Geophysical Research Abstracts
Vol. 14, EGU2012-6375, 2012
EGU General Assembly 2012

Distributed Temperature Sensing as a tool for monitoring heat transfer processes in the shallow subsurface

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Experimental data will be used to illustrate how Distributed Temperature Sensing (DTS) can be used to study spatial and temporal variability in heat and moisture fluxes in the shallow subsurface. In DTS, fiber-optic cables are used as temperature sensors. Temperature can be measured at resolutions of 25cm to 1m along cables several kilometers in length, and the measurement interval can be under a minute. Given this unique combination of spatial and temporal resolution and coverage, DTS has become a powerful and increasingly popular tool in environmental monitoring. It has been used to provide both qualitative and quantitative information on many processes with a thermal signature. Here, we will focus its current and future role in studying the spatial and temporal patterns in moisture and heat transport processes in the shallow soil surface.

Two types of DTS measurements can be used. In “Passive DTS”, cables are typically buried at a number of depths and used to monitor the natural temperature dynamics in the soil. Soil thermal properties (and hence soil moisture) can be determined using an inversion technique or they can be calculated from the difference in amplitude and phase between temperature measurements at the different depths. In “Active DTS”, one or more cables are buried in the soil. The protective cable armor is heated, and the fiber monitors temperature changes in the cable. The temperature response in the fiber can be directly related to the soil moisture, or equivalently the thermal properties of the surrounding soil. In addition to monitoring soil temperature and moisture, the thermal conductivity determined from either Passive or Active DTS can be combined with the temperature profile to estimate the soil heat flux. By improving our ability to monitor the transfer of water and energy at the land surface, DTS can yield new insight into land-atmosphere interactions at fine scales. We will conclude by outlining the potential value of DTS in small-scale meteorology, hydrology and soil sciences.