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Soil Moisture Monitoring using Distributed Temperature Sensing

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Soil moisture is a key storage term coupling the energy and water balances. Measurements of soil moisture are critical to advance our understanding of land-atmosphere interactions and to monitor how these interactions are changing in time. Typically, soil moisture measurements are made with TDR, neutron or heat pulse probes and validated with occasional gravimetric sampling. However, these are point measurements with a measurement volume of a few cubic centimeters. Soil moisture is also monitored using remote sensing, with products available from ERS, AMSR-E and ESA's recent SMOS mission. However, these provide a single value of soil moisture over a large area (e.g. 35km by 35km) every few days. Soil moisture heterogeneity is known to be driven by variability in precipitation, soil texture and vegetation, each of which varies at scales smaller than a satellite footprint. Our ability to advance our hydrological understanding based on remote-sensing of soil moisture requires us to reconcile traditional point-scale measurements with those from remote-sensing. Several new measurement techniques, including COSMOS, GPS and distributed temperature sensing offer a means to bridge this resolution gap.

In Distributed Temperature Sensing, fiber-optic cables are used as thermal sensors capable of measuring temperature every meter, every few minutes along cables up to 4km in length. Because the thermal properties of soil depend on its moisture content, monitoring temperature dynamics can yield information on the water content. Both active and passive methods have been developed to measure soil moisture (SoilDTS). In passive DTS, the soil temperature response to solar radiation is observed. In active DTS, the cable is heated and the cumulative temperature change is related directly to the soil moisture content.

Here, we present details of a recent SoilDTS installation at the SMAP in-situ test bed in Stillwater, Oklahoma. In October 2010, a custom-built plow was used to bury cable at three depths along a ground track of over 600m. These temperature data will be combined with a coupled heat-moisture transfer model to estimate surface and root zone soil moisture. The long term goal of this installation is to compare the spatially distributed fields of soil moisture observed using DTS to the point measurements from traditional sensors and the larger-scale measurements from COSMOS and GPS. Preliminary results will be presented from the first few months of DTS data collection.