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Heat and Water Transport in Soils and Across the Soil-Atmosphere Interface: Comparison of Model Concepts

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Abstract text:

Evaporation from the soil surface represents a water flow and transport process in a porous medium that is coupled with free air flow and with heat fluxes in the system. We give an overview of different model concepts that are used to describe this process. These range from non-isothermal two-phase flow two-component transport in the porous medium that is coupled with one-phase flow two-component transport in the free air to isothermal water flow in the porous with upper boundary conditions defined by a potential evaporation flux when available energy and transfer to the free air flow are limiting or by a critical threshold water pressure when soil water availability is limiting. The latter approach corresponds with the classical Richards equation with mixed boundary conditions. We formulated the different equations and identified assumptions behind simplified forms. Conditions for which lateral and up and downward air flow in the porous medium and vapor diffusion in the pore space play an important role were identified using simulations for a set of scenarios. When comparing cumulative evaporation fluxes from initially wet soil profiles, only small differences between the different models were found. The effect of vapor flow in the porous medium on cumulative evaporation could be evaluated using the desorptivity, S_{evap}, which represents a weighted average of liquid and vapor diffusivity over the range of soil water contents between the soil surface water content and the initial soil water content. Vapor flow influences the shape of the moisture front close to the soil surface. Simulated evaporation fluxes under dynamic forcing, e.g. due to diurnal variations in net radiation, differed considerably between the models. Experimental methods that allow monitoring of diurnal evaporation fluxes are therefore essential for model discrimination and parameterization.

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