Investigation of the Green-Ampt infiltration model in rainfall-runoff simulations with a robust 2D shallow water model

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The Green-Ampt model was developed more than 100 years ago and is still one of the most commonly used approaches to consider infiltration in rainfall-runoff models, which can be either conceptual catchment models as well as 2D hydrodynamic models. When coupling, for example, the Green-Ampt model for infiltration with a 2D shallow water model for the flow, the calculated ponding water depths are transferred from the flow model to the Green-Ampt model to calculate the infiltration rates, and the resulting infiltration rates represent then sinks in the mass balance equation of the shallow water model. The so-called Green-Ampt parameters in terms of saturated water content, hydraulic conductivity, and suction head at the wetting front, are needed as model input in addition to the initial water content. Often, the Green-Ampt parameters are not directly measured in the field for the area that should be modeled but are only assumed based on average values from the literature depending on the dominant soil texture class. If reliable data of certain rainfall-runoff events are available for the study area, the values of the Green-Ampt parameters can be determined besides other calibration parameters within reasonable ranges. However, in some cases, a calibration of the Green-Ampt parameters is not possible due to a lack of measurements, for example during suddenly occurring flash floods or in completely ungauged basins. This study aims to investigate with a coupled shallow water flow and infiltration model if the Green-Ampt parameters could be appropriately assumed based on average values from literature depending on the given soil texture classes. Furthermore, the effects that could lead to an inappropriate representation of infiltration with tabulated Green-Ampt parameters are studied, such as surface clogging, sub-grid rill-flow, and coarse DEM resolution. To investigate the general suitability of using average Green-Ampt parameters from literature dependent on soil texture classes, different small-scale test cases with available data for calibration are shown, where two of them are laboratory experiments and one is a rainfall-runoff experiment on a small plot in Senegal. Finally, a case study on flash floods in a desert region in Egypt is represented. The results show that in the laboratory experiments, the infiltration rates with average Green-Ampt parameters are underestimated, while for the field experiment in Senegal infiltration rates are overestimated. For the case study in Egypt, infiltration with Green-Ampt parameters from literature as well as with measured infiltration rates from double ring infiltrometer tests is strongly overestimated in the model. It is planned to conduct plot-scale rainfall-runoff experiments with a rainfall simulator for the study area in Egypt to better represent the natural conditions during
heavy rainfalls and compare the measured infiltration rates with the ones from literature and double ring infiltrometer test.