Geophysical Research Abstracts
Vol. 16, EGU2014-10744-2, 2014
EGU General Assembly 2014

Coupled water and heat flow in laboratory evaporation experiments and its effects on soil hydraulic properties estimated by the simplified evaporation method

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The prediction of water fluxes in the field requires an accurate determination of soil hydraulic parameters which define the soil water retention and hydraulic conductivity function. The evaporation method has become a standard tool to quickly and reliably determine soil hydraulic properties in the wet to medium pressure head range. Recently, the method has profited from a significant improvement of soil sensors and data evaluation methods. In most cases, the data obtained from a transient evaporation experiment are evaluated using simplifying assumptions, like the ones implicit to Schindler's or Wind's methods. In the past, the effect of these simplifications on the identification of hydraulic properties has been investigated and found to be relatively minor. These studies were based on the evaluation of computer-generated data which were created by numerical modeling of the evaporation process with the Richards equation, i.e. by assuming isothermal liquid flow. Since evaporation from bare soil will always lead to loss of energy, the assumption of constant temperature is questionable. In addition, the effects of thermal and vapor fluxes on simplified evaluation methods have so far hardly been investigated.

In this contribution we analyze the effects of (1) coupled heat and water flow and (2) temperature effects on physical parameters. We firstly generated data by a numerical model which solves the coupled heat and water flow problem first derived by Philip and de Vries, and then used these data as source for the estimation of hydraulic properties with the evaluation methods of Schindler and Wind. The virtual realities covered different atmospheric forcings like changing wind speed and varying incoming shortwave radiation. The objective of this study was to identify under which atmospheric conditions, for which soil textures, and in which pressure head range the simplified evaluation methods lead to unbiased estimates of the soil hydraulic properties.