Hydrol. Earth Syst. Sci. Discuss.,
https://doi.org/10.5194/hess-2018-448-AC2, 2018

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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Received and published: 28 December 2018

We appreciate the Referee #3's comments and suggestions on our manuscript. We have attempted to address every point raised by them. Our responses are as follows. Anonymous Referee #3: General comment: This study attempts to investigate climate change impact on river runoff in four river basins across China, using hydrological model simulations forced by meteorological data representing 1.5 and 2 C global warming based on 5 global climate models (GCMs) under 4 emission scenarios (RCPs). The objective is further to quantify the uncertainties in the projected changes given by the GCMs and RCPs.There are a couple of general problems in the study

that need to be addressed in order to be accepted: Comment 1: There is very little information about how the hydrological model was calibrated. Which parameters were calibrated, and which criteria were used for the calibration? The inconsistent response in river runoff to the increasing precipitations over the study basins suggests that the results are strongly controlled by changes in evapotranspiration (as a result of changes in temperature and water availability). Thus we need to know more about how evapotranspiration is simulated in the model, and if and how parameters related to evapotranspiration were part of the calibration. There is also a lack of evaluation of how well the model manages to explain the observed changes in river runoff, which are referred to in the introduction. As a summary, it is doubtful if the current model is adequate for the impact study presented in the paper. Response: Thanks for this suggestion. (1) Using sensitivity analysis procedures embed in SWAT resulted in the six most sensitive parameters (Table S3) in the hydrological model for each of the four rivers and then used for model calibration. The consistent sensitive parameters among all four river basins included parameter "CN2" and "GWQMN" which control the runoff process and soil water moving process respectively. The consistent sensitive parameters for the two river basins located in the northern China was parameter "ALPHA_BF" which reflect the groundwater flow response to changes in recharge; for the two river basins located in southern China, the common sensitive parameter was "RCHRG_DP" which was a coefficient that define the aquifer percolation fraction. However, because the differences in meteorological and hydrological conditions, topography and soil properties, there was specific sensitive parameters for each river basin, such as for the Shiyang River, the specific sensitive parameters were "SMTMP" and "TIMP" which are temperature related parameters for snow; for the Chaobai River, the specific sensitive parameter "GW_DELAY" which control the delay time or drainage time of the overlying geologic formations; for the Huaihe River, the specific parameter was "GW_REVAP" which define the amount of water moving into the soil zone from the shallow aquifer; for Fujiang river, the specific sensitive parameter was parameter "CANMX" which control the canopy storage of water. The definition of parameters showed in Table

S2. (2) There is no long term ET observation available for simulated ET verify, so we compared the simulated ET based on WFD and downscaling climate data from 5 GCMs. The result showed that there are good coherence between the ET simulated based on these two kinds of dataset. The monthly distribution of ET were not changed for the most simulated runoff based on WFD and downscaling GCMs climate data. The simulated ET was underestimated for the Shiyang River, especially during the summer, with the peak of ET earlier based on the simulation of GCM HadGem2-ES. The simulated monthly ET based on GCM MIROC-ESM_CHEM also showed earlier peak in the Fujiang River. (3) The coefficient of determination (R2), Nash–Sutcliffe efficiency (Ens) were used to measures the goodness-of-fit of simulated monthly discharge with observation, and percentage of bias (Pbias) were used to evaluate systematic over- or under estimation and when the absolute value is applied it shows the magnitude the simulated monthly runoff (Green and van Griensven, 2008Moriasi et al., 2007). In general, the model simulation is considered acceptable when the Ens values are greater than 0.5, and the Pbias less than ±25% (Moriasi et al., 2007). Comment 2: A related problem is the selection of meteorological forcing data used in the study. First of all, there is no assessment presented of the agreement during the historical period between the data used for the model calibration (WFD) and the data used for the climate projections - thus we cannot assess to what extent the calibrated model us suitable for assessing the climate change impact with these data. Secondly, there is very little motivation or details given regarding the selection of the GCM models, or the selection of the 30 year periods representing 1.5 and 2.0 C warming, respectively. The selection of GCM models should be crucial for the quantification of uncertainties, which is pointed out as one of the objectives of the paper. Response: We are appreciate for the reviewer's suggestion about clarify of meteorological dataset used this research. (1) 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 projections, this study adopted downscaled climate projection data derived from the 5 GCMs and validated SWAT models and projected the impact of climate change on river runoff. The 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. 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. (2) 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). (3) Response: Future time horizon of global warming of 1.5°C and 2°C is derived based on 30-year running mean of global mean temperature (GMT) for each one of the 20 combinations of four RCPs (RCP2.6, RCP4.5, RC6.0 and RCP8.5) and five GCMs. When the GMT anomaly of 30-year running mean relative to pre-industrial level reaches the threshold of 1.5°C or 2°C, the 30-year window is sampled as corresponding time horizon of global warming scenario. Then year in Table S5 is estimated by averaging all center-years of the 30-year samples for all GCMs under each RCP and under each global warming scenario. Among these 20 combinations, 16 scenarios show mean GMT increases exceeding the threshold of 2°C above pre-industrial level, and 18 scenarios exceed the threshold of 1.5°C. But the changes in projected variables

(annual temperature and precipitation) are quantified relative to present day (1976 – 2005) instead of pre-industrial period in this research. We have clarify the GCMs selection and supplemented the methodology about define the 1.5âĎČ and 2.0âĎČ warming in the revised manuscript. Comment 3: In addition to the methodological and presentation issues, the paper is very uneven in the quality of the English writing, which makes it difficult to understand some of the statements. Response: Thanks for this comments. We have polished the English writing throughout the all revised manuscript and tried our best to make it more readable. Specific comments Comment 4: Figure 1: I would assume that the dark grey areas represent the study basins, but what is represented by the light grey area? I would further assume that the basin locations following the position of the surrounding graphs, but I cannot be sure without consulting the text. What is presented in the small embedded graph? It looks like some mistake. Response: Many thanks for this comment and sorry for this confusion caused by vague figure illustration. 1) 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). 2) The mall embedded graph is the South China Sea Islands. These small inlands are presented in an embedded graph because it can't present at the same scale in the figure. So this is not a mistake. 3) 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. Methodology section: Comment 5: How was the model calibrated? Which model parameters? Which objective function was used in the calibration? Response: Thanks for this suggestion. Prior to calibration, a Latin Hypercube one-at-a-time (LH-OAT) technique, proposed by Morris (1991), and implemented in SWAT-CUP (SWAT Calibration and Uncertainty Programs) was applied to investigate the sensitivity of parameters.. Using sensitivity analysis procedures embed in SWAT resulted in the six most sensitive parameters (Table S1) in the hydrological model for each of the four rivers and then these sensitive parameters were used for model calibration. Sequential Uncertainty Fitting (SUFI2) algorithm (Abbaspour., et al., 2007) in SWAT-CUP generic interface was applied for automatic calibration and parameter optimization in the Chaobai River (Hao., et al., 2018), and manual calibration of model parameters were application for the Shiyang, Huaihe (Wang et al., 2018), and Fujiang River. The objective function used in model calibration is the Nash–Sutcliffe efïňĄciency with the threshold of greater than 0.5. We have supplemented the method of sensitive parameters analysis and model calibration of SWAT in the four river basins in the revised manuscript. Comment 6: Please give some more explanation how the 30 year periods were selected for the different global warming thresholds - as well as how the standard deviations referring to the GCMs and the RCPs, separately were quantified. How was the standard deviation originating from the GCMs and the RCPs aggregated into the values presented in Table3? Response: Thanks for this suggestion. (1) Future time horizon of global warming of 1.5°C and 2°C is derived based on 30-year running mean of global mean temperature (GMT) for each one of the 20 combinations of four RCPs (RCP2.6, RCP4.5, RC6.0 and RCP8.5) and five GCMs. When the GMT anomaly of 30-year running mean relative to pre-industrial level reaches the threshold of 1.5°C or 2°C, the 30-year window is sampled as corresponding time horizon of global warming scenario. Then year in Table S3 is estimated by averaging all center-years of the 30-year samples for all GCMs under each RCP and under each global warming scenario. Among these 20 combinations, 16 scenarios show mean GMT increases exceeding the threshold of 2°C above pre-industrial level, and 18 scenarios exceed the threshold of 1.5°C. But the changes in projected variables (annual temperature and precipitation) are quantified relative to present day (1976 – 2005) instead of pre-industrial period in this research. (2) The uncertainty caused by RCPs was estimating using standard deviation of the mean of all GCMs under 1.5âĎČ and 2.0âĎČ global warming respectively, and the uncertainty constrained by GCMs was estimated using standard deviations of all RCPs under the two threshold of global warming, whereas the all source of uncertainty of climate change scenarios was estimating using the standard deviation of all the 18 and 16 climate scenarios under 1.5âĎČ and 2.0âĎČ global warming. (3) We have supplemented the methodology about define the 1.5âĎČ and 2.0âĎČ warming in the revised manuscript. Results section: Comment 7: I would prefer not to use sentences that only refer to a table or a figure without describing any of the results. Describe the result in the text and use the tables and figures as support. For instance, I would recommend to refer more directly to the specific results in Table 3 that supports the various statements in section 4.1. Response: Many thanks for this suggestion and this will helpful for improve my scientific wringing. I have revised the manuscript and describe the result in the text by using the information included in the table sand figures.

Please also note the supplement to this comment:
https://www.hydrol-earth-syst-sci-discuss.net/hess-2018-448/hess-2018-448-AC2-supplement.pdf

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