Variation Trend of Discharges into Sea from the Yangtze River

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ABSTRACT

Based on daily-averaged discharges of Datong station at the Yangtze River, Pettitt change-point tests are employed to detect the change-points of discharge time series accounting for the durations of dry season, flood season and flood recession period, respectively. The discharge time series are divided into several segments by change-points. The tendency of discharges is studied by employing Mann-Kendall method. During the latest 62 years, the annual mean discharges exhibit an indistinctive decrease trend. As for the mean discharges of dry season, significant change-points can be found in the end of 1980s, a remarkable increase trend appears during the latest 62 years. As for the mean discharges of flood recession period, significant change-points are found in the end of 1980s and 2003, and a remarkable decrease trend appears during the latest 62 years.

KEY WORDS: Yangtze River; discharge into sea; Pettitt change-point test; Mann-Kendall trend analysis

INTRODUCTION

Changes of discharges into sea, partially induced by climate changes and human activities, can have influences on hydrodynamics, water environmental conditions and morphodynamic evolutions of estuaries (Wang et al., 2008). Some large dams have been built on the Yangtze River. The Three Gorges Dam, located on the main stream of Yangtze River, has integrated functions of flood protection, power generation and navigation. The Gezhou Dam is located in 38km downstream of the Three Gorges Dam (Chen et al., 2006; Zhao, 1999). The operations of the Three Gorges Dam and the Gezhou Dam, have some influences on inter-annual discharge distribution of the Yangtze River (Mao and Shen, 1994; Zhang and Chen, 2003).

The Yangtze River, originating from Tibet Plateau and approaching the sea at Shanghai city, China, is the third longest river in the world. It has a length of 6 300 km, a basin area of 1 800 000 km² and hundreds of tributaries. More than 46 000 dams have been built in the Yangtze River basin, which greatly contribute to the discharge changes of the Yangtze River (Zhou et al., 2007). There is a discharge decrease during 1970s~2011 at Yichang station in upstream, as well as decrease during 1956~1998 before increasing during 1999~2011 at Hankou station in the middle reach and at Datong station in the lower reach (Zhang et al., 2007). Datong station is used as a hydrological station of Yangtze River for observing water and sediment fluxes into sea (Zhang and Chen, 2003; Zhang et al., 2006). The annual mean discharges (1923~2004) at Datong station are about 9 156×108 m³ (Xu and John D, 2009; Yang et al., 2002; Zhang et al., 2008; 2011). The maximum and minimum annual mean discharges are 43 100m³/s and 21 400m³/s, respectively, which shows a significant fluctuation of the annual mean discharges into sea (Fang et al., 2011; Gong et al., 2012).

Studies on the discharge variation trend of the Yangtze River are mainly focused on large time-scale hydrology series (Zhou et al., 2007). Such methods as Periodogram Analysis, Maximum Entropy Spectrum Analysis (Wu and Zhang, 2009), Mann-Kendall Trend Analysis (Qing et al., 2005), etc, have been employed to explore some hydrological issues, e.g., runoff changes in different time-scales (Zhou et al., 2007), salt intrusion after the construction of the Three Gorges Dam (Wu and Zhang, 2009), as well as flood situation keeping the pace of global warming (Qing et al., 2005).

Based on daily-averaged discharge data during 1950~2011 of Datong station, Pettitt change-point tests and Mann-Kendall Trend Analysis are used to detect change-points and variation trends, respectively, accounting for the duration of dry season, flood season and flood recession period. The causes and the contribution of climate changes and human activities on discharge variations are discussed in this paper.

CHANGE-POINT ANALYSIS OF DISCHARGES INTO SEA OF THE YANGTZE RIVER

Pettitt Change-point Tests (A N, 1979; Ling et al., 2007; 2008)

Pettitt change-point test method, based on non-parameters, is able to distinguish change-points of time series effectively. Giving two samples x1,…xt and xt+1,…xT of the same time series, statistical function $U_{t,T}$ and $V_{t,T}$ can be calculated as: