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Comparison of two different approaches to modeling subsurface runoff at the hillslope scale

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Two conceptually different approaches to numerical modeling of a hillslope response to a rainstorm are presented and compared. In the first approach, the flow of water in a variably saturated hillslope segment is described as vertical planar flow using two-dimensional Richards' equation. Preferential flow effects are taken into account by formulating a dual set of two-dimensional governing equations, which reflects the dual character of the flow in the soil matrix and in the preferential flow domain. In the second approach, one-dimensional variably saturated vertical flow is coupled with one-dimensional saturated subsurface flow along the soil-bedrock interface. The saturated downhill flow is described by one-dimensional diffusion wave equation while the vertical flow is modeled using a dual set of one-dimensional Richards' equations. Even without considering the preferential flow effects, excessive computing power is necessary to simulate the soil water dynamics using the two-dimensional Richards' equation model for hillslopes longer than several tens of meters. The simplified model, based on combination of one-dimensional vertical flow with one-dimensional downhill flow, is less general in terms of geometric, material and boundary conditions to which it can be applied, but far more efficient in terms of the computing speed.