Dear Editor and Reviewers:

First, we would like to thank the editor and reviewers for their helpful comments and suggestions, which improved the quality of our manuscript. We agree with most of the concerns raised by the reviewers and have therefore modified the manuscript according to the reviewers' comments and suggestions. Newly added and modified text is highlighted in yellow in the revised manuscript, and our point-by-point responses to the reviewers' comments are provided below. We hope that the revised manuscript is now suitable for publication in Hydrology and Earth System Sciences.

Reply to Reviewer (#1)'s Comments:

Authors have addressed my concerns in revised manuscript. I feel that manuscript is in good shape and could be accepted after minor revision. I have two concerns:

► We appreciate the reviewer's feedback and helpful comments. Kindly find our detailed response to each comment below.

1. Kindly revise figure 3, figure S5 and figure S6. Plot should have OBS value and difference (in percentage for precipitation and runoff and in ^{o}C for temperature) between MME and OBS.

► We have revised the figures (Figure 3, Figure S5 and Figure S6) and added a related description in the manuscript.

: The percentage bias (hereafter referred to as BIAS) between the OBS and MME is calculated to examine the quantitative error in the MME. The MME properly captures both the spatial pattern and the magnitude of PANN and PX1D (Figure 3a, b). The relatively large magnitude of bias in PANN (PX1D) is shown in the region with low PANN (PX1D).

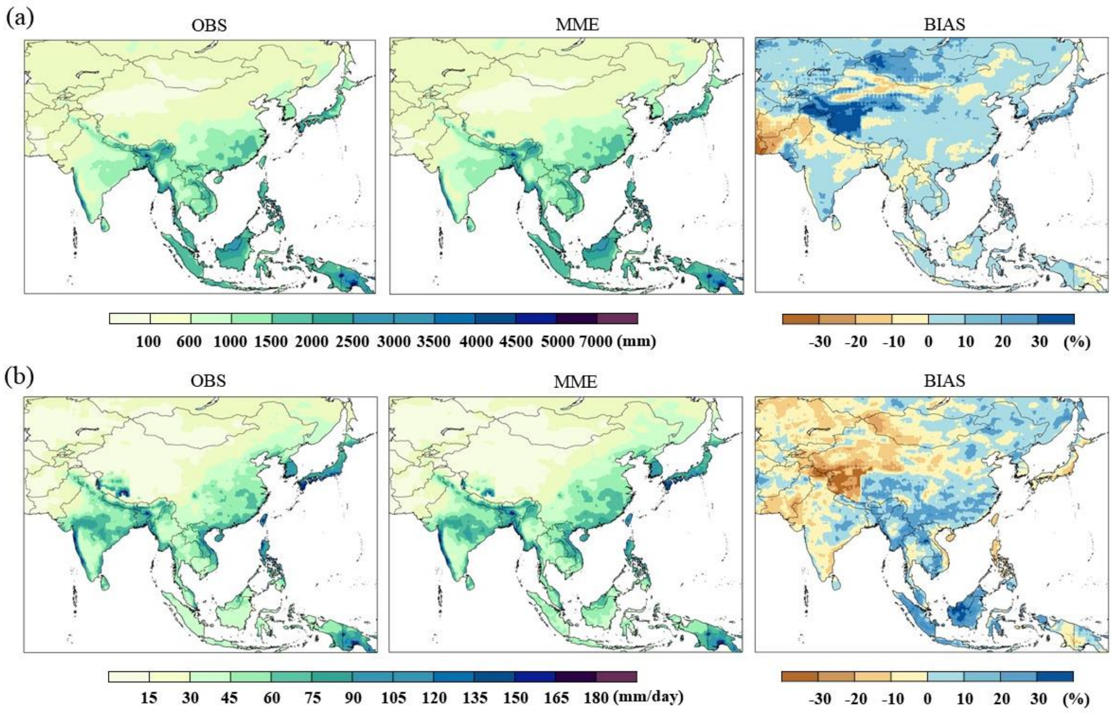

Figure 3: Spatial distributions of the (a) annual mean precipitation (PANN) and (b) annual maximum precipitation (PX1D) for the historical period (1976-2005) in the Asian monsoon region derived from observations (OBS) and the MME of bias-corrected outputs from the five GCMs. BIAS (i.e., the 3rd column in each row) represents the percentage bias in PANN (PX1D) between OBS and MME.

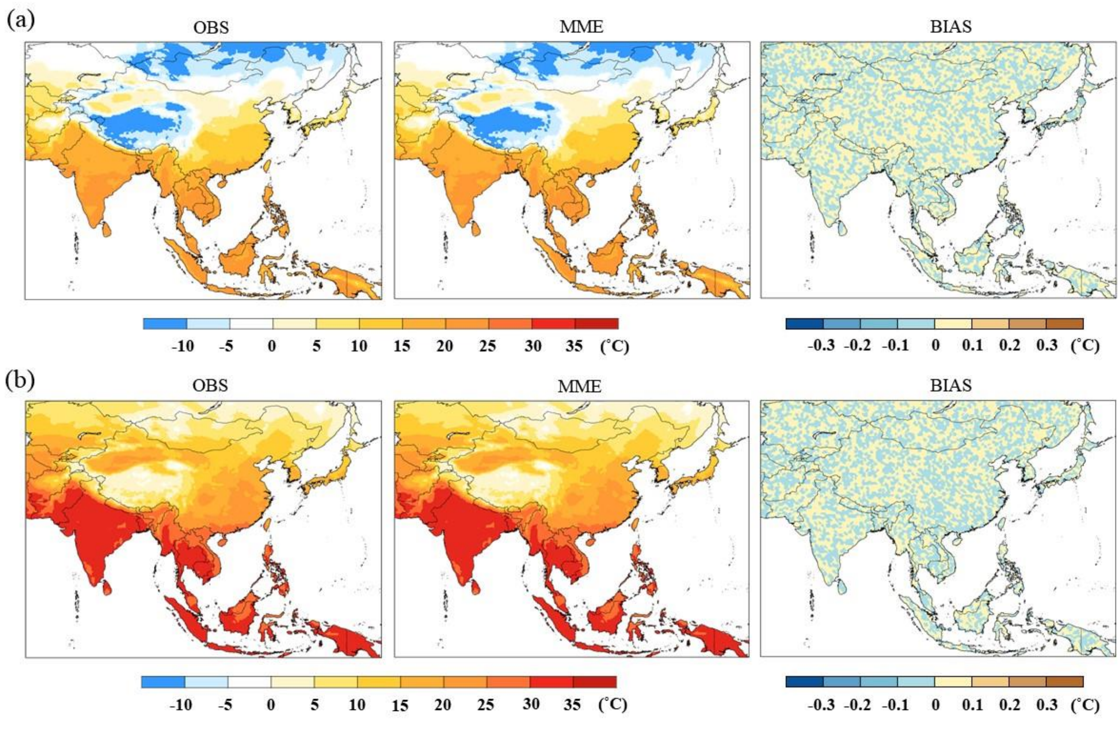

Figure S5: Spatial distributions of the (a) annual minimum temperature (unit: °C) and (b) annual maximum temperature (unit: °C) for the historical period (1976-2005) in the Asian monsoon region. OBS and MME denote the values obtained from the observational temperature dataset and the MME of bias-corrected outputs from the five GCMs, respectively. BIAS (i.e., the 3rd column in each row) represents the percentage bias in individual variables between OBS and MME.

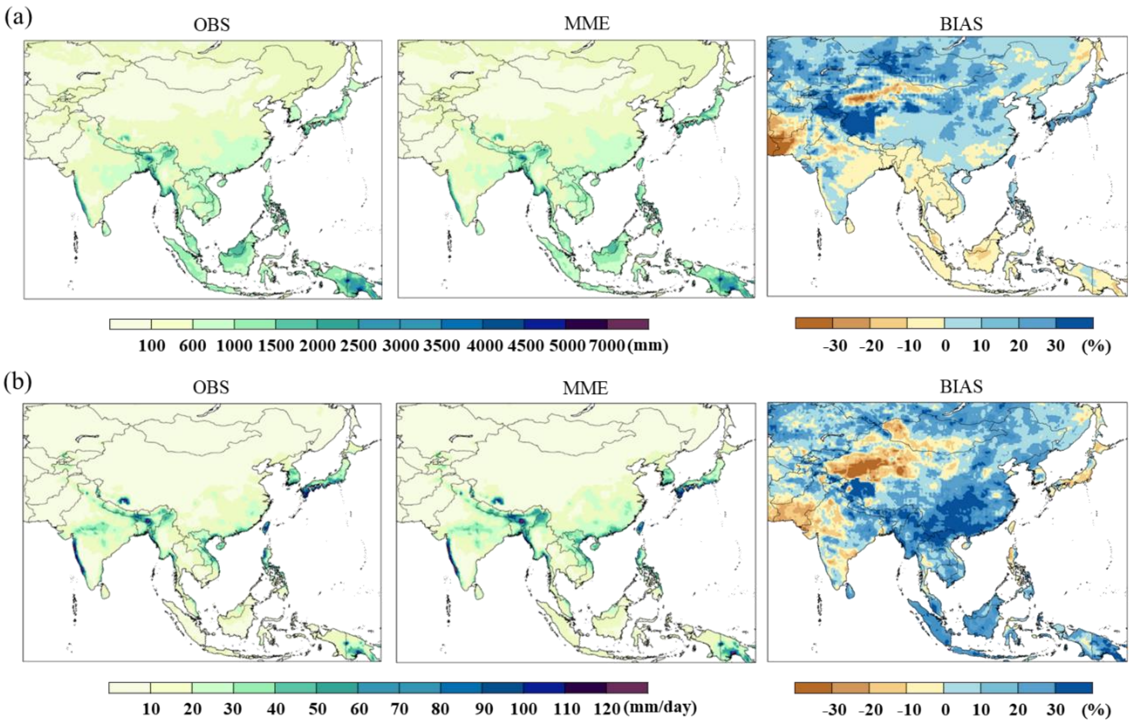

Figure S6: Spatial distributions of the (a) annual mean runoff (unit: mm) and (b) daily maximum runoff (unit: mm/day) for the historical period (1976-2005) in the Asian monsoon region. OBS denotes the simulated runoff from the VIC model fed by observational precipitation data (i.e., APHRODITE). MME denotes the simulated runoff from the VIC model fed by the MME of the bias-corrected outputs from the five GCMs. BIAS (i.e., the 3rd column in each row) represents the percentage bias in individual variables between OBS and MME.

2. Quality of figures is not up to mark. I recommend to use Generic Mapping Tools (GMT) or R or other plotting software.

► Thank you for this comment. Although we used the general tool (and software) in this study (e.g., NCAR Command Language (NCL) and Grapher), the quality of figures were not enough due to the file format in the manuscript. We checked and submitted the figures with high quality as a ".zip" file (i.e., Individual image files in TIF format; 600 dpi).

Reply to Reviewer (#2)'s Comments:

The revised manuscript has improved considerably in its presentation as well as description of methods and results. The authors have adequately addressed the main issues raised by the reviewers. The manuscript presents an interesting analysis of likely changes in hydro-climatic extremes considering different climate regions in the Asia monsoon region. The addition of flowchart is useful to understand the methodology. The paper can be considered for publication after minor improvements in presentation, a few are suggested below.

► We appreciate the reviewer's feedback and helpful comments. Kindly find our detailed response to each comment below.

1. The abstract still reads quite poorly and needs to be improved. The abstract focuses on generalized insights while missing out on highlighting the regional differences, which is the main contribution of this paper. While the last line says that the sensitivities are different, this difference is merely mentioned in the 2nd last line in reference to the cold and polar climates. In addition, the abstract has some unclear text. Some editorial suggestions:

► We fully agree with your valuable suggestion. As the reviewer suggested, we have modified the abstract considering the raised suggestions, including the above comments from 1a to 1f, as follows:

: Understanding the influence of global warming on regional hydroclimatic extremes is challenging. To reduce the potential risk of extremes under future climate states, assessing the change in extreme climate events is important, especially in Asia, due to spatial variability of climate and its seasonal variability. Here, the changes in hydroclimatic extremes are assessed over the Asian monsoon region under global mean temperature warming targets of 1.5 and 2.0 ℃ above preindustrial levels based on representative concentration pathways (RCPs) 4.5 and 8.5. Analyses of the subregions classified using regional climate characteristics are performed based on the multimodel ensemble mean (MME) of five bias-corrected global climate models (GCMs). For runoff extremes, the hydrologic responses to 1.5 and 2.0 ℃ global warming targets are simulated based on the variable infiltration capacity (VIC) model. Changes in temperature extremes show increasing warm extremes and decreasing cold extremes in all climate zones with strong robustness under global warming conditions. However, the hottest extreme temperatures occur more frequently in low-latitude regions with tropical climates. Changes in mean annual precipitation and mean annual runoff and low runoff extremes represent the large spatial variations with weak robustness based on intermodel agreements. Global warming is expected to consistently intensify maximum extreme precipitation events (usually exceeding a 10 % increase in intensity under 2.0 ℃ of warming) in all climate zones. The precipitation change patterns directly contribute to the spatial extent and magnitude of the high runoff extremes. Regardless of regional climate characteristics and RCPs, this behavior is expected to be enhanced under the 2.0 ℃ (compared with the 1.5 ℃) warming scenario and increase the likelihood of flood risk (up to 10 %). More importantly, an extra 0.5 ℃ of global warming under 2 RCPs will amplify the change in hydroclimatic extremes on temperature, precipitation and runoff with strong robustness, especially in cold (and polar) climate zones. The results of this study clearly show the consistent changes in regional hydroclimatic extremes related to temperature and high precipitation and suggest that hydroclimatic sensitivities can differ based on regional climate characteristics and type of extreme variables under warmer conditions over Asia.

a. Consider rephrasing the first sentence in the abstract. Suggestion: 'Understanding the influence of global warming on regional hydro-climatic extremes is challenging.'

► We have revised the abstract considering the reviewer's comment.

b. Line 2: 'change of extreme' should be 'change in extreme'

► We have revised the abstract considering the reviewer's comment.

c. Line 3: 'due to various …. ' can be 'due to spatial variability of climate and its seasonal variability'.

► We have revised the abstract considering the reviewer's comment.

d. Line 14: 'significant' is a statistical term, is a statistical significance implied here? I suggest to review the use of 'significant' and 'robustness' throughout to present a mathematically consistent meaning.

► Thank you for this comment. We understand the concern raised by the reviewer. The level of agreement among the multiple projections, which is used to assess the robustness (or confidence) of climate projections (Tebaldi et al., 2011; Saeed et al., 2018), is suggested to provide a certain level of reliability in this study. Therefore, we have revised the abstract and added this point to the manuscript as follows:

: The level of agreement among the multiple projections is used to assess the robustness (or confidence) of climate projections (Tebaldi et al., 2011; Saeed et al., 2018).

: Tebaldi, C., Arblaster, J.M. and Knutti, R.: Mapping model agreement on future climate projections, Geophysical Research Letters, 38, L23701, 2011.

Saeed, F., Bethke, I., Fischer, E., Legutke, S., Shiogama, H., Stone, D.A. and Schleussner, C.-F.: Robust changes in tropical rainy season length at 1.5 °C and 2 °C, Environmental Research Letter, 13, 064024, https://doi.org/10.1088/1748-9326/aab797, 2018.

e. Lines 14-15: 'fewer than 45 days…. Fewer than 32 days' how are these related to warm and cold extremes, which should be captured on a temperature scale.

► We have revised the abstract considering the reviewer's comment.

f. Lines 15-16: 'changes in precipitation …. show' can be 'mean annual precipitation, mean annual runoff and low runoff extremes show'

► We have revised the abstract considering the reviewer's comment.

2. Line 74: remove 'the impact of' from 'the impact of global temperature...'

► We revised this point in the manuscript (line 72).

3. Line 74: replace 'separately' with 'differently'

► We revised this point in the manuscript (line 72).

4. Lines 75-76: 'hence, global ...' this line is redundant and repeats information from prior sentence. Please restructure this part of the text.

► Thank you for this comment. We fully agree with your valuable suggestion. We performed the suggested revision as follows:

: The hydroclimatic changes in response to global warming reflect unique regional responses because the global temperature increases impact each region differently due to changes in regional climate features. However, examining how different regional hydroclimatic extremes are caused by the impact of global warming remains challenging. To the best of our knowledge, relatively few studies have examined the impacts of global warming on extreme hydroclimatic variable-related responses considering the regional climate in Asia (Liu et al., 2019; Kim et al., 2020; Zhao et al., 2020).

5. Lines 81-82: Remove 'since climate extremes ....component'

► We revised this point in the manuscript (line 81).

6. Line 235: 'gridded runoff'

► We revised this point in the manuscript (line 236).

7. Line 254-255: 'Overall, the validation ...' this claim is conflicting with the explanation prior that there is underestimation of observed maximum runoff values, though the inter-quartile range are captured. Perhaps this line is not needed and the readers can themselves decide how adequate are the simulations based on the observations reported earlier in this paragraph.

► Thank you for this comment. We fully agree with your valuable suggestion. Therefore, we have removed this sentence in the manuscript (line 255).

8. Line 328: what is 'not suggested'

► We clarify this point in the revised manuscript as follows:

: These features (e.g., change patterns and spatial distributions) are shown in the results under RCP8.5 (related figure not suggested here).

Figure 5 shows the area-averaged changes in the cold and warm extreme indices derived from the results under RCP4.5 shown in Figure 4 (and under RCP8.5);

9. Line 385: ')' without an opening round bracket

► We revised this point in the manuscript.

10. Figures 5, 7, 9, 11: can all be consolidated into a single table. Right now the number of figures for the manuscript is on the higher side.

► Thank you for this comment. We understand the concern raised by the reviewer. However, we would like to keep the original figures as it is. If we consolidate these figures as a single table, it contains a large number of individual values (e.g., for individual climate zones, RCPs, extreme indices, global warming conditions). For this reason, figures could be more effective for identifying and comparing the different regional patterns of each climatic extreme.

11. Section 3.2 and 3.3 mainly present several quantitative results. They are tedious to read with the numbers interspersed throughout (see for example, lines 400-405). Perhaps the text in these sections can be rewritten to focus on the important insights related to regional differences and differences between 1.5 and 2.0 degree warmings. A table can be used to consolidated the numbers being discussed.

► We fully agree with your valuable suggestion. We have minimized the quantitative results and modified the text in "Sections 3.2 and 3.3". Therefore, we performed the suggested revision as follows:

: The change in FD over Asia represents the largest decrease of approximately -10.0 days at 1.5 ℃ of warming and -14.1 days at 2.0 ℃ of warming under the two RCPs. The change in ID also decreases by approximately -6.4 days at 1.5 ℃ of warming and -9.0 days at 2.0 ℃ of warming under the two RCPs. A large reduction in both FD and ID is detected in the cold climate zones (Ds, Dw, and Df) and polar climate zones (ET) with lower temperature records than the other climate zones. In contrast, the change in TR over Asia represents the largest increase of approximately 13.6 days (15.0 days) at 1.5 ℃ of warming and 20.6 days at 2.0 ℃ of warming under the two RCPs. Similarly, the change in SU is an increase of approximately 11.2 days at 1.5 ℃ of warming and 15.7 days at 2.0 ℃ of warming under the two RCPs. While the difference in the value of the results from the RCPs is the largest (i.e., approximately 1.4 days) in TR, it is similar in the other temperature extremes (i.e., FD, ID and SU).

: Warm days (TX90P) over Asia are projected to increase by 27.4 % under 2.0 ℃ of warming and by 18.7 % under 1.5 ℃ of warming for the two RCPs. Moreover, warm nights (TN90P) are projected to increase by 33.0 % under 2.0 ℃ of warming and by 23.6 % under 1.5 ℃ of warming under the two RCPs. The rate of warm days (TX90P) increase and warm nights (TN90P) increase are higher under RCP8.5 compared to RCP4.5. Conversely, cold days (TX10P) are projected to decrease by -7.4 % above PI levels on average in Asia at 2.0 ℃ of warming and by -6.1 % at 1.5 ℃ of warming under the two RCPs. Cold nights (TN10P) are projected to decrease by -8.3 % under 2.0 ℃ of warming and by -7.1 % under 1.5 ℃ of warming under the two RCPs. The rate of cold days (TX10P) decrease and cold nights (TN10P) decrease are slightly steeper under RCP8.5 than under RCP4.5. A large disparity between RCP4.5 and RCP8.5 is found in the change patterns of TX90P above the 50th percentile compared to TN90P. Overall, these change features in TN are more intense than those in TX (Figure 6a, c), which agrees with previous findings (IPCC, 2018). : Figure 9 presents the area-averaged changes in annual mean precipitation (PANN) and PX1D compared to the REF period under 1.5 and 2.0 ℃ warming conditions based on RCP4.5 (RCP8.5). The changes in PX1D are greater than the changes in PANN in most climate zones except Bs and Bw (shown in Figure 8a and Figure S7a) under both RCP4.5 and RCP8.5. An increase in PANN under global warming based on the two RCPs compared with the REF period ranges from 0.1 % to 10.7 % at 1.5 ℃ of warming and from 11.7 % to 11.9 % at 2.0 ℃ of warming. Similarly, under the two RCPs, PX1D is projected to significantly increase from 5.7 % to 11.2 % under 1.5 ℃ of warming and from 8.0 % to 15.2 % under 2.0 ℃ of warming. Namely, warming of 2.0 ℃ results in higher precipitation than warming of 1.5 ℃ in terms of both the PANN and PX1D irrespective of RCP scenarios.

12. Line 426: remove 'changes in the', also please consider introducing all shorthands (MDF, RANN etc.) in the methods section. It is also difficult to follow the shorthands for climate zones, consider using the full form itself instead of the shorthand whenever possible.

► Thank you for this comment. We have made the suggested revision in the manuscript.

► We have introduced all shorthands related to the extremes in the "Section 2.6 Extreme indices" and others in the relevant section. Additionally, we have attempted to suggest the full form with the shorthands in the manuscript whenever possible.

13. Line 446-447: seems to be contradictory to the main claim in the abstract that there are considerable regional differences in climate sensitivities. Please correct the abstract to reflect the specific results. Use generalization only when supported by the analysis. Instead use specific results such as those mentioned on line 466.

► We modified the abstract considering this point and performed the suggested revision in the manuscript (line 473).

14. The text uses a confusing writing style. For example line 449-450 'changes in temperature ..... change patterns'. What is a 'change pattern' and avoid using change twice in the same sentence. Please check the entire text to correct for this issue.

► We understand the concern raised by the reviewer. We have thoroughly reviewed and modified the expression.

15. Figure 1: Perhaps it will be more interesting to visualize boundaries of large river basins that cover the region (as opposed to political boundaries). The major rivers in this region serve one of the largest populations in the world.

► Thank you for this comment. We fully agree with your valuable suggestion. Of course, it is more interesting and informative to visualize the boundaries of large river basins in Figure

1. However, the description of the classified climate zone can be more familiar to readers when it is based on the political boundaries rather than boundaries of large river basins. Additionally, considering the aspects of consistency with other figures and related descriptions, we would like to keep the original political boundary in Figure 1.