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An analytical model for cumulative infiltration into a dual-permeability media

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Modeling of water infiltration into the vadose zone is important for better understanding of movement of water-transported contaminants. There is a great need to take into account the soil heterogeneity and, in particular, the presence of macropores or cracks that could generate preferential flow. Several mathematical models have been proposed to describe unsaturated flow through heterogeneous soils. The dual-permeability model assumes that flow is governed by Richards equation in both porous regions (matrix and fractures). Water can be exchanged between the two regions following a first-order rate law. A previous study showed that the influence of the hydraulic conductivity of the matrix/macropore interface had a little influence on cumulative infiltration at the soil surface. As a result, one could consider the surface infiltration for a specific case of no water exchange between the fracture and matrix regions (a case of zero interfacial hydraulic conductivity). In such a case, water infiltration can be considered to be the sum of the cumulative infiltrations into the matrix and the fractures. On the basis of analytical models for each sub domain (matrix and fractures), an analytical model is proposed for the entire dual-porosity system. A sensitivity analysis is performed to characterize the influence of several factors, such as the saturated hydraulic conductivity ratio, the water pressure scale parameter ratio, and the saturated volumetric water content scale ratio, on the total cumulative infiltration. Such an analysis greatly helps in quantifying the impact of macroporosity and fractures on water infiltration, which can be of great interest for hydrological models.