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Comparison and validation of different approaches for modeling evaporation fluxes from the soil surface

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The interface between soil and atmosphere has an important function in the water balance of natural hydrosystems. The exchange between soil and atmosphere is typically described through water infiltration, evaporation and transpiration of plants. Yet, problems associated with the modeling of fluxes across this interface still pose significant theoretical and practical challenges. For instance, when modeling flow in the subsurface, different semi-empirical approaches can be used to describe the evaporative fluxes across the soil surface. Depending on the theoretical or empirical background behind them, these approaches can vary in complexity as well as in effectiveness.

Motivated by this, we test three different approaches for modeling evaporative fluxes from porous media in the second stage of evaporation, where capillary forces cannot drive enough water upwards to provide the potential evaporation. The first approach is a simple two-phase flow model for the unsaturated zone, combined with an empirical approximation of the evaporation flux through the boundary condition. In the second approach, we include in the two-phase flow equations an artificial diffusion term and describe the evaporation flux through the surface with a free-flow boundary condition of vapor at the top. In the third approach, the diffusion of water in the air phase and the transfer of vapor through the porous medium is based on an energy balance using a more sophisticated two-phase two-component model.

The three approaches are also compared to 1-D measurements of saturation in a homogeneous porous medium that is subject to evaporation. This analysis shows the potential and limits of the three modeling approaches to capture the evaporative flux through the surface and at the same time predict the saturation distribution in the porous medium beneath it.