Dear Editor:

First, we would like to thank the editor for their helpful comments and suggestions, which improved the quality of our manuscript. In the process of validation of revised paper, we were informed by an editorial support team that "Table 5" including the colors in the previous version of the manuscript (accepted by the Editor) will not be possible in the final version of the paper. If we want to adjust this, after the editor decision, the status changes to file upload, it can be acceptable that we upload the revised version to the system. Therefore, we have changed "Table 5" to "Figure 12" and uploaded the modified the manuscript. We hope that this manuscript is considered as a final version for publication in Hydrology and Earth System Sciences.

Newly modified text is highlighted in yellow in the revised manuscript (i.e., "Section 4") as follows:

: (Figure 12 presents the relative changes (%) in the average and extreme hydroclimatic indices under a further 0.5 ℃ increase in temperature from the difference in the global mean temperature in each climate zone between the 1.5 and 2.0 ℃ warming scenarios for RCPs (i.e., RCP4.5 for Figure 12a and RCP8.5 for Figure 12b). Based on both RCP4.5 and RCP8.5, all the changes in the individual hydroclimatic extremes except for the runoff indices (MDF, DWF07, and DWF30) exhibit similar change signals in all the climate zones under an extra 0.5 ℃ of warming. However, the influence of an additional increase of 0.5 ℃ of warming on the hydroclimatic extremes shows diverse change patterns and magnitudes with regard to different regions and types of extreme climate indices. Temperature extremes present the same change signals (e.g., an increase or a decrease) with a high degree of robustness over all climate zones. As the globe warms, changes in the warm extreme indices (e.g., SU, TR, TX90P, and TN90P) exhibit an increasing trend over most climate zones, except for SU and TR in the Af and ET zones. On the other hand, the cold extreme indices (e.g., FD, ID, TX10P, and TN10P) have a distinct tendency to increase across Asia. Large increases in the extreme warm indices are observed in arid climates (BS and BW) and cold climates (Ds, Dw and Df), whereas they are projected to decrease considerably in warm temperate climates (Cs, Cw and Cf). Furthermore, the changes in the extreme precipitation indices (e.g., P95, P99, PX1D, PX2D, PX3D, and PX5D) exhibit large increasing patterns compared to PANN with an extra 0.5 ℃ of warming. The change in MDF is similar to that in PX1D because the change patterns of precipitation influence those of runoff. These results represent an increase in the risks of runoff and flooding in most climate zones over Asia. The changes in the Cs and Ds zones with dry summer features show somewhat greater variability than the other climate zones in terms of both the average and the extreme precipitation (and runoff) indices under a climate environment characterized by an extra 0.5 ℃ of warming. In general, in comparison with those of MDF, the change patterns of the low runoff indices (DWF07 and DWF30) show relatively less robust patterns, especially in terms of the lower magnitude of change and decreasing change patterns (e.g., MacDonald et al., 2018). Although the future projections of low runoff contain levels of uncertainty due to variations among the individual GCMs, the Cf and

Bw zones are likely to face challenges in coping with low runoff under global warming (Figure 10 for RCP4.5 and Figure S8 for RCP8.5).

However, zones D and E are highly susceptible to an extra 0.5 ℃ of warming. These regions show robust changes in temperature extremes, high-precipitation extremes and high-runoff extremes, as depicted in Figure 12. Under RCP4.5 (RCP8.5), the area-averaged cold extremes in this region are expected to decrease by -4.0 % (-2.8 %) in FD and -6.8 % (-5.2 %) in ID, while the area-averaged warm extremes are projected to vastly increase by 57.2 % (50.8 %) in SU and 80.8 % (68.3 %) in TR. Similarly, the high-precipitation extremes are projected to increase by approximately 3.3~3.6 % (1.1~1.9 %) for PX1D, PX2D, PX3D, and PX5D and approximately 10.5 % (5.6 %) and 18.7 % (9.8 %) for P95 and P99, respectively. Consequently, the high-runoff extremes (i.e., MDF) are expected to increase by 3.4 % (0.3 %) under RCP4.5 (RCP8.5), which is likely to result in a risk of more intensified flooding. In contrast, the changes in the low-runoff extremes (DWF07 and DWF30) show low robust change signals in these regions as a result of small changes under a further 0.5 ℃ of global warming and substantial uncertainty in the GCM projections; this finding agrees with previous results (e.g., Chen et al., 2017; Donnelly et al., 2017; Marx et al., 2018). However, the change behavior in the hydroclimatic extremes (except for the low-runoff extremes) tends to be amplified at 2.0 ℃ of warming compared with 1.5 ℃ of warming regardless of the RCP. Although substantial changes in the characteristics of the various extreme indices are found under RCP8.5, the small differences in these change patterns between the two selected RCPs are evidenced by the large changes under the 1.5 ℃ warming condition in comparison to RCP4.5. More importantly, under RCP8.5, global warming is likely to occur faster, and the degree of warming is much higher (e.g., above 3.0 ℃ of global warming) compared to RCP4.5. Our results imply the necessity for mitigation to alleviate the negative impacts of anthropogenic warming and to reduce the increased risk of hydroclimatic extremes under a far warmer climate.

Next, we focus on the changes in hydroclimatic extremes across diverse climate zones over Asia in response to warming scenarios of 1.5 and 2.0 ℃ under two emission forcings (RCP4.5 and RCP8.5) above the PI level. Five CMIP5 GCMs are selected considering their performance in the historical simulations. The central years and 30-year periods reaching warming targets of 1.5 and 2.0 ℃ are identified based on the individual GCMs. After removing systematic biases, five GCMs are used as meteorological forcings for the VIC distributed hydrological model, and the simulated surface runoff is converted into area-averaged runoff according to each climate zone. Future changes in various extreme indices (e.g., temperature, precipitation, runoff-related indices) are calculated by applying the relative concept to the differences between the individual warming conditions (1.5 and 2.0 ℃) and the REF period. Our focus is to estimate and compare the change patterns of the extreme temperature, precipitation, and runoff indices among the various climate zones under 1.5 and 2.0 ℃ of global warming.

In all climate zones, an extra 0.5 ℃ of global warming has a considerable influence on the changes in hydroclimatic extremes. The changes in temperature indices show the strongest robustness over Asia (with 5 out 5 model agreements) and project a greater increase in high-percentile maximum and minimum temperatures. Although there is great uncertainty in the precipitation and runoff projections, the high-precipitation and high-runoff extremes show increasing patterns with a high level of robustness.

This finding supports the concept that global warming leads to an intensified hydrological response, such as an increase in high-precipitation extremes (e.g., Trenberth, 1999; Giorgi et al., 2014; Im et al., 2017; Kim et al., 2020). Consequently, consistent with the change patterns of precipitation extremes, high-runoff extremes under warmer conditions are likely to increase the risks of water-related disasters in most climate zones of Asia. Our findings are generally consistent with previous studies that have suggested likely increases in high-runoff extremes under warmer climate conditions above PI levels (e.g., MacDonald et al., 2018; Jacob et al., 2018; Paltan et al., 2018; Kim et al., 2020). Finally, although these behaviors are taken from a limited number of GCMs, our CMIP5 MME-derived findings reveal accelerated extremes compared to the long-term mean. Since hydroclimatic sensitivity differs based on regional climate characteristics, understanding the change behaviors of hydroclimatic extremes is clearly required at the regional scale. As shown in Figure 12, the unique regional responses (with high significance measured by the intermodal agreement level) of an extra 0.5 ℃ of global warming reveal the need for different adaptive measures to expected hydroclimatic extremes. Although the vulnerability of temperature extremes will be increased in all climate zones over Asia, the frequencies of summer days and tropical nights are increased by 10 % and 20 %, respectively, in cold climate regions (D zones) under extra global warming. This temperature-related risk is likely to increase the adverse effects on human health, such as heat-related illnesses. Regarding precipitation extremes, adaptation for intensified heavy rainfall in terms of both frequency and intensity will be needed in most climate zones except for some climate regions with dry summer features (e.g., BW, Cs, and Ds). Changes in heavy rainfall amplify the risks associated with flood extremes and consequently flood damage (e.g., loss of life and economic losses). The daily maximum runoff, which is related to flood hazards, will be increased by 4~8 % in zones Cw, Cf, Dw, and ET. Therefore, both structural (e.g., flood-adaptive design for hydraulic structures) and nonstructural measures (e.g., flood forecasts and measurements) are needed for flood risk management in these regions. Although the potential impacts of low-runoff extremes (e.g., minimum consecutive 7-day and 30-day runoff) show low significance in all classified climate zones under extra global warming, the low-runoff extremes are amplified by more than 10 % at 2.0 ℃ of global warming compared to 1.5 ℃ of global warming in the western parts of India and the high latitudes (above 40° N), thus increasing the risk of water supply issues for drinking and irrigation as well as drought conditions. As the global temperature increases, regional climate change impacts hydroclimatic conditions and related aspects (e.g., human health, water supply, water-related disasters, hydraulic structures). These results suggest positive benefits of 0.5 ℃ less warming in terms of hydroclimate extremes and the necessity of adaptive regional planning.

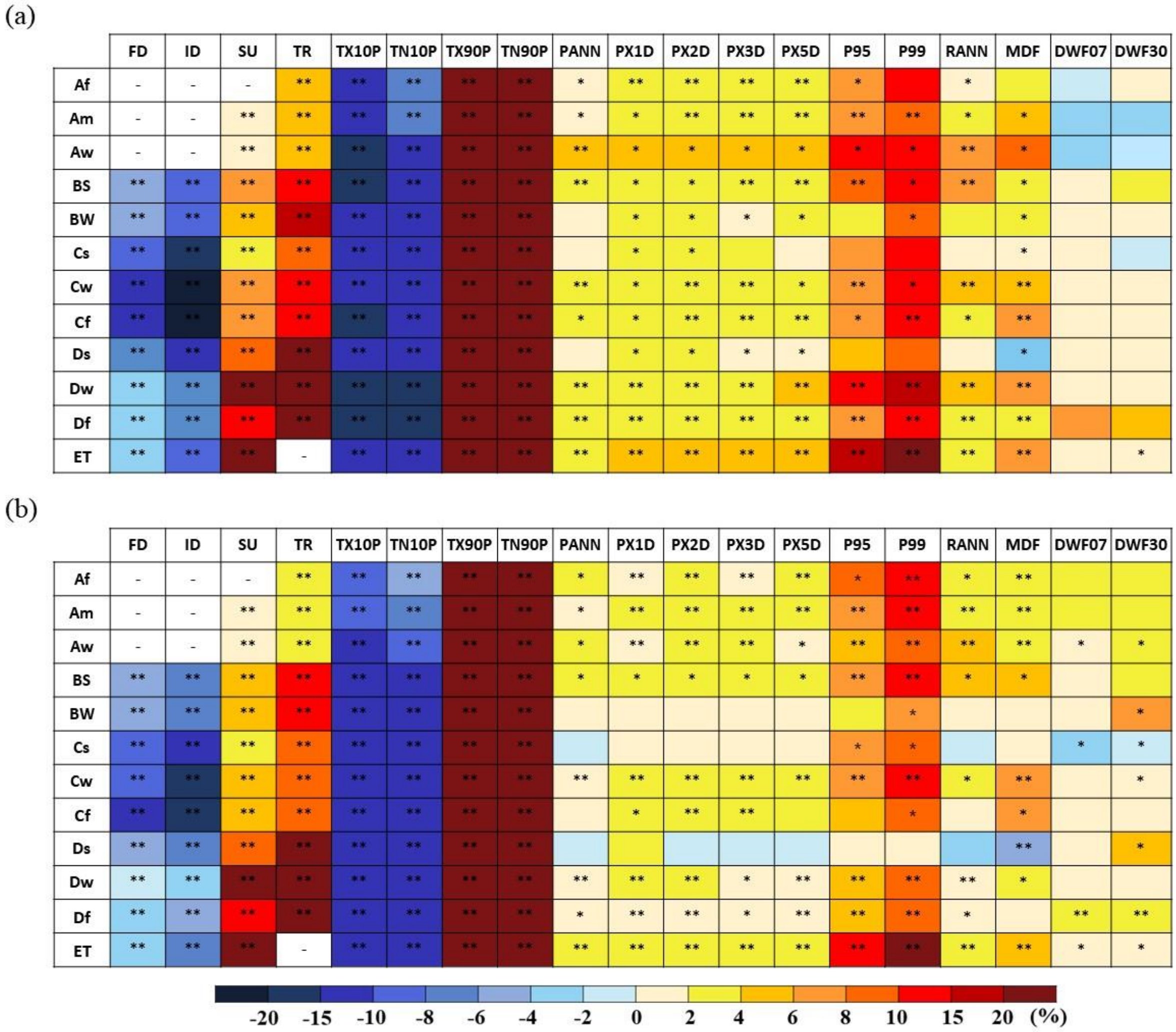

Figure 12: Plots of the percentage changes (%) in the climate extreme indices in response to additional warming of 0.5 °C in the climate zones over Asia under (a) RCP4.5 and (b) RCP8.5, where '*' and '' represent significance at the 80 and 100 % levels, respectively.**