Responses to the comments from Reviewer #2

We are very grateful to the reviewer for the positive and careful review. The thoughtful comments have helped improve the manuscript. The reviewer's comments are italicized and our responses immediately follow.

This is an interesting paper that analyzes the future changes in the streamflow extremes and its contributions from ecological factors over the Sanjiangyuan region based on observational data and model outputs driven by the CMIP6 data. Besides a regional accelerated hydrological cycle at different warming levels, the high risk of dry and wet extremes over the headwater of Yellow river and Yangtze river are also found. More importantly, the individual and combined impacts of land cover change and CO2 physiological forcing on projected hydrological changes are figured out and emphasized. Overall, the manuscript is well structured and presented, and there are a few minor comments below.

Response: Thanks for the comment.

1. *Line 156: I suggest references for CLM and CoLM are required here.*

Response: Revised as suggested.

2. *Lines 242-243: How to understand the phenomena that both the ET and runoff increase with the increase in precipitation, while the local water storage TWS changes little? Is it a common issue in the accelerated hydrological cycle in other regions? Maybe a further explanation for the little TWS change would be useful.*

Response: Thanks for the suggestion. We have explained it as follows:

"The terrestrial water storage, however, shows a slight but significant decreasing trend as increased evapotranspiration and runoff are larger than the increased precipitation. This decreasing trend of terrestrial water storage in the warming future is also found in six major basins in China (Jia et al., 2020)." (L410-414)

3. Line 251: Is "55%" statistically significant? I also suggest the significance tests for the rest of the changes at different warming levels in sections 3.2 and 3.3.

Response: Thanks for the suggestion. We have clarified it as:

"The frequency of streamflow dry extremes over the Yellow river is found to increase by 55% at 1.5°C warming level (Figure 5b), but the uncertainty is larger than the

ensemble mean." (L327-329)

Actually, we used the bootstrap method to estimate the uncertainty, and changes are considered to be significant when the ensemble mean is larger than the uncertainty range. We have clarified as:
"The relative changes in frequency of dry/wet extremes between the reference period and different warming periods were first calculated for each GCM under each SSP scenario, and the ensemble means were then determined for each warming level. To quantify the uncertainty, the above calculations were repeated by using the bootstrap 10,000 times, and 11 GCMs were resampled with replacement during each bootstrap (Christopher et al., 2018). The 5% and 95% percentiles of the total 10,000 estimations were finally taken as the 5~95% uncertainty ranges." (L257-263)

We have also added some statements on the uncertainties or significance in sections 3.2 and 3.3 as suggested:
"... the results become significant (Figure 5b). No statistically significant changes are found ..., as the uncertainty ranges are larger than the ensemble means."(L332-334)
"Moreover, contributions from climate change and ecological change are both smaller than the uncertainty ranges (not shown), suggesting that their impacts on the changes of dry extremes over the Yangtze river headwater region are not distinguishable." (L340-343)

4. Line 270: In Figure 5a, the PDF of precipitation at 1.5 degrees warming level doesn't shift to the right against the reference period. Please correct the statement.
Response: We have revised it as: "Over the Yellow river, PDFs of precipitation and evapotranspiration both shift to the right against the reference period, except for the precipitation at 1.5°C warming level." (L350-352)

5. Lines 269-272 and Lines 281-282: "Over the Yellow river. . . the increasing trend of ET is stronger than that of precipitation". "Over the Yangtze river, however, intensified ET is much smaller than the increased precipitation". How to understand the opposite phenomenon over the two regions? The change in ET significantly influences the streamflow extremes changes over the Yellow and Yangtze rivers headwaters. Maybe a brief mention of that here would be useful.

Response: Thanks for the comment. Actually, differences between headwaters of Yellow and Yangtze rivers are mainly caused by precipitation changes, as the increasing rate of ET at the Yangtze river headwater are similar to that at the Yellow river headwater. We have revised the statement as: "Over the Yangtze river, however, intensified precipitation is much larger than the increased evapotranspiration,...". (L365-366)

Different changing rates of precipitation over these two river source regions are beyond this work, so we do not discuss this in detail. Further work is needed to investigate the changes in horizontal moisture transport and local land-atmospheric exchanges.

6. Line 278: Change "Figure 3e" to "Figure 5e"?

Response: Thanks. We have changed "Figure 3e" to "Figure 6e" as a new figure was added to show the model structure.

7. Lines 274-280: "The above two factors together induce a heavier left tail in the PDFs of P-ET for the warming future than the reference period (Figure 5e). This indicates a higher probability of less water left for runoff generation at different warming levels, given little changes in TWS (section 3.1). Moreover, Figure 3e also shows little change to the right tails in the PDF of P-ET (P-ET>130mm) at different warming levels, suggesting little change to the probability of high residual water." It's hard to clearly distinguish the "heavier left tail" and "little change to the right tails" in Figure 5e and thus explain the large dry extremes and insignificant wet extremes. Can you give a more clear clue for that?

Response: Thanks for the suggestion. We have calculated the cumulative probability for both low and high P-ET values and added them in the manuscript to show the changes of PDFs more clearly.

"... together induce a heavier left tail in the PDF of P-ET .... The probability of P-ET<80mm increases from 0.1 during historical period to 0.11, 0.13 and 0.16 at 1.5, 2.0 and 3.0°C warming levels individually. ... shows little change to the right tails in the PDF of P-ET as probability for P-ET>130mm stays around 0.1 at different warming levels ..." (L357-362)

8. Line 320: How to get the value of "4-6%" for the acceleration of the hydrological

cycle under global warming of 1.5 degrees?

Response: Thanks for the comment. We have clarified as: "... is found to accelerate by 4~6% ..., according to the relative changes of precipitation, evapotranspiration and total runoff." (L409-410)

9. Lines 323-324: What's the period for the change of streamflow extremes?

Response: We have clarified as "Although ... compared with that during 1985~2014." (L416-417)

10. Lines 327-329: I'm not sure what does the "nonlinear changes" mean. Can you add some detail for the nonlinear changes from future warming over Europe?

Response: We have clarified the nonlinear changes as "The changes from 1.5 to 2.0 and 3.0°C are nonlinear compared with that from reference period to 1.5°C, ..." (L420-422)

To be specific, the wet extremes over Yangtze river source region increase by 138% at 1.5°C warming levels, which indicates a linear rate of 46%/0.5°C. However, projected change of wet extremes from 1.5 to 2.0°C warming levels is 64% which is much larger than the linear rate.

11. Lines 347-350: "Considering the LAI projections from different CMIP6 models are induced by the climate change, it can be inferred that the indirect influence of climate change (e.g., through land cover change) has the same and even larger importance. . .compared with the direct influence (e.g., through precipitation and evapotranspiration)." How to understand the direct and indirect influence of climate change on the streamflow extremes changes? Can you give a further explanation for that?

Response: The indirect influence of climate change means the climate change will induce land cover change and then the land cover change can also influence the hydrological extremes. The direct influence of climate change means the influence of meteorological forcings (e.g., precipitation, temperature, radiation) changes.