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Effect of water vapor diffusion enhancement on soil moisture/temperature and evaporation – A numerical study

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Experimental and numerical studies concerning the coupled flow of liquid water and water vapor in porous media have shown differences in observed and Fickian diffusion-based modeled water vapor fluxes. Early studies explain these differences with evaporation-condensation effects in liquid islands in the variably saturated zone and enhanced water vapor flux due to local thermal gradients which differ between the different phases (air, water and solid) due to non-equilibrium effects at the pore scale. Consequently, an "enhancement factor" was introduced to correct for differences between model simulations and observations. Although widely used, recent studies question the existence of enhanced vapor diffusion because enhanced vapor-phase diffusion has never been measured or observed directly. In this contribution, we present results from numerical experiments in which we simulate coupled water and heat flow. The impact of the enhancement factor was evaluated by including or excluding it in the parameterization of the systems' properties. We designed three different model scenarios: one scenario with boundary conditions that represent field conditions and two scenarios representing different kinds of laboratory soil column experiments, to investigate under which conditions the impact of the enhancement factor could be observed in experiments. Finally, we tested with model simulations whether liquid water flow in films, which is not considered in the classical Mualem- van Genuchten parameterization of the hydraulic conductivity curve, can be an alternative explanation for larger than expected evaporation fluxes.