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The role of local heterogeneity in transport through steep hillslopes.

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A stochastic model is developed for the analysis of the travel time distribution in a hillslope. The latter is represented as a system made up from a highly permeable soil underlain by a less permeable subsoil or bedrock. The heterogeneous hydraulic conductivity K is described as a stationary random space function. The travel time distribution is obtained through a stochastic Lagrangian model of transport, after adopting a first order approximation in the logconductivity variance. The results show that the travel time pdf pertaining to the soil is power-law, with exponent variable between -1 and -0.5; the behavior is mainly determined by unsaturated transport. The subsoil is mainly responsible for the tail of the travel time distribution. Analysis of the first and second moments of travel time show that the spreading of solute is controlled by the variations in the flow-paths (geomorphological dispersion), which depend on the hillslope geometry. Conversely, the contribution of the K heterogeneity to spreading appears as less relevant. The model is tested against a detailed three-dimensional numerical simulation with reasonably good agreement.