Impacts of the change in extreme climate on simulated runoff in the Yellow River Basin

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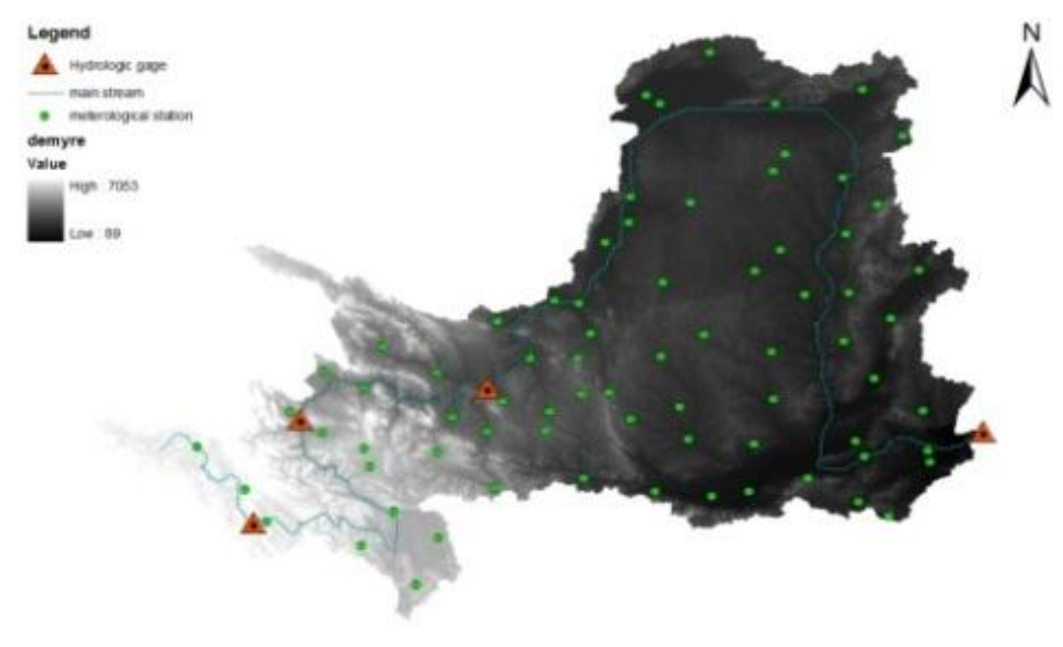
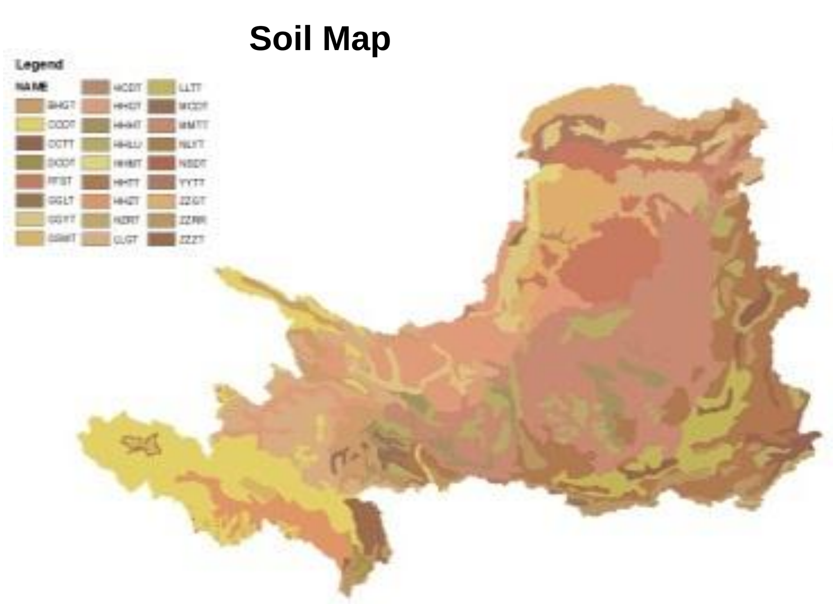
1 Introduction

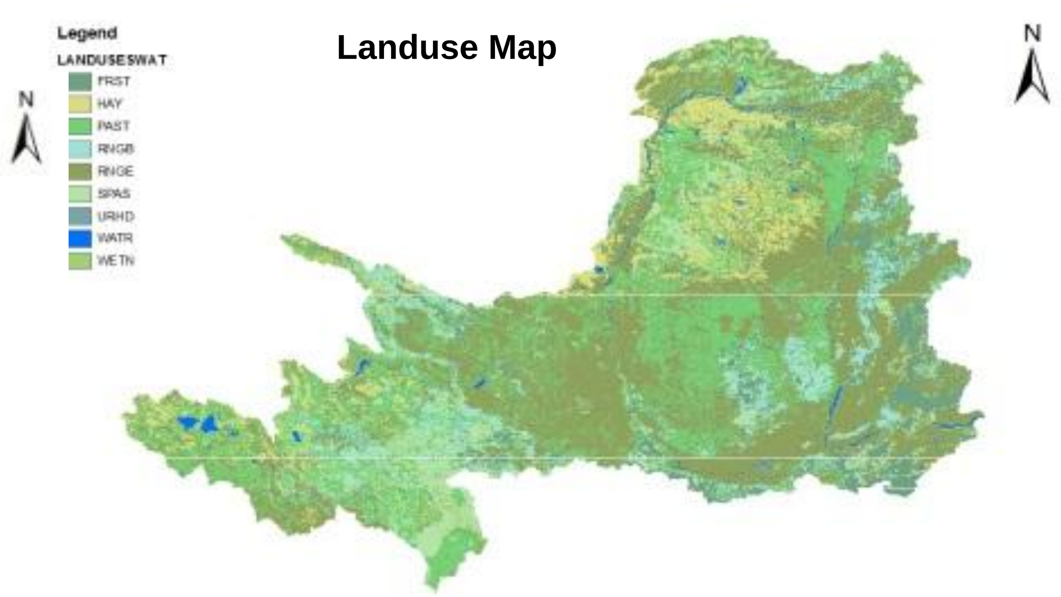
Historical observations show that extreme climate events have increased in frequency in the Yellow River Basin. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR4) projects higher climate variability in a warmer climate, suggesting an increase of extreme climate frequency in the 21st century. The responses of available water resources to the extreme climate remain relatively unexplored in the Yellow River Basin. This study mainly focus on examining the change in temporal distribution of precipitation and its impacts on streamflow using a long time series of runoff estimated from the Soil and Water Assessment Tool (SWAT) model.

2 Study Area

This basin extends from 32 ° N to 43° N latitude and 95 ° E to 115° E longitude, draining a total area of 795,000km^2. The flood season is for June to September (65%～85%).
Name of stream gauges are Ji Mai, Tang Naihai, Lan Zhou and Hua Yuankou, respectively.





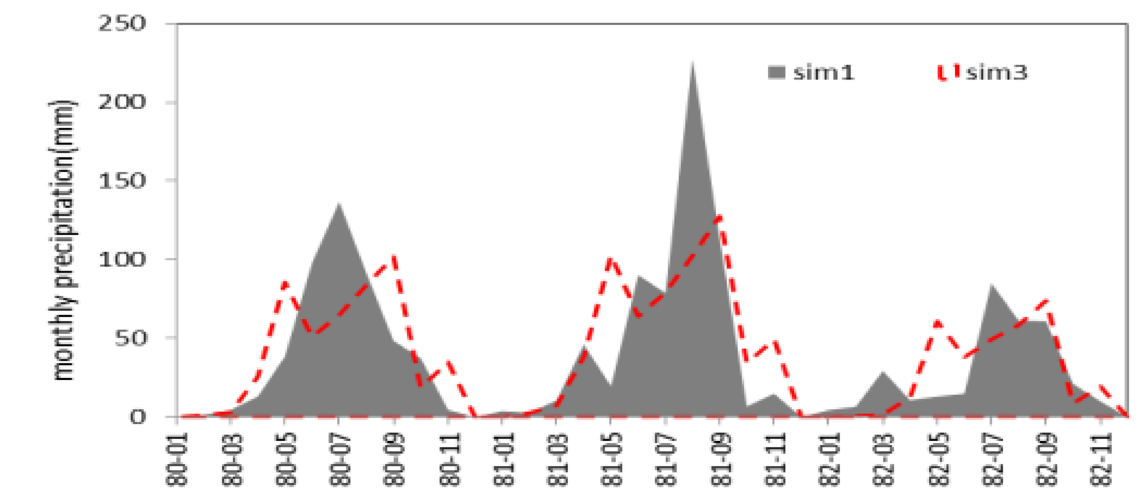


3 Data and Methods

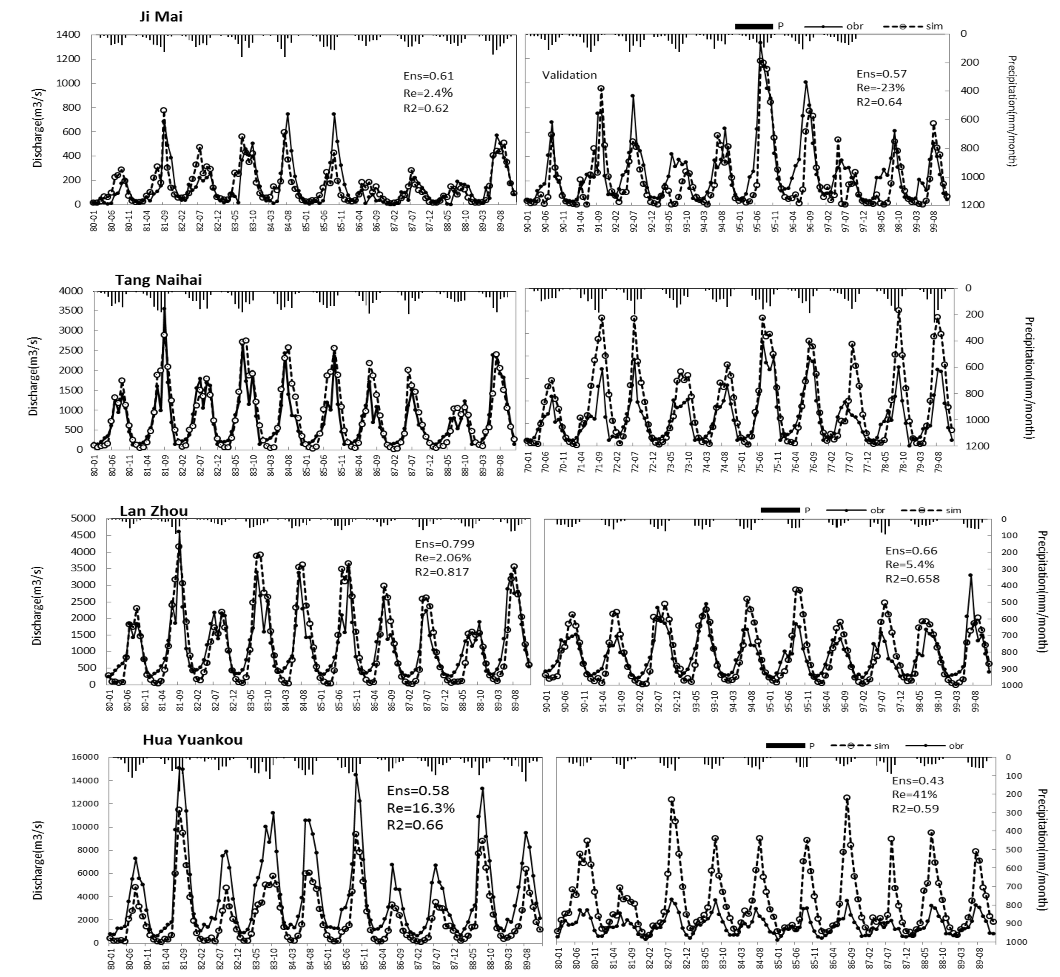
Table 1 The data required for this study

Data	Source	Resolution
DEM	http://datamirror.csdb.cn/admin/datademMain.jsp	1km*1km
Soil map	ISSCAS	1:4,000,000
Soil data	http://www.soil.csdb.cn	
Land use		1km*1km
Meteorological data	NMIC	Daily (1957-2009)
Runoff data	Reconstructed natural runoff	Monthly (1956-2000)

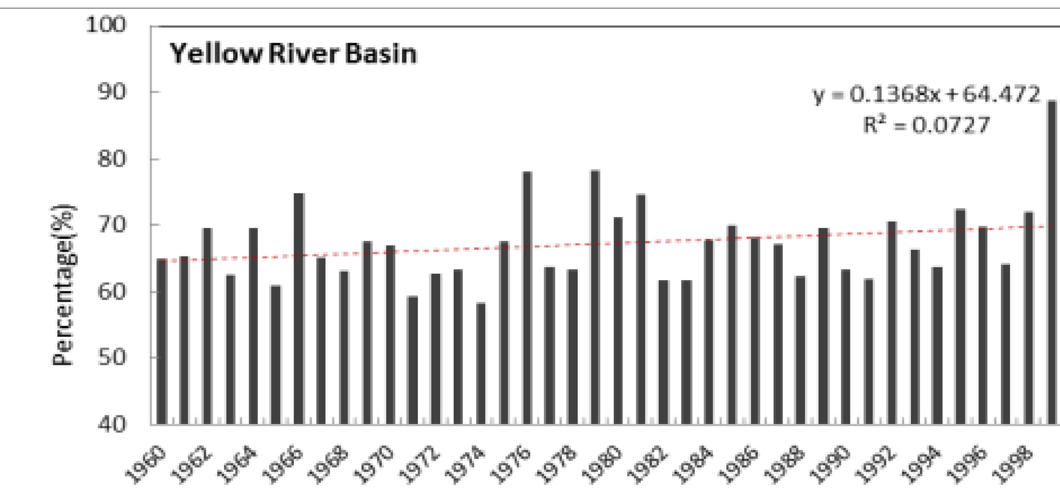
In this study, the change of extreme precipitation is measured by the percentage of rainy season precipitation in the annual precipitation. The percentage gets larger when the distribution of precipitation is more concentrated in the rainy season. The rainy period is defined as the period from June to September. The rainy season precipitation is denoted as PE, and the total precipitation is P, $percentage = PE / P * 100\%$. We firstly detect the change in the change of extreme precipitation. Then, three SWAT experiments are conducted. The first experiment is a control experiment using the observed climate data. The second experiment is driven by a de-trended climate data in which the linear trend is removed and the mean values are fixed to the means of the first decade. The third experiment is a stable simulation using the precipitation distribution repeating the first decade. In the third experiment, not only the mean precipitation but also the temporal distribution of precipitation do not change. An example of the precipitation difference in the experiments is shown in the right Figure. Finally, we compare and analyze the three simulated runoff in the Yellow River basin.



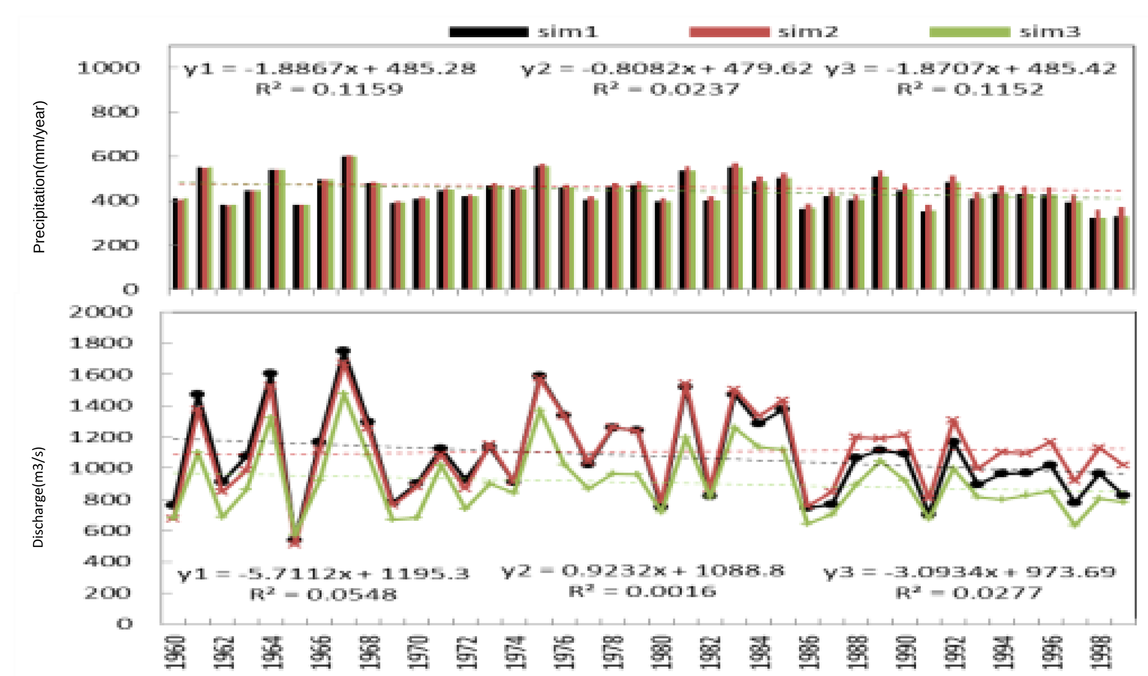
4 Results

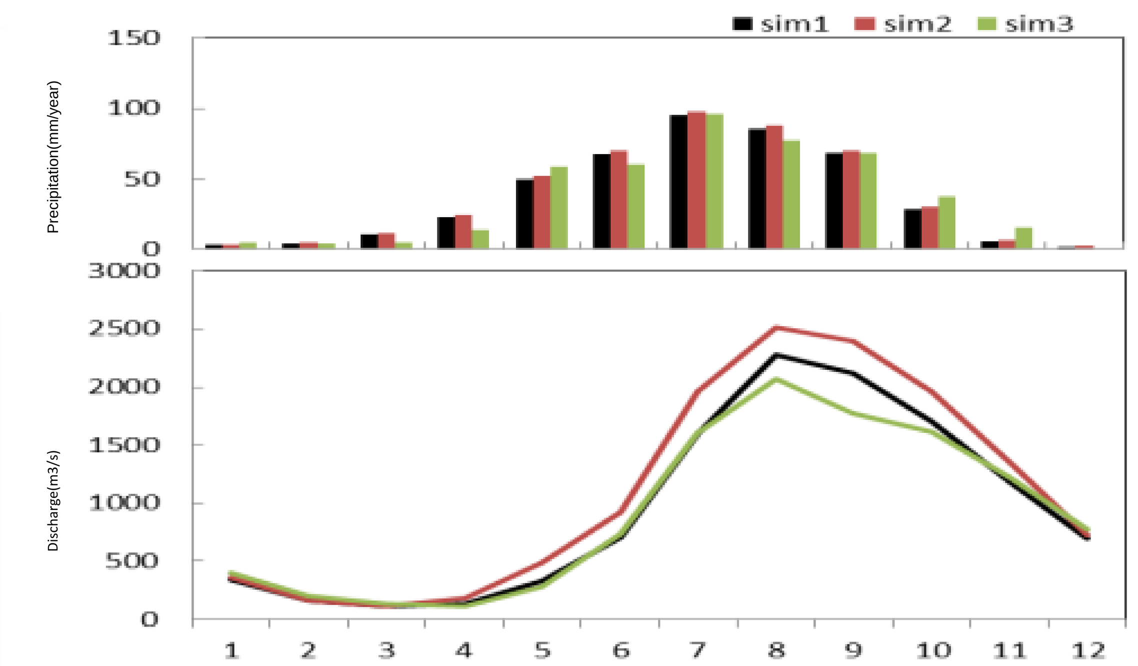


The model is first calibrated for the decade 1980-1989 using the naturalized runoff observations. The model is then validated for the period 1990-1999. Overall, the calibration and verification accuracy of the model is acceptable for inter-annual and inter-monthly runoff analysis.



The long-term change trend of the observed extreme precipitation in the study basin are presented. In the Yellow River basin, the percentage shows a increase trend. It suggests that the precipitation becomes more unevenly distributed in the Yellow River basin although substantial difference has been found in different areas.





The left figure displays the simulated annual runoff of the three experiments. We found that the runoff of the second simulation and the result of the first simulation are very similar before 1986. However, after that the difference between the two experiments becomes larger and the second experiment predicts high runoff. The right figure shows the comparison of the monthly mean runoff. From June to September both precipitation and runoff of the third experiment are smaller than that of the first experiment whereas both precipitation and runoff amount are larger from October to February.

5 Conclusion

We examined the change in precipitation and its impacts on SWAT simulated runoff. Our results show that an experiment using the mean precipitation of the 1960s and observed temporal variability (the second experiment) predicted higher runoff than the experiment using the repeating precipitation of the 1960s (the third experiment). It suggests that the change in temporal distribution of precipitation may have induced more runoff even if the mean precipitation does not change in the Yellow River basin.

References

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