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Temporal and spatial trends of precipitation and river flow in the Yangtze River Basin, 1961–2000

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Abstract

The suspected impact of climate warming on precipitation distribution is examined in the Yangtze River Basin. Daily precipitation data for 147 meteorological stations from 1961–2000 and monthly discharge data for three stations in the basin have been analyzed for temporal and spatial trends. The methods used include the Mann–Kendall test and simple regression analysis. The results show (1) a significant positive trend in summer precipitation at many stations especially for June and July, with the summer precipitation maxima in the middle and lower Yangtze River basin in the 1990s; (2) a positive trend in rainstorm frequency that is the main contributor to increased summer precipitation in the basin; and (3) a significant positive trend in flood discharges in the middle and lower basin related to the spatial patterns and temporal trends of both precipitation and individual rainstorms in the last 40 years. The rainstorms have aggravated floods in the middle and lower Yangtze River Basin in recent decades. The observed trends in precipitation and rainstorms are possibly caused by variations of atmospheric circulation (weakened summer monsoon) under climate warming.

Keywords: Temporal and spatial trends; Precipitation; River flow; Yangtze

1. Introduction

The spatial and temporal redistribution of precipitation, which is the direct source of flood and drought hazards, is one of the major impacts of global warming (IPCC, 2001a). As the water-holding capacity of the atmosphere increases with temperature, warmer temperatures suggest a higher potential of intense precipitation (Kundzewicz, 2005). An increase in the frequency of heavy precipitation events was reported by stations sited in the middle to high latitudes of the northern hemisphere in the last half of the 20th century (IPCC, 2001b), these included stations from the USA (Karl et al., 1996; Karl and Knight, 1998; Groisman et al., 1999), Europe (Brunetti et al., 2000; Osborn and Jones, 2000), and East Asia (Iwashima and Yamamoto, 1993; Zhai et al., 1999), etc. Impacts of precipitation change on hydrological processes have been examined by modeling and observational analyses. These impacts vary across regions because of spatial differences in precipitation change (Kwadijk and Rotmans, 1995; Dvorak et al., 1997; Vogel et al., 1997; Arnell, 1998; Xu, 2000; Burn and Hag Elnur, 2002; Menzel and Bürger, 2002; Eckharadt and Ulbrich, 2003). At a global scale, Labat

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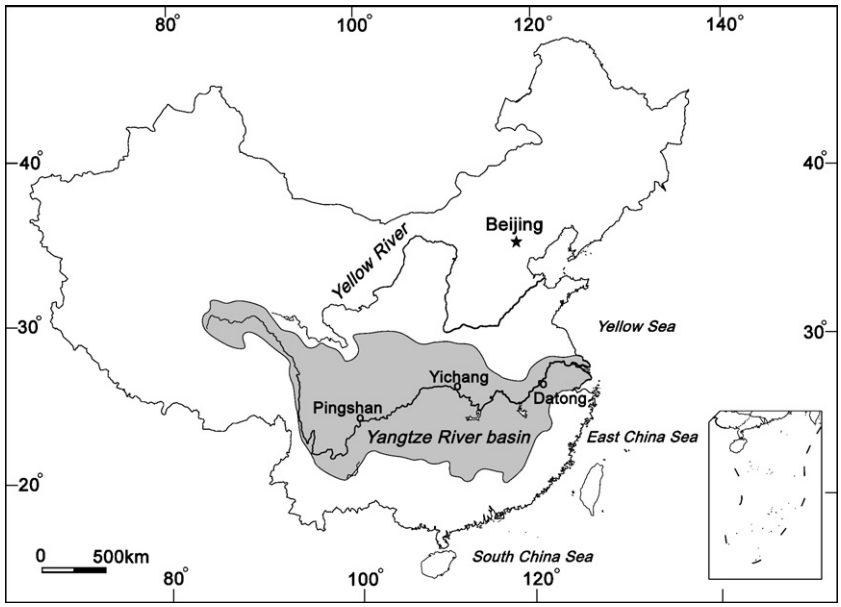

Fig. 1. Location of the Yangtze River basin in China.

et al. (2004) proposed that intense evaporation over the oceans has been closely associated with the variability of continental precipitation and evaporation, leading directly to the change of global continental runoff.

The present study focuses on the Yangtze River Basin. The Yangtze River is 6300 km long with a basin area of 180×10^4 km^2 (Fig. 1). Owing to great topographic variability, the Yangtze River Basin can be divided into three physiographic regions (Chen et al., 2001a): the Tibetan plateau, Mid-basin mountains, and the eastern low plain (Fig. 2).

The Yangtze is frequently flooded (Hu and Luo, 1992), a pattern that has intensified since the 1990s (Yin and Li, 2001). As the basin is densely populated and highly industrialized, the effects tend to be devastating. Increased intensity in summer rainfall, particularly from rainstorms covering large areas of the basin, initiate the floods (CWRC, 2002). The growing population pressure of the past decades, deforestation, lake reclamation, and embankment construction on riverbanks all exacerbated the flood situation (He and Jiao, 1998). Previous studies using trend analysis revealed an increasing precipitation in the winter months in the Yangtze River Basin between 1990–1999 (IPCC, 2001b) plus a significantly increasing trend in summer precipitation over the middle and lower basin in the second half of the last century (Zhai et al., 1999; Becker et al., 2003; Gong and Ho, 2003; Gemmer et al., 2004; Su et al., 2004). Evapotranspiration has decreased significantly in the Yangtze River Basin over the past 30 years, due to decreasing wind speed and

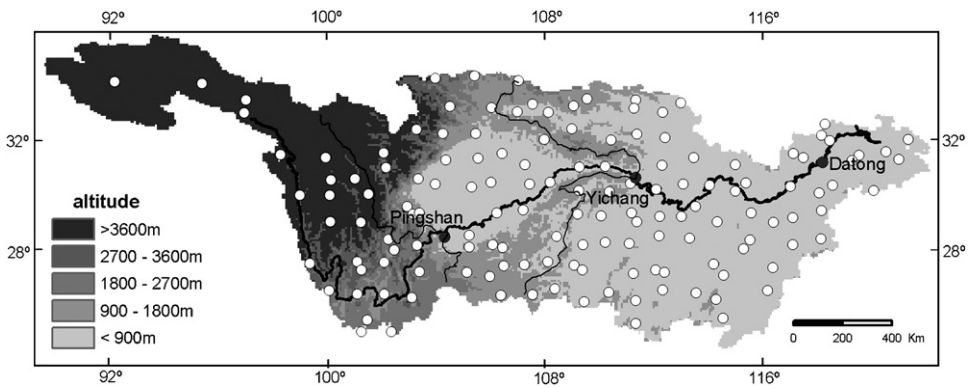

Fig. 2. Elevation of the Yangtze River Basin and the location of the observatory stations.