Effects of small-scale vertical unsaturated flow on the exponent of a runoff-storage power-law relationship in catchment storm runoff models

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Numerical experiments on vertical unsaturated flow using the Richards equation were conducted to examine the physical basis of why storm runoff responses from mountainous catchments in tectonically active regions can be simulated by simple runoff models with a runoff-storage power-law relationship. An interdependent relationship between the total storage of a soil column and the outflow rate from the bottom in the recession stage obtained experimentally was approximated by a power-law equation derived from relationships between total storage and constant outflow under steady-state conditions. The exponent of the power-law equation approaches a maximum of unity as the column length decreases, and it approaches the minimum value obtained from the intrinsic relationship between soil hydraulic conductivity and volumetric water content as the column length increases. This result strongly suggests that vertical unsaturated flow at the smallest scale may play an important physical role in the production of storm runoff responses at the catchment scale.

Keywords: Vertical unsaturated flow, Runoff-storage power-law relationship, Storm runoff response, Scale dependencies of hydrologic processes

