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Effect of the Three Gorges Dam Project on flood control in the Dongting Lake area, China, in a 1998-type flood

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Abstract

To evaluate the protective effect of the Three Gorges Dam Project (TGP) against flooding in the middle region of the Changjiang River basin, we applied an integrated watershed hydrological model using gauged daily precipitation data for 1998, when the second largest flood of the last century occurred in the basin. From the results simulated by applying the daily average discharge rate controlled by each of the upper limit values of 40,000, 45,000, 50,000, and 55,000 m^3/s as the safety discharge in the downstream reach, we were unable to find any clear reduction effect on the water level during the flood period, not only in Dongting Lake, but also in the Changjiang mainstream, when the upper discharge limit exceeded 50,000 m^3/s. When an upper discharge limit of 40,000 m^3/s was used, although a flood protection effect was clearly exhibited in both the mainstream and the lake, the simulated storage volume of the TGP reservoir markedly exceeded the total flood control volume (221.5×10^8 m^3) at the inflow peak. These results suggest that the TGP would not work efficiently for decreasing flood damage in the Dongting Lake area in the event of another 1998-type flood without other countermeasures to control the increased water level in the lake.

Keywords: Flood; Three Gorges Dam; Changjiang River basin; Dongting Lake; Hydrologic model

1. Introduction

The plain and lake area in the middle and lower regions of the Changjiang River basin is well known to have the most concentrated, frequent, and severe floods and waterlogging disasters in China, even though it has been one of the major areas for producing commodity grain, cotton, and edible oil, as well as being an economically developed area. In the last century, five severe flood disasters occurred in 1931, 1935, 1949, 1954, and 1998. During the 40 years after the 1954 flood, prevention of medium- and small-scale flooding was much improved in the middle and lower reaches, but the threat of major flooding remained. As a result, the second largest flood of the last century in 1998 claimed 1562 lives and caused $30 billion worth of economic damage (Xu et al., 2000). In terms of flood probability based on the observed data at Yichang (hydrologic station #1, in Fig. 1), the 1998 flood corresponded to only a 6- to 8-year flood from the viewpoint of peak flow rate (63,300 m^3/s). However, the total runoff volumes for 30 days and 60 days during the flood period in 1998 were 138 billion m^3 and 255 billion m^3, which were similar to, or exceeded those volumes in the largest flood of the last century in 1954 (139 billion m^3 for 30 days and 245 billion m^3 for 60 days, respectively). Regarding the total runoff volumes in the flood period, the 1998 flood corresponded to a 100-year flood (Changjiang Hydrologic Bureau, Changjiang Water Resources Commission, Ministry of Water Resources, 2000). At present, the flood diversion standard in this area ranges from a 10-year to a 20-year flood frequency,

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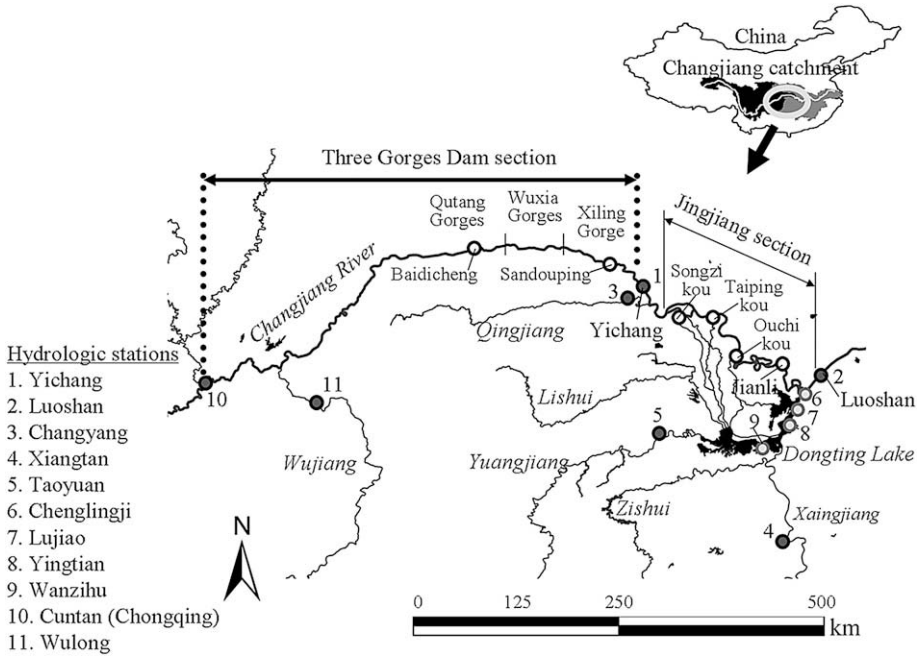

Fig. 1. Location of the study area in the Changjiang River basin, Three Gorges Dam section, and the hydrologic stations used in this study for input of the model data and validation of the model's performance.

and if a flood exceeds this standard, the flood diversion regions, which are all reclaimed, cultivated and densely populated, would have to be used to divert floodwater, undoubtedly resulting in immense losses. The Jingjiang section in particular is considered to be in a more critical condition. The total plain area along both sides of this section, supporting a population of 15 million, is about 40,000 km^2, of which 15,300 km^2 is farmland. Currently, however, the dikes in this section can only prevent a less than 10-year flood, and in the flood season the Changjiang water level is generally 10 m over the ground surface north of the bank.

The Three Gorges Project (TGP) is the largest water conservancy project ever undertaken in China, and indeed the world, with a normal pool level (NPL) at 175 m and a total reservoir storage capacity of 39.3 billion m^3. The TGP is expected to control flooding not only in the area along the Changjiang mainstream but also in the area surrounding Dongting Lake, which connects directly with the Changjiang River. In the joint report issued by the Environmental Impact Assessment Department (EIAD), Chinese Academy of Sciences (CAS) and the Research Institute for Protection of Yangtze Water Resources (RIPYWR) (1993), as the key project for flood control in the middle and lower reaches of the Changjiang River, it is estimated that the TGP will directly control 95% of the Jingjiang section's flood inflow and 2/3 of the flood inflow upstream of Wuhan City with a reservoir flood control storage capacity of 22.15 billion m^3. This direct control is intended to improve the flood control capability in the Jingjiang section from the present 10-year one to once a century. The report also mentioned the mitigation effect of the TGP on the flood threat of the Changjiang River to Dongting Lake, including a slowdown of sediment deposition in the lake, by reservoir regulation.

We have no doubt that the TGP would exert a marked flood protection effect in the Jingjiang section because of the direct contribution of discharge control from the dam site. However, in the case of a 1998-type flood occurring simultaneously over the whole basin involving both an initial flood in the upper region and a prolonged high flood period in the middle and lower regions due to abnormal weather, and other factors, it is difficult to understand accurately the mitigation effect on Dongting Lake only from the viewpoint of the TGP flood control capacity without considering the water balance in the lake over a short time interval consisting of inflow from its catchment and outflow as a result of hydraulic interaction with the Changjiang River. Furthermore, without a quantitative analysis of lake water balance, it is impossible to evaluate the flood control effect of the TGP on the downstream reaches of the Changjiang mainstream after its juncture with the lake. Although there has been no report of research on flood control by the TGP in the area surrounding Dongting Lake based on water dynamics with a catchment scale, a retrospective simulation study of previous severe flood events should be done using a distributed hydrologic model with a large catchment scale to evaluate not only the flood control ability of the TGP but also the effect of flood protection methods currently being used by the Chinese Administration, such as the return of farmlands to forest areas and the return of paddy fields to lakes.

Hayashi et al. (2004) have applied the Hydrological Simulation Program – FORTRAN (HSPF; Bicknell et al., 1997) as a distributed model to the whole upper region of the Changjiang basin and described its availability for the simulation of daily runoff and sediment load processes. Then, to simulate daily runoff in the middle and lower regions of the Changjiang basin in 1987 and 1988, they integrated the HSPF