Numerical appraisal of the relationship between a lake's shrinkage and flooding: a case study of Dongting Lake, China

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We support the Sustainable Development Goals

WLC18- 0171

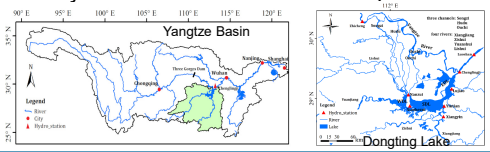
Introduction

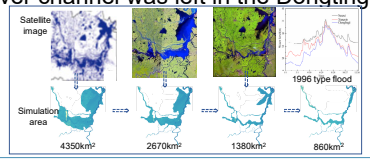
It is well known that a lake plays an important buffer role against the impacts of floodwaters during wet seasons. In recent years, a lot of lakes around the world are shrinking. Dongting Lake is the second largest freshwater lake in China, located in the middle of the Yangtze River, which has shrunk 4350 km^2(1950S) to 2670 km^2 (2010S) with the water storage capacity decreasing from 27 to 17 km^3. Consequently, more frequent floods with higher water levels have been observed. But few quantified analyses of the relationship between the lake shrinkage and the flood process were conducted in the literature. Therefore, it is needful to conduct a quantitative investigation to clarify the relationship between the floodwater level and lake shrinkage.

Methodology

Dongting Lake is the second-largest freshwater lake in China, which is located at approximately 400 km downstream away from Three Gorges Dam (TGD). Dongting Lake's area and storage capacity have decreased by about 39.3% and 41.3% since 1949.

A 2D depth-averaged hydrodynamic model was used to investigate the impact of the shrinkage of the lake on the flooding process in Dongting Lake using a 1996 type flood. A series of cases were chosen to represent the change of Dongting Lake. i) For case S0, the area of Dongting Lake was enlarged to 4350 km^2 according to the record in 1949. ii) the boundary of case S1 was based on the satellite image in the wet season of 1995;iii) the boundary of case S2 according to the water surface area in the wet season in 2011. iv) For case S3, a hypothesis was made that the lake area was fully silted with sediment and only the main river channel was left in the Dongting Lake area.

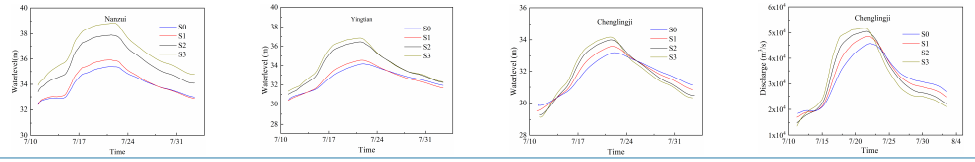




Case	Area(km²)
S0	4350
S1	2670
S2	1380
S3	860

Results

The average rise of the water level is around 2.5 m at high water level period (> 33 m) when the lake area decreases from 4350 to 860 km^2 at Nazui station and Yingtian station. For Chenglingji station and Luoshan station, the water level increases with the decrease of the lake area during the rise stage while it decreases with the decrease of the lake's area during the falling stage, which indicates that the water level rises and falls steeply with the shrinkage of Dongting Lake. The peak discharge increases by around 13% (i.e., 6025 m^3/s) when the lake area decreases from 4350 to 860 km^2. The flood wave travels faster with the decrease of the lake area, i. e., the peak flow occurs 21 hours earlier compared to Case S0 and Case S3. This means that flood disasters will become more severe if the lake continues to shrink.



Conclusions

The shrinkage of Dongting Lake has a great impact on the water level in the lake. The water level increases drastically during the flood period as the peak water level increased by 2.8 m, 2.5 m and 1.02 m in west, south and east Dongting Lake if the lake area decreases to 860 km^2. The peak discharge increases by around 13% and the peak flow occurs 21 hours earlier when the lake area decreases from 4350 to 860 km^2. The flood flow rises more rapidly during the rising stage and recedes faster during the falling stage with a higher peak discharge due to the reduced storage capacity of floodwater after the lake shrinkage.

Acknowledgments

This research was supported by the National Natural Science Foundation of China (Grant Nos. 52109006), the Natural Science Foundation of Hunan Province, China (Grant No. 2021JJ40589) and the Water Conservancy Science and Technology Project of Hunan Province (Grant No. XSKJ2019081-46).

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