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Bottom-Discontinuous Riemann Solver for Modeling of Wave Overtopping

Abstract

Depth-integrated numerical models represent an adequate and efficient method to describe near-shore processes including wave breaking. A limitation to these models is encountered as a wave overtops a vertical breakwater. The vertical flow structure cannot be recreated, leading to inaccurate results or numerical instabilities. The Riemann solver containing a bottom discontinuity presented by Murillo and Garcia-Navarro (2010; 2012, Journal of Computational Physics) may alleviate this limitation. In this study, a review of the Riemann solver and its incorporation into a one-dimensional second-order MUSCL-Hancock scheme are presented. The first series of validation tests mimics the Riemann problem with an emphasis on overtopping over a bottom discontinuity. The model results give good overall agreement to those from OpenFOAM (an open-source computational fluid dynamics code), but show underestimation of the downstream propagation speed when free fall of water is involved. A laboratory experiment was conducted in a 9.14 m long flume to provide validation data for solitary wave overtopping of a vertical breakwater. The numerical model shows slightly more reflection from the breakwater and underestimates the overtopping volume. Despite the discrepancies, the bottom-discontinuous Riemann solver performs reasonably well in approximating the overall processes given the simplicity of its formulation.