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Developments of a flood inundation model based on the cellular automata approach: testing different methods to improve model performance

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In the last decade, several flood inundation models based on a reduced complexity approach have been developed and successfully applied in a wide range of practical cases. In the present paper, a model based on the cellular automata approach is analyzed in detail and tested in several numerical cases, comparing the results both with analytical solutions and different hydraulic models. In order to improve the model performance, the original code based on the diffusive wave equations and a constant time step scheme is modified through the implementation of two techniques available in literature: an inertial formulation for the computation of discharges, originally developed for the LISFLOOD-FP model by Bates et al. (2010); and the incorporation of a local adaptive time step algorithm, based on a technique originally presented by Zhang et al. (1994).
The analysis of the numerical cases showed that the proposed model can be a valuable tool for the simulation of flood inundation events. When applied to one-dimensional numerical cases, the model reproduced the wave propagation well, whereas it showed some limitations in reproducing two-dimensional flow dynamics with respect to a model based on the full shallow water equations. However, differences were found to be comparable with the uncertainty levels related to available data for actual flood events.
The use of the inertial formulation was very effective in all the cases, and reduced run time up to 97% with respect to the diffusive formulation, although it did not improve the overall accuracy of results. Such results were comparable with those of the LISFLOOD-FP model.
Finally, the incorporation of the local time step algorithm produced a speedup from 1.2x to 4x, depending on the simulation and the model version in use, with no loss of accuracy in the results.