Available online at www.sciencedirect.com
ScienceDirect
Journal of Hydrodynamics
2011,23(4):521-526
DOI: 10.1016/S1001-6058(10)60145-X
www.sciencedirect.com/science/journal/10016058

A COUPLED 1-D AND 2-D CHANNEL NETWORK MATHEMATICAL MODEL USED FOR FLOW CALCULATIONS IN THE MIDDLE REACHES OF THE YANGTZE RIVER*

HAN Dong, FANG Hong-wei, BAI Jing, HE Guo-jian
Department of Hydraulic Engineering and State Key Laboratory of Hydroscience and Engineering, Tsinghua University, Beijing 100084, China, E-mail: hand02@mails.tsinghua.edu.cn

(Received June 27, 2010, Revised May 28, 2011)

Abstract: A coupled one-dimensional (1-D) and two-dimensional (2-D) channel network mathematical model is proposed for flow calculations at nodes in a channel network system in this article. For the 1-D model, the finite difference method is used to discretize the Saint-Venant equations in all channels of a looped network. The Alternating Direction Implicit (ADI) method is adopted for the 2-D model at the nodes. In the coupled model, the 1-D model provides a good approximation with small computational effort, while the 2-D model is applied for complex topography to achieve a high accuracy. An Artificial Neural Network (ANN) method is used for the data exchange and the connectivity between the 1-D and 2-D models. The coupled model is applied to the Jingjiang-Dongting Lake region, to simulate the tremendous looped channel network system, and the results are compared with field data. The good agreement shows that the coupled hydraulic model is more effective than the conventional 1-D model.

Key words: Coupled 1-D and 2-D model, looped channel network system, Alternating Driection Implicit (ADI), Jingjiang-Dongting Lake region

Introduction

1-D mathematical models are commonly adopted to solve the looped channel network system in a large river basin[1,2] because 2-D mathematical models would take too much computational effort and the precise terrain data is not easy to obtain. In recent years, the parameter identification method sees a considerable development for modeling river networks[3,4] and the 1-D calculation accuracy is thus greatly improved. However, at some important nodes connecting more than 3 rivers, the 1-D model does not take into account of the impact of complex topography. This simplification reduces the calculation accuracy of the flow diversion, thereby would affect subsequent calculations of sediment transport. In order to solve this problem, Williams[5] provided an algorithm for fine-ssing 1-D hydraulic models into 2-D performance.

Horritt and Bates[6] evaluated the performance of HES-RAS, LISFLOOD-FP, and TELEMAC-2D to predict the river flood inundation. Lin et al.[7] proposed to integrate a 2-D model with ISIS to enhance its capability to simulate floodplain flows. Zhang et al.[8] used a 2-D hydrodynamic model to simulate a complex system composed of the Jingjiang River and Dongting Lake, and the model takes about 0.96 h to complete the computation of a 76 d flood.

Recently, in order to meet the needs of urban development, coupled 1-D and 2-D models see a great progress in urban flood simulations[9-11]. They were adopted in researches of the natural river, Lai and Wang[12] proposed a new method called overlapping-projecting method, which was applied to develop a coupled numerical model of unsteady flow, and Zhu et al.[13] carried out a coupled 1-D and 2-D hydrodynamic numerical simulation for a bay-channel network, in which a 1-D model is joined with a 2-D model at the river mouth. Xu and Yin[14] developed a coupled 1-D and 2-D hydrodynamic model for tidal rivers. Kuiry et al.[15] proposed a simplified numerical model for the simulation of the floodplain inundation

* Project supported by the National Natural Science Foundation of China (Grant Nos. 10872110, 10902061).
Biography: HAN Dong (1985-), Male, Ph. D.
Corresponding author: FANG Hong-wei,
E-mail: fanghw@tsinghua.edu.cn