2016/12/09

Reply to Editor and Reviewers

Manuscript title: Effect of land use/land cover and climate changes on surface runoff in a semi-humid and semi-arid transition zone in Northwest China

Dear Editor and Reviewers:

Thank you for carefully reading the manuscript and for providing constructive suggestions and comments. We appreciate your time and effort in considering the manuscript for publication.

All of the questions/comments have been carefully addressed in the revised manuscript. In this revision, the newly added content is given in blue, and the revised content is given in red.

The following are point-by-point answers to each question/comment.

Editor & Reviewer Comments and our Responses

Editor Comments:

1. separate Results and Discussion.

Responses:

Thank you for your valuable comments.

Considering the comments from all of the reviewers, we separated section 3 ('Results and Discussion') into two sections (Table R1): section 3 ('Results') and section 4 ('Discussion'), and revised the related content. Please see the revised manuscript for details.

Table R1 Structure changes due to separation of section 3 ('Results and Discussion').

Revised structure in the manuscript	Structure of section 3 in the previous manuscript
3 Results	3 Results and Discussion
3.1 Climate change	3.1 Climate change
3.2 LULC change	3.2 LULC change
3.3 Performance of the SWAT model	3.3 Performance of the SWAT model
3.4 Simulated surface runoff	3.4 Impacts of LULC and climate changes on surface runoff
4 Discussion	3.5 Uncertainty in model simulations
4.1 Impacts of LULC and climate changes on surface runoff	
4.1.1 Isolated impacts of LULC change	
4.1.2 Isolated impacts of climate change	
4.2 Uncertainty in SWAT model simulations	

2. The authors have to make insightful analyses and discussion on the mechanism behind so that highlight the scientific merit of the paper, otherwise the study is trivial.

Responses:

Thank you for your valuable comments.

As shown in Table R1, we reorganized our manuscript and discussed: 1) 'the effects of LULC and climate changes on surface runoff' including the 'Isolated impacts of LULC change' and the 'Isolated impacts of climate change', and 2) the simulation uncertainty in the context of SWAT modelling due to parameterizations. The added discussion provides potential explanations for the conflicting results regarding the effects of LULC and climate changes on runoff in relatively large basins.

Please see our revised manuscript for details as well as our response to the reviewers' comments.

Reviewer: 1

This manuscript investigates the relationships between land use and climate changes and corresponding hydrological responses in northwest China. The paper reveals some interesting findings. The manuscript can be considered for publication, if the following comments can be addressed properly.

Major comments

1. The effects of land use change and climate change should be discussed separately.

Responses:

Thank you for the valuable comments.

Combined with comments from another reviewer and the Editor, we separated section 3 ('Results and Discussion') into two sections: section 4.1.1 ('Isolated impacts of LULC change') and section 4.1.2 ('Isolated impacts of climate change'), and discussed 'the effects of LULC and climate changes on surface runoff') separately (Table R1). The new sections discussing the effects of land use and climate changes are as follows:

Table R1 Structure changes due to separation of section 3 ('Results and Discussion')

Revised structure in the manuscript	Structure of section 3 in the previous manuscript
3 Results	3 Results and Discussion
3.1 Climate change	3.1 Climate change
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4.1 Impacts of LULC and climate changes on surface runoff

The hydrological effects were analysed using the simulated runoff data rather than the observed data. The combined effects of LULC and climate changes on surface runoff are presented in section 3.4. The simulated runoff increased between the 1970s and the 1980s, while precipitation increased from 521 mm to 527 mm during the same period. Thereafter, runoff decreased as precipitation decreased. However, runoff decreased by 11.1% from the 1980s to the 1990s but decreased by 15.5% from the 1990s to the 2000s. These results indicate that, although precipitation can considerably affect runoff simulation, variations in runoff and precipitation were nonlinear due to the combined effects.

The isolated impacts of LULC and climate changes on surface runoff can be analysed by comparing two sets of simulations. The differences between S1 and S2 (as well as between S4 and S5 and S7 and S8) reflect the impacts of climate change on runoff. Accordingly, the differences between S1 and S3 (as well as between S4 and S6 and S7 and S9) reflect the impacts of climate change on runoff.

4.1.1 Isolated impacts of LULC change

During the first two decades, LULC changes increased runoff by 2.30 $m^3 s^{-1}$ and accounted for 7.73% of the total change (29.75 $m^3 s^{-1}$). Thereafter, LULC change decreased runoff by 6.83 $m^3 s^{-1}$, which accounted for 54.25% of the total change in runoff (12.59 $m^3 s^{-1}$) from the 1980s to the 1990s. The impacts of LULC changes on runoff increased during the last two decades because the contribution of LULC changes to runoff increased to 70.67% from the 1990s to the 2000s (Fig. 9).

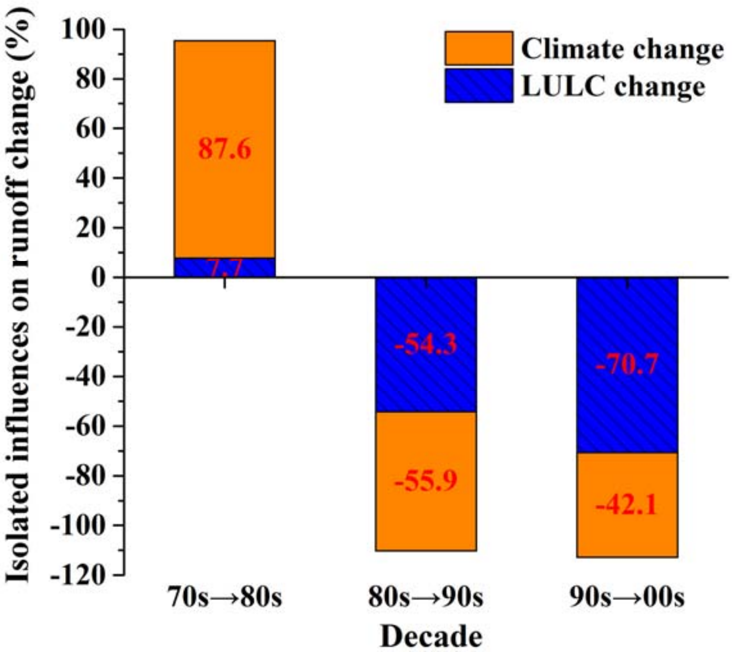
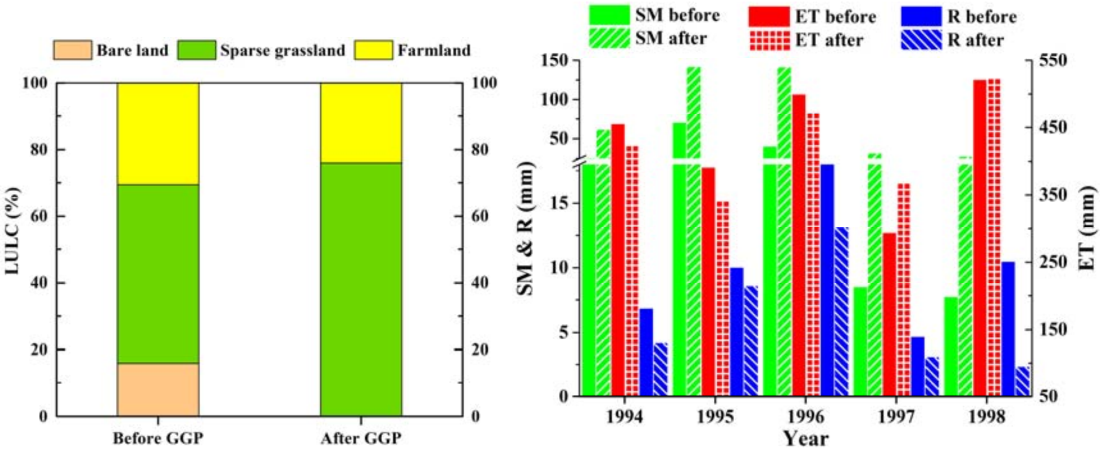


Figure 9. Isolated impacts of LULC and climate changes on surface runoff. Positive values indicate that runoff increased due to these factors, whereas negative values indicate that runoff decreased due to these factors. The summation of the isolated influences is not equal to 100% due to simulation uncertainty (see section 4.2 for details).

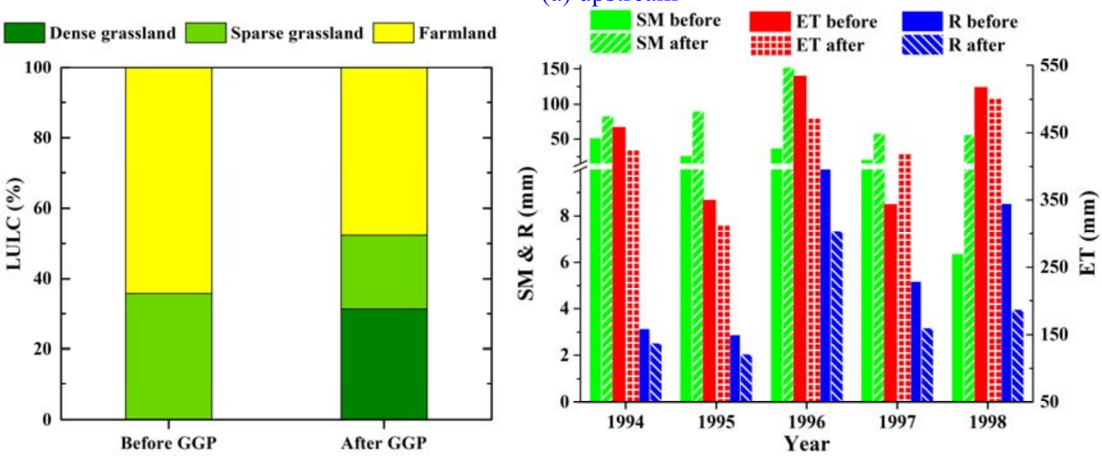
The results in section 3.2 show that the LULC changed slightly from the 1970s to the 1980s. For example, the area of cropland marginally increased by 0.76%, and the vegetative area decreased by 3.19%. This small LULC change indicates that human activities minimally influenced runoff during the first two decades because the LULC changes only accounted for 7.73% of the increase in runoff. However, the LULC changed considerably with social development and population growth beginning in the 1980s. The vegetative area decreased by 7.81% from the 1980s to the 1990s, and the percentages of cropland, barren areas, and urban and built-up areas increased by 2.39%, 5.43%, and 0.11%, respectively. LULC changes associated with increased human activities accounted for 54.25% of the increase in surface runoff. Furthermore, the GGP, which was initiated in the late 1990s, mitigated the decreasing trend in vegetation. Although cropland and urban and built-up areas still expanded by 2.40% and 0.82%, respectively, from the 1990s to the 2000s, vegetation increased by 6.00%, and barren areas decreased by 9.33%. Therefore, LULC change exhibited a relatively large influence on the surface runoff change, contributing to 70.67% of the surface runoff in the last two decades.

In addition, the spatial distributions of different land use types influence the generation of runoff. As reported in our previous publication (Qiu et al., 2011), the soil moisture content and evapotranspiration were modified by LULC changes (i.e., the GGP) after the GGP in the JRB, which led to changes in surface runoff. However, the modification was different. Fig. 10 shows that, after the GGP, the soil moisture content increased in the three selected sub-basins from the upstream to downstream regions, while the runoff and evapotranspiration decreased. When considering the upstream area as an example, barren land, with an initial percentage of 15.90%, and partial farmland, with an initial percentage of 6.56%, were converted to grassland due to the GGP, which improved water filtration and increased the soil moisture (Fig. 10 (a)). The simulation in Fig. 10 shows that the soil moisture content increased by 163.66%, 208.23%, and 262.66% in the sub-basins from the upstream to downstream, whereas the surface runoff (evapotranspiration) decreased by -37.53%, -38.55%, and -49.01% (-1.21%, -3.06%, and -25.90%), respectively. These results indicate that the impacts of LULC changes on flow regimes were larger in the downstream areas of the basin than in the upstream areas.

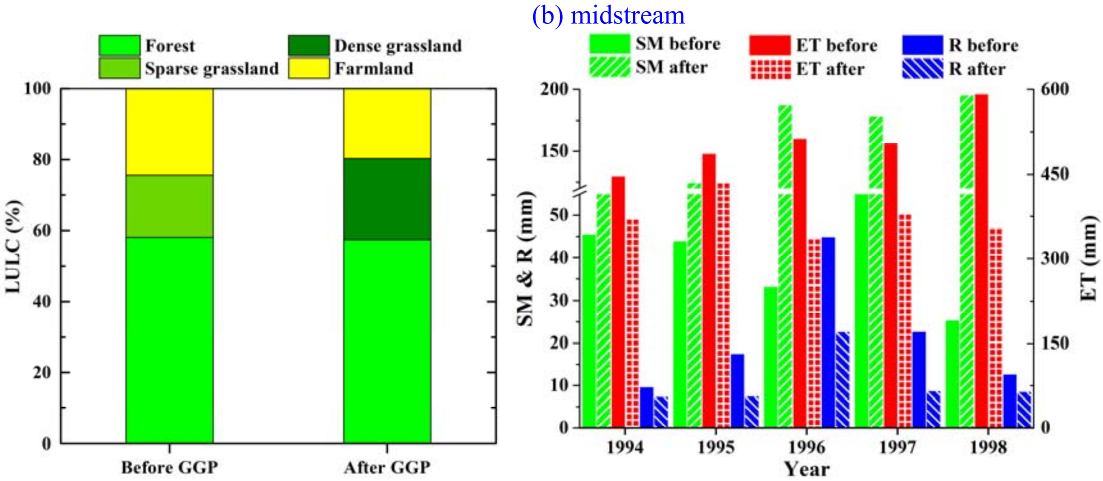
Although climate variables were held constant when simulating LULC changes, the isolated influences of LULC changes on runoff did not exclude the impacts of precipitation variations because the climate (including precipitation) varied in each decade (Table 3). Nonetheless, the above results indicate that LULC changes contributed considerably to decreased runoff, as reported in previous studies (e.g., Zhang et al., 2011; Zuo et al., 2014; Wang et al., 2014b; Wang et al., 2016). Additionally, the results suggest that vegetation restoration due to the GGP reduced surface runoff, which agrees with the results of other studies (e.g., Li et al., 2009; Nunes et al., 2011).



(a) upstream



(b) midstream



(c) downstream

Figure 10. Impact of LULC changes on surface runoff in selected sub-basins distributed in the upstream, midstream, and downstream areas of the basin. The left column shows the land use types and corresponding ratios, and the right column shows the simulated changes of the soil moisture content (SM), evapotranspiration (ET), and surface runoff (R) before and after the Grain for Green Program (GGP) scenarios while holding climate constant.

4.1.2 Isolated impacts of climate change

Unlike the contributions of LULC changes, the influences of climate change decreased in recent decades (Fig. 9). Climate change increased runoff by 26.07 $m^3 s^{-1}$ from the 1970s to the 1980s, accounting for approximately 87.63% of the increased total runoff during that period. Since the 1980s, surface runoff decreased, and the contributions of climate change to decreased runoff were 55.92% and 42.11% from the 1980s to the 1990s and from the 1990s to the 2000s, respectively. The influence of climate change on runoff agrees with climatic warming and drying trends. Decreasing precipitation will potentially lead to less runoff, whereas increasing temperatures will result in increased evaporation.

In summary, LULC and climate changes accounted for 7.73% and 87.63% of the total runoff increase (29.75 $m^3 s^{-1}$) in the 1970s and 1980s, respectively. The isolated influences of LULC and climate changes on runoff were nearly the same from 1980 to 1999 (54.25% and 55.92%, respectively) compared to the total decrease in runoff. In the last two decades, the percentage of the total runoff decrease that was caused by LULC changes (70.67%) was greater than that caused by climate change (42.11%).

Although uncertainties exist in the simulations (see section 4.2 for details), the above results indicate that the contribution of climate variability decreased over the last four decades, while the contribution of LULC change increased. Unlike the results reported by Liang et al. (2015), the findings in this study suggested that runoff fluctuations are influenced less by climate change and more by human activities. The results also indicate that the impacts of human activities on runoff have gradually increased in the JRB, which agrees with the results of other studies (Zhang et al., 2011; Zuo et al., 2014; Wang et al., 2016).

New reference was also added:

Wang, G., Yang, H., Wang, L., Xu, Z., Xue, B.: Using the SWAT model to assess impacts of land use changes on runoff generation in headwaters, Hydrological Processes, 28, 1032–1042, 2014b.

2. To explicitly assess the impact of land use changes on runoff generation, the impact of rainfall variation should first be excluded. Relevant discussion should be included on this topic.

Responses:

Thank you for the valuable comments. Even the isolated influence of LULC changes on runoff can be simulated by varying LULC while holding climate constant. However, the climate (e.g., precipitation) varied in each decade.

To address this comment, we added the following discussion in the revised manuscript:

Although climate variables were held constant when simulating LULC changes, the isolated influences of LULC changes on runoff did not exclude the impacts of precipitation variations because the climate (including precipitation) varied in each decade (Table 3). Nonetheless, the above results indicate that LULC changes contributed considerably to decreased runoff, as reported in previous studies (e.g., Zhang et al., 2011; Zuo et al., 2014; Wang et al., 2014b; Wang et al., 2016). Additionally, the results suggest that vegetation restoration due to the GGP reduced surface runoff, which agrees with the results of other studies (e.g., Li et al., 2009; Nunes et al., 2011).

3. I would encourage authors to rewrite the methodology description section. Give a clear message to the reader what you did and how you did. Some parts in the results analysis and discussion section (e.g. model calibration and validation) are more suitable to be in the methodology section.

Responses:

Thank you for this comment. In this study, we simulated runoff changes using the SWAT model.

Based on your recommendation, we reorganized section 2 ('Methods and materials'), particularly sections 2.2 to 2.4 (Table R2), and revised some of the related content.

Table R2 Changes in the structure of section 2

Structure of section 2 (Methods and materials) in the revised manuscript	**Structure of section 2 in the previous manuscript**
2 Methods and materials	2 Methods and materials
2.1 Study area	2.1 Study area
2.2 Runoff change simulation	2.2 SWAT model and data collection
2.2.1 SWAT model and data collection	2.3 Model calibration and validation
2.2.2 Model calibration and validation	2.4 Runoff change simulation
2.2.3 Simulation scenarios	

4. The values in Table 2 are not acceptable, the authors should re-check the reference (Moriasi et al., 2007).

Responses:

We re-checked the reference (Moriasi et al., 2007) and found that the values of the Nash–Sutcliffe coefficient (*Ens*) given in Table 2 in the previous manuscript were misleading.

Reference:

Moriasi, D. N., Arnold, J. G., van Liew, M. W., Binger, R. L. Harmel, R. D., and Veith, T.: Model evaluation guidelines for systematic quantification of accuracy in watershed simulations, Trans. Am. Soc. Agr. Biol. Eng., 50, 885–900, 2007.

According to this comment, we revised Table 2 as follows:

Table 2. SWAT performance of runoff simulations according to the Nash–Sutcliffe coefficient (Moriasi et al., 2007).

Simulation performance	Nash–Sutcliffe coefficient (*Ens*)
Very good	$0.75 < Ens \leq 1.00$
Good	$0.65 < Ens \leq 0.75$
Satisfactory	$0.50 < Ens \leq 0.65$
Unsatisfactory	$Ens \leq 0.50$

5. The influences of different land use types (such as area and spatial distribution) are also important to runoff generation. How to assess these effects?

Responses:

Yes, the spatial distributions and areas of different land use types can influence runoff generation. Some studies (e.g., Wang et al., 2014) have been conducted to investigate how the spatial distributions of different land use types influence runoff generation. Although we can obtain the spatial distributions of different land use types, assessing the influences of spatial changes in land use on runoff is difficult.

Reference:

Wang, G., Yang, H., Wang, L., Xu, Z., Xue, B.: Using the SWAT model to assess impacts of land use changes on runoff generation in headwaters, Hydrological Processes, 28, 1032–1042, 2014.

However, we added some discussion regarding how the spatial distributions and areas of different land use types affect surface runoff in section 4.1.1 (Isolated impacts of LULC change) (see our reply to major comment 1 or the revised manuscript for more details).

6. It seems that the authors discussed the effects of the "Conversion of Cropland to Forest and Grassland Program" on the water budget of the Jinghe River basin (Qiu et al., 2011, Journal of Environmental Quality, 40, 1–11). What's the difference between the previous publication and this study?

Responses:

In our previous publication (Qiu et al., 2011), we discussed the effects of the "Conversion of Cropland to Forest and Grassland Program" on the water budget in the Jinghe River Basin. However, for simplicity, we only chose three typical sub-basins distributed in the upstream, midstream, and downstream areas (Fig R1). In addition, we did not address climate change or SWAT simulation uncertainty in our previous publication.

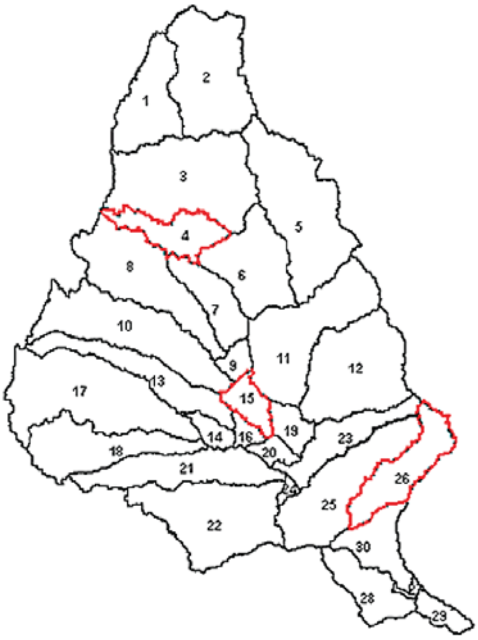
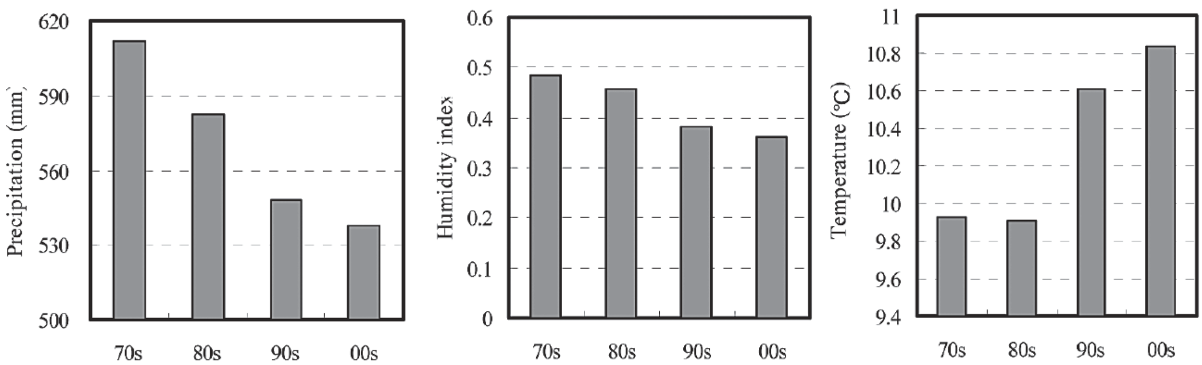


Fig. R1 The results of our previous publication (Fig. 2 in Qiu et al., 2011), which was based on three typical sub-basins, 4, 15, and 26, which are shown in red.

In this study, we focused on the entire basin and discussed the effects of both land use/land cover (LULC) changes (e.g., conversion of cropland to forest and grassland) and climate change on surface runoff. Furthermore, meteorological data from different stations (e.g., precipitation and air temperature: Fig. 2) were updated to 2009, and values were recalculated. The data in Qiu et al. (2011) were from 1970 to 2005 (Fig. R2). Nonetheless, some of the results (e.g., validation, land use classification) are adopted in this manuscript.



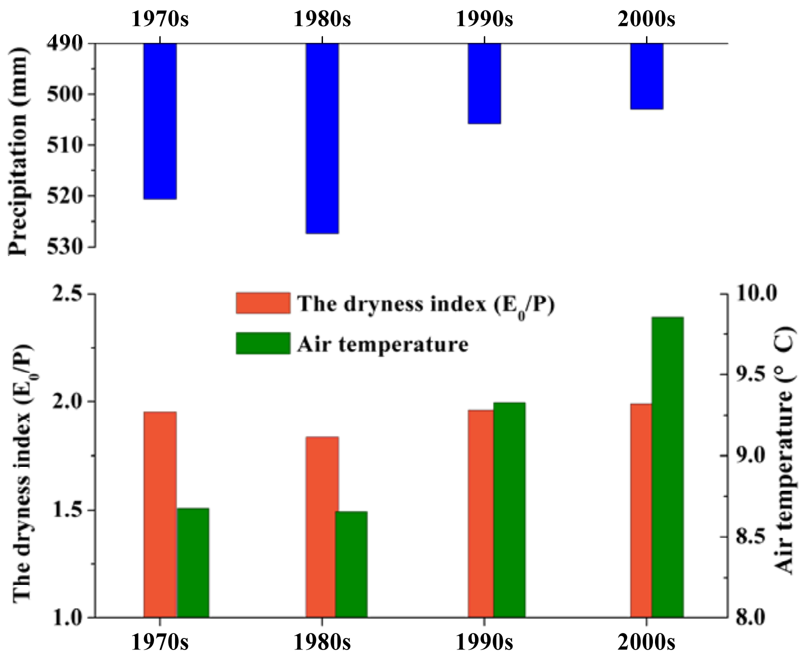


Fig. R2 Difference between the weather data used in the previous study (upper figures in black and white) and this study (bottom figures in colour).

The data used for model simulation and validation were the same in both of these studies.

To avoid similarity, we reorganized some of the content related to model calibration and validation. Please see our revised manuscript for details.

Minor comments

1. 3-28, The objectives. I would suggest the authors to add an objective to discuss how the LULC and climate changes affect surface runoff.

Responses:

Thank you for this comment. Our revised manuscript discusses this issue (section 3.5 'Isolated impacts of LULC and climate changes on surface runoff'), and we added the objectives as suggested.

Therefore, the objectives of this study were as follows: 1) to assess the surface runoff variability influenced by LULC and climate changes in recent decades in the JRB by using the SWAT model, which differs from the climate elasticity model based on the Budyko framework; 2) to quantify the combined and isolated impacts of LULC change and climate variability on surface runoff in the basin from 1971 to 2005 by using scenario simulations after calibrating and validating the SWAT model at monthly and yearly time scales; 3) to discuss how LULC and climate changes affect surface runoff; and 4) to discuss the simulation uncertainty in the context of SWAT modelling due to parameterizations and provide potential explanations for the conflicting results regarding the effects of LULC and climate changes on runoff in relatively large basins.

2. 4-6. Although finally draining into the Yellow River, the Jinghe River is a tributary of the Weihe River.

Responses:

We changed the ‘Yellow River’ to the ‘Weihe River’ in the revised manuscript.

The main stream of the Jinghe River, with a length of 450 km, originates in the Liupan Mountains in the Ningxia Autonomous Region and flows across Gansu and Shanxi Provinces before draining into the Weihe River.

3. 5-10. How many runoff data was used and who performed the measurement?

Responses:

The runoff data were measured by the Yellow River Conservancy Commission (YRCC) of the Ministry of Water Resources, China, between 1970 and 1990. According to this comment, we added the following information:

Daily runoff data measured at Zhangjiashan gauging station between 1970 and 1990 were collected from the State Hydrological Statistical Yearbook. These data were compared to the modelled surface flow during model calibration and validation.

4. 5-18. ‘determination coefficients’ should be ‘determination coefficient’.

Responses:

Thank you for this valuable comment. We revised the text as suggested:

Model performance was assessed qualitatively using visual time series plots and quantitatively using the coefficient of determination (R^2) and the Nash-Sutcliffe efficiency coefficient (*Ens*) (Eq. (1)) (Moriasi et al., 2007).

5. 8-31. I suggest the authors unify the number of decimal places.

Responses:

Thank you for this valuable comment. We used a consistent number of decimal places throughout the manuscript. For example, the following edit was made in the revised manuscript.

In the first two decades, LULC changes increased runoff by 2.30 $m^3\,s^{-1}$, accounting for 7.73% of the total change (29.75 $m^3\,s^{-1}$).

6. 9-32. The citation style for two authors. The authors sometimes use ‘and’, but sometimes ‘&’. I suggest the authors unify the citation style.

Responses:

Thank you for this valuable comment. We checked the manuscript and changed ‘&’ to ‘and’. For example, we made the following change:

Previous studies (e.g., Chu et al., 2011; Masih et al., 2011; Shope and Maharjan, 2015) have suggested that the density of rainfall measurement stations has a significant impact on SWAT simulations; …

7. The language need to be improved. There are many grammatical and spelling mistakes.

Responses:

Thank you for this valuable comment. We sent the manuscript to American Journal Experts (AJE) for English language editing prior to submission. The revised manuscript has been re-edited by AJE (Fig. R3). Please see our revised manuscript for details.


AMERICAN JOURNAL EXPERTS

EDITORIAL CERTIFICATE

This document certifies that the manuscript listed below was edited for proper English language, grammar, punctuation, spelling, and overall style by one or more of the highly qualified native English speaking editors at American Journal Experts.

Manuscript title:
Effect of land use/land cover and climate changes on surface runoff in a semi-humid and semi-arid transition zone in Northwest China

Authors:
J. Yin, G. Y. Qiu, F. He, Y. J. Xiong

Date Issued:
August 30, 2016

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Fig. R3 Certificate for English language editing

Reviewer: 2

This MS investigates both the combined and isolated impacts of land use/land cover and climate changes on surface runoff in a semi-humid and semi-arid transition zone. I reviewed the discussion paper and a revised version by Xiong on behalf of the authors on Agu. 31, 2016. Most of my concerns are similar to that of the previous reviewer. I found that the authors have addressed most of the previous comments/suggestions and made significant changes to the paper, which has improved its quality considerably. The methods, results, and discussion are now rather well described, and the manuscript may be considered for publication after addressing the following minor concerns.

Specific comments

1. Page 21, line 442. The sentence contains misleading statement because resolution of the soil map is 1:1 000 000 whereas the LULC map has a resolution of 30 m.

Responses:

Thank you for your valuable comments. We rewrote this sentence as follows:

In addition, the coarse vegetation information provided by the LULC data in this study can lead to uncertainty in the simulations because vegetation distinction is required in SWAT modelling. Although the LULC data had a relatively high resolution of 30 m, we can only provide a general vegetation categorization, such as forest, due to the data limitation.

2. Citation and reference list. I found last name and publication year of some citations were the same; however, the full citations in the reference section showed different first names, e.g., Wang et al., 2014. In addition, some citations in the reference section were repeated (e.g., page 24 line 521). The authors should proof read the manuscript to avoid such confusions or repetitions.

Responses:

Thank you for the valuable comments. We checked the citations carefully, deleted repeated citations, and corrected mistakes. For example, the citations of 'Wang et al., 2014' in the text and reference section were revised as follows:

Both climate and land use/land cover (LULC) changes are key factors that can modify flow regimes and water availability (Oki and Kanae, 2006; Piao et al., 2007; Sherwood and Fu, 2014; Wang et al., 2014a).

Nonetheless, the above results indicate that LULC change contributed considerably to decreased runoff, as reported in other studies (e.g., Zhang et al., 2011; Zuo et al., 2014; Wang et al., 2014b; Wang et al., 2016).

Wang, R., Kalin, L., Kuang, W., and Tian, H.: Individual and combined effects of land use/cover and climate change on Wolf Bay watershed streamflow in southern Alabama, Hydrological Processes, 28, 5530–5546, 2014a.

Wang, G., Yang, H., Wang, L., Xu, Z., Xue, B.: Using the SWAT model to assess impacts of land use changes on runoff generation in headwaters, Hydrological Processes, 28, 1032–1042, 2014b.

3. If possible, can you separate the result and discussion sections.

Responses:

Thank you for the valuable comments.

Combined with comments from another reviewer and the Editor, we separated section 3 ('Results and Discussion') into two sections (Table R1): section 3 ('Results') and section 4 ('Discussion'), and revised the related content.

Table R1 Structure changes due to separation of section 3 ('Results and Discussion').

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4.2 Uncertainty in SWAT model simulations	

4. In the line 19, I don't think the Jinghe river is a "large" basin.

Responses:

We agree that the term "large" is not very quantitative.

According to this comment, we revised this sentence as follows:

However, conflicting results regarding the effects of LULC and climate changes on runoff have been reported in relatively large basins, such as the Jinghe River Basin (JRB), which is a typical catchment (> 45000 km^2) located in a semi-humid and arid transition zone on the central Loess Plateau, Northwest China.

5. suggest change the "cropland to forest and grassland program (CCFGP)" to "Grain for Green" program.

Responses:

Thank you for this comment. We replaced "cropland to forest and grassland program (CCFGP)" with "Grain for Green Program" throughout the manuscript. Please see our revised manuscript for details.

The end