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Experimental investigations on the influence of temperature on heat and mass transfer in the vadose zone

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Precise knowledge of the relevant parameters influencing heat and mass transfer as well as their coupling and variation is crucial for an adequate planning and operation of many technical applications located in the vadose zone (e.g. shallow geothermal energy, district heating pipes, buried energy cables, remediation of contaminations). The mass flow of liquid and vaporous water has a large influence on the convective and latent heat transfer and vice versa the temperature level and gradient have a large influence on the decisive mass transport processes of the liquid and vaporous water. For example, under certain circumstances, the mass transport mechanisms can even transport more heat than with pure conduction. Therefore, a coupled approach should always be followed in such technical applications.

The hydraulic and thus also the thermal properties of unsaturated soil or artificial porous media are subject to strong fluctuations due to natural as well as operational influences such as changing water content or temperature. Nevertheless, the measurements of the corresponding parameters are often only carried out at defined conditions of a sample and the determined values are assumed to be invariable. One reason for these simplifying assumptions is often the high laboratory effort required to get measured values for the different properties over the complete relevant saturation range. However, the required parameters can be determined using slightly modified, widely used laboratory tests with comparatively low effort.

In this contribution, the influence of temperature on the thermal and hydraulic properties of unsaturated porous media according to the approach of Philip & de Vries (1957) will be described. Furthermore we make some recommendations for the indirect and direct experimental determination of the relevant water transfer processes.