Geophysical Research Abstracts
Vol. 15, EGU2013-10539, 2013
EGU General Assembly 2013

Modeling evaporation from porous media influenced by a turbulent free flow

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Modeling evaporation processes from partially saturated soils into the ambient air is a challenging task involving complex processes at the surface of the porous domain. Usually, a variety of interacting processes is involved, which depend on the multitude of properties of the fluids and of the porous medium. Often, the ambient free-flow and the porous-medium compartments are modeled separately with a specification of the evaporation rate as boundary condition.

In Mosthaf et al. (WRR, 2011), a coupling concept has been developed, which allows the combined modeling of a laminar free-flow and a porous medium under non-isothermal conditions with the evaporative fluxes across the soil-atmosphere interface as model output. It is based on flux continuity and local thermodynamic equilibrium at the interface. The coupled model uses Darcy's law in the porous medium and the laminar Stokes equations in the free flow. However, air flow is often turbulent, leading to the formation of boundary layers and an enhanced mixing in the free air stream. Several algebraic turbulence models are tested for their suitability for the modeling of evaporation under turbulent free-flow conditions. The laminar coupled model has been extended by expressions for the eddy viscosity, which represents the influence of turbulent velocity fluctuations. The enhanced mixing of transported quantities is accounted for using eddy diffusivity and eddy thermal conductivity models. The models are presented and their influence on the simulated evaporation rates is discussed.