Dual-Permeability Model and Atmospheric Boundary Condition with Surface Water Layer

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Example presented in Figure 5 of Šimůnek et al. (2003) was rerun with the atmospheric boundary condition, which considered the surface water layer. In this example we assume that water initially infiltrates into the matrix at a rate that is equal to precipitation. Once the ponding is reached, the boundary condition is switched from the flux boundary condition to the variable pressure head boundary condition, and all excess water (difference between precipitation and infiltration) accumulates at the surface until the thickness of the water layer reaches the maximum allowed value (1 cm). Only at this moment the excess water starts flowing into the fracture domain. Once precipitation stops, the thickness of the water layer decreases below the critical thickness (1 cm), and flow into the fracture domain stops. Water accumulated at the soil surface infiltrates into the matrix domain, until all water is used up.

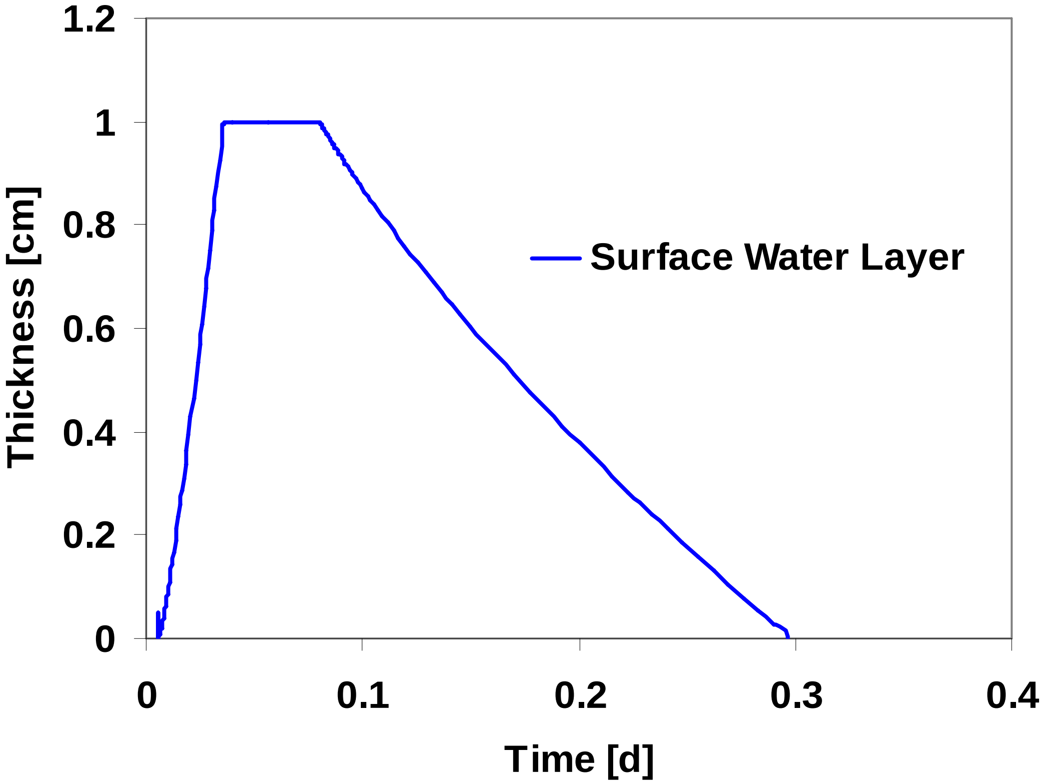

Figure 1 shows the thickness of the surface water layer. It is shown that ponding develops at about 0.005 d, the critical thickness of the water layer (1 cm) when water starts flowing to the fracture domain is reached at about 0.036 d. The critical thickness of the water layer remains till the end of the precipitation event (i.e., 0.08 d). After that, water keeps on infiltrating into the matrix domain (not anymore to the fracture domain since the thickness of the water layer is smaller than the critical value) until 0.3 d, when all water infiltrates.

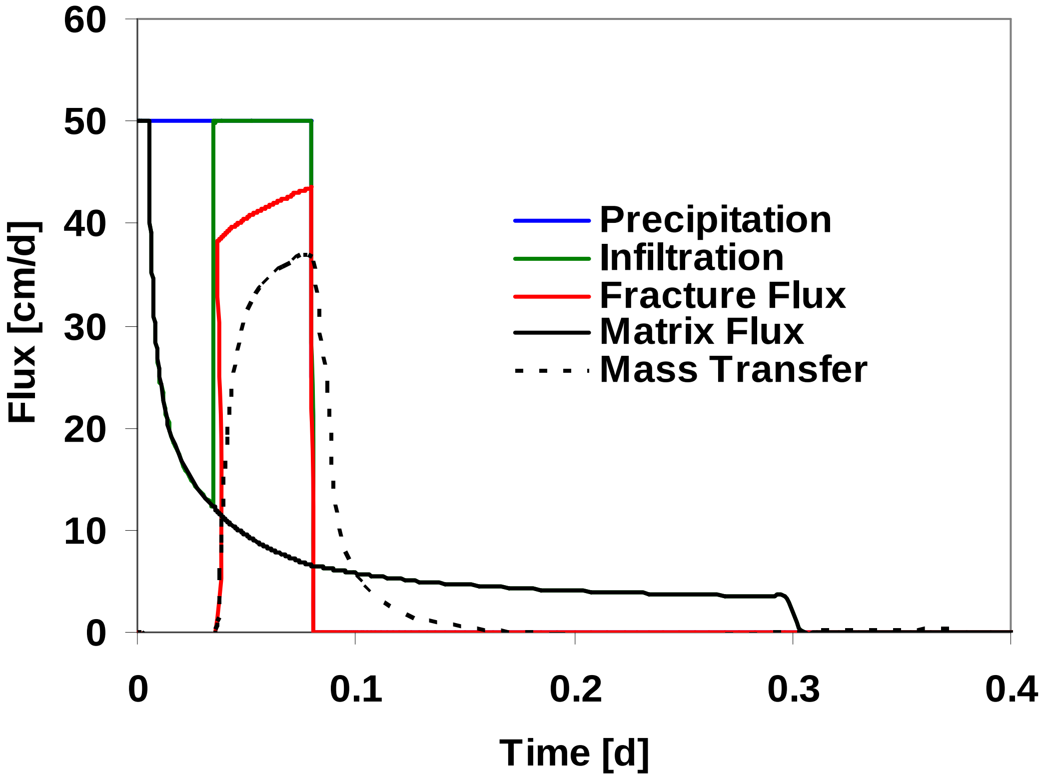

Figure 2 shows various fluxes. The precipitation event lasts for 0.08 d and has an intensity of 50 cm/d (blue line). After ponding is reached at about 0.005 d, infiltration flux into the matrix (black line) decreases dramatically. The excess water, i.e., the difference between precipitation and infiltration is stored in the surface water layer (see Figure 1, which shows increasing thickness of the water layer). After the critical thickness of the surface water layer is reached (0.036 d), water starts flowing into the fracture domain (red line). The overall infiltration (green line), i.e., infiltration into both matrix and fracture domains, is again equal to precipitation. Once precipitation stops, the thickness of the surface water layer decreases below the critical value and flow into the fracture domain stops. However, infiltration into the matrix domain continues until all water from the surface water layer infiltrates (0.3 d). Once water starts infiltrating into the fracture domain, there is also the mass transfer between the fracture and matrix domains (dashed line).

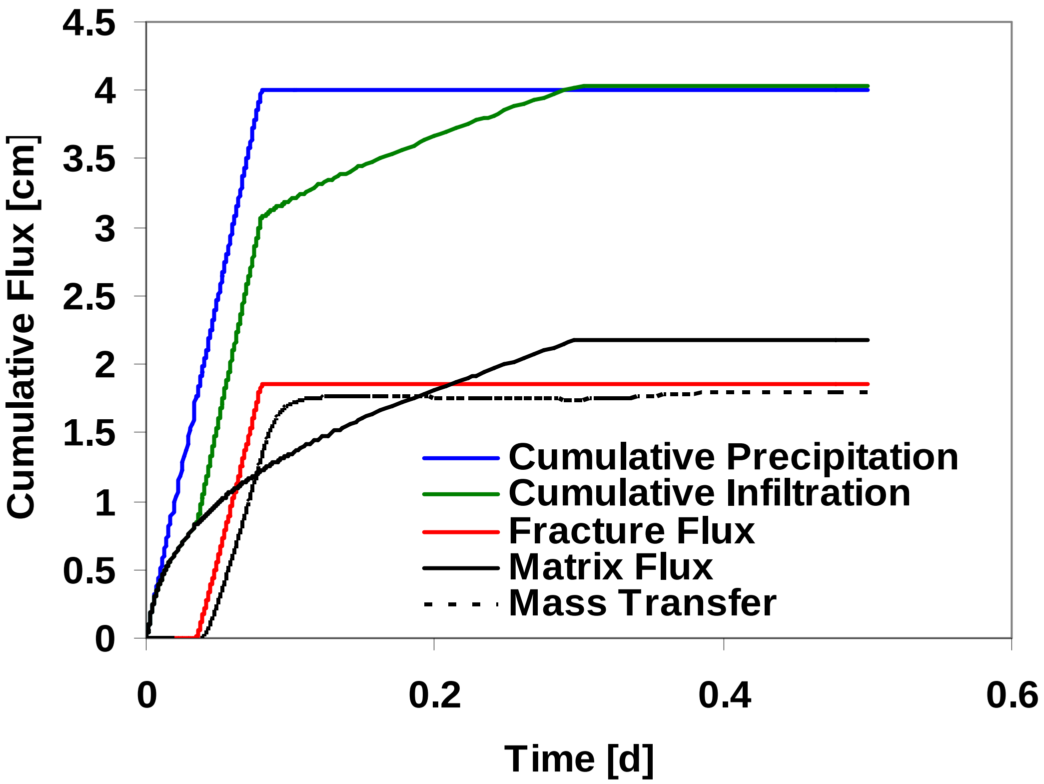

Figure 3 shows cumulative fluxes and it basically provides the same information as Figure 2. Notice the parallel blue and green lines representing cumulative precipitation and infiltration. The difference between these two lines reflect the amount of water in the surface water layer. The difference increases between 0.005 and 0.036 d, i.e., between ponding and when the critical thickness of the surface water layer is reached. It remains constant after that until precipitation stops. Then the difference decreases as water infiltrates into the matrix domain. Note again, that infiltration into the fracture domain is active only when the thickness of the surface water layer is at its critical level.

Šimůnek, J., N. J. Jarvis, M. Th. van Genuchten, and A. Gärdenäs, Review and comparison of models for describing non-equilibrium and preferential flow and transport in the vadose zone, *Journal of Hydrology*, 272, 14-35, 2003.

Šimůnek, J. and M. Th. van Genuchten, Modeling nonequilibrium flow and transport with HYDRUS, *Vadose Zone Journal*, doi:10.2136/VZJ2007.0074, Special Issue “Vadose Zone Modeling”, *7*(2), 782-797, 2008.