Thermal non-equilibrium between solid and liquid phases in forced convective heat transport

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The thermal equilibrium between the solid and the liquid phases is generally assumed for numerical simulations in heat transport through soils. However, the validation of this assumption is not well examined, especially in heat transport through coarse materials that have low thermal conductivity. In this study we conducted one-dimensional heat transport experiments using different size fractions of glass beads and plastic balls to examine the validation of thermal equilibrium assumption. In the experiments, hot water (38℃) was injected to the 50-cm long column packed with glass beads or plastic balls. The temperatures of the solid and liquid phases were measured independently. The convection-dispersion equation with the assumption of the thermal equilibrium was applied to the measured thermal responses under different water fluxes. We found that thermal conductivity of the materials was not a dominant factor that affects thermal equilibrium between solid and fluid phases. In addition, the thermal dispersion coefficient obtained by applying the convection-dispersion equation to the thermal responses in the solid phase and fluid phase were similar.

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