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The Effect of Pulse Release Date and Soil Characteristics on Solute Transport in a Combined Vadose Zone-Groundwater Flow System: Insights from Numerical Simulations

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The scope of the present study was to analyze the effect of both soil type and pulse application date on the movement and spreading of a conservative solute tracer in a 3-D, heterogeneous, combined vadose zone-groundwater flow system, which, in turn, is subject to time-dependent, external forcing conditions, F(t) (characterized by a time period, τp), imposed on a flat soil surface. Of particular interest were the suitability of the time-invariance assumption of the solute travel time distribution and the related issue of the capability of an equivalent, steady-state vadose zone flow model to describe solute transport in a realistic, transient, flow system.
The analyses were performed through a series of detailed numerical simulations of flow and transport.
Considering flow systems in which the water table is located at sufficiently large distance from the flat soil surface, the main results of this study suggest that the velocity associated with the wetting front position, which, in turn, may be considered as an 'effective' velocity, is soil- and calendar date-dependent. Consequently, characteristics of the transport (i.e. solute displacement and spreading, first- and peak-arrival times) are soil- and pulse release date-dependent. The soil-dependent solute travel time PDF at a horizontal control plane (CP) located in the vicinity of the water table, however, may be considered as essentially independent of the pulse release date, particularly in the fine-textured (clay) soil associated with mean travel time, τ0 that substantially exceeds τp. Furthermore, for τ0>τp, the equivalent steady-state definition of the flow problem may be quite effective in describing the solute travel time PDF of the actual transport process occurring under non-monotonous, transient flow conditions.