Hillslope response to rainfall based on upscaling from Darcy's flow

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Understanding runoff generation processes occurring in a hillslope is of great importance for catchment hydrological modeling. In this study we aim to establish an empirical relation for subsurface stormflow at the hillslope scale based on upscaling from Darcy's flow at the micro-scale. A two-dimensional numerical model coupled with multiple hillslope hydrodynamic processes is established, which is based on Richards equation and validated by using the field experiment data in Panola Mountain Research Watershed, USA and Xitaizi Mountain Research Watershed, China. The dominating factors controlling subsurface stormflow are explored by numerical experiments, which account for rainfall volume and intensity, slope, soil depth and distribution, soil hydraulic conductivity, bedrock permeability, and antecedent wetness. The threshold phenomenon of hillslope runoff response to rainfall is identified and the empirical relationship is established, which could be potentially incorporated into catchment hydrological models.