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A model of dunnian flow at hillslope scale

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The development of a thin stream above the soil surface (overland flow) is associated to two mechanism of runoff generation on the hillslope: the infiltration excess (hortonian flow) and saturation excess (dunnian flow) mechanism. The first one is typical of arid and semi-arid regions, usually characterised by high rainfall intensities on soil exhibiting low permeability. The second one, firstly introduced by Hewlett and Hibbert, constitutes the main mechanism of runoff generation in humid regions, characterised by high groundwater table. In the last mechanism runoff is produced by contributing areas of restricted extent that expands with time, where near to the bottom of the hillslope a high value initial soil water content occurs and gradually decreases versus upstream of the hillslope. Following this sketch, under the hypothesis of constant depth of the permeable layer, for stationary rainfall of indefinite duration, this work aims to investigate on the implications of temporal variability of active hillslope length on the hydrologic response for the dunnian mechanism of runoff generation. The flow in the unsaturated zone is modelled by the piston displacement model of Beven (1982a, 1982b). Once the wetting front reaches the impermeable layer (with different times along the hillslope), the transportation process, over and under the hillslope, is represented as the envelope of the infinite sequence of hydrographs, corresponding to the progressive lengths activated by the infiltration process and Ta - shifted from the beginning of the rainfall, where Ta is the starting up time associated to the active length. The overland hydrographs are modelled with the analytical solution of Agnese et al. (2001) over a plan hillslope, recently introduced. The subsurface stormflow hydrographs is modelled by using the classical linear storage model.