Dear reviewer,

Thank you for your letter and for the comments concerning our manuscript entitled "Tracing seasonal signals in dry/wet status for regions with simultaneous rain and heat from Eastern and Central Asia since the Last Glacial Maximum". Thanks very much for giving us such a precious chance. Those comments and suggestions are all valuable and very helpful for revising and improving our paper, as well as the important guiding significance to our research. We have studied all of the comments and suggestions carefully and made corresponding corrections in the manuscript with colored text. A detailed list of revisions against each point of reviewer that is being raised is below.

Reviewer 2

The authors presented a comprehensive analysis on the short-term and long-term climate changes in the Central Asia and the East Asia by making use of multiple datasets and simulation results. The conclusions are reasonably reliable based on the spatiotemporal correlation results. However, I have to say that most conclusions have been available throughout previous publications. Therefore, the authors are expected to indicate clearly what's new in their works in comparison to previous publications.

Response: We'd like to thank your constructive comments and suggestions on our manuscript. We appreciate the chance to clarify some concepts and have adopted all suggested changes raised by Reviewer 2. In addition, we have scrutinized the text for additional minor errors and to improve clarity and readability, which are also highlighted in the revised version. We sincerely hope this revision meets with your approval. Considering your concern, we would like to reiterate the innovation of the article, hoping to meet your requirements, as follows: First, we traced the impact of seasonal signals in dry/wet status for EA and CA based on the climate phenomenon of simultaneous rain and heat. We divided summer precipitation regimes and winter precipitation regimes based on multi-year summer and winter mean precipitation. A comprehensive study of multi-timescale datasets including modern observations, paleoclimate records, and paleoclimate simulations since the LGM was carried out for

EA and the east of CA with the summer precipitation regimes. Secondly, we clarified the differences and linkages between dry/wet status in EA and CA at multi-time scales. Although there are overall differences in climate change patterns between the two regions, they also share some spatial connections. Finally, we proposed that the seasonal precipitation signal driven by simultaneous rain and heat is an important factor creating this connection between EA and CA. We suggested the common influence of the seasonal signal on EA and the east CA with summer precipitation regimes, both on short-term and long-term timescales. In summary, we analyzed the contradictions in dry/wet status in EA and CA from a new perspective and combined a variety of data to confirm it from various aspects.

1. Generally, definition of the Central Asia and the East Asia is a geographical, or even geopolitical, rather than climatological concept. Misunderstanding may arise certainly when performing spatiotemporal correlation referring to the domains of the Central Asia and the East Asia. For instance, the authors indicated that "In summer precipitation, the centers of positive values are mainly distributed in the north of EA, while the negative values are mainly distributed in CA and south of EA" (Lines 248-250). If this is the case, the north of EA separates from the south of EA, which shares a feature of CA. Climatologically, CA and south of EA should belong to the same domain, while the north of EA belongs to another domain. A similar concern arises out in respect to the winter and annual precipitation.

Response: Thanks very much for your comments. First, we agree with your perspective on defining EA and CA, and indeed, we defined the scope of the study area based on the geographical distribution of EA and CA. Subsequently, we found that by observing the differences in summer and winter precipitation in the EA and CA, non-simultaneous regions of rain and heat periods mostly belong to the core area of CA, while simultaneous regions of rain and heat periods are primarily located in EA and the east of CA (the arid regions of Northwestern China and Southern Mongolia) (China's monsoon region). Now, given your emphasis on the geographical concept, along with previous studies on hydroclimate changes in EA and CA (Chen et al., 2021; Ren et al.,

2021; Qi and Han, 2022;), we have outlined the region's scope of EA and CA and updated the description in the revised manuscript, as follow:

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In this study, we divide the boundaries of CA and EA mainly according to the modern Asian summer monsoon limit designed by Chen et al. (2008, 2019). CA is the largest arid and semi-arid areas in the mid-latitude hinterland of the Eurasian continent, extending from the Caspian Sea in the west to the modern Asian summer monsoon limit in the east, comprising the central Asian countries, NW China, and southern Mongolian Plateau (Fig. 1). Considering that the strength and trajectory of monsoon circulation is a major control on moisture in EA, we viewed Chinese monsoon region in the east and south of the modern Asian summer monsoon limit in China as EA (Fig. 1). We calculated the precipitation difference between the summer (April, May, June, July, August, and September) and winter (January, February, March, October, November, and December) half year over 1971-2020, and then defined the region greater than 0 mm as the simultaneous region of rain and heat periods. Therefore, we define the simultaneous region of rain and heat periods in CA as the east of CA (Fig. 1). The seasonality perspective implies that different precipitation regimes could affect the difference and linkage in climate change modes from EA and CA at the multi-time scale. Taking seasonal signals as the dividing criteria, the core region of CA is characterized by a wet cold-season climate, whereas EA and the east of CA are characterized by a wet warm-season climate (Fig. 1).

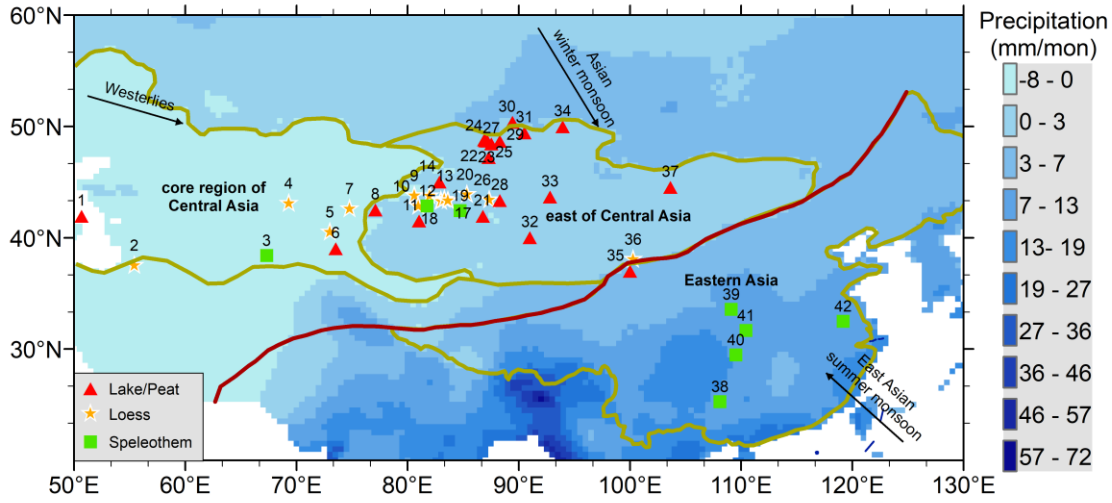

Figure. 1 *Overview map showing the paleoclimate record sites selected in this study from EA and CA, the difference between summer and winter precipitation over 1965-2014 (shade), and the dominant circulation systems, including the westerlies, Asian winter monsoon and East Asian summer monsoon. The modern Asian summer monsoon limit (red solid line) is summarized by Chen et al. (2008, 2019). The gray slash represents the simultaneous region of the rain and heat periods. The brown solid line represents the range of CA, the core region of CA, the east of CA, and EA as defined in this study.*

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Secondly, reanalyzing the EOF of precipitation in the four seasons, we found that the similarities between the summer precipitation in Central EA and the core region of CA are indeed a notable feature. And this feature exists in both summer and winter EOF, but similar EOF results between CA and south of EA do not always exist in winter and summer, therefore, we suggested that this feature may not be able to be specialized. Meanwhile, given the focus of our study on hydroclimate changes in eastern Central Asia, we did not analyze this feature in depth. Based on your comment, we added some new descriptions to avoid misunderstanding.

Reference:

Chen, C et al. (2021): Increasing summer precipitation in arid central Asia linked to the weakening of the East Asian summer monsoon in the recent decades. Int. J. Climatol. 41, 1024-1038.

Hu, Q et al. (2022): Northward Expansion of Desert Climate in Central Asia in Recent Decades. Geophys. Res. Lett. 49, e2022GL098895.

Ren, Y et al. (2021): Attribution of Dry and Wet Climatic Changes over Central Asia. J. Clim. 35,1399-1421.

2. The authors studied the seasonal signals at short-term timescales, and seasonal signals at long-term timescales. These two parts are quite distinguished, leaving the contribution is lack of a clear focus. It's certainly true that investigating the past climate is key to informing future climate change, but the authors may need to give an at-least roughly explanation how their works from the past decades and the last glacial period can be applied for such a purpose.

Response: Thanks very much for your suggestions. Based on the analyses of seasonal signals at short-term timescales and long-term timescales, our results provide a hypothesis that seasonal signals of precipitation derived from the simultaneity of rain and heat periods govern the difference and linkage in dry/wet status from EA and CA at multi-time scales. According to your suggestions, we added some speculations about possible future climate scenarios in the final paragraph of our discussion, i.e. "*With global warming and continued increase in winter solar radiation, we suggest that the core region of CA could face a persistent reduction in precipitation in the future. Meanwhile, the decrease in summer solar radiation could lead to a strengthening and southward shift of the summer westerly jet stream over CA, potentially increasing precipitation in the east of CA with summer precipitation regimes. However, more quantitative analyses are required to understand how future interannual variations in atmospheric and oceanic circulation might control the seasonal precipitation signals that influence dry/wet status in the east of CA.*". Moving forward, the focus of our research will be on quantitative analysis of future climate trends, and on comparing them with paleoclimate changes on multi-time scales.

3. The authors presented a compilation of 42 proxy records, which were divided into two groups in name of their precipitation regimes, i.e., winter or summer precipitation

regimes. I missed to find how the authors classificated the 42 proxy records. Especially, Lake Karakul (No. 6 in figure 1) and Lake Issyk- Kul (No.8) are included into winter or summer precipitation regimes, respectively. However, the sediment cores from Lake Karakul and Lake Issyk-Kul shared a common past climate feature (, wetter conditions during the EH and MH periods, see Lines 328-330). If this is the case, what's the reason(s) to label them into different precipitation regime?

Response: Thanks very much for your comments and suggestions. We apologize for this oversight. We defined the winter precipitation regimes and summer precipitation regimes based on the difference between the multi-year average summer and winter precipitation, the results showed that Lake Karakul and Lake Issyk-Kul belong to the winter precipitation regime and the summer precipitation regime, respectively. Figure 5f-i mainly indicates that the paleoclimate record with the summer precipitation regime in the east of CA has a comment dry/wet evolution with the EA mode affected by the East Asian summer monsoon. Therefore, Lake Karakul is not suitable as a typical climate record in this study to compare the dry/wet status in EA and CA and is incorrectly displayed here. Notably, the sediment cores from Lake Karakul with winter precipitation regime definitely have a similar dry/wet status with the paleoclimate records from EA since the LGM. The explanation in the original literature (Heinecke et al., 2017; Aichner et al., 2019) is that wetter conditions during the EH and MH periods are the result of the strengthening of the Indian summer monsoon. For these reasons, we deleted this curve in Figure 5.

Reference:

Aichner, B et al. (2019): Hydroclimate in the Pamirs was driven by changes in precipitation -evaporation seasonality since the last glacial period. Geophysical Research Letters, 46, 13,972–13,983.

Heinecke, L et al. (2017): Climatic and limnological changes at Lake Karakul (Tajikistan) during the last ~29 cal ka. Journal of Paleolimnology, 58(3), 317-334

4. In the abstract, the authors wrote that "seasonal signals of precipitation derived from the simultaneity of rain and heat periods could govern the difference and linkage in dry/wet status from EA and CA. EOF analysis results of mean annual precipitation". I wonder how to get seasonal signals from results of mean annual precipitation.

Response: Thanks very much for your comments. Our description here is not sufficiently clear. The original intent was to indicate that the EOF of mean annual precipitation highlighted the spatial diversity in EA and CA. Subsequently, by analyzing the EOF of precipitation in different seasons, we found similarities between precipitation regimes in EA and the east of CA, further confirming that summer precipitation regimes have a similar impact on EA and the east of CA. Based on your suggestion, we have amended the description in the abstract to "*At short-term timescales, EOF analysis results of mean annual precipitation uncover the spatial diversity of overall precipitation pattern in EA and CA.*".