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The fluctuation of the beginning time of flood season in North China during AD1766–1911

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ABSTRACT

This study is based on the Qing government water level gauge records from Wanjingtan of the Sanmenxia Gorge in the middle reaches of the Yellow River, Muluandian in the lower reaches of Qinhe River, and Shijingshan and Lugou Bridge in the lower reaches of Yongding River. The beginning of the flood season has been reconstructed. The anomaly series of the flood season is assessed using pentad scales. The sequence represents the middle reaches of the Yellow River, the lower reaches of the Qinhe River, and the lower reaches of Yongding River. Within the research period, the middle reaches of the Yellow River and the lower reaches of the Qinhe River began the flood season on 6–10 July on average, and Yongding River began 16–20 July. The Yongding River is relatively stable and the start of rainy season of its upstream was basically maintained in early July. The middle reaches of the Yellow River and the lower reaches of the Qinhe River show great fluctuation, with discrepancies up to 3 months. The same anomalous fluctuation in the flood season of the middle reaches of the Yellow River and the Qinhe River is more obvious after the mid-19th century. The delay of flood season by about one pentad in the middle reaches of the Yellow River, Qinhe River, and Yongding River is in accordance with the relative low temperature of the Loess plateau in summer, while the early flood season of the middle reaches of the Yellow River and Qinhe River corresponds with the relative high summer temperature in the Loess Plateau. The beginning time of the flood season in the research area is the time the rainy season begins. The length of summer-monsoon rainy season during 1860s–1940s has been reconstructed, as the Little Ice Age transformed to the Modern Warm Period in China. Rapid warming could change the summer rainy season by 2–3 pentads.

1. Introduction

The Asian Monsoon plays an important role in transporting large quantities of heat and moisture to the most-populated regions of the world. Precipitation and the dare of first rain are sensitive to the East Asian Summer Monsoon (EASM) intensity (An, 2000). The rainy season related to EASM has great significance for annual precipitation over northern China (He et al., 2007). The starting date of the rainy season is critical for crop planting and yields (Griffiths, 1994; Tao et al., 1997; Zhu et al., 2011), and changing EASM leads to the changing dates of the river flood season. In this article, three rivers in semi-humid northern China were chosen to study the change of timing of the flood season related to the EASM from 1766 to 1950 (Fig 1).

Rain-fed agriculture is the most important part of the economy of China during the past thousands of years. Rainy summers and autumns lead to river floods, and throughout Chinese history government has had to manage flooding to avoid agricultural loss. The Yu-Xue-Fen-Cun (YXFC, Yu/rainfall-Xue/snowfall-Fen/Chinese length unit, approximately 0.32 cm-Cun/10Fen, 3.2 cm) archives of Qing Dynasty (1644–1911) were used to reconstruct the precipitation in the middle-lower reaches of Yellow River, and the rain dates in the semi-arid region of North China (Zheng and Wang, 2005; Ge et al., 2011).

In the early 18th century, the Qing government (1644–1912) began to set up water level observation stations on rivers in China. The water level observation station at Wanjintan is on the Yellow river, north of Laoxiancheng, Shanxian county, Sanmenxia city,

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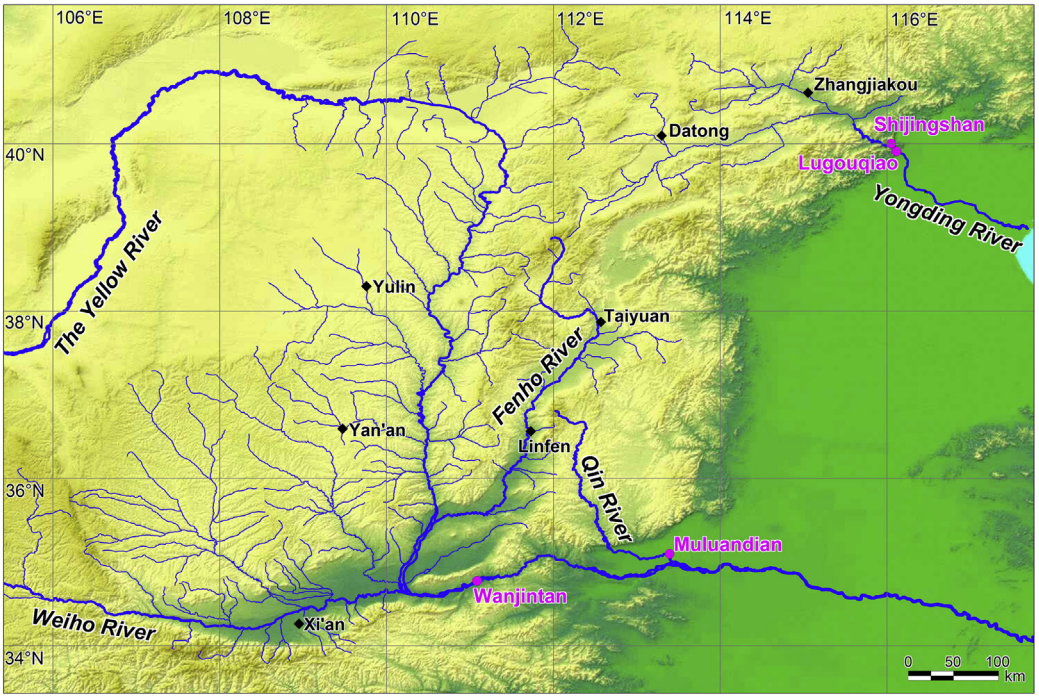

Fig. 1. Study area.

Henan province. It is an important data source for monitoring the water conditions of the middle reaches of the Yellow River. Similarly, there are observation stations on the Qinhe River and Yongding River, located at Muluandian in Wuzhi County and Shijingshan-Lugouqiao, respectively. According to the rules of Qing Dynasty, when the water level rises 2 *Chi* (*Chi* is a Chinese length unit; 1 *Chi* = 0.32 m) or more, the date and height must be reported to the imperial government. At present, these reports are scattered through the following sources: 'Extracts of the water condition of historical floods in Qing Dynasty at Wanjintan and Xiakou on the Yellow River; Muluandian on the Qinhe River; and Gongxian on the Yiluo River', edited by the Yellow River Conservancy Commission in the 1980s as internal documents.

2. Methods

The first date of rising water was converted to pentad-scale, that is to say, July 1 is converted to 7/1, i.e. the first pentad in July. The method of assessing the dates of flood season on the pentad-scale was used in a similar study of the rainy season start date during 1644–1911 (Yang et al., 2007). Use of historical documents is especially suitable for such studies. Pan et al. (2012) studied the annual dates of first rising water at the Wanjintan station on the Yellow River. In light of their conclusion, the average beginning time of flood season in the Sanmenxia Region was July 6–10 during 1766–1911. This date corresponds with the date of the last stage of Meiyü (plum rain) in the middle and lower reaches of the Yangtze River (Ge et al., 2008). When the summer rain-belt moves northward into the Huanghe River valley and North China, the rivers enter flood season in these areas. It agrees with the process of the summer rain-belts, so it should be possible to convert the annual first water rising dates to pentad scale.

The Qing Dynasty (AD 1644–1912) was concerned with weather, hydrological events, droughts, and floods. The empire constructed a very efficient recording system using reports from officers and regional intellectuals. Three kinds of archives are very important to this paper. 1) Water level records of the Qing government from the early 18th century; 2) Yu-Fen-Cun (YFC), recording the beginning/ending dates, duration and rainfall infiltration depths into soil for individual precipitation events; and 3) Hydrological records for 1912–1950.

3. Results and analysis

3.1. Fluctuation of the beginning time of flood season

According to the average situation of the reconstruction, the beginning times of flood seasons of both the Yellow River and Qinhe River range from July 6 to July 10. Meanwhile, the flooding season of the Yongding River begins a little later, and ranges from July 16 to July 20. Here, we reconstruct the chronology of the beginning of the flood season of the three rivers on a pentad scale. The standard deviations of Yellow River, Qinhe River and Yongding River are 1.19, 1.01 and 0.64, respectively. There are significant fluctuations in the Yellow River's flood season, and the Qinhe River shows significant instability in its flood season. By comparison, the Yongding River is the most stable one, which shows that the rainy season in the northern Loess Plateau during the Qing Dynasty was relatively stable. Fig. 2 shows the 5-point smoothing average curve of the beginning time of the flood season. Except for an evident fluctuation between 1880 and 1890, the Yongding River's flood season has changed very little.

Table 1 shows the extreme value of the date of flood season initiation. All of the extreme events occurred in the period without modern weather and hydrological records. 1842/3-2 is the second pentad in March AD1842 (6–10th March). The extreme value of the flood season dates for the middle reaches of the Yellow River is much larger than for the Qinhe and Yongding Rivers. That was the period when flood disasters along the Yellow River occurred most frequently and severely in eastern Henan Province. At that time,