WELL-BALANCED FINITE VOLUME MODEL FOR LONG-WAVE RUNUP

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ABSTRACT

The presentation discusses the formulation, verification, and validation of a two-dimensional finite-volume model for long-wave run-up calculations. The model uses a conservative form of the nonlinear shallow-water equations with source terms and an explicit Godunov-type scheme along with the exact Riemann solver for the flux and moving waterline. A second-order scheme splits the two-dimensional problem into two sequential one-dimensional problems for time integration. The surface-gradient method leads to a well-balanced formulation of the flux and source terms and a piecewise linear interpolation reconstructs numerical data at cell interfaces to achieve second-order accuracy in space. This provides accurate descriptions of the conserved variables for shock capturing and small flow-depth perturbations near the moving waterline. The model is shown to satisfy the well-balanced criteria through comparison with the asymptotic solution of a frictionless flow over varying bathymetry. The computed surface elevation and flow velocity are verified with analytical solutions for periodic wave reflection from a plane beach and wave resonance in a circular parabolic basin under nonbreaking conditions. Previous laboratory data for solitary wave runup on a plane beach and a conical island validate the finite volume model. The results show good approximation of a breaking wave as a propagating bore or a stationary hydraulic jump and shows remarkable capability in conserving volume during the entire runup and rundown process. The present model, despite the shallow-water and wave breaking approximations, provides accurate predictions of nonbreaking and breaking wave runup and has potential applications in flood hazards mitigation.