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Trends of precipitation intensity and frequency in hydrological regions of China from 1956 to 2005

Xiaoying Zhang, Zhentao Cong *

State Key Laboratory of Hydroscience and Engineering, Department of Hydraulic Engineering, Tsinghua University, Beijing 100084, China

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ABSTRACT

Daily precipitation data of 741 meteorological stations ranging from 1956 to 2005 were used to run a preliminary investigation of changes in temporal and spatial distribution of precipitation intensity and frequency in ten hydrological regions in China. Average annual and seasonal spatial values of indices of precipitation characteristics (i.e. precipitation amount, intensity and frequency) were obtained using a Kriging interpolation method. Temporal tendencies were calculated by Mann-Kendall's method. The trends of extreme rainfall events and precipitation-based droughts were also discussed in ten hydrological regions using the maximum daily precipitation and dry spell duration in a year. Results show that precipitation intensity has significant increasing trends while precipitation frequency has significant decreasing trends over China. Meanwhile precipitation has a major decline in autumn and a slight increase in winter. Both extreme rainfall events and precipitation-based droughts show a general increasing trend. The aggravated spatial and temporal unevenly distributed precipitation leads to more water shortage as well as floods in China.

1. Introduction

Climate change refers to any significant change in measures of climate lasting for an extended period (Giorgi, 2006). It is generally observed in the variations of temperature, precipitation, snow cover, sea level, atmospheric and oceanic circulation patterns, extreme weather events, etc. (Houghton et al., 2001). Scientists from different research fields have put much effort into revealing and exploring the mechanism of climate change for its huge impact on social and economic development. Typically, changes in global and local climate can affect regional water resources by altering the amount and distribution of precipitation in a certain area (Labat et al., 2004). Cubasch et al. (2001) predict that in the 21st century the global hydrological cycle is accelerated by about 1%–2%/K and further study implies that there must be a decrease in light or moderate precipitation and/or a decrease in the frequency of precipitation events (Trenberth et al., 2003).

The spatial and temporal variations of precipitation in China have been widely discussed over the last decade. Liu et al. (2005) found that precipitation in China increased by 2% while the frequency of precipitation events decreased by 10% from 1960 to 2000. Zhang et al. (2011) indicated that in general seasonal precipitation has an increasing trend in winter and summer but a decreasing one in spring and autumn. Regional differences have also been taken into consideration for China's large terrestrial area with many climatic and hydrological regions. Studies show that great differences occur in the spatial distribution and temporal trend of precipitation in different regions (Song et al., 2011). For instance, a Mann–Kendall test result shows that in general the middle and the lower sections of the Yangtze River are dominated by increasing annual, summer and winter precipitation while for the Haihe River Basin precipitation of 1958–2007 has been decreasing except for spring (Zhang et al., 2009; Chu et al., 2010).

Another hydrologic change in precipitation coupled with land cover changes, urbanization and industrialization is the change of extreme rainfall events and droughts (Feddema et al., 2005; Guo et al., 2006). Scientists and policy makers have come to realize that immoderate human activities lead to more intense precipitation and make water resources management harder than before. Different extreme precipitation indices are introduced like duration of maximum consecutive wet days in a year (Zhang et al., 2012), maximum consecutive rainy days (Peng et al., 2011), annual maximum 1-, 3-, 5- and 7-day rainfall (Zhao et al., 2012) and so on.

Precipitation is the driver of runoff and river runoff is one of the main water resources used by humans. Runoff is controlled not only by precipitation amount but also by precipitation intensity and precipitation frequency. Specially, floods caused by extreme precipitation and precipitation-based droughts are important hydrological issues for the water resources management. Most of water resources managements are put into practice in the basin scale. For China which is under different climatic and hydrological conditions, it is valuable to identify the precipitation patterns and their trends in different hydrological regions.

* Corresponding author at: Room 316, Institute of Hydrology and Water Resources, New Hydraulic Building, Tsinghua University, Haidian District, Beijing, 100084, China. Tel.: +86 10 62781285; fax: +86 10 627969715.
E-mail addresses: zhangxy109@163.com (X. Zhang), congzht@tsinghua.edu.cn (Z. Cong).

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In this study, spatial and temporal variations of precipitation in China are analyzed both in a yearly and a seasonal time scale. Precipitation amount, intensity and frequency are calculated under specific definitions and their trends in ten hydrological regions in China are then described in figures and tables. The distribution of extreme precipitation as well as the precipitation-based drought in different regions is also provided in following parts.

2. Data and methodology

2.1. Data

Daily precipitation data of 741 meteorological stations ranging from 1956 to 2005 were used to run a preliminary investigation. Weather data came from the Climate Data Center, National Meteorological Information Center, China. Daily precipitation has been measured by the tipping-bucket or siphon recording rain gauges in these stations. Observation for one day starts at 20:00 (Beijing time) the day before and ends at 20:00. Data serials are organized and pre-analyzed by the National Meteorological Information Center and the preprocessing includes data integrity test, consistency check and extreme value test. Using the same data source, Z.H. Jiang et al. (2008) applied standard normal homogeneity test (SNHT) to yearly precipitation data with 5% significant level. When the correlation standard is 0.8–0.9, which is adopted in Alexandersson's (1986) research and commonly used afterwards, only 2 stations of 681 stations show inhomogeneity. Even the correlation standard is 0.5–0.9, only 4% stations show inhomogeneity. Therefore, we consider the precipitation data to be homogeneous.

China is divided into ten hydrological regions, which are depicted in Fig. 1. These hydrological regions are located in different latitudinal zones ranging from arid and semiarid regions to semi-humid and subtropical ones.

2.2. Methodology

Generally in models describing precipitation distribution, three indices are used to basically describe precipitation characteristics: precipitation amount, intensity and frequency. These indices can be calculated statistically through precipitation data recorded in meteorological stations and its variation and tendency be analyzed. Sun et al. (2007) calculated precipitation frequency by dividing the number of days with precipitation within an intensity interval or a precipitation category by the number of all days with data and intensity as the mean precipitation rates averaged over the days with the corresponding precipitation events. Similarly in this study, we use daily period for calculating precipitation frequency, which is similarly the number of rainfall events divided by the number of days in a year and intensity, which is the amount of total rainfall in a year divided by the number of rainfall events. As the daily calculation period is used, the number of rainfall events is also the number of rainy days.

The calculation result is presented as yearly and seasonal precipitation amount, intensity and frequency of 741 meteorological stations

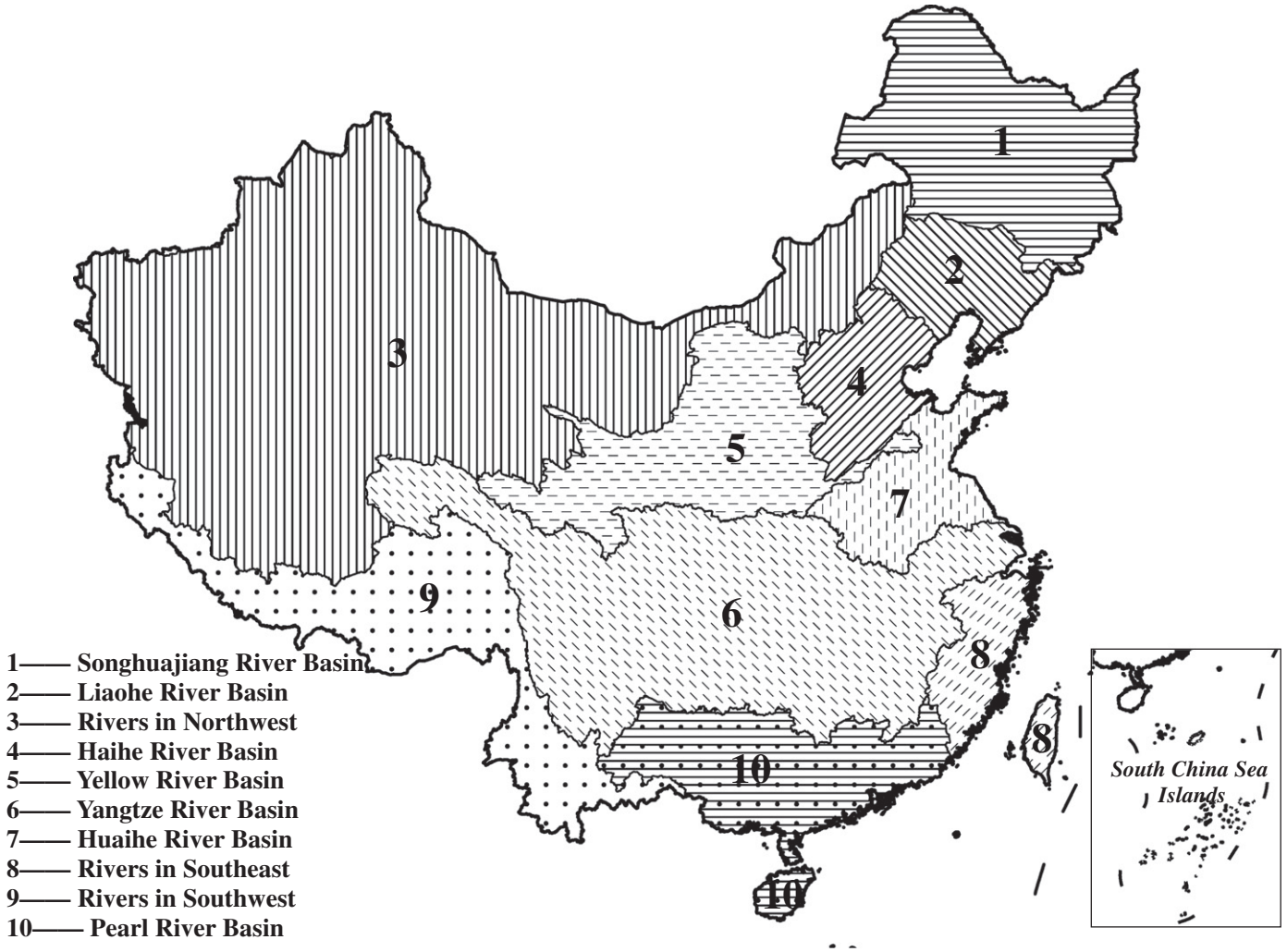

Fig. 1. Ten hydrological regions in China.