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Hydrology and Earth System Sciences Discussions

Interactive comment on "The past and future changes of streamflow in Poyang Lake Basin, Southeastern China" *by* S. L. Sun et al.

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The authors of "The past and future changes of streamflow in Poyang Lake Basin, Southeastern China" have developed a novel approach of building a statistical water balance model for four watersheds within the Poyang Basin. The water balance model has been calibrated utilizing observational data from weather stations within the watershed boundaries. The performance of the water balance model has been described with respect to streamflow in the basin. The authors have then characterized the contributions of climatic variables with observed changes over the past 40 years. Given those changes and the driving climatic variables they have utilized projections of future climate to make assertions of streamflow in the 21st century. Overall the novel

approach of utilizing a statistical water balance model to attribute changes in runoff to the hydrometeorological drivers is a nice contribution to the field of climate change and hydrology. However, there are some areas which need significant considerations within the manuscript. Answer: Thanks for the valuable comments of reviewer 1. We tried to address all comments.

1. First the language and communication can be improved significantly reducing reader uncertainty of meaning. Answer: Thanks for the suggestion of the referee. We will invite the experts in this related study fields to improve the language and communication for reducing the reader uncertainty of meaning.

2. Many aspects of attribution are based upon the analysis of linear trends from the observed period. Precipitation is known to have interannual to interdecadal cycles as does streamflow. How are these types of phenomena accounted for within the trend analysis presented? Answer: You are right. There are interannual to interdecadal cycles in precipitation and streamflow. In this study, we are concerned mainly with whether stream flow and climate variable have increasing and decreasing trends in the given period. So, the interannual to interdecadal cycles is not accounted for here. We had tried to analysis the temporal trend of the five-year moving average series and found that there were not obvious differences for the trends between the original series and the five-year moving average series.

3. Why are linear trends presented for some hydrometeorological drivers (e.g. Table 4) but decadal variation is emphasized for streamflow (e.g. Table 3)? Answer: The core issues in our research are about the changes of annual streamflow and the contributions of climate change. So we only presented the linear trends of some hydrometeorological drivers, and focused on analyzing characteristics of annual streamflow changes including the linear trends and the decadal variations.

4. While there is significant amount of information provided with respect to the fitting/calibration/and validation of the water balance model for the retrospective period

the analysis of climate change is not as well described and not enough information is provided to evaluate how this was accomplished and thus the discussion and conclusions drawn from that aspect of the study. Answer: The main goals of this study are to analyze the historical trends of streamflow, quantified the contributions of different variables to these trends and project the possible changes of streamflow under different climate change scenarios using a water balance approach. The water balance model is tool for this study. It needs to be fitted, calibrated and validated. Detailed information in these processed. There are many studies on the temporal variations of different climate variables conducted in this area. Do to the limitation of paper length we did not report the conclusions on the temporal trends of climate variables again.

5. Additionally is setting up the motivation for the work presented the authors note "The influences of other climatic variables, such as radiation, wind speed, and vapor pressure, on water cycle have not been thoroughly studied? In this paper, the roles of various climatic variables in streamflow of Poyang Lake Basin, southeastern China were quantified using historical streamflow and climate data on the basis of water balance." This reviewer feels that the work has not evaluated radiation, wind speed, nor vapor pressure impacts on the water balance. The information provided is almost exclusively focused on precipitation and evaporation. In fact later in the manuscript the authors note "Net radiation, actual vapor pressure, temperature and wind speed indirectly impact on streamflow through their roles in evaporation." Thus only through net evpotranspiration is there any discussion of these other variables. This reviewer suggests the authors reevaluate motivation (which is well justified) focused on precipitation and evaporation. Answer: For the historical period, we analyzed the effects of precipitation and other climate variables (radiation, wind speed, and vapor pressure) on streamflow. The roles of radiation, wind speed, and vapor pressure in streamflow in affecting streamflow is identified by decomposing the equation to calculate evaporation. For the future period, there is no detailed data of radiation, wind speed, and vapor pressure available. We assess the influences of precipitation and evaporation on future streamflow. Evaporation implicitly integrates effects of temperature, radiation,

wind speed, and vapor pressure on streamflow. We will revise the manuscript to clarify the confusion.

Specific comments are presented below: 1. Suggest careful review of language. Three examples: (1) "The change of streamflow exhibited different characteristics the four watersheds exist different increasing trends during 1961 – 2000." This sentence is very difficult to interpret. Answer: Thanks very much for the check! I am very sorry that this error is caused by my carelessness. I will correct this sentence. The sentence can be corrected as "For the four watersheds, the change of streamflow exhibited different increasing trends during 1961 – 2000". (2) Introduction – ". . .natural variability of water resources is associated closely with climate change." Actually this is what the paper is exploring. I believe what the authors meant to say was ". . .natural variability of water resources is associated closely with natural climate variability." Not "change". Answer: Thank the referee for the valuable comments! I have to recognize that I had some troubles in the select of the suitable words. Recently, we will invite some professors in the related research fields to help us check the words and the sentences for reducing the same/similar errors. Lastly, I accept this correction.

(3) This is very confusing "As increase/decrease of temperature causes evaporation to increase/decrease, streamflow will correspondingly decreases/increases. However, when evaporation increases/decreases with decrease/increase in actual vapor pressure, streamflow will decrease/increase." Answer: I am very sorry that this sentence confuses the readers. We would like to show the physical mechanism of the interactions and feedbacks between temperature or actual vapor pressure and streamflow through the interim variable (evaporation). The sentences can be reformulated as "Evaporation is positively related to temperature. With increasing temperature, evaporation will increase, then streamflow will correspondingly decreases, and vice versa. In contrast, the relationship between evaporation and actual vapor pressure are opposite. Decrease of evaporation caused by increasing actual vapor pressure will make streamflow to increase, and vice versa."

2. "…The global warming may even be speeded up in the future, consequently leading to an increase in both floods and droughts." -> not entirely accurate. IPCC 2007 indicated that climate change will increase probabilities of floods and droughts, but calling that "global warming" is not term of art. Answer: Thanks the referee's recommendation! I accept it and the sentence can be rewritten as ""…Climate change may even be speeded up in the future, consequently leading to an increase in probabilities of floods and droughts."

3. Documentation needs to be improved about the climate scenarios assessed. The authors refer only to GCMs from a retrospective period and then three emissions scenarios. There is no documentation of why specific GCMs were used or selected nor how they were utilized (downscaled? bias corrected?) making it difficult to assess the quality of the methodology. The authors only refer the reader to Lawrence Livermore National Laboratory for GCM documentation. This is not sufficient as there are over a hundred runs of GCMs within the CMIP3 experiments. Answer: The contemporary scenario (20C3M) and three emissions scenarios are all selected from the datasets supported by IPPC-4. These datasets selected here has been applied widely in the researches about climate change, hydrology and so on. Outputs from GCMs utilized in this study are chosen based on two considerations: 1) Outputs from GCM should include the data in 2100. 2) should have the variables used in this study. In our paper, we didn't utilize the complicate method (e.g., statistical downscaling and dynamic downscaling) to process this datasets, but we used a simple approach (named Delta method) to obtain the climate change scenarios which may occur in this study region. Since the Delta method was proposed by the United States Global Change Research Program (USGCRP), it has been compared with other downscaling methods in the United States (Hay L.E., Wilby R.L. and Leavesley G.H, 2000) and Yellow River Basin of China (Zhao F.F. and Xu Z.X., 2007) and applied in the related researches (e.g., hydrology and climate) widely all over the world. Recently, several scholars in China have used this method to evaluate the simulation capability of GCMs in Changjiang River Basin, Poyang Lake Basin and Jiangxi Province, and gave the ratios or differences of

climate variables between the contemporary scenario and the future scenarios. Taking the scholars' results as the reference, we evaluated the ratios or differences calculated in our study and found that there were little differences compared with their research. The ratios of climate variables can support the initial fields for the model to estimate the streamflow changes in the future compared with the contemporary scenario. So we didn't describe these in detail to prevent this paper to be redundant. In summary, these datasets and the method of process are reasonable on the basis of their applicability. Of course, the referee's comment is very valuable for us, and we will reformulate these contents about datasets of GCMs selected and the method of process in the revised manuscript.

4. In the development of the methodology the authors utilize the same variables with different meanings. "a" is used within the water balance model as well as the expression of a linear trend model. Suggest making variables unique. Answer: Thanks the referee for the suggestion! I accept the recommendation. In the revised manuscript we will utilize other signs to represent he expression of a linear trend model.

5. Equation 4- Mean water level of what? The lake? The river? Authors need to do more to express why this is appropriate. Isn't there soil moisture that stores water? Groundwater? Simple evaluation of a surface water level cannot possible account for storage. Answers: Thank the referee for the valuable comments! Mean water level is for the river. We compared the results from the two models (the model proposed in this paper and the model without Delta WR), which are shown in Table 2. There are little differences in the parameters' values, RME and RMSE between these two models. However, we utilized the model with Delta WR in our research for calculating streamflow accurately. Of course, we must recognize this problem mentioned by the referee. There is tight linkage between long mean soil water storage and rive level at the outlet in a watershed. In wet periods, both soil water storage and river level increase, vice versa. Of course, the changes of soil water storage and river level might not be at the same phase. The main purpose of this study is to analyze the long term

trends of annual stream flow and their linkage with climate change. It is reasonable to take the change of rive level as the surrogate of the change of soil water storage under the situation without soil storage data available. Undoubtedly, this is an approximation and acknowledged in the revised manuscript.

6. The proposed methodologies are utilizing GCM information at what scale (2 degree) to calibrate their very fine scale expressions of water balance? Also is the bias correction implemented in Equation (9) documented within the literature? Seems like a very simplistic approach when trying to explain such a precise set of hydrologic variables. There are documented bias correction methodologies in the literature (e.g. Wood et al. 2002, 2004). Answer: The proposed methodologies are utilizing GCM information at different scales (which depend on GCM selected here) to calibrate their very fine scale expressions of water balance. For example, the resolution of miroc3_2_hires and the gfdl_cm2_0 model is 302×160 grid and 144×90 grid, respectively. We didn't to correct the bias of climate variables between the contemporary scenario (20C3M) and the observations. We only want to get the potential scenario of climate in future. Therefore, we calculate the ratios of climate variables from 20C3M to ones from three emissions scenarios in Eq.9 with Delta method, and then the differences between the contemporary observations and ones in future are provided the initial fields to estimate the future changes of streamflow. Since the datasets from the report of IPCC-4 was proposed, a number of scholars have done lots of works about the evaluation of GCMs' simulation capability in China, and had published some academic articles. Taking their results as references, we evaluated the ratios or differences calculated in our study and found that there were little differences compared with their research. Additionally, if we evaluate each GCM's simulation capability, we will take lots of time and computing resources. A number of domestic and foreign scientists have utilized this similar method to evaluate the potential changes of streamflow or other scientific researches (Miller N.L., et al. 2003; Ju W.M., et al. 2007; Cramer W., 2001). Therefore, we think it is not necessary to do so.

7. The authors have described the importance of all the hydrologic and weather phenomena that determine streamflow (including wind speed radiation etc...) however these variables are not coming out of GCMs. Therefore attribution statements which are expressed within equation (10) and subsequent discussion only focus on evaporation and precipitation. It is not clear how these are linked? Answer: Thanks the referee for the valuable comments! The contribution of each climate variable to streamflow changes in the past is calculated using the observations at weather stations. The contributions of precipitation and evaporation to streamflow changes in the future are estimated, but the contributions of other climate variables are not estimated because these variables are not coming out of some GCMs.

8. There is something confusing about the discussions of trends within 3.3. Why would pan evaporation be going down as temperature increases in the ways described? Is a linear trend analysis really the right tool to evaluate these potential changes? Answer: A number of studies had revealed the phenomenon of decreasing evaporation (i.e., Roderick et al., 2002, 2004, 2005a, b, 2007). And the review about this phenomenon (McVicar et al., 2012) has been published in Journal of Hydrology and gives the causes of decreasing evaporation. The review summarizes the results of several recent studies and points out that declining evaporative demand are primarily governed by trends in the aerodynamic component (primarily being the combination of the effects of wind speed (u) and atmospheric humidity) and secondarily by changes in the radiative component. However, the causes of decreasing evaporation are different in space. In our previous paper published in Transactions of the Chinese Society of Agricultural Engineering (in Chinese with English Abstract), we had evaluated the contribution of climate change (i.e., wind speed, temperature, percentage of sunshine duration, and vapor pressure) to decreasing pan evaporation quantitatively in Jiangxi Province (account for more than 90% of the whole Poyang Lake Basin) in this paper and found that decrease of wind speed was the major driver of pan evaporation decrease. Here, we give the main results of our previous paper: the relative contributions of the five environmental factors to the observed pan evaporation variations were listed

in the order of importance: wind speed (56.46%)> percentage of sunshine duration (45.08%)>minimum temperature (-10.94%)> maximum temperature (-6.57%) >vapor pressure (-2.63%). The tool to evaluate these potential changes of streamflow is developed from the method proposed by Roderick et al. (2007). This approach proposed by Roderick is derived from the Penman-Monteith with physical mechanisms, and has been applied in other regions widely. So we think this method can be used to evaluate the contribution of climate change to streamflow trend.

9. The discussion of the climate scenarios and associated impacts on streamflow with the largest increase being A1B followed by B1 and finally A2 appears to be more a reflection of GCM model choice a less a statement about anthropogenic forcing. At what look ahead period are these statements being made 2010 – 2050? 2050 – 2100? Answer: Yes, we have been aware of this problem that GCM model choice would influence the increase of annual streamflow in the future and had a less a statement about anthropogenic forcing. We are only concern with the potential changes of annual streamflow in each future climate scenario. If the referee thinks that it is not suitable, we can redo this section through selecting the same number of GCMs belonged to one future scenario, and compare the annual streamflow differences among the three future climate scenarios. Sorry, we didn't evaluate the potential changes of annual streamflow in 2010 – 2050 and 2050 – 2100. To evaluate the potential changes of annual streamflow in 2061-2100 is based on the consideration that the periods of annual streamflow analysis in the past bring into correspondence with ones in the future, and the potential changes of annual streamflow are obtained by comparing with observations in 1961-2000.

10. I am not sure that assertions about future streamflow can be made upon the analysis provided, at least not within the information currently provided within the manuscript. Answer: Firstly, we should recognize that other factors (humanity activities, interactions and feedbacks between vegetation and atmosphere, and land use/cover changes) except for climate change can influence annual streamflow. Without consideration of

other factors' influences, impacts of climate change on annual streamflow are the core contents of our study, and the contribution of each climate variable is evaluated with the method proposed in this paper. Additionally, we had given the discussions (P9413 L25âĂŤP9414 L13) about the uncertainties of our results without consideration of other factors' influences. At the assumptions that the impacts of other factors and Delta WR are ignored, the potential changes of annual streamflow caused by climate changes in the future are estimated.

11. Many of the discussions and conclusions should be reevaluated after methodological questions have been resolved. Answer: Thanks very much! In the revised manuscript, we will try our best to resolve this problem.

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/8/C5798/2012/hessd-8-C5798-2012-supplement.pdf

Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 8, 9395, 2011.

Table1 Comparison of the results from the model proposed in this paper and ones from the model without **Delta WR** during 1961-1990

	Meigang		Saitang		Gaosha		Xiashan	
	With Delta WR	Without Delta WR	With Delta WR	Without Delta WR	With Delta WR	Without Delta WR	With Delta WR	Without Delta WR
a	0.96	0.92	0.82	0.73	0.82	0.82	0.85	0.83
b	0.38	0.33	0.30	0.21	0.33	0.33	0.34	0.32
c	-0.15	/	-0.32	/	-0.19	/	-0.11	/
RME	-1.11%	-1.22%	-2.19%	-2.26%	-1.26	-1.50%	-1.94%	-2.18%
RMSE	55.24	55.77	10.45	10.77	16.46	17.31	49.92	50.66

Fig. 1.