This paper quantitatively isolated the relative contributions that human activities and climate variability made to decadal streamflow changes in Jinghe Basin of China using an elasticity-based method and two hydrological models (TOPMODLE and VIC models). There are three major concerns with this manuscript.

1. I think the results could be made more concise and understandable, and the discussion should be deeper, especially for the uncertainties of the three methods.

2. The logic and statement should be consistent throughout the whole paper.

3. The paper is understandable but the English would need considerable improvement from a native speaker before it should be published.

Response: Sincere gratitude is extended to the reviewer for the 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.

We have made the results more concise and easily understood. The logic and statement were checked and modified throughout the paper. Meanwhile, the manuscript language has been edited.

Specific Comments

Abstract

1. P12748 L10 Relative to what, the decreased speed of streamflow was higher?

Response: In the part of Sect. 4.1 (P12757 L16-24), we have described as following:

"The multi-year average streamflow (from 1960 to 2010) was 37.03 mm, and the average annual streamflow was 43.47 mm from 1960 to 1990, which meant that the streamflow from 1960 to 1990 increased by 17.39% compared with the multi-year average streamflow. The average annual streamflow was 27.05 mm during 1991-2010 and was reduced by 26.96% compared with the multi-year average value; therefore, the speed of the streamflow decrease was higher since 1990.".

In order to be better understood, we have changed the statement into "The results showed that the maximum value of the moisture index (E0/P) was 1.91 and appeared in 1991-2000, and the decreased speed of streamflow was higher since 1990 compared with 1960-1990".

2. P12748 L13 Please specify "the multi-year average value" represents the average value from which year to which year.

Response: "the multi-year average value" represents the average value from 1960 to 2010.

3. P12748 L18 Please point out what does the 99 and 40.4% mean, respectively?

Response: In the part of Sect. 5.1 (P12763 L7-13), we have described as following:

The most significant climate variability impacts were 2.7×10^8 m^3 (47.4%), 2.5×10^8 m^3 (43.9%) and 1.7×10^8 m^3 (29.9%) for TOMODEL, VIC model and the elasticity based model, respectively, appearing in the 1990s. The most significant human activities impacts were 3.8×10^8 m^3 (95%), 4.5×108 m^3 (112.5%) and 3.7×10^8 m^3 (92.4%) for TOMODEL, VIC model and the elasticity based model, respectively, appearing in the 1980s.

Therefore, the average contribution ratios of human activities and climate variability of the three methods were 99% and 40.4%, respectively. In order to be better understood, we have changed the sentence into "The maximum contribution value of human activities was 99% when averaged over the three methods, and was appeared in 1981–1990 due to the effects of soil and water conservation measures and irrigation water withdrawal. Climate variability made the greatest contribution to runoff reduction in 1991–2000, the values of which was 40.4%."

4. P12748 L19 What is the significance to emphasize the errors and uncertainties that may occur in the methods used in the study.

Response: Since some factors tend to disturb the results of the paper, it is necessary to point out the uncertainty of the methods. So, we qualitatively discussed the errors and uncertainties in the section of 5.2, however there is no quantitatively discussions. We will make an attempt for further research.

Introduction

5. P12750 L10 The "Yellow River basin" only appear once in the paper, I think that's no necessary to use the abbreviation of YRB. Similarly, the MWR for the Ministry of Water Resources and the CMR for the China Meteorological Administration.

Response: Corrected.

6. P12750 L10-12 The references should be noted for the numbers of 1.28 ℃/50 years and 8.8%.

Response: According to the comment, we have supplemented the reference:

Yang D, Li C, Hu H, et al. Analysis of water resources variability in the Yellow River of China during the last half century using historical data[J]. Water Resources Research, 2004, 40(6).

7. P12750 L12-13 "A combination of these effects reduced the streamflow." Does the streamflow reduced significantly?

Response: The changes of the annual streamflow shown in Fig.3 in the paper indicated that the streamflow reduced significantly compared with the baseline period (1960-1970). Meanwhile, the decrease tendency of the streamflow is reported in some papers (Chang et al, 2015; Gao et al. 2013).

8. P12750 L13-16 The streamflow variation of the Jinghe River was mainly caused by the combination effect of climate change and human activities. As one important drinking water source for a population of over 6 million people, I think the streamflow variation of the Jinghe River should have been investigated by several previous researchers. The study about the relative contribution of climate change and human activities on the streamflow variation of the Jinghe River is probably few. Please elaborate clearly.

Response: There are some researches about the impact of human activities on streamflow variation in the JR. For example, Peng (2015) evaluated the impacts of soil and water conservation in JRB by means of the distributed eco-hydrological model, and the results showed that the streamflow might decrease as the vegetation evapotranspiration increased. Chen (2008) analyzed the vegetation dynamic changes and the relationship between precipitation and NDVI in JRB, and the results showed that vegetation dynamics in different areas tended to be induced by climate changes and human activities. Few studies assessed the impact of climate change and human activities on the streamflow in the JR.

Peng H, Jia Y, Niu C, et al. Eco-hydrological simulation of soil and water conservation in the Jinghe River Basin in the Loess Plateau, China[J]. Journal of Hydro-environment Research, 2015, 9(3): 452-464.

Chen C, Xie G, Zhen L, et al. Analysis on Jinghe watershed vegetation dynamics and evaluation on its relation

with precipitation [J]. Acta Ecologica Sinica, 2008, 28(3):925-938.

9. P12750 L17 The objective of the study should be stated more clearly, especially, the innovation of the study.

Response: The aims of this study were to: 1) present a generic framework that investigate the impact of climate variability and human activities on streamflow using the concept of streamflow elasticity and hydrological models, the TOPMODEL and VIC models, which are fundamentally different in regard to their representation of streamflow generation; and 2) compare these methods.

Study area and data

Methodology

10. P12752 L13-14 What's does the meaning of the sentence that "the historic streamflow series can be split into subseries from a year before when human activities were negligible"?

Response: We split the historic streamflow series into two subseries according to the streamflow break year, and human activities in the recorded years prior to the break year can be negligible.

11. P12755 L8-9 "Hydrological models can also be used to assess the impact of climate change on streamflow." Does the impact of human activities on streamflow also can be assessed by the hydrological models?

Response: Yes, the impact of human activities on streamflow ΔQ_H) also can be assessed by the hydrological models. In this paper, ΔQ_H was estimated as the difference between the mean annual average of the simulated streamflow and the mean annual average of the observed streamflow during the changed period.

12. P12757 L3 Why the break points appeared in the 1970s? Was it caused by human activities? Or climate change?

Response: We used sequential cluster method to estimate the break points of precipitation and streamflow series as shown in Fig.2, and the break points appeared in 1968 and 1970 respectively. The impact factors for decreased streamflow include human activities and climate change. The main objective of

this paper is to investigate the impact of climate change and human activities on streamflow

13. P12757 L8 The mathematic expression of the NSE and WBE percentage should be given in the paper. Meanwhile, what's the evaluation standard for the calibration and validation results?

Response: We have added the mathematic expression of the NSE and WBE in the manuscript.

$$NSE = 1 - \frac{\sum_{i=1}^{N}\left(Q_{o,i} - Q_{s,i}\right)^2}{\sum_{i=1}^{N}\left(Q_{o,i} - \overline{Q_o}\right)^2} \tag{9}$$

$$WBE = \left| \frac{100 * \left(\sum_{i=1}^{N} Q_{s,i} - \sum_{i=1}^{N} Q_{o,i}\right)}{\sum_{i=1}^{N} Q_{o,i}} \right| \tag{10}$$

Where $Q_{o,i}$ is the observed streamflow of period i, $Q_{s,i}$ is the simulated streamflow of period i, and $\overline{Q_o}$ is the mean of observed streamflow.

We used the NSE and WBE as the evaluation standard for calibration and validation. The NSE value between 0.6 and 0.8 indicates that the model performs reasonably. Value between 0.8 and 0.9 indicates that the model performs very well and value between 0.9 and 1.0 indicates that the model performs extremely well. WBE performs best when a value of 0 is generated since no difference between simulated and observed streamflow occurs. The WBE between -5% and +5% indicates that a model performs well, while the WBE between +5% and +10% or -10% and -5% indicates a model with reasonable performance (Gumindoga W, 2014).

Gumindoga W, Rientjes T H M, Haile A T, et al. Predicting streamflow for land cover changes in the Upper Gilgel Abay River Basin, Ethiopia: A TOPMODEL based approach [J]. Physics and Chemistry of the Earth, Parts A/B/C, 2014, 76: 3-15."

Results and discussion

14. P12757 L10 The sub-title of "Results and discussion" repeats with the sub-title of the "Discussion".

Response: We have changed "Results and discussion" to "Results".

15. P12758 L1-4 "…however, the minimum occurred in different years, which resulted from water withdrawal and other reasons, such as changes in groundwater." This sentence is ambiguous. What does it mean the minimum occurred in different years?

Response: We mean that the minimum of precipitation and streamflow occurred in different years, which were 1997 and 2009 respectively.

16. P12758 L8 As we know, the runoff ratio decreased during dry years, while increased during wet years. Please elaborate why the increased runoff ratio during the wet years was emphasized, and the value of runoff ratio during the wet season should also be provided.

Response: The runoff coefficient reflects the influence of physiographic elements to the relationship of precipitation and runoff in the basin, and it is large in wet years. In Table1, we showed the characteristics of the inter-annual streamflow and precipitation in the JRB. The mean annual runoff ratio is 0.05, and runoff ratios during the wet year and wet season were 0.08 and 0.06, respectively.

17. P12760 L15-16 "The correlation of the simulated streamflow and measured streamflow was higher during the calibration period and the R value exceeded 0.8." What does the "higher" mean? Does the correlation coefficient of the simulated and measured streamflow was higher during the calibration period than that during the validation period? Maybe it's better to note the correlation coefficient in each subfigure of the Fig. 7.

Response: Yes, the correlation of the simulated streamflow and measured streamflow was higher during the calibration period compared with the validation period. The R values of TOPMODEL are 0.987 and 0.944 during the calibration and validation periods, respectively. And in VIC model, they are 0.944 and 0.940. We have noted the R value in the Fig.7.

18. P12760 L18-21 "The NSE and WBE values during the validation period suggested that both the rainfall-runoff models and the calibration method used in the study were robust for the calibrated model to be used over an independent simulation period adequately." 1) How to quantitatively evaluate the models used in the study

is robust? 2) The different NSE and WBE values during the calibration period and the validation period was caused by the time-varied parameters inputted into the models. I think it is not sufficient to use the NSE and WBE values to indicate the models and calibration method used in the study were robust.

Response: 1) In general, the performance of the hydrological model is evaluated by some indexes, such as Nash-Sutcliffe efficiency (NSE), water balance error (WBE), co-efficient of determination (R) and total water error (TWE) (Liu Y, 2012; Nepal S, 2016). These indexes evaluate the results of the hydrological model from different aspects. NSE and R reflect the degree of agreement between the simulated and measured values, while WBE and TWE are used to evaluate the degree of deviation between the average observation value and average simulated value. In this paper, NSE, WBE and R were used to quantitatively evaluate the models.

2) It is sure that the difference of NSE and WBE values during the calibration period and the validation period was caused by the time-varied parameters inputted into the models. As mentioned above, the hydrological model is usually evaluated according to some statistical parameters. In the paper, the NSE, WBE and R of TOPMODEL are 0.79, 2.1% and 0.987 in the calibration period, and are respectively 0.78, 9.2% and 0.944 in the validation period. The NSE, WBE and R of VIC model are 0.77, 3.5% and 0.944 in the calibration period, and are respectively 0.83, 4.7% and 0.940 in the validation period. We concluded that the models and calibration method used in the study were robust based on the evaluation standard of parameter NSE, WBE and R explained in 13.

Liu Y, Zhang J, Wang G, et al. Quantifying uncertainty in catchment-scale runoff modeling under climate change (case of the Huaihe River, China) [J]. Quaternary International, 2012, 282: 130-136.

Nepal S. Impacts of climate change on the hydrological regime of the Koshi river basin in the Himalayan region [J]. Journal of Hydro-environment Research, 2016, 10: 76-89.

19. P12761 L7-8 “The time series plots in Fig. 9 show that the simulated annual streamflow values were always higher than the observed streamflow.” What I got from the Fig. 9 is that the simulated annual streamflow was always higher than the

observed streamflow before 1990, while the simulated streamflow was lower or similar to the observed values after 1990.

Response: The number of the years that the simulated streamflow was higher than the observed streamflow was 26 from 1970 to 2010 for TOPMODEL, and the number was 25 for VIC model. Additionally, most of the years appeared before 1990 or after 2005 for both of the models, and in the rest of the years the simulated streamflow was similar or lower to the observed value. We have revised the corresponding representation in the paper.

Discussion

20. P12763 L5-14 Please elaborate why the significant climate variability impacts appeared in the 1990s, while the most significant human activities impacts appeared in the 1980s. Does the impact decrease/increase the streamflow? What does the percentage mean in the bracket? Why the most significant human activities impact was 112.5% for the VIC model in the 1980s?

Response: The results of the three methods showed that the significant climate variability impacts appeared in the 1990s, and the significant human activities impacts appeared in the 1980s (Table 4, 5, 6). The precipitation and temperature are the dominant factors of climate changes, and we can see from the following table 1 that the maximum decrease of precipitation appeared in the 1990s compared with baseline period (1960s), and the minimum decrease was in the 1980s. The temperature showed a significant increase in the 1990s, but an insignificant increase in the 1980s. The changes of precipitation and temperature for different decades verified that the significant climate variability impacts appeared in the 1990s.

The percentages in the bracket mean the contribution ratios for streamflow decrease. The results of the three methods showed that human activities decreased the streamflow, and climate changes also decreased the streamflow except in the 1980s with VIC model. As shown table 6 , the streamflow increased by 0.5×10^8 m^3 impacted by climate changes in the1980s, while the streamflow decreased by 4.5×10^8 m^3 due to human activities, so the streamflow decreased by 4.0×10^8 m^3

compared with baseline period (1960s). Therefore, the contribution ratio of human activities was 112.5% ($\frac{4.5}{4.0}*100\%$) for the VIC model in the 1980s.

Table 1. Changes of the inter-annual precipitation and temperature of the JRB.

Time	Precipitation (mm)	Temperature (℃)	ΔP (mm)	ΔT (℃)
1960s	561.2	8.6	—	—
1970s	500.1	8.8	-61.1	0.2
1980s	535.5	8.8	-25.6	0.2
1990s	462.4	9.4	-98.8	0.8
2000s	506.5	9.8	-54.6	1.2

where ΔP and ΔT are the changes in precipitation and temperature, respectively

21. P12763 L19 What does the "two methods" represent?

Response: The "two methods" represents the climate elasticity method and the Soil and Water Assessment Tool (SWAT) model.

22. P12763 L21-26 What's the relationship of Zhan et al. (2014) with this study?

Response: In the paper, the study area is Jinghe River, the largest tributary of the Weihe River. The purpose of quoting this paper (Zhan et al. 2014) is to compare with our study. Zhan et al. (2014) utilized the climate elasticity model to evaluate the impacts of human activities and climate changes on streamflow in Weihe River, and the results showed that the human activities played a more important role than the climate changes.

23. P12764 L19-22 "For the hydrological model …… the predictions of physically based distributed models commonly contained a certain degree of uncertainty." I think the information from this paragraph is common. That's no sense to emphasize the paragraph. However, a further discussion on the uncertainties of the TOPMODEL and VIC models is necessary.

Response: Since some factors tend to disturb the results of the paper, it is necessary to point out the uncertainty of the methods. The resources of hydrological model uncertainty include model structure, input data, and model parameters. There are

many methods for analyzing uncertainty, such as GLUE, BaRE and MCMC, etc. We have applied modified GLUE method to discuss the TOPMODEL uncertainty. However, since this work contains lots of computation and analysis, we will write a paper focused on this topic.

24. P12765 L2-3 As mentioned above, the study area is a highly urbanized region and water withdrawal were extensive during the last several decades (P12749). Please elaborate how to get the result that "the human-induced reduction in streamflow in the JRB was primarily caused by soil and water conservation measures". If it is possible, please provide a multi-temporal land use map and briefly introduce it.

Response: I' m sorry that we had an inaccurate expression here. As we have described in the paper that the main human activities in the Jinghe River include water conservancy projects and water withdrawal, and we have not quantitatively analyzed the contribution ratios of the water conservation measure and water withdrawal. Hence, the statement of "the human-induced reduction in streamflow in the JRB was primarily caused by soil and water conservation measures" wasn't preciseness. We have revised it.

Some previous studies also illustrate that the human activities mainly come from the soil and water conservation measures and water withdrawal. For example, Shi (2013) analyzed the 11 factors that impacted streamflow, and the climate change, water consumption and soil conservation measures were all the major causes of runoff reducing in the second half of the last century in the middle Yellow River; Zhao (2013) quantitatively analyzed the effects of climatic factors and human activities on runoff in Weihe River, and the results showed that the influence of human activities can be mainly attributed to urbanization, irrigated agriculture, and water and soil conversion projects.

Shi C, Zhou Y, Fan X, et al. A study on the annual runoff change and its relationship with water and soil conservation practices and climate change in the middle Yellow River basin [J]. Catena, 2013, 100: 31-41.

Zhao, G., Mu, X., Tian, P., Wang, F., Gao, P., 2013. Climate changes and their impacts on water resources in semiarid regions: a case study of the Wei River basin, China. Hydrol. Process. 27, 3852-3863.

25. P12765 L14-17 If only the total comprehensive effect of the soil and water

conservation measure and irrigation water withdrawal was assessed in the study, how to get the result mentioned in P12765L2-3 that the soil and water conservation measures is the primarily reason for the human-induced streamflow reduction?

Response: I think this issue is similar to NO.24. According to the comment, we have revised the paper.

Conclusions

26. P12766 L3-7 I think this paragraph is a method introduction but not a conclusion.

Response: Thanks for the comment. We have removed this paragraph from "Sect.6 Conclusion"

27. P12766 L17-19 As mentioned in P12751 L15-16, water withdrawal has increased rapidly due to the increase of the population, industry and agricultural water demand. However, the conclusion is the maximum contribution value of human activities appeared in 1981-1990 due to the effects of soil and water conservation measures and irrigation water withdrawal. Does the irrigation is the primary cause for the water withdrawal? If so, please elaborate it in the result and discussion section but not only in the conclusion section.

Response: In China, agricultural is the main water user. Hence, the irrigation is the primary cause for water withdrawal. However, we didn't quantitatively evaluate of the individual effect of industry and agricultural water withdrawal on the decreased streamflow, therefore, we revised the conclusion.

28. P12766 L20 What does the "which" represent?

Response: The "which" represents the average contribution ratios of human activities and climate variability.

Tables and Figures

29. Table 2 It should be noted that the potential evaporation is an estimated value. The observation period for the temperature should also be noted.

Response: Corrected.

30. Table 3 What do the parameters of Cv, Cs, E0 and T mean? The presentation of parameters should be consistent in Table 2 and Table 3. The time scale of the mean value of the potential evaporation and temperature should also be noted.

Response: Corrected. Cv is the deviation coefficient; Cs is the skewness coefficient. E0 and T respectively mean the potential evaporation and temperature.

31. Table 5, Table 6 What does the parameter of ηc represent? Please also elaborate the parameter of ηc in the text.

Response: The parameter of η_C and η_H respectively represent the contribution ratios of climate changes and human activities to streamflow.

32. Fig. 1. The legend for the Jinghe River and the Weihe River is same. As mentioned in the text, Jinghe River is the secondary tributary of the Yellow River, the largest tributary of the Weihe River in China. I suggest to label the Yellow River and Weihe River in the Fig. 1.

Response: Corrected.

33. Fig. 2 No scale mark.

Response: Corrected

34. Fig. 4 It seems that the temperature values during the period from 2000 to 2010 are missed.

Response: Corrected.

35. Fig. 5 The such-titles are mismatch with the sub-figures of (b) and (c). Please check it.

Response: Corrected.