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Integrated hydrodynamic model for simulation of river-lake-sluice interactions. (English)

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Summary: In this paper, an integrated model for simulating the hydrodynamic process of river-lake-sluice (RLS) systems is presented. It includes a novel one-dimensional (1D) and two-dimensional (2D) coupling method called the coupling-zone iteration-correction (CZIC) method, and an improved numerical algorithm for the sluice problem. The 1D river-network model and the 2D lake model are coupled by establishing a coupling region, and iterative correction is carried out to ensure the accurate transfer of hydraulic parameters. The convergence conditions of the CZIC method are discussed theoretically, and the proper spatial step of the coupling zone is adopted according to different inflow conditions to ensure stable computation. In order to deal with the transition of flow regimes during the gate operation, a method for calculating the discharge capacity is presented. In addition, a general difference coefficient of the river reach is deduced for hydrodynamic calculation with sluices included. Simulations on open channels demonstrate that (1) simulated values of the CZIC method are consistent with the results of the full 2D model; (2) the sluice solving algorithm can stably handle the flow transition between the orifice flow and weir flow. Furthermore, the developed integrated model is applied to the middle and lower reaches of the Huaihe River, including the Hongze Lake and fifteen sluices. Numerical simulation results reproduced the hydrodynamic process during the flood season of 2007 accurately and efficiently. The errors of the present model are also compared with that of the MIKE model, and the results show that the proposed methods perform better than MIKE, especially in rising and flood periods. Therefore, it seems likely that the developed integrated model will work well in hydrodynamic modelling of large-scale complex RLS systems.

MSC:

76 Fluid mechanics
92 Biology and other natural sciences

Keywords:

river-lake-sluice system; 1D-2D coupling; iteration-correction method; convergence condition; sluice simulation; Huaihe River Basin

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