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Vadose zone water fluxes under arid conditions – bench-scale soil column experiments and 1D-modeling

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Under arid conditions, vadose zone water fluxes are close to zero and thus close to measurement errors as generally annual evaporation rates by far exceed annual precipitation rates. Additionally, the complex and non-linear processes involved in unsaturated water flow under non-isothermal and low water content conditions are yet not fully understood. As especially in arid regions, vadose zones can reach thicknesses of several tens of meters, processes within the unsaturated zone govern groundwater recharge. For a sound groundwater management, understanding and quantifying vadose zone processes are therefore of uttermost importance.

In general, vertical unsaturated water fluxes are imposed by gradients in total soil water potential and gradients in temperature. To better understand and quantify the interaction of the physical water flux processes, soil column experiments were developed that can mimic soil water states, temperature profiles and soil-atmospheric conditions as they can be expected in arid regions. Within the experiments, the processes of water infiltration, evaporation, redistribution and percolation are analyzed. For this, measurements are performed in high spatial and temporal resolution on water content and temperature in the column as well as on water and vapor fluxes into and out of the column. By running the experiments with defined initial and boundary conditions, the numerical model Hydrus 1-D (Šimůnek et al., 2009), which uses a modified Richards equation (Richards, 1931) for unsaturated flow, was setup and calibrated. Within Hydrus, hydraulic and thermal properties of the soil, which are initially defined in the laboratory, can be adjusted by an automated inverse calibration procedure with data of column outflow, soil water content and soil temperatures. Based on the calibrated model further model predictions that simulate recharge for critical precipitation rates or extreme temperature events are feasible without any further experimental investigations.

Results showed that depths of infiltration are mainly influenced by infiltration amount rather than infiltration intensity whereas infiltration intensities govern rates of evaporation. Additionally, thermal water fluxes have increasing influence on redistribution patterns with increasing temperature gradients whereas isothermal water fluxes dominate infiltration processes. Overall, predominant factors affecting the direction and amount of water fluxes under changing meteorological conditions throughout the year are investigated to determine thresholds for possible groundwater recharge.

References

Šimůnek, J., M. Šejna, H. Saito, M. Sakai, and M. Th. van Genuchten. The Hydrus-1D Software Package for Simulating the Movement of Water, Heat, and Multiple Solutes in Variably Saturated Media. Version 4.08. HYDRUS Software Series 3. Department of Environmental Sciences, University of California Riverside, Riverside, California, USA, 2009.

Richards, L.A. (1931). Capillary conduction of liquids through porous mediums. Physics 1 (5): 318–333. doi:10.1063/1.1745010.