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The influence of pressure pumping on heat and vapor transport in the topsoil.

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For applications such as soil moisture remote sensing and climate modeling it is essential to accurately predict the temperature profile of the first few centimeters of the soil. Previous work showed that measured temperature profiles in this zone could not be explained by continuum models that include conductive heat transfer coupled with diffusive water vapor transfer. A significant heat sink was identified. Latent heat transfer sustained by enhanced water vapor transfer can explain this sink. Enhanced water vapor transfer in the topsoil is mostly related to temperature gradients. Yet the underlying mechanisms are not fully understood on the pore-scale and present continuum models rely on empirical enhancement factors. An alternative explanation for enhanced vapor transfer is pressure pumping. In this work we investigate the hypothesis that surface pressure fluctuations propagate into the soil and enhance the transport of water vapor, thereby altering the temperature profile in the topsoil. We present a dimensional analysis on the relevant processes on the pore-scale and discuss their effects on the continuum scale. We quantify the contribution of advection, diffusion and dispersion to water vapor and latent heat transport for varying surface pressure spectra and porous media characteristics.