A PARSIMONIOUS DYNAMIC FLOW MODEL FOR HYDROLOGICAL APPLICATIONS

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Abstract In hydrodynamic modeling, various simplifying assumptions are often made to the Saint-Venant (dynamic) equations in order to maintain computational efficiency. These simplified versions are derived by neglecting select terms in the momentum equation. Of the alternate forms, the kinematic-wave equation retains the fewest terms, and its simplicity makes it an attractive method for modeling overland flow. Kinematic-wave theory is derived from the assumption that the acceleration and pressure gradient terms in the momentum equation are negligible. Additionally, it is assumed that the remaining terms, the gravitational and frictional forces, are in balance, implying locally uniform flow. For the case of steep slopes and low flow depths, this approximation generally gives results that are highly consistent with the full dynamic wave solution. The applicability of the kinematic wave equation is dependent on the scaling of the individual problem and the flow characteristics. When modeling unsteady flow over complex terrain, however, the appropriate scales themselves become variable, and hence the criteria determining its applicability must continually be reassessed. Further, the theory fails completely for the case of flat terrain. In order to allow for such natural variability, we are developing a 2-dimensional, finite volume, hydrodynamic model with the capability to choose between solving the full dynamic wave equations or the simplified kinematic equation as required by the terrain and input. This asymptotic model becomes fully dynamic or kinematic as needed, thus addressing two issues in modeling overland flow: eliminating the unnecessary computational cost of solving the full dynamic equation when the kinematic wave equation is sufficient, and allowing for a wide range of variability of surface slopes, roughness coefficients, and rainfall that would not be possible with a fully kinematic-wave model.