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Transport rate-based model for overland flow and solute transport: Parameter estimation and process simulation

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A one-dimensional mathematical model, termed a transport rate-based model, is developed for solute transport over infiltrating soil slopes under constant rainfall and declining sources. The model is comprised of (1) the kinematic-wave equation for overland flow, (2) a transport rate-based advection equation for overland solute transport, (3) a moment-based method for estimation of the parameters involved in the flow and solute transport equations, and (4) a semi-Lagrangian algorithm for numerical solution of the solute transport equation. Data from a single soil flume experiment under constant rainfall established the proof-of-concept for this new model. Sodium chloride was applied to the soil surface to simulate the presence of a declining diffuse pollutant. The parameters involved in the flow equation were found to take on the values that correspond to turbulent flow. With these turbulent flow parameters the simulated hydrograph displayed an initial rising limb, followed by a constant flow discharge. The profile of solute concentration exhibits a steep receding limb transitioning into an elongated tail. The solute transport rate follows a non-Gaussian distribution that does not appear to have been derived before. These theoretical hydrographs and pollutographs are in good agreement with those measured in laboratory, demonstrating the laboratory proof-of-concept for the transport rate-based model on soil and pavement blocks.