UNSTEADY TWO-DIMENTSIONAL MODELLING OF WETTING-DRYING EFFECTS IN SHALLOW FLOWS OVER COMPLEX TOPOGRAPHY

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Current developments of two-dimensional (2D) shallow water models offer increased opportunities to examine unsteady problems relating to hydraulics in rivers and estuaries. In dealing with these problems, one has often to cope with different processes such as alternately flood and dry out over the complex topography, which makes the numerical simulation of free surface flows a challenging task. In recent studies the problems of modeling the impact of sharp bed level changes have received attention. In modeling river and dam-break flows strong bed level variations are the rule rather than the exception. For two-dimensional flow problems, most of the test cases used in the literature are numerical tests with usually a simple geometry. Little attempt has been made to verify models against complex geometries and topographies.

Natural topographies involve positive and negative bed slopes that can be steep in some areas. The presence of extreme slopes, high roughness and strong changes in the irregular geometry represent a great difficulty that can lead to important numerical errors arising from the source terms discretization and treatment of the wetting-drying fronts (Brufau et al. 2004). Apart from numerical stability, mass conservation is affected by careless treatment of the wetting-drying process. Therefore there is a need for more work on model development for large scale complex natural rivers.

In this work, shallow water equations are descritized based on the finite volume method FVM. The equation set is hyperbolic and, therefore, it has an inherent directional property of propagation, therefore the Exact Riemann solver, which is based on characteristic theory, was utilized for the estimation of the flux over the cells boundaries.

The presence of the source terms in the equation set, namely bed slope and friction, presents a great difficulty that can lead to numerical errors presumably arising from those. We use a novel method presented by Komaei (2004) for the bed slope terms, in which the flow depth h is not constant over the cell and bed elevation z varies linearly. The method preserves the steady state case, where the nonzero flux gradients are exactly balanced by the source terms.

Using explicit methods to handle the friction source term causes instabilities due to the small values for the flow depth h. We utilized an effective implicit method using the advanced values after the flux summation over the cell boundaries for the treatment of the friction term.

In FVM moving boundaries are considered as wetting-drying fronts. A cell can be considered as dry if the flow depth is below a specific value. By comparing the water surface elevation in wet cell and the adjacent dry cell it can be decided whether the fluid can flow to the dry cell or not. In case of no flux an imaginary wall was considered between the wet and dry cells for the wet one.

In order to demonstrate the flexibility of the algorithm two test cases are considered; 1) a dam-break in a channel with 90° bend. 2) Malpasset dam-break. The simulated results show good agreement with field and measured data. Figure 1 shows the computed results and field data at different observation points after Malpasset dam-break.

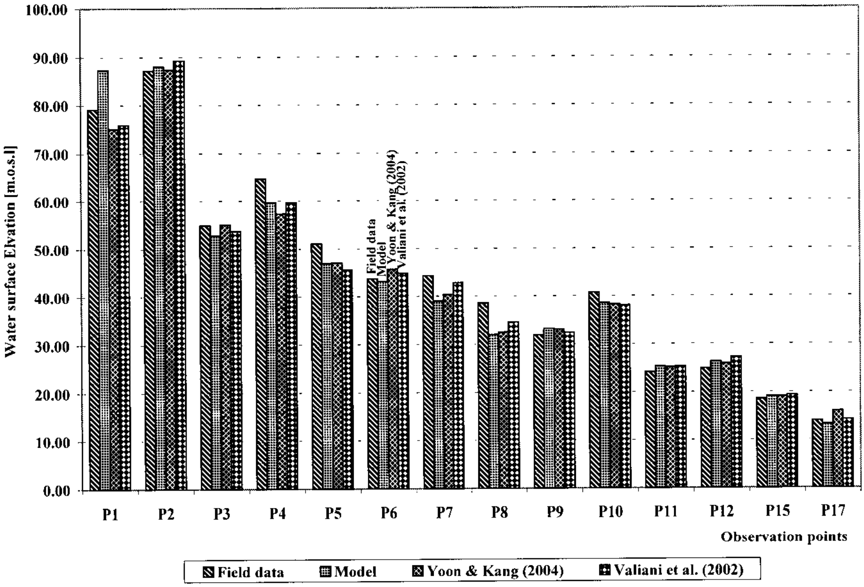

Fig. 1 Comparison of computed results and observed data

REFERENCES

Brufau, P., Garcia-Navarro, P. And Vázquez-Cendón, M.E., 2004. Zero mass error using wetting-drying conditions in shallow flows over dry irregular topography. *International Journal for Numerical Methods in Fluids*, 45, 1047-1082.

Komaei, S., 2004. An improved, robust implicit solution for the two dimensional shallow water equations on unstructured grids. *RiverFlow 2004*, 1065-1072, M. Greco, A. Carravetta, R. Della Morte, eds., Taylor and Francis Group, London.