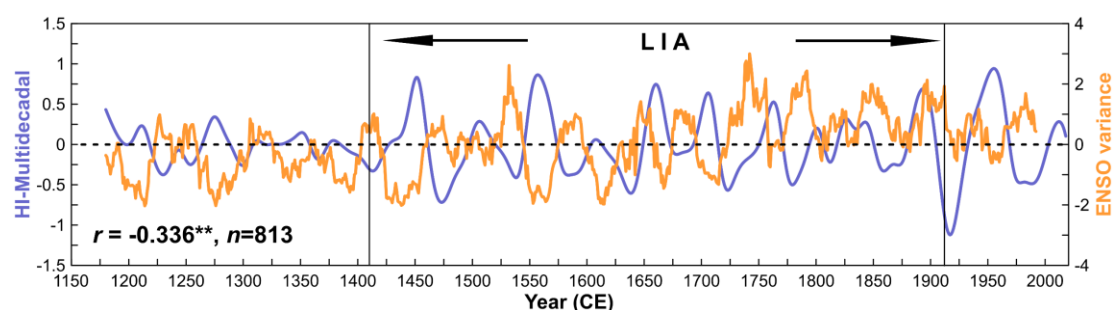


Figure 1. The comparison between the multidecadal component of HI extracted by EEMD and ENSO variance (Li et al., 2011).

3. Figure 6 shows the comparison of humidity records from Lake Dalongchi with other records. However, the authors only use one sentence to describe it (Lines 146-149). It would be better to add more statements.

Thanks for the comment. We have added more discussions about the comparison of our humidity records with other records. (Lines 207-232)

**Minor comments**

1. In Line 140, the authors stated that "Positive and negative Z-scores indicate dry and wet climatic conditions (Fig. 5a)." But this statement is opposite to the contents of Figure 5.

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

2. The authors used bacon 2.2 to establish the age-depth model. However, the latest version is bacon 2.5.7, which used new calibration curve.

Thanks for the reminder. We have used bacon 2.5.7 version to establish the age-depth model in the revised manuscript and updated all figures based on new chronology model.

3. The statement of "at different timescales" should be changed to "on different timescales". This issue should be revised throughout the whole manuscript.

Thanks! We have revised the whole manuscript accordingly.

4. Line 89: Is "mass susceptibility" supposed to "magnetic susceptibility"?

Yes. Thank you. We have revised it to "magnetic susceptibility". (Line 130)

5. Line 119, 120: Change "fraction" to "percentage".

Thanks. We have revised the manuscript accordingly. (Line 167, 168)

6. Line 133: Change "high susceptibility" to "high MS values".

Thanks. We have revised it. (Line 191)

7. Line 143: Given that the correlation coefficient between humidify index and instrumental data is only 0.298, it's inaccurate to state it as "good consistency".

Thanks for your reminder. We appreciate this comment. We have revised our statement in the manuscript as follows: "There is a generally positive correlation (r = 0.298*) between the reconstructed HI and the instrumental relative humidity records

over the past 60 years from the nearby Bayanbuluk meteorological station at the 0.05 significant level, verifying the reliability of the humidity reconstruction." (Lines 200-202).

8. Line 245-247: The DOI of this paper was missed.

Thanks. We have revised it. (Lines 406-408)

9. Line 358: The "." should be removed from "10.1029/2009GL040951.,".

Thanks. We have revised it. (Line 689)

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