Water resources and hydrological process response to climate change in Tarim River, China[1]

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Introduction

Global climate change could have significant impacts on both natural and social systems. Water resources and ecosystems are particularly likely to be affected by climate changes. In the case of large, complex, and heavily modified river systems, such as the Tarim River basin, the potential impacts of climate changes can be understood by detecting the long-term trends of both climatological and hydrological processes. Climate change affects both the total volume and temporal pattern of runoff in the basin. This suggests that hydrological changes caused by any long-term climate change will have ecological and socioeconomic impacts that may affect the management of the water resources (Cohen *et al*. 2000).

Located in the arid area of north-western China, Tarim River (short T.R), about 1,321km long, is the longest continental river in the world (Fig.1). It is mainly fed by glacial - snow melt water, which occupies 48.2% of the total water volume in the basin. The ecological environment in T.R basin is extremely vulnerable, the contradiction between the ecological protection and the economic development is increasingly extrusive during the exploitation and utilization of water resources, and the sustainable development of the regional society and economy is seriously restricted. In this paper, the plausible association between climate change and the variability of water resources and hydrological process response was detected. The plausible long-term trends of the temperature, precipitation time series were investigated. The aim of the study is to forecast the plausible impact of future climate change on water resources and hydrological process.

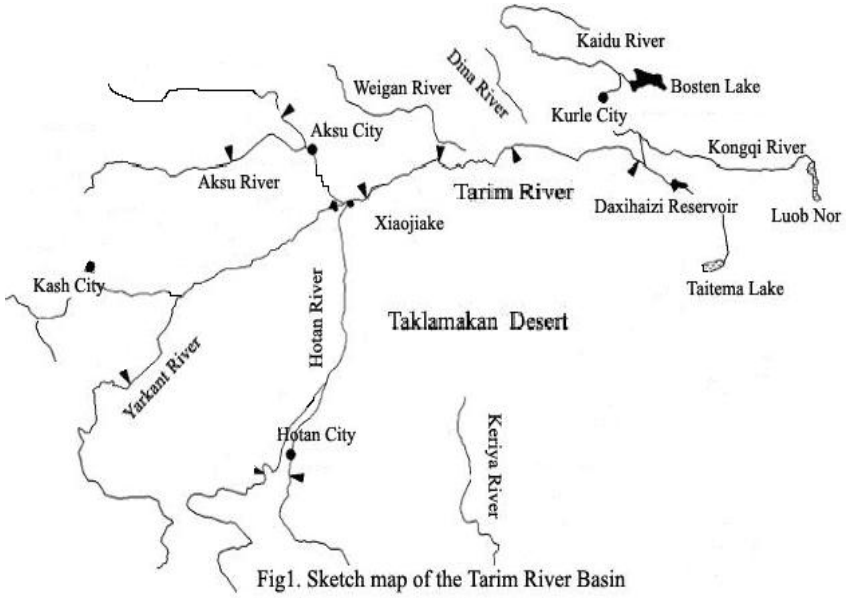

Fig1. Sketch map of the Tarim River Basin

Data and methods

The Tarim River basin covers more than two thirds of the area of Xinjiang and the impact of climate change usually involves a large area, so both temperature and precipitation data from 77 meteorological stations and the precipitation from 61 rain gauges over the whole Xinjiang were used in this study. The nonparametric Mann-Kendall method is employed to detect possible trends in hydrological processes.

Results and analysis

Figs.2 and 3 show the annual average temperature and the change of average annual precipitation in the study area. Both monotonic trend and step changes are obvious in both time series. The long-term trend of mean annual temperatures in the study area is detected by using both parametric and nonparametric techniques in this study. The research results show that both parametric t-test and the nonparametric Mann-Kendall test reject hypothesis H_0. It means that the increasing tendency of the temperature is significant at the 5% level of significance, and the temperature increased by nearly 1^{o}C over the past fifty years. The test result for the long-term trend of the precipitation show that although the t-test rejects the hypothesis H_0, the Mann-Kendall test accepts the H_0 at the 5% level of significance. Both parametric and nonparametric tests show an increasing tendency in precipitation. The

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precipitation showed a significant decrease in the 1970s, and a significant increase in the1980s and 1990s, the average annual precipitation exhibited an increasing trend with the magnitude of 6.8 mm per decade. Muttiah R S (2002) got the conclusions that the average temperature of the United States has risen by about 0.6℃, and precipitation has increased by about 5%~10% throughout the 20th century, mainly due to the increase in intense rainstorms. The increased precipitation may partly weaken the effect from the increased temperatures, which may increase evaporation and thereby resulted in the reduction in the river runoff and water supply (Philip, *et al*.2002).

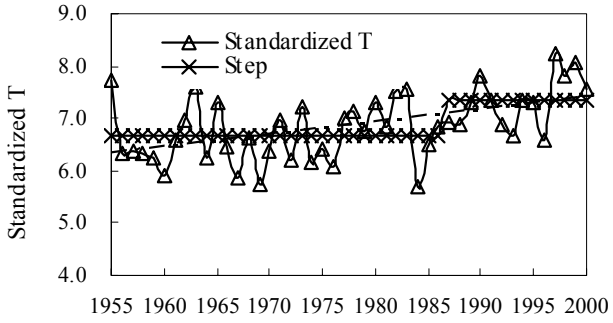

Fig.2. Standardized average annual temperature in the study area.

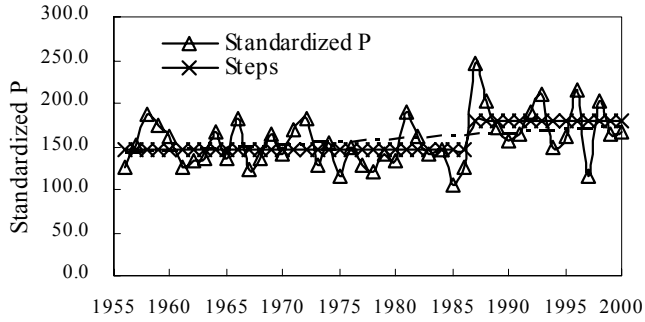

Fig. 3. Standardized average annual precipitation in the study area.

The standardized streamflow runoff from three major tributaries: Aksu, Yarkand, and Hetan rivers are shown in Fig.4. The increasing tendency of the Aksu River is significant at the 95% level of confidence, the streamflow of the Yarkand River exhibits an increasing trend and that of the Hetan River shows a downward trend, but both trends are not distinct.

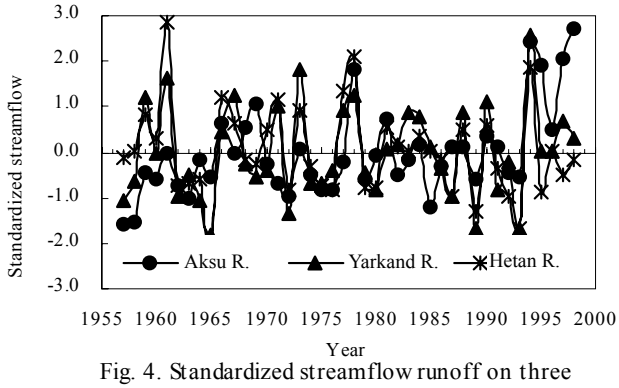

Fig. 4. Standardized streamflow runoff on three major tributaries of the Tarim River.

Discussion and conclution

The research results show that a step change occurred in both temperature and precipitation time series around 1986. Similar changes have been found in Europe by Franks (2002). Whether this kind of step changes resulted from climate change, further investigation on climatic physics is required. The physical mechanism producing this kind of jump changes needs further investigation. The increased temperatures may be attributed to global warming, but the increase in precipitation may be attributed to global change, and possibly to the increase of water surface, both resulting in the increase of evaporation and the hydrological cycles.

Acknowledgements

The research was supported by KIPCAS (Knowledge Innovation Project of Chinese Academy of Sciences) and JSPS (Japan Society for the Promotion of Sciences).

Reference

[1] Cohen, S. J., Miller, K. A., Hamlet, A. F., and Avis, W. (2000). Climate change and resource management in the Columbia River basin. *Water International*, **25**(2), 253-272.

[2] Franks, S. W. (2002). Assessing hydrological change: deterministic general circulation models or spurious solar correlation. *Hydrol. Process*., **16**, 559-564.

[3] Muttiah R S, Wurbs R A. Modeling the impacts of climate change on water supply reliabilities. *Water International*, 2002, 27(3): 407~419

[4] Philip G B, Biney C A. Management of freshwater bodies in Ghana. *Water International*, 2002, 27(4): 476~484