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Numerical investigation of the link between unsaturated soil properties and runoff dynamics on hillslopes

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It has been suggested by post-flood investigations that Mediterranean small watersheds, where flash-floods occur, may be characterized by threshold runoff dynamics. However, the mechanisms and processes related to these floods are not well understood. One of the research goals is to determine the influence on runoff dynamics of factors such as rainfall (amount and intensity), geomorphological and hydrodynamical soil properties (soil thickness, slope, ...).

To investigate the sensitivity of runoff dynamics in relation to these factors, numerical simulations on theoretical hillslopes are conducted using a 2-D coupled model describing sub-surface flow by Richards' equations and surface flow by the diffusive wave equations.

The present study focuses on the link between runoff dynamics and properties of the unsaturated zone. First we present the simulation results obtained on a simple hillslope (a one-layer 50 meter-long 1 meter-deep homogeneous soil with a 10% slope), under constant rainfall and hydrostatic initial conditions, for different soil properties. It is shown that flow velocity and initial water storage capacity in the unsaturated zone can activate different mechanisms and modify runoff dynamics (downstream hydrograph shape and response time). Then we discuss the role of the initial conditions which have an influence on both the storage capacity of the slope and the flow velocity in the unsaturated zone.