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A Hybrid Artificial Intelligence and Two Dimensional Depth Averaged Numerical Model for Solving Shallow Water and Exner Equations Simultaneously

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Abstract : Modeling sediment transport processes by means of numerical approach often poses severe challenges. In this way, a number of techniques have been suggested to solve flow and sediment equations in decoupled, semi-coupled or fully coupled forms. Furthermore, in order to capture flow discontinuities, a number of techniques, like artificial viscosity and shock fitting, have been proposed for solving these equations which are mostly required careful calibration processes. In this research, a numerical scheme for solving shallow water and Exner equations in fully coupled form is presented. First-Order Centered scheme is applied for producing required numerical fluxes and the reconstruction process is carried out toward using Monotonic Upstream Scheme for Conservation Laws to achieve a high order scheme. In order to satisfy C-property of the scheme in presence of bed topography, Surface Gradient Method is proposed. Combining the presented scheme with fourth order Runge-Kutta algorithm for time integration yields a competent numerical scheme. In addition, to handle non-prismatic channels problems, Cartesian Cut Cell Method is employed. A trained Multi-Layer Perceptron Artificial Neural Network which is of Feed Forward Back Propagation (FFBP) type estimates sediment flow discharge in the model rather than usual empirical formulas. Hydrodynamic part of the model is tested for showing its capability in simulation of flow discontinuities, transcritical flows, wetting/drying conditions and non-prismatic channel flows. In this end, dam-break flow onto a locally non-prismatic converging-diverging channel with initially dry bed conditions is modeled. The morphodynamic part of the model is verified simulating dam break on a dry movable bed and bed level variations in an alluvial junction. The results show that the model is capable in capturing the flow discontinuities, solving wetting/drying problems even in non-prismatic channels and presenting proper results for movable bed situations. It can also be deducted that applying Artificial Neural Network, instead of common empirical formulas for estimating sediment flow discharge, leads to more accurate results.

Keywords : artificial neural network, morphodynamic model, sediment continuity equation, shallow water equations
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