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Hydrology and Earth System Sciences
Discussions

# *Interactive comment on* "Assessment of climate change impact and difference on the river runoff in four basins in China under 1.5 °C and 2.0 °C global warming" *by* Hongmei Xu et al.

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Anonymous Referee #2: We appreciate the Referee #1's comments and suggestions on our manuscript. The following are our point-point replies, with reference to the order of the comments by the reviewer. Comment 1: There are some fundamental problems with this paper that make me very uneasy about recommending it for publication. Firstly, the choice of five GCMs from a much large available set of AR5 projections needs to be justified. At the very least, we need to know why these five were chosen and whether they differ from the larger set in terms of their future projections. I'd also like to know how these five perform under historical conditions. Related to this, we

need to know how the historical projections from the GCMs compare with the historical data used to calibrate the model. Section 3.2 is very unclear about this. If the historical GCM data is wildly different from the historical calibration data, I cannot see how it can be used to assess current conditions and therefore used to assess projected changes. Similarly, the SWAT calibration statistics are rather poor. The biases in calibration of 16% and 25% are much greater than the projected changes in runoff. How can we have any confidence in these projected changes when the calibrations are unable to get even the correct volume of runoff? Using the model to project seasonal changes when historical seasonal statistics were not examined is also unacceptable. The inadequacy of the model for use in climate change studies is re-iterated by the -11 to +18% change in precipitation for the Shiyang River leading to reductions in annual flow of 10% to 60%. This is not credible, and clearly the model is giving too much weighting to the impact of increases in PET. There is some value in the estimates of changes in temperature and precipitation across the four river basins, but the large bias in the hydrological model calibrations means that I cannot see how these changes in precipitation can be converted into changes in even annual runoff. Also, the changes in temperature and precipitation are predicated on just five GCMs, and we would need to know where these fall within the range of all GCMs in AR5. The authors have pretty much ignored the very large body of work emanating from Australia, the US and Europe on estimating impacts of climate change on water availability. I'd strongly suggest they go back and read the approaches that have been used elsewhere and modify their approach based on this. Response: We are appreciate for the reviewer's all comments. This study followed the top-down methodology that common used in IPCC AR4 and AR5 WGII report. Within the IPCC AR 4 and AR5 water sector, most hydrological projection studies use the precipitation and temperature downscaled from GCMs to driven hydrological models. This study adopted climate projection information derived from Inter-Sectorial Impact Model Intercomparison Project (ISIMIP). Several publication from US and Europe have by add in the revised manuscript. For the detailed information about dataset and methodology used in this study, we responded in the following parts separately, and more information have been involved in the revised manuscript.

Specific comments: From the abstract, it appears as if the focus of the paper is on the impact of an additional 0.5 degrees global warming, not the impact of 1.5 and 2.0 degrees compared to current conditions. However, the paper does not focus on this 0.5 degree difference. Response: this research analysis the impact of 1.5 and 2.0 degrees warming compared to present day and also discuss the difference caused by the 0.5âĎČ more warming. We have clarified this objective in the introduction part in our manuscript. Line 6. The target of 1.5 degrees is thought to be the one which might limit dangerous climate change impacts, not 2 degrees as proposed here. In fact, the comparison of 2 to 1.5 degree warming can be considered to be 'what if' we don't manage to keep to 1.5 degrees of warming? What might the additional 0.5 degrees do? That could be a useful focus of the paper, however the problems raised above mean that this cannot be done with the current approach. Response: The Paris Agreement central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius (UNFCCC, 2015) So, we take 1.5 and 2.0âĎČ as the thresholds. This study followed the methodology and Inter-Sectorial Impact Model Intercomparison Project (ISIMIP), the publication of ISI-MIP have contributed to IPCC 1.5 Special report. We developed the work main keen to give a picture how the water resource will changes under 1.5 and 2.0âĎČ global warming , how the difference in impacts will caused by additional 0.5 degree warming, and the result will useful for decision maker of China. Comment 1: Considering the enormous range of projected changes across the AR5 GCMs, the reader needs to know why the authors selected the five GCMs used in this study. Were they just more accessible? How does the range of projections from those GCMs compare to the larger set of GCMs in AR5? Without knowing this, we have no idea if these projected changes represent a wetter/drier hotter/cooler part of the spectrum of future climate change projections. Response: We are appreciate for the reviewer's consideration about GCMs selection in this research. The number of models contributing to CMIP5 varies with the specific experiment, but ranges from 25 to 42 for the projections under four Representative Concentration Pathway (RCP) scenarios. The large size of the CMIP5 ensemble can be particularly problematic in studies where the GCM data are used as part of a model chain including downscaling and/or impact models. However, to quantify the uncertainty associated with GCMs in climate change impact assessment, five"priority" GCMs were selected in this study recommended by ISI-MIP. The GCMs selected to span global mean temperature change and relative precipitation change as effectively as possible (Warszawski et al. 2014). The FRC index (Fractional range coverage) of the five GCMs in ISI-MIP project is 0.75 and 0.59, respectively, which is better than the five GCMs randomly selected from CMIP5, and can reasonably represent the changes of regional average temperature and precipitation (McSweeny and Jones, 2016). Comment 2: One of the key issues in hydrological modelling studies is whether the model is able to represent the current conditions well enough to be able to be used in climate change studies. In this paper, the authors claim that the model calibration and validation results are 'satisfactory'. While this may be true to some extent for the Huiaihe and Fujiang Rivers, the calibration and validation statistics for the other rivers are poor at best (remembering that they are only attempting to produce monthly, not daily streamflow). Even more concerning however in a study such as this one is that the calibration bias is 25% for the Baihe and 16% for the Huaihe River. As the projected change in annual runoff is much less than that, I cannot see how the authors can justify using such a poor calibration. I am not familiar with the WFD climate data, but I strongly suspect that is the main reason the calibrations are so poor. Are there any other datasets (local precipitation for example) that could be used instead? Also, was SWAT run on a monthly or daily basis? No information is provided. It is not at all clear which precipitation data were used to drive the SWAT model under the future climate scenarios. Section 3.2 is confusing and not at all clear. Did the authors simply take the precipitation from the climate models directly and run SWAT for both the historic and future scenarios? If so, how did these precipitation projections, particularly the historical projections' compare to those used in the historic calibration? If they were significantly different, this gives us some information about how well the GCM's are predicting historical conditions and some confidence (or likely not) in their use in the future projections. Response: Many thanks for these suggestions which really helpful for us to revised the manuscript. (1) The WFD combined the daily statistics of ERA-40 with the monthly mean characteristics of CRU and GPCC datasets and represented a complete gridded observational dataset for bias correction of global climate data over land. WFD has been compared with CRU data and GPCC data for monthly temperature, wet days, and precipitation totals etc. WFD is considered an acceptable dataset for forcing hydrological models in comparison with gridded observation database at global scale (Essou et al., 2016). Furthermore, WFD has been used in climate change impact assessment at regional or catchment scale in China (Hao. et al., 2018; Liu et al., 2017; Chen et al, 2017; Su et al., 2017). (2) I agreed with the reviewer's comment that high resolution climate forcing or situ based observation maybe improve the hydrological model performance. The purposes of using WFD to force the SWAT hydrological model in this study: (i) to avoid the uncertainty caused by the inhomogeneity of the spatial distribution of meteorological stations, (ii) to allow a consistent analysis of climate change impacts on water resource at basin scale; (iii) to provide the case study for global comparison under ISI-MIP project. I prefer to do further investigate using available high resolution climate forcing to calibrate and validate SWAT hydrological model the four river basins to compare the hydrological model performance with forcing with 0.5 degree WFD dataset in the future research. (3) Furthermore, whether the hydrological model structure can reflect the specific hydrological process is the key factor to determine the hydrological model performance. There was a few cases showed that SWAT could be used in snowmelt-dominated streamflow (Wang and Melesse, 2005; Tolston and Shoemaker, 2007; Grusson et al., 2015), a few previous researches have indicate that SWAT model did not adequately predict winter flows or snowmelt-dominated runoff in several watershed (Peterson and Hamlett, 1998; Srivastava et al., 2006;

Chanasyk et al., 2003; Benaman et al., 2005) , which could be one reason that the low values of the Nash-Sutcliffe efficiency for the Shiyang and Chaobai rivers in the northern China with cold winter. We have explained the reason for the low values of the Nash-Sutcliffe efficiency for Shiyang and Chaibai rivers in the revised manuscript. (4) The simulations using the SWAT model were forced by WFD climate data, and they were spun-up for the period 1958–1960. The SWAT models were run at daily step and were then calibrated for the 1961–1990 and validated for 1991–2001 using monthly river runoff data from the gauging stations of the four basins. The WFD (which covers period of 1958-2001) was used to force SWAT, and also was used for bias correction of climate model outputs adopted in this study. The climate model outputs derived from Inter-Sectoral Impact Model Intercomparison Project (ISI-MIP) are spatially interpolated into 0.5° resolution and corrected using trend-preserving bias correction approach based on WFD dataset for the period 1950–2005 for historical simulation and 2006-2099 for future projection under (Hempel et al., 2013). For subsequent hydrological simulation, this study adopted downscaled GCMs data derived from five GCMs and validated SWAT models, and projected the impact of climate change on river runoff. he changes in averages of the annual and monthly runoff under 1.5âĎČ and 2.0âĎČglobal warming were compared based on the simulated runoff under all climate scenarios and with the simulated runoff based on the baseline period (1976-2005) from the five GCMs rather than the actual observed discharge data or simulated discharge forcing by WFD. This technique was used to avoid systematic errors that the SWAT model would introduce in comparing the projection period with the baseline period. (5) Furthermore, we compared the downscaled climate data from 5 GCMs with WFD during 1961-2001. Table S6 and Figure S3 showed the agreement of WFD with the historical simulation of 5 GCMs at mean annual scale and monthly scale. The downscaled GCMs historical climate simulation showed very good agreement with WFD for both the mean annual temperature and precipitation. The differences in mean annual temperature between WFD and downscaled 5 GCMs output were -0.03âĎČ∼0.36âĎČ for the four river basins, while those of mean annual maximum and minimum temperature were -0.02âĎČ∼0.29âĎČ and -0.07âĎČ∼0.41âĎČ respectively. There were general overestimate for mean annual precipitation based on the downscaled historical climate simulation from 5 GCMs. The difference in mean annual precipitation were 5.2%∼14.8% between WFD and downscaled historical climate simulation from 5 GCMs in the Shiyang River, those were 6.3%∼9.7% in the Chaobai River, 3.9%∼5.4% in the Huaihe River, and 5.6%∼11.0% in the Fujiang River. The downscaled GCMs historical climate simulation fitted the distribution of mean monthly temperature and precipitation with WFD very well during the 1961-2001. Generally, the downscaled GCMs output from ISI-MIP were acceptable unified set of climate drivers to allow a consistent analysis of climate change impacts on water resource at basin scale. The downscaled GCMs historical climate simulation fitted the distribution of mean monthly temperature with WFD very well during the 1961-2001. The most of month with precipitation were overestimated by the downscaled GCMs simulation than underestimated for the four river basins, especially for the precipitation in spring and autumn. However, those differences in monthly precipitation based on WFD and downscaling climate historical simulation from five GCMs didn't change the seasonal pattern of precipitation. The downscaled GCMs output from ISI-MIP were reliable unified set of climate drivers to allow a consistent analysis of climate change impacts on water resource at basin scale. Commnent 2: Figure 2 shows that all future projections for the Shiyang River are for reductions in annual flow (of between 10% and 60%), but Table 3 states that annual precipitation shows a range of changes from an 11% decrease to an 18% increase. If the modeling indicates that an 18% increase in precipitation will lead to a reduction in annual runoff then the model is clearly inadequate for use in climate change studies. Response: Many thanks for this comment. We have noticed this issue in this research, and have discussed the possible reason of reduction in annual runoff. Precipitation is the main input of surface water resources and evapotranspiration (ET) is the main output. Ma et al. (2008) indicated that decreased precipitation and increased potential ET contribute most to the reduction of streamflow in northwest China. In Shiyang River under 1.5 and 2.0âĎČ global warming, the projected ensemble mean annual precipitation increased 3% and 5%, and range of changes from 11% decrease to 18% increase. While, the simulated change of ET in the Shiyang River showed robust increase of 22% and 14%, and range of changes from 3% decrease to 52% increase. This implies the increase in simulated ET contributes most to the decrease in simulated annual runoff in the Shiyang River. As mentioned in SWAT model calibration and validation part, a few previous researches have indicate that SWAT model did not adequately predict winter flows or snowmelt-dominated runoff in several watershed, which could be one reason that the low values of the Nash-Sutcliffe efficiency for the Shiyang. Moreover, Li et al. (2016) indicated that frozen soil meltwater accounted for about 20% of river runoff during the flood season, while glacier meltwater contributed only about 3% in the Shiyang River. However, the glacier meltwater process was not considered in SWAT-based simulations in this study, which would have also contributed to the decrease in simulated annual runoff in the Shiyang River. These all induce high uncertainties using SWAT for hydrological simulation in the Shiyang River. We have clarify this finding in the revised manuscript. Comment: While it is written well overall, considering the authors all presumably have English as a second language, there are a few sentences that do not make sense, such as line 23-25. Response: we have revised this sentence to “For the region with simulated water resource declined, the uncertainties in simulated runoff usually constrained by global hydrological models.” Figure 1. What does the light grey shading signify? What is the inset attempting to show? Response: Many thanks for this comment and sorry for this confusion caused by vague figure illustration. The dark grey area represent the study basins, and the light grey area represent the main river basin that the study basins belonged to, and which are the Inland River Basin in northwest China (the Shiyang River), the Haihe River Basin (the Chaobai River), the Huaihe River Basin (the Huaihe River), and the Yangtze River Basin (the Fujiang River). We have marked the main river basin in Figure 1 to the location of study areas in the main river basins of China in the revised manuscript.

Please also note the supplement to this comment:
https://www.hydrol-earth-syst-sci-discuss.net/hess-2018-448/hess-2018-448-AC3-supplement.pdf

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