Application and calibration of 2-dimensional flowmodel for small tidal rivers with insufficienthydrographic data in Vietnamese Mekong Delta

[課程博士・論文博士共通]

博士学位論文内容要旨
Abstract

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In recent years, in the Vietnamese Mekong Delta (VMD) riverbank erosion and collapse have been excessively occurring in many rivers, especially in small rivers, and threatening people living near the riverbank not only their properties but also their future, even their lives. Erosion and collapse are predicted to increase significantly under the influence of tidal range, sea-level rise (SLR), and land subsidence. To confront with erosion and riverbank collapse, small rivers should be intensively studied together with large rivers as most recent studies. However, making research on small rivers in VMD, especially in modeling a depth-averaged two-dimensional (2-D) flow model, will be very difficult because of the lack of hydraulic data. The main objective of this study is to demonstrate how to apply and calibrate a 2-D flow model for small tidal rivers in the VMD with insufficient hydrodynamic data.

Three primary problems on applying a 2-D flow model to these kinds of small tidal rivers are insufficient bathymetric data, insufficient data for setting up the open boundary conditions, and insufficient data for calibrating the parameters of the model. To solve these problems the following steps were proposed. First, two measurement campaigns were conducted to collect the field data, including depth samples along the river in zigzag distribution, total discharge at the upstream cross-section in 36 hours, daytime hourly water levels near the estuary of the study river (i.e. My Thanh River, Soc Trang Province, Vietnam). Next, a new searching method was proposed as an effective interpolation method to reproduce the river bathymetry with sparse zigzag depth data. Based on the estimated bathymetry, the method suggested by Takagi *et al.* (2019) was applied to a 2-D flow model for the study river with some modifications. Finally, the spatio-temporal velocity along the river recorded by Acoustic Doppler Current Profiler (ADCP) devices during the measurement campaigns was applied to re-calibrate and optimize the 2-D flow model.

Four primary results were obtained at this research. First, a proposed searching method, named Curvilinear search, is the most suitable to apply with Inverse distance weighting (IDW), Ordinary Kriging (OK), and Radial Basis Functions (RBF) interpolation methods to estimate the bathymetry of the river using sparse zigzag data; and two regional interpolation methods (i.e. Curvilinear-IDW method for estimating the near riverbank areas combining with Curvilinear-RBF or Rectilinear-RBF method for estimating the middle river area, respectively) working effectively with this kind of data were also figured out. Second, it was found that the Riemann boundary condition is very helpful in case of insufficient upstream discharge data but needs to be modified to be compatible with the 2-D flow model. Third, the suggested flow model was improved significantly after re-calibrating with spatio-temporal velocity, reviewing the primary tidal constituents, considering the upstream discharge, and downstream tributary. Particularly, Root-Mean-Square Error (RMSE) of estimated water levels near downstream, upstream, and depth-averaged velocity over upstream cross-section were declined by 50%, 9%, and 12%, respectively; the estimated spatio-temporal velocity was also optimized 16%. Finally, it was demonstrated that the proposed 2-D flow model can be easily applied to simulate the flow of a small tidal river in a long period by applying downstream tidal data and Riemann Boundary. This research will be helpful for other studies with similar field conditions in the future.