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Prediction of soil moisture content from soil temperatures

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Soil moisture is a key variable in surface hydrology and land atmosphere-interactions, and consequently important in numerical weather forecasting and climate prediction. Various methods to obtain in-situ point observations of soil moisture exist, but monitoring large-scale variability of soil moisture is hampered by the fact that the standard measurement techniques, i.e. the thermo-gravimetric method or dielectric methods, are time- and labour-expensive. Hence, measurement of large-scale soil moisture content by proxy represents a promising prospect. Remote sensing (e.g. using passive microwave or visible/near infrared and thermal infrared airborne data) allows for large-scale estimates of soil moisture content, but the effect of vegetation on the signal needs to be taken into account carefully, if reliable and accurate values are to be obtained. Alternatively, in-situ observations of soil temperature can be used to derive (large-scale) estimates of soil moisture content because the subsurface temperature regime is strongly dependent on soil thermal properties, which in turn are highly dependent on soil moisture content. The advantage is that soil temperature data are widely available at weather stations, thereby providing high temporal frequency and synoptic spatial coverage.

The objective of the study is to understand the factors that affect the relationship between temperature-derived thermal properties and soil moisture content in order to develop a predictive tool to be used for large-scale soil moisture prediction. Soil temperature records for the Lindenberg Meteorological station, from October 2002 until December 2008, were used to calculate daily apparent soil thermal diffusivity (D_h) with various methods (Amplitude, Arctangent and Logarithmic methods), for three different soil layers. The values were then related to the corresponding average daily soil moisture content (θ). Correlation between D_h and θ was initially poor. The data points were then filtered with a variety of criteria based on above- and below-ground environmental factors. This improved the precision of the $D_h(\theta)$ function, allowing a predictive equation to be derived. Given the high variability of $D_h(\theta)$ values only 2-weekly, and ideally monthly, averaged θ could be predicted with reasonable accuracy, for Spring months only. Nevertheless, this method could still provide useful large-scale estimates to initialise, nudge or verify numerical weather prediction models, for example. A study currently in progress is testing the validity of such an approach for a multiple of locations.