Numerical Analysis of One-Dimensional Coupled Water, Vapor and Heat Transport in the Unsaturated Zone using HYDRUS

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http://www.tuat.ac.jp/˜vadose/

Understanding the simultaneous movement of liquid water, water vapor and heat in the vadose zone of arid or semi-arid regions is critical to accurately evaluate the water and energy balance of the subsurface environment. Vapor movement is often an important part in the total water flux in such regions when the soil moisture is relatively low. Although it is well known that liquid water and/or water vapor flow and heat transport processes are closely coupled and strongly affect each other, their simultaneous interactions are rarely considered. As part of this study we implemented in the HYDRUS-1D code the coupled movement of liquid water, water vapor, and heat in the subsurface, as well as interactions of these processes with the mass and energy balance at the soil surface. The code considers the movement of liquid water and water vapor in the subsurface to be driven by both pressure head (isothermal transport) and temperature (thermal transport) gradients. The heat transport module considers movement of soil heat by conduction, convection of sensible heat by liquid water flow, transfer of latent heat by diffusion of water vapor, and transfer of sensible heat by diffusion of water vapor. The modifications allow a very flexible way of using various types of meteorological information at the soil-atmosphere interface for evaluating the surface water and energy balance. The coupled model is evaluated using field soil temperature and water content data collected at different field sites. Simulated temperatures and water contents were in good agreement with measured values. Analyses of the distributions of the liquid and vapor fluxes versus depth showed that soil water dynamics is strongly associated with the soil temperature regime.