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Numerical test of the simplified evaporation method using coupled water, vapor and heat flow modeling

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The simplified evaporation method is frequently applied to determine soil hydraulic properties in the laboratory. In the past, numerical simulations have been used to quantify the accuracy of the SEM. These tests have led to the conclusion that the method yields accurate estimates of hydraulic properties, but they neither accounted for heat flow, nor thermal fluxes of liquid water and water vapor, nor temperature effects on the transport properties. This is problematic because evaporation experiments are under most circumstances non-isothermal. The objective of this study was to test the accuracy of the simplified evaporation method using numerical simulations with a coupled model based on the Philip-de Vries theory. The model includes the fluxes of water, vapor, and heat flow, solves the surface energy balance and therefore provides a state-of-the-art description of the fluxes of water, vapor and energy occurring in laboratory evaporation experiments. We first present simulation results for three soil textures and different evaporation rates during stage-one, and analyze the accuracy of the evaporation method using the simulation data. The mean error for the estimated volumetric water content as function of matric head is smaller than 0.0025 and the relative error of hydraulic conductivity ranges from 5-15 % for sandy loam and clay loam. For sandy soil, the error in hydraulic conductivity is markedly higher but the shape of the hydraulic conductivity curve is still identified well. The average error of the SEM turned out to be only slightly higher compared to previous analyses of the evaporation method which used isothermal flow modeling.