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RESEARCH ARTICLE

Combining BPANN and wavelet analysis to simulate hydro-climatic processes——a case study of the Kaidu River, North-west China

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Abstract Using the hydrological and meteorological data in the Kaidu River Basin during 1957–2008, we simulated the hydro-climatic process by back-propagation artificial neural network (BPANN) based on wavelet analysis (WA), and then compared the simulated results with those from a multiple linear regression (MLR). The results show that the variation of runoff responded to regional climate change. The annual runoff (AR) was mainly affected by annual average temperature (AAT) and annual precipitation (AP), which revealed different variation patterns at five time scales. At the time scale of 32-years, AR presented a monotonically increasing trend with the similar trend of AAT and AP. But at the 2-year, 4-year, 8-year, and 16-year time-scale, AR presented non-linear variation with fluctuations of AAT and AP. Both MLR and BPANN successfully simulated the hydro-climatic process based on WA at each time scale, but the simulated effect from BPANN is better than that from MLR.

Keywords hydro-climatic process, Kaidu River, simulation, wavelet analysis (WA), back-propagation artificial neural network (BPANN), multiple linear regression (MLR)

1 Introduction

Water shortages and related ecological degradation are the most pressing environmental issues in northwestern China. To establish proper water management strategies, thoroughly understanding the mechanism of the hydro-climatic process is important (Xu et al., 2010).

In the past 20 years, many studies have been conducted to evaluate climate change and hydrological processes in northwestern China (Chen and Xu, 2005; Wang et al., 2010; Zhang et al. 2010). A number of studies indicated that there was a visible transition in the hydro-climatic processes during the past half-century (Chen et al., 2006; Shi et al., 2007; Hao et al., 2008), which was characterized by a continual increase in temperature and precipitation, added river runoff volumes, increased lake water surface elevation and area, and elevated groundwater levels. However, such inquiries may be designed to determine if these changes represent a localized transition to a warm and wet climate type in response to global warming, or merely reflect a centennial periodicity in hydrological dynamics.

Theoretically, a hydro-climatic process can be evaluated to determine if it is in an ordered, deterministic system, an unordered, random system, or a chaotic, dynamic system, and whether change patterns of periodicity or quasi-periodicity exist. However, it is difficult to achieve a thorough understanding of the complex mechanism of a hydro-climatic process (Cannon and McKendry, 2002). Specifically, effective means have not been discovered to thoroughly understand the dynamics of hydro-climatic process at different time scales (Xu et al., 2008a; Xu et al., 2013). Therefore, more studies are required to explore the hydro-climatic process from different perspectives and using different methods (Xu et al., 2009a, b). Specific to the Kaidu River, a question of interest will be the variation patterns of the hydro-climatic process at different time

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