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Hydrology and Earth System Sciences Discussions
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Interactive comment on "Assessing the impact of climate variability and human activity to streamflow variation" *by* J. Chang et al.

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Sincere gratitude is extended to the reviewer for her/his careful review of the manuscript. Those comments are all valuable and very helpful for revising and improving our paper, as well as the important guiding significance to our researches. Here are our responses to the reviewers' comments. To begin with, we agree on the viewpoint of the reviewer that elasticity method and the method based on the hydrological models have been widely used in assessing the impacts of climate change and human activities on streamflow. We have been thinking about how to analysis the impacts of environment change on streamflow reasonably and effectively in the Jinghe river basin, and this is our original motivation to write this paper. Since these methods have been reported and applied in literature with satisfied results, so the elasticity method and hydrological models are used in this paper. Another purpose of selecting these methods is to compare the results derived from different models. Furthermore, this reviewer has found some several inaccuracies, structural and grammatical errors. Sincere gratitude is extended to the reviewer for her/his careful review of the manuscript. Complying with the Reviewer's suggestion, we have revised my paper point-by-point as follows: Specific comments: (1) In the title of this paper, the authors used the phrase "human activity", but the phrase "human activities" appears many times in the body of this paper. Response: Thanks for the comment. In the Jinghe basin, there were several kinds of human activities which influenced streamflow, therefore, we have corrected "human activity" as "human activities" in the paper. (2) Abstract, Line 7: Jinhe basin or Jinghe basin? Response: We have changed "Jinhe" to "Jinghe" in the revised manuscript. (3) Line 10: What does "climatic differences" mean? Response: Climatic differences means climate variability, and we have changed "climatic differences" to "climate variability" in order to be consistent with the later description. (4) Line 14: "contribution" may be a better phrase than "change impacts". Response: We have changed the word "change impacts" with "contribution" in the revised manuscript. (5) Lines 13-23: The description of the study results is very messy. It is difficult for the readers to understand what the authors have found in their study. Response: We have re-written the abstract. Water resources in river systems have been changing under the impacts of both climate variability and human activities. Assessing the respective impacts on decadal streamflow variation is important for water resources management. By using an elasticity-based method, calibrated TOPMODEL and VIC hydrological models, we have quantitatively isolated the relative contributions that human activities and climate variability made to decadal streamflow changes in Jinghe basin located in northwest of China. This is an important watershed of Shaanxi Province that supplies drinking water for a population of over 6 million. The results show that the average annual streamflow from 1990-2010 reduced by 26.96% compared with the multi-year average value. The maximum value of the moisture index (E0/ P) was 1.91 appeared in 1991-2000, and the decrease speed of streamflow was higher since 1990. The estimates of climate variability and human activities impacts from the hydrological models are similar to those from the elasticity-based method. The maximum contribution value of human activities was appeared in 1981-1990 due to the effects of soil and water conservation measures and irrigation water withdrawal, whereas climate variability made the greatest contribution reduction in 1991–2000, the values of which were respectively 99% and 40.4% when averaged over the three methods. (6) The last sentence in Abstract: The readers will be confused when reading about "We emphasized various source of errors and uncertainties. . .". Did the author analyze the errors and uncertainties of these methods? What are the specific findings about the errors and uncertainties of these methods? Response: Thanks for pointing out this issue. Since some factors tend to disturb the results of the paper, it is necessary to analyze the uncertainty of the methods. We have discussed the errors and uncertainties qualitatively in the section of 5.2, however there is no quantitatively discussions. We will make an attempt for further research. (7) Introduction: Line 1: is or are? Response: We have changed "is" to "are" in the revised manuscript. (8) Line 8: "separate and quantify the effects of climate variability/climate change" In this paper, the authors used the concept of climate variability, and I wonder water is the difference between climate variability and climate change? Since the aim of this paper is assessing the impact of climate variability and human activity to streamflow variation, it is better to change this sentence into "separate and quantify the effects of climate variability and human activities". Response: Thanks for the comment, which we all think is useful in improving our paper. According to the comment, we have changed "separate and quantify the effects of climate variability/climate change" to "separate and quantify the effects of climate variability and human activities" in the revised manuscript. (9) Lines 23-25: Since the hydrological models have been regarded to have such many disadvantages, why did the authors applied these methods in this study? Response: We all know that hydrological models are used for various applications, ranging from the estimation of catchment water yield to the estimation of land use and climate change impacts on runoff characteristics. So, we used different models for this study. However, we cannot deny the fact that hydrological models have disadvantages such as uncertainty of model parameters and model structure. The objective of this project is to identify the dominant factor between climate change and human activities on streamflow variation instead of accurately simulating streamflow, and such issue could be addressed through hydrological models (Lan Cuo, Yongxin Zhang,Yanhong Gao, Zhenchun Hao, Luosang Cairang: The impactsof climate change and land cover/use transition on the hydrology in the upper Yellow River Basin, China, Journal of Hydrology, 502, 37-52, 2013. Zhenxin Bao, Guobin Fu, Guoqing Wang, Junlinag Jin, Ruimin He, Xiaolin Yan, Cuishan Liu: Hydrological projection for the Miyun Reservoir basin with the impact of climate change and human activity, Quaternary Internatinal, 282, 96-103, 2012.). (10) Page 4, Last sentence: Please put some proper references for this statement. Response: According to the comment, we have put some proper references (Chang et al., 2014; Du and Shi, 2012) in the revised manuscript. Jinghe River is the largest tributary of the Weihe River Basin, and the hydrological control station is Zhangjiashan hydrological station. The results of the two studies show that the runoff of Zhangjiashan hydrological station presents a significantly decreasing trend since 1990. Chang, J.-X., Wang, Y., Istanbulluoglu, E., Bai, T., Huang, Q., Yang, D., and Huang, S.: Impact of climate change and human activities on runoff in the Weihe River Basin, China, Quatern. Int., doi:10.1016/j.quaint.2014.03.048, online first, 2014. Du J., and Shi C.: Effects of climate factors and human activities on runoff of the Weihe River in recent decades. Quaternary International. 282, 58-65, 2012.) (11) Page 5, Lines 6: Since the abbreviation of JRB has appeared before, it is unnecessary to put this information again. Response: We have changed the word “The Jinghe river basin (JRB)” to “The JRB” in the revised manuscript. (12) Lines 23-24: The author should put the proper references to support the statement of “climate variability combined with human activities has contributed to the decrease of the streamflow in the JRB.” Response: According to the comment, we have supplemented reference in the revised manuscript (Du J., and Shi C.: Effects of climate factors and human activities on runoff of the Weihe River in recent decades. Quaternary International. 282, 58-65, 2012.). In this paper, climate variability combined with human activities has contributed to the decrease of the streamflow in the Zhangjiashan hydrological station of JRB. (13) Lines 25-26: Please reword this sentence. Response: We have revised the section about data. In this paper, catchment information data set, including catchment boundary and runoff ratio, was from the Ministry of Water Resources (MWR) of the People's Republic of China. Daily, monthly, and annual climate variables and observed runoff were used. Daily meteorological data of ten stations during 1960–2010, including precipitation, air temperature, sunshine hours, relative humidity, and wind speed, were collected from China Meteorological Administration (CMA). The monthly and annual precipitation, and monthly and annual maximum, minimum, and mean air temperature values were then calculated according to the daily data. The monthly potential evaporation was calculated according to the monthly wind speed, sunshine hours, relative humidity and air temperature by using the Penman-Monteith method. The daily streamflow data of Zhangjiashan hydrological station for the same period were gathered from the Shaanxi Hydrometric and Water Resource Bureau. The DEM data were obtained from the SRTM 40 m Digital Elevation Data. The soil data were extracted from the FAO two-layer 5-min 16-category global soil texture maps. Figure 1 shows the location of the meteorological stations and hydrological station in the basin. (14) Page 5, Line 1: Please check "196-2010". Response: Thanks for the comment. We have changed the word "196-2010" to "1960-2010" in the revised manuscript. (15) Lines 5-6: Please reword this sentence. It is difficult to understand. Response: We have changed the sentence into "The monthly and annual air temperature values (maximum, minimum, and mean) were then calculated according to the daily data." in the revised manuscript. (16) Line 13: It is better to merge Figure 1 and Figure 2, since they give the similar information. Response: We have merged Figure 1 and Figure 2 in the revised manuscript.

Fig. 1. Location of hydrological and meteorological stations in the Jinghe River

(17) Page 7 Eq. (4-5): Eq.(5) should has the same form with Eq.(4). Response: We have changed "Eq.(5)" to the same form with "Eq.(4)" in the revised manuscript. Thus, precipitation elasticity and evapotranspiration elasticity of streamflow were

defined by Schaake (1990) as $\varepsilon\_P\ (P,Q)=(dQ/Q)/(dP/P)=dQ/dP\ P/Q$ (4) $\varepsilon\_(E\_0\ )\ (E\_0,Q)=(dQ/Q)/((dE\_0)/E\_0\ )=dQ/(dE\_0\ )\ E\_0/Q$ (5)

(18) Page8 Line 1: were or are? Response: We have changed “were” to “are” in the revised manuscript. (19) Line 7: What’s the meaning of “Eq. ()”? Response: It is Eq.(6). (20) Lines 9-11: All Budyko-type equations do not include the term of streamflow (as displayed by the Eq. (8) in this manuscript). Please correct this statement. Response: Thanks for the comment. We have revised the statement of Budyko hypothesis. The Budyko hypothesis (Yang et al., 2008; Teng et al., 2012; Wang et al., 2015) produces a simplified but powerful coupled water-energy balance method. It is a holistic approach that assumes the equilibrium water balance is controlled by water availability and atmospheric demand. The water availability can be approximated by precipitation, the atmospheric demand represents the maximum possible evapotranspiration and is often equated with potential evapotranspiration. The role of landscape properties on mean annual water balance is mainly implicit, and is deemed as being subservient to the dominant role of climate. In some formulations of the Budyko formulation, the role of the landscape is represented by a separate, lumped parameter (Yu et al., 2014; Donohue et al., 2007), which is nevertheless estimated empirically. (21) Eq. (7): The symbol “F ()” has not been defined. The authors just present the expression of the elasticity of precipitation, but I wonder how is the elasticity of potential evaporation estimated? Using the Eq. (5) or subtracting the elasticity of precipitation from 1? What is the difference between these two methods? Response: F () is a function proposed by the Budyko, it not only satisfies the boundary conditions under the land surface evapotranspiration, but also keeps independent from the balance equation of hydrothermal coupling (the water balance and energy balance), we have added this explanation in the revised manuscript. The equation ($\varepsilon\_P+\varepsilon\_(E\_0\ )=1$) is derived from the water balance equation (Q = P - Ea) and the Budyko hypothesis, the results of two equations ($\varepsilon\_(E\_0\ )\ (E\_0,Q)=(dQ/Q)/((dE\_0)/E\_0\ )=dQ/(dE\_0\ )\ E\_0/Q$ and $\varepsilon\_P+\varepsilon\_(E\_0\ )=1$) are equal. In this study, the elasticity of potential evaporation is calculated according to the later equation, i.e. $\varepsilon\_P+\varepsilon\_(E\_0\ )=1$. (22) Lines 26-27: “w was set to 2.0 according to

the land use and land cover status in the study area". Is there a certain relationship between the parameter and land use/cover status? If any, please present this relationship. The value of this parameter can be estimated by using the observed data, and I wonder what is the difference between the estimated value from the observed hydrological data and the value set in this manuscript? Response: Thanks for the comment, which we all think is valuable. Several studies have demonstrated that w is related to land surface characteristics, including vegetation, soil types, and topography, as well as climate seasonality (Milly, 1994; Yang et al., 2009). In other words, given the same dryness index, land surface hydrology still varies due to variations in these factors. For example, the vegetation coverage reflects the effect of climate seasonality (Gutman and Ignatov, 1998). Lower vegetation coverage might be associated with a large seasonal phase mismatch between precipitation and radiation, which is known to reduce the actual evapotranspiration (Milly, 1994; Yokoo et al., 2008). In this paper, the value of w was set according to the study of Li et al (2013). During their study, a simple parameterization for the w parameter based on remotely sensed vegetation information is proposed and applied in the 26 global rivers, for example Amazon, Amur, Mississippi and Yellow River. The basins monthly time series of water budget terms, i.e., precipitation, evapotranspiration, runoff, and water storage changes is used in the paper. The results improves predictions of annual actual evapotranspiration as compared to the default w value used in the Budyko curve method. The modeled w for the Yellow River is similar to 2 according to study, and the Jinghe River is a branch of the Yellow River Basin. Hence, the parameter of w was set to 2.0 in our study. Gutman, G., and A. Ignatov, The derivation of the green vegetation fraction from NOAA/AVHRR data for use in numerical weather prediction models, Int. J. Remote Sens., 19(8), 1533–1543, 1998. Li, D., Pan, M, Cong, Z., and Wood, E.: Vegetation control on water and energy balance within the Budyko framework, Water Resour. Res. 49, 969-976, doi: 10.1002/wrcr.20107, 2013. Milly, P. C. D. (1994), Climate, soil-water storage, and the average annual water-balance, Water Resour. Res., 30(7), 2143–2156. Yang, D. W., W. W. Shao, P. J. F. Yeh, H. B. Yang, S. Kanae, and T. Oki (2009), Impact of vegetation

coverage on regional water balance in the nonhumid regions of China, Water Resour. Res., 45, W00A14, doi:10.1029/2008WR006948. Yokoo, Y., M. Sivapalan, and T. Oki (2008), Investigating the roles of climate seasonality and landscape characteristics on mean annual and monthly water balances, J. Hydrol., 357(3–4),255–269. (23) Page 9 Lines 2-3: hydrological or hydrologic? Response: It is hydrological. (24) Lines 7-11: Please show how to estimate the simulated streamflow during changed period. Since TOPMODEL is usually applied at the daily or shorter time scale, how did the authors simulate the mean annual streamflow by using this model? Response: The scale of TOPMODEL output data are related with the input data. Since we chose the monthly data as the input data, and the output data were monthly streamflow. Then, we make a mathematical statistics to calculate the annual streamflow. Some previous studies (Peng D. Z., and Xu, Z. X., 2010) also conducted similar investigation about this topic. Peng D. Z., and Xu, Z. X.: Simulating the impact of climate change on streamflow in the Tarim River basin by using a modified semi-distributed monthly water balance model. Hydrol. Process. 24, 209–216 (DOI: 10.1002/hyp.7485). 2010. (25) Page 10 Line 9: Please put some proper references for the Xinanjiang model. Response: According to the comment, we have put some proper references for the Xinanjiang model in the revised manuscript. Lin, K., Lv, F., Chen, L., Singh, Vijay P. Zhang, Q. and Chen, X.: Xinanjiang model combined with Curve Number to simulate the effect of land use change on environmental flow, J. Hydrol., 519,3142-3152,2014. Yao, C., Li, Z., Yu, Z., and Zhang, K.: A priori parameter estimates for a distributed, grid-based Xinanjiang model using geographically based information, J. Hydrol., 468-469, 47-62, 2012. (26) Line 20: What's the specific meaning of "corresponding data"? Response: The "corresponding data" was the ten meteorological stations data from 1960 to 2010 of research area, since it was mentioned in line 26 of page 5, we have no description here. (27) Lines 21-24: The author concluded that the streamflow had a larger decrease than precipitation, but why the regression slope of precipitation was larger than that of streamflow? Response: According to the comment, we have checked the Fig.2. It was a double-coordinate line chart, and the units were different, so the regression slope of the precipitation and runoff were not comparable. (28) Lines 24-26: It is ambiguous for this sentence. What's the meaning of "reduced by 17.39 % compared with the multi-year average streamflow"? How the value of 17.39% was calculated? The same issue for the value of -26.96% in next sentence. I suggest the authors to reword this paragraph, because it is hard to understand. Response: We feel very sorry to have brought the trouble to the reviewer. We have checked the results and corrected the sentence.The multi-year average streamflow (from1960 to 2010) was 37.03mm, and the average value was 43.47mm from 1960 to 1990, which means the streamflow from 1960 to 1990 increased by 17.39% (((43.47-37.03))/37.03*100%) compared with the multi-year average value. The average annual streamflow was 27.05mm during 1991-2010, reduced by 26.96% (((27.05-37.03))/37.03*100%) compared with the multi-year average value, therefore, the speed of streamflow decrease was higher since 1990. (29) Page 11 Lines 22-23: Please distinguish evaporation and potential evaporation. The terms of 60s, 80s should be written as 1960s, 1980s. Please check this kind of issues. Response: Since the data of monthly potential evaporation was calculated by Penman-Monteith method, we have changed "evaporation" to "potential evaporation". We have checked this issue (the terms of 60s, 80s et al.), and changed the wording in the revised manuscript. (30) Page 12 The first paragraph should be put into the section of methods. Response: According to the comment, we have put this section into "3.3 Modeling-Based Approach for ΔQC or ΔQH" in the revised manuscript. (31) Page 13 Lines 14-15: Why did the authors select the period of 1960-1970 as the baseline period? Response: By means of sequential cluster analysis method, we have obtained the break points of precipitation and streamflow in Jinghe River. The break points appeared in 1970s, so we selected the period of 1960-1970 as the baseline period. We have put the investigation results into the manuscript. The break points of precipitation and streamflow are as follows:

Fig.2 The abrupt change points of precipitation and runoff in JRB with Sequential cluster (32) Page 15 Section 4.5: This section should be put before the results of the hydrological models to agree with the presentation of the methods. In section 3, the elasticity method was firstly presented. Response: We have restructured the order of the article, section 4.5 was put the before the results of the hydrological models. (33) Line 9: Eqs. (3)-()? Response: It is Eqs. (3)- (8). (34) Lines 25: It is better to put the reference (Willmott and Feddema, 1991) into the section of methods. Response: We have studied the paper, and it's helpful for us to understand the Budyko hypothesis. Willmott, C.J., Robeson, S.M., and Feddema, J.J.: Influence of spatially variable instrument networks on climatic averages. Geophysical Research Letters, 18, 2249-2251, 1991. (35) Page 16, title of 5.1: Please reword the tile of this section. Response: We have changed it into "Results comparison of the three methods" (36) Lines 12-13: It is only here that readers find the time scales of the two hydrological models. Please put this information into the section of methods. TOPMODEL was usually applied at daily or shorter time scale, why was it applied at monthly scale in this paper? Since the authors just need to analyze the change of mean annual streamflow, what's the advantage of the hydrological simulation based on daily or monthly scale? Response: We have supplemented the description about the model scale in the introduction section, i.e. "The elasticity based method only provide results at mean annual time scale whereas the hydrological modelling results are at a monthly and daily scale and they are aggregated to the mean annual time scale for comparison with those obtained from the statistical method." Also, there is description about the model scale in the section of "Hydrological model calibration and validation", i.e. "Monthly precipitation, potential evapotranspiration and observed streamflow acted as input data" and "The VIC model was used for streamflow simulation at a 0.5°spatial and daily temporal resolution in the JRB (Fig. 4)." The input data of TOPMODEL could be monthly scale, and some studies also used monthly data to conduct similar investigation (Peng D. Z., and Xu, Z. X., 2010). We selected the monthly input data to simulate the monthly streamflow, and applied statistical methods to calculate the annual streamflow. The input data of VIC model can only be daily data, so the daily streamflow was simulated, then the annual streamflow was calculated. Peng D. Z., and Xu, Z. X.: Simulating the impact of climate change on streamflow in the Tarim River basin by using a modified semi-distributed monthly water balance model. Hydrol. Process. 24, 209–216 (DOI:10.1002/hyp.7485). 2010. (37) Line 13: Vic or VIC? Response: It is VIC. (38) Page 19: In the section of conclusion, the authors present their findings by using a lot of numbers. It is difficult for the readers to understand the results of this study from a macroscopic perspective. Response: We have revised the section of conclusion. This paper investigated the impacts of human activities and climate variability on streamflow using observed data and three methods (an elasticity-based method, a calibrated TOPMODEL and VIC model) for JRB in China. (1) The variability of streamflow, precipitation, potential evaporation and temperature in the JRB is analyzed. Both the annual precipitation and streamflow showed a statistically decreasing trend, while the streamflow had a larger decrease, and the decrease speed was higher since 1990. The potential evaporation presented an insignificant increasing trend, however the temperature had a significant increasing trend. (2) The TOPMODEL and VIC hydrological model were calibrated and validated for the study catchment by using meteorological data and observed streamflow for the baseline period of 1960-1970. Then, the calibrated models were used to quantify the effects of climate variability and human activities on streamflow during the 1971–1980, 1981–1990, 1991–2000, and 2000–2010. (3) The precipitation elasticity (ε_P) and evapotranspiration elasticity (ε_E0) of streamflow for different periods in the JRB were calculated by using the Budyko formulation of Fu. The results indicated that a 10% decrease in precipitation would result in 14.8% drop in streamflow, while a 10% decrease in potential evapotranspiration would induce 4.8% increase of streamflow. (4) Compared with the baseline period of 1960-1970, streamflow in the JRB greatly decreased during 2001–2010. Climate variability and human activities impacts from the hydrological models are similar to those from the elasticity-based method. (5) The maximum contribution value of human activities was appeared in 1981-1990 due to the effects of soil and water conservation measures and irrigation water withdrawal, whereas climate variability made the greatest contributions reduction in 1991–2000, the values of which were respectively 99% and 40.4% when averaged over the three methods. (39) Table 6: The font size is too small. Response: Corrected.

Table 6 The impact of climate variability and human activities on the streamflow with VIC model

(40) Figures: Please adjust the font sizes in all figures. The font sizes in Figures. 5-9 are too small. It harms the quality of presentation. Response: Corrected.

fFig.3. Changes of annual streamflow and precipitation of JRB

Fig.4. Changes of annual potential evaporation and temperature of JRB

Fig.5. (a) Elevation maps of the study area at 40 m resolution. (b) Grid of VIC model. (c) Sub-basin of TOPMODEL

Fig.6. the simulated and observed streamflow for the calibration and validation period for TOPMODEL and VIC model (a) calibration period (b) validation period

Fig. 7. Comparison of observed and modelled monthly streamflow for calibration and validation periods

Fig. 8. Comparison of observed and modelled monthly streamflow in 1971-2010 (a)TOPMODEL (b) VIC model.

Fig. 9. Time series of observed and model simulated annual streamflow for JRB for the entire modelling period

Please also note the supplement to this comment:
http://www.hydrol-earth-syst-sci-discuss.net/12/C3310/2015/hessd-12-C3310-2015-supplement.pdf

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Interactive comment on Hydrol. Earth Syst. Sci. Discuss., 12, 5251, 2015.

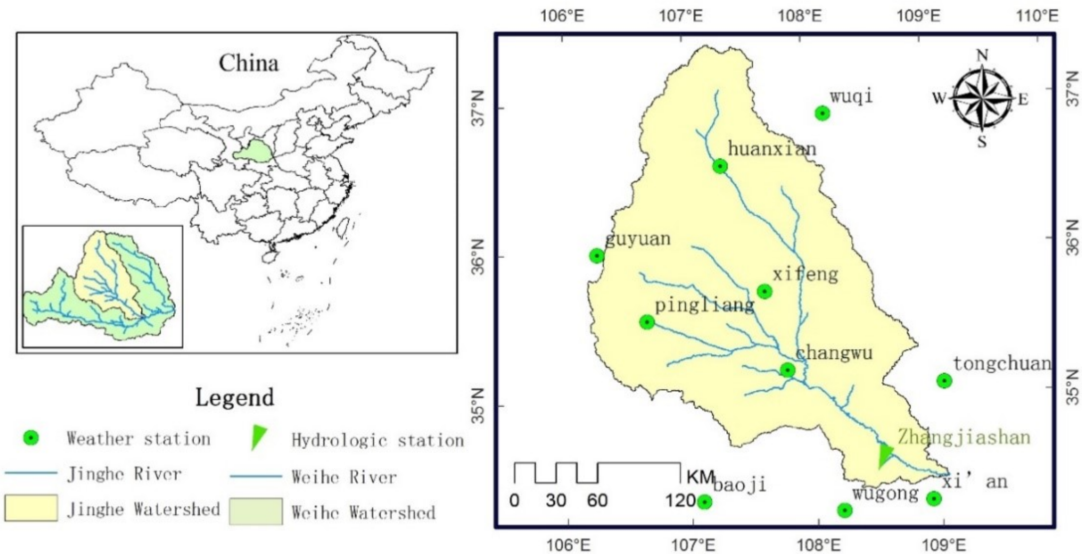

Fig. 1. Fig. 1. Location of hydrological and meteorological stations in the Jinghe River

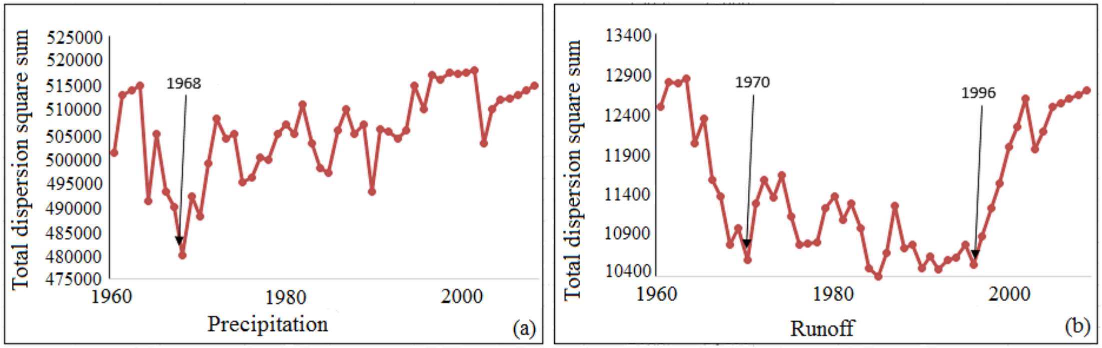

Fig. 2. Fig.2. The abrupt change points of precipitation and runoff in JRB with Sequential cluster

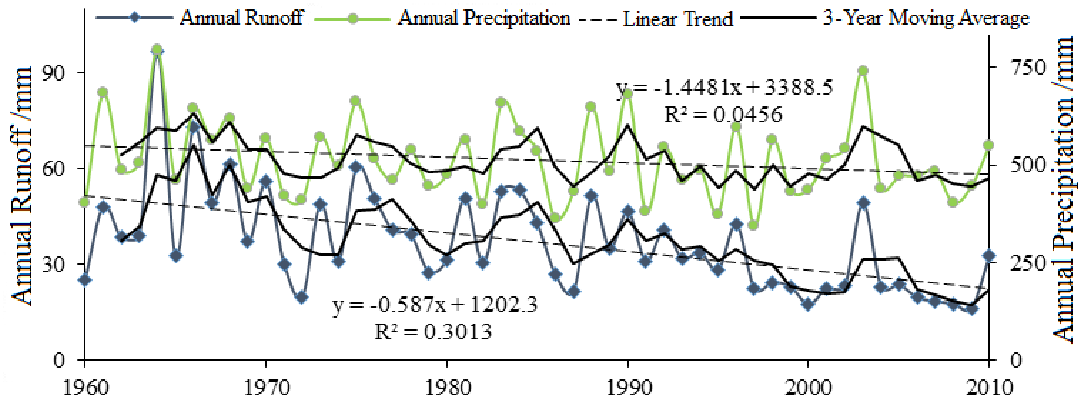

Fig. 3. Fig.3. Changes of annual streamflow and precipitation of JRB

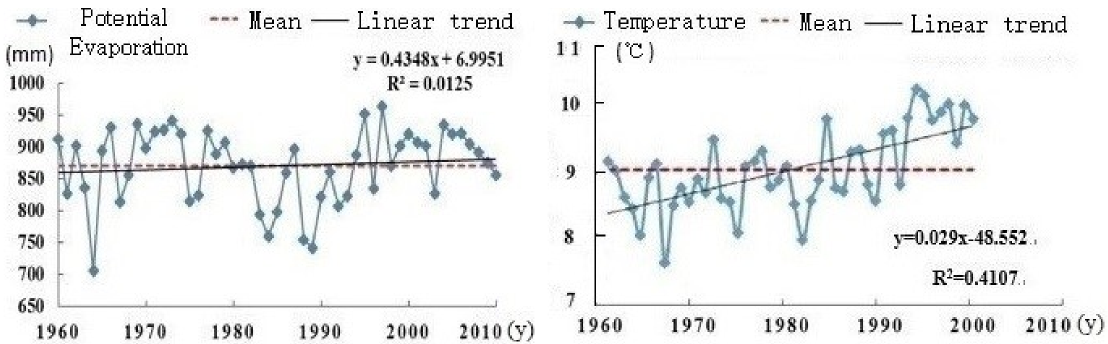

Fig. 4. Fig.4. Changes of annual potential evaporation and temperature of JRB

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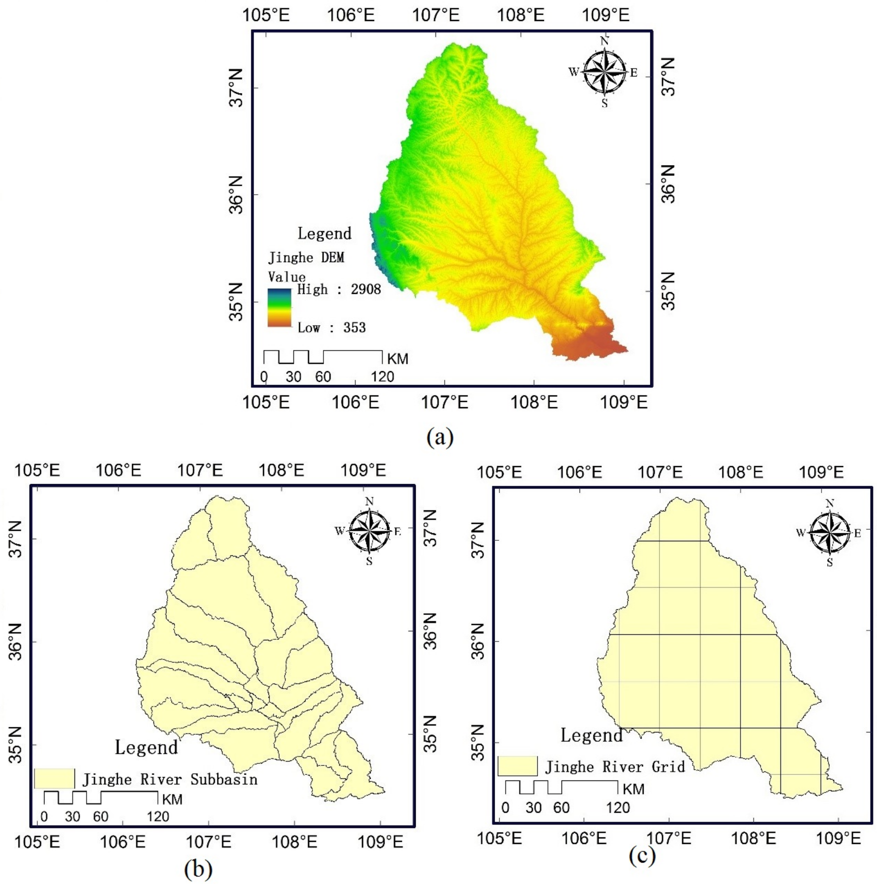

Fig. 5. Fig.5. (a) Elevation maps of the study area at 40 m resolution. (b) Grid of VIC model. (c) Sub-basin of TOPMODEL

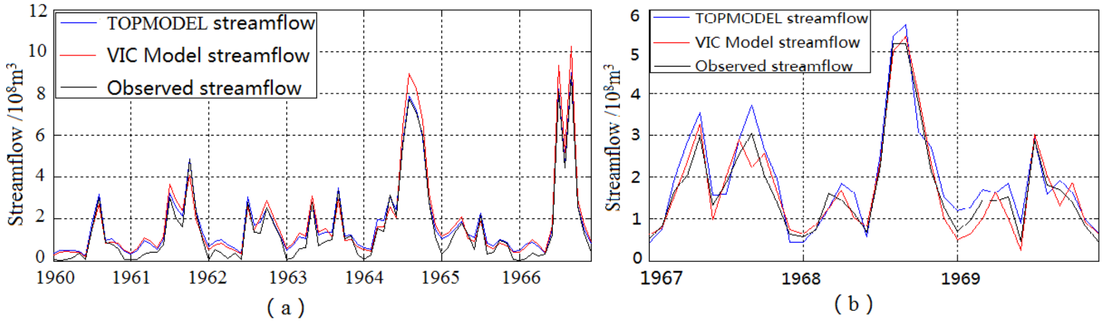

Fig. 6. Fig.6. the simulated and observed streamflow for the calibration and validation period for TOPMODEL and VIC model (a) calibration period (b) validation period

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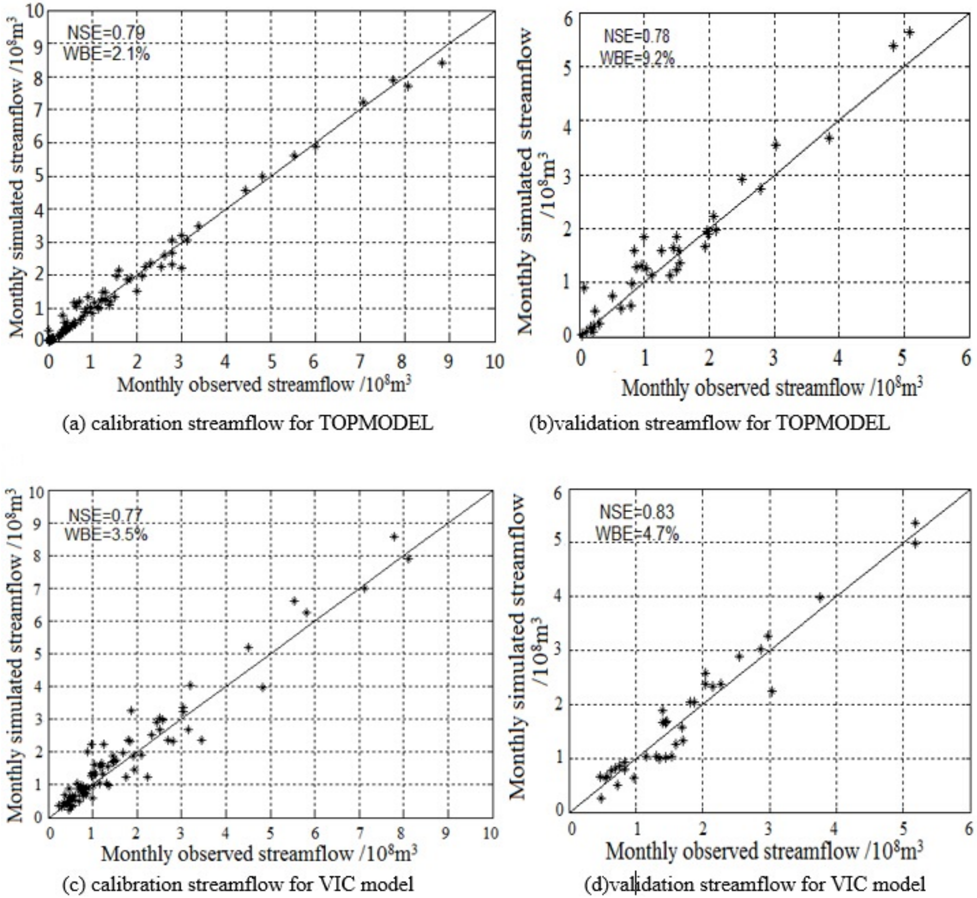

Fig. 7. Fig. 7. Comparison of observed and modelled monthly streamflow for calibration and validation periods

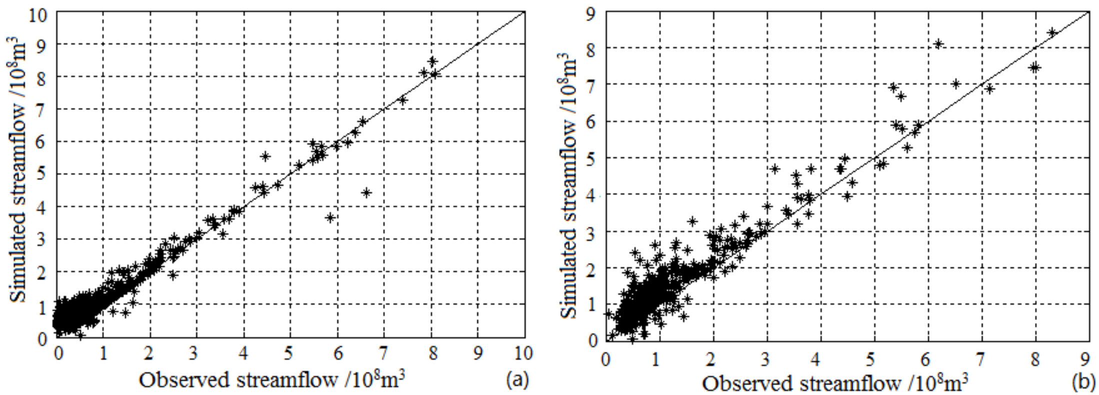

Fig. 8. Fig. 8. Comparison of observed and modelled monthly streamflow in 1971-2010 (a)TOPMODEL (b) VIC model

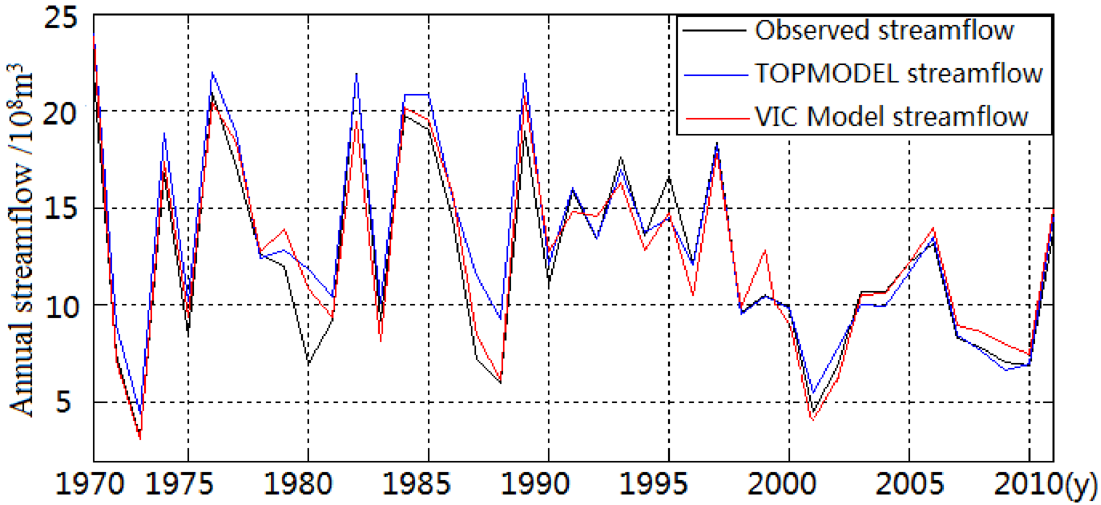

Fig. 9. Fig. 9. Time series of observed and model simulated annual streamflow for JRB for the entire modelling period

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period	Annual mean streamflow			Human activities		Climate variation	
	Q_B (10^8m^3)	ΔQ (10^8m^3)	Q_S (10^8m^3)	ΔQ_H (10^8m^3)	η_H (%)	ΔQ_C (10^8m^3)	η_C (%)
1960-1970	18.3	—	—	—	—	—	—
1971-1980	11.4	-6.9	17.1	-5.7	82.6	-1.2	17.4
1981-1990	14.3	-4.0	18.8	-4.5	112.5	0.5	-12.5
1991-2000	12.6	-5.7	15.8	-3.2	56.1	-2.5	43.9
2001-2010	10.9	-7.4	16.7	-5.8	78.4	-1.6	21.6
1971-2010	12.3	-6.0	17.0	-4.7	78.3	-1.3	21.7

Fig. 10. Table 6 The impact of climate variability and human activities on the streamflow with VIC model

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