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Physically based numerical modelling of flooding in mountain areas

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While the recent decades have seen significant progresses in numerical modelling of environmental shallow water flows, which could involve shock waves, computational difficulty arises from the highly irregular topography in mountain areas. In particular, under a conventional operator-splitting framework, a very small time step is found to be necessary for numerical stability, and this is dictated by the magnitude of the source terms in relation to the irregular topography and inevitably increases the computational cost. Here a two-dimensional shallow water hydrodynamic model is presented for flooding in mountain areas as induced by heavy rainfall or dam break. The model is based on the complete hydrodynamic equations, incorporating boundary resistance and infiltration loss. Refined numerical solution is achieved under an operator-splitting framework, a second-order Total-Variation-Diminishing version of the Weighted-Average-Flux method along with the HLLC approximate Riemann Solver for the homogeneous equations, and a Runge-Kutta scheme for the ordinary differential equations of source terms. A self-adaptable time step method is proposed for the Runge-Kutta scheme, which facilitates an efficiency-enhanced numerical algorithm for flood modelling in mountain areas. The applicability of the model is demonstrated through two cases, one is flash flooding-prone area due to heavy rainfall and the other subject to flooding because of possible outburst of a glacier lake.