Available online at www.sciencedirect.com
ScienceDirect
Journal of Hydrodynamics
2017,29(4):586-595
DOI: 10.1016/S1001-6058(16)60771-0
www.sciencedirect.com/science/journal/l0016058

Prediction of the future flood severity in plain river network region based on numerical model: A case study *

Zi-jun Hu (胡孜军)[1,2,3], Ling-ling Wang (王玲玲)[1,2], Hong-wu Tang (唐洪武)[1,2], Xiao-ming Qi (戚晓明)[4]
1. *State Key Laboratory of Hydrology-Water Resources and Hydraulic Engineering, Nanjing 210098, China*
2. *College of Water Conservancy and Hydropower Engineering, Hohai University, Nanjing 210098, China*
3. *Power China Huadong Engineering Corporation Limited, Hangzhou 311122, China,*
E-mail: hu_zj@ecidi.com
4. *Computer Science and Technology Department of Bengbu College, Bengbu 233000, China*

(Received July 27 2015, Revised January 25, 2016)

Abstract: Suzhou is one of China's most developed regions, located in the eastern part of the Yangtze Delta. Due to its location and river features, it may at a high risk of flood under the climate change background in the future. In order to investigate the flood response to the extreme scenario in this region, 1-D hydrodynamic model with real-time operations of sluices and pumps is established. The rain-runoff processes of the urban and rural areas are simulated by two lumped hydrologic models, respectively. Indicators for a quantitative assessment of the flood severity in this region are proposed. The results indicate that the existing flood control system could prevent the Suzhou Downtown from inundation in the future. The difficulty of draining the Taihu Lake floods should be given attention to avoid the flood hazard. The modelling approach based on the in-bank model and the evaluation parameters could be effective for the flood severity estimation in the plain river network catchment. The insights from this study of the possible future extreme flood events may assist the policy making and the flood control planning.

Key words: Flood control, hydrodynamic model, sea level rise, extreme rain, Suzhou District

Introduction

Numerous studies reveal that the level of the China East Sea is rising due to the climate change[1,2]. The number of extreme rains (ER) in the lower-middle region of the Yangtze River Basin is also in increase[3,4]. The flood often causes a severe damage, leading to substantial economic losses and even the loss of life[5]. Even more dangerous is that the warming climate during the 20th century would increase the risk of floods in many places of the world[6,7]. Therefore, the Suzhou district faces the intensified flood risks both induced by ER and sea level rise (SLR) in the future. The study of the flood response to the extreme scenario related to ER and SLR in this region will assist the policy making and the flood control planning.

Many policies related to the future urban development require information of climate change risks to cities[8]. Therefore, the flood response to ER and SLR has attracted more and more attention of the related departments. Some numerical models were developed to investigate the flood risks of the Taihu Lake Basin[9-11]. Among the simulation methods, with the 2-D model based on the digital elevation data[9], the hydraulic characteristics of the river networks cannot be accurately obtained in an acceptable computing time. Moreover, the available hydrological and topographical data are usually not enough to establish such a complicated 2-D model. Wicks et al.[12] and Xu and Liu. [13] constructed 1-D models with a simplified river network in the Taihu Lake Basin. However, the rivers and the flood control structures in the Suzhou district were overly simplified. Thus, the hierarchical flood

* Project supported by the National Key Research and Development Program of China (Grant No. 2017YFC0405600, 2016YFC0401503), the Special Fund for Public Welfare of Water Resources Ministry (Grant No. 201501007, 201201017) and the State Key Pro- gram of National Natural Science of China (Grant No. 51239003).
Biography: Zi-jun Hu (1988-), Male, Ph. D.
Corresponding author: Ling-ling Wang,
E-mail: wanglingling@hhu.edu.cn

control structure system in this region is not well reflected. Especially after the 1999 flood, a number of key projects and the related operating rules had been completed. Therefore, it is high time to establish a numerical model which can reflect the characteristics of the Suzhou District and has the ability to simulate the large number of flood control structures.

The flood risk assessment for the plain river network region remains a challenging task, due to the large number of control structures, the complicated river-lake networks, the repeated human intervention, and the spatial variations in economic values. A GIS-based approach called the Taihu Basin Flood Risk Analysis System (TBRAS) for analyzing the flood risks in the Taihu basin was developed by Yu et al.[14]. The flood volume and distribution caused by breaching and overtopping of the dike were calculated based on the digital elevation data. Thus, the flood risks can be estimated based on the distributed socioeconomic data in the flood cell. In the presented study, if the TBRAS or the similar methods were adopted, the more detailed socioeconomic data would be required. However, they are usually unavailable. Moreover, the county level socioeconomic distribution situations in the future are difficult to be predicted [15]. Thus, a simplified estimation approach of the flood hazards in the complex river network region is more appropriate.

In the present study, for investigating how to make a quick estimation of the future flood severity in the plain river network region with lack of economic data, the river networks of the Suzhou District are selected as a typical case in China. A 1-D hydraulic model with the real-time operation of the flood control structures in this region is established. Two lumped conceptual models NAM and Urban of the MIKE software are employed to simulate the rain-runoff process of the rural and city regions in the study area, respectively. The measured data in the medium rainfall year of 1988 are used for the model calibration and validation. The SLR combined with the ER scenario is designed based on the available data. The current flood control planning is validated and the severity of the future flood is estimated. The results may help the policies making and the flood control planning.

1. Methodology

1.1 *Study area and simplification method*

The study area (Fig.1) is a hydrological independent part of the Suzhou District, and it is connected to the Yangtze River Estuary. It lies between 120°19′E- 121°17′E and 31°0′N-31°59′N, covers an area of 4654.04 km^2 (excluding the Taihu Lake). The topography of the study area is low-lying with an average ground elevation from 3.5 m to 5.5 m. Figure 1 shows the complex river networks in the study area. During the flood season, one has to drain not only the runoff in the region, but also the upstream flood from the Taihu Lake. The flood is drained into the tidal current limit region of the Yangtze River at last.

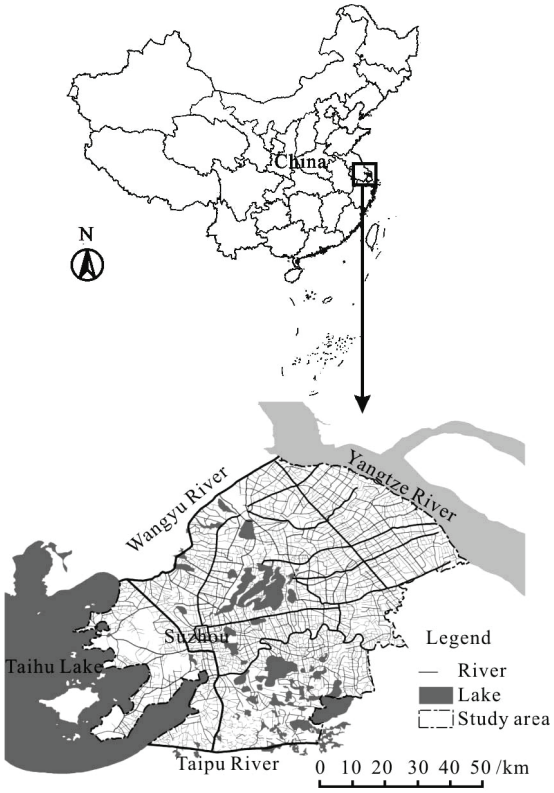

Fig.1 Location map of the study area

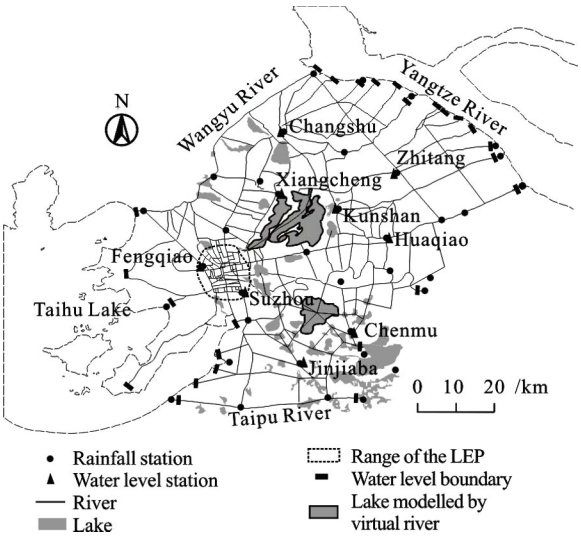

Fig.2 Simplified river networks to establish the hydrologic-hydrodynamic coupled model

In order to establish a hydrodynamic model with a suitable complexity, the complicated river networks