

Thermal conductivity of binary sand mixtures evaluated through the full range of saturation

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Abstract. Mixing of different sized soil particles affects soil physical and hydraulic properties however little is known on its effect on soil thermal properties. To better understand how soil mixing controls soil thermal properties, especially thermal conductivity, a set of laboratory experiments was performed using binary mixtures of two uniform sands with seven different mixing fractions over the full range of saturation. For each binary mixture, thermal conductivity, capillary pressure and water content were measured. For each sample, the effect of packing on thermal conductivity was isolated as a function of porosity. The apparent thermal conductivity, l , to saturation, S , relationship exhibited distinct characteristics based upon the percentage of fine grained sand. The critical fraction of fines causing a shift between coarse and fine controlled mixtures occurred at a fine fraction of 0.3, with fine particles controlling the thermal behavior above 0.3. Coarse-controlled mixtures were characteristic of more abrupt, rapidly decreasing l from saturated to residual conditions. Fine-controlled mixtures portrayed more gradual decreases in l . Changes in rate of decrease for binary mixtures are correlated with the four saturation regimes (i.e. hydration, pendular, funicular and capillary). Measured l - S properties were then compared with independent estimates from five models. Results show good agreement for the Campbell et al. (1994) and Lu and Dong (2014) models. A comparison between the experimental results and model predictions highlight the importance of understanding the impact of packing conditions on the thermal conductivity of soils and the need for accurate experimental data sets to improve modeling.