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Lateral water redistribution during evaporative-driven upward flow and its effect on solute transport

M. Bechtold, J. Vanderborght, M. Herbst, L. Weihermueller, R. Kasteel, and H. Vereecken
Agrosphere Institute, ICG-4, Forschungszentrum Juelich GmbH, Germany (m.bechtold@fz-juelich.de)

Evaporative conditions may lead to transport towards and accumulation of solutes, e.g. salts and contaminants, at the soil surface. The transport during periods with upward flow may affect the leaching of solutes under transient conditions with longer drying periods. While research in the field of solute transport mainly focused on downward flow conditions, both experimental and numerical studies are scare that focus on the effect of soil heterogeneity on solute transport under upward flow conditions. However, differences in hydraulic gradients, soil moisture distributions, and outflow boundary condition between infiltration and upward flow conditions reveal that it may be instructive to focus on solute transport under upward flow conditions.

Using numerical simulations, we investigate the effect of evaporative-driven upward flow intervals on solute breakthrough under transient conditions. Breakthrough curves are compared with the breakthrough of the steady-state scenario for the same net infiltration rate. Simulations indicate that solutes are laterally redistributed during upward flow. We identify that redistribution occurs at two depths, near-surface (from fine to coarse material) and 'deeper' within the soil (from coarse to fine material). For specific boundary conditions, solutes may loop within the soil during a sequence of evaporation and precipitation, which might enhance the filtering potential of soils, in particular with respect to reactive transport. Our simulations show that solute redistribution during upward flow cannot only retard the breakthrough of solutes, as shown by Vanderborght et al. (2005), but may also cause its acceleration. We demonstrate how the effect on solute breakthrough is related to scale and type of heterogeneity as well as to changing boundary conditions.