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A cellular automata approach for modeling surface water runoff

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This abstract reports the development and application of a two-dimensional cellular automata based model, which couples the dynamics of overland flow, infiltration processes and surface evolution through sediment transport. The natural hill slopes are represented by their topographic elevation and spatially varying soil properties infiltration rates and surface roughness coefficients. This model allows modeling of Hortonian overland flow and infiltration during complex rainfall events. An advantage of the cellular automata approach over the kinematic wave equations is that wet/dry interfaces that often appear with rainfall overland flows can be accurately captured and are not a source of numerical instabilities. An adaptive explicit time stepping scheme allows for rainfall events to be adequately resolved in time, while large time steps are taken during dry periods to provide for simulation run time efficiency. The time step is constrained by the CFL condition and mass conservation considerations. The spatial discretization is shown to be first-order accurate.

For validation purposes, hydrographs for non-infiltrating and infiltrating plates are compared to the kinematic wave analytic solutions and data taken from literature [1,2]. Results show that our cellular automata model quantitatively accurately reproduces hydrograph patterns. However, recent works have showed that even through the hydrograph is satisfyingly reproduced, the flow field within the plot might be inaccurate [3]. For a more stringent validation, we compare steady state velocity, water flux, and water depth fields to rainfall simulation experiments conducted in Thies, Senegal [3]. Comparisons show that our model is able to accurately capture these flow properties. Currently, a sediment transport and deposition module is being implemented and tested.

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