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Adaptive time stepping scheme for numerical modelling of unsaturated flow

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Richards' equation (RE) is the mathematical model typically used to describe water flow in the vadose zone. In hydrological studies and engineering applications, numerical schemes have to be robust and efficient, meaning that a reduced computational work should be needed to reach a fixed level of the solution's accuracy. In the considered time dependent problem, the time step size management and the truncation error control are consequently important issues to achieve this general aim.

The spatial discretization approach for solving the mixed form of RE is based upon the mixed hybrid finite element method, which approximates simultaneously the pressure head and the velocity field. A lumped formulation of the method is implemented to prevent unphysical oscillations that can appear ahead a simulated sharp infiltration front. A main part of the study is devoted to the coupling of the promising developed numerical method and the temporal discretization approach. Especially, different time stepping schemes are presented; they include i) heuristic techniques based on convergence aspect or the tolerance on the state variable variation and ii) *a priori* techniques based on the truncation error, computed using grid and order extrapolation methods. A set of numerical experiments (1D and 2D) are performed to study the accuracy and the efficiency of the related approaches.