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Distributed Soil Moisture Profiles Using Heated Optical Fiber

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Monitoring fluctuations of soil moisture remains a hard challenge despite its importance to understand the dynamic of water, especially in the vadose zone. Time and Frequency Domain Reflectometry (TDR and FDR) have been improved in the last years but their spatial resolution is limited to few centimeters. Optical fibers offer a promising alternative to these dielectric techniques.

Thanks to recent improvements, Fiber Optic Distribute Temperature Sensing (DTS) techniques, based on the emission of a laser beam inside the fiber and the detection of the photons backscattered for Raman effect, whose Anti-Stokes component is temperature dependent, have been demonstrated to provide extremely accurate temperature measurements over long distances. Monitoring the temperature evolution during and after the application of a heat pulse (realized by heating the stainless steel sheath of the optical fiber) allows inferring soil-moisture content along the whole heated cable. An attempt to test the applicability of this technique in a large weighable lysimeter has been realized during a field campaign in summer 2010.

The lysimeter has been homogeneously filled with loamy soil and instrumented with a set of sensors to monitor volumetric water content, capillary pressure and temperature. Additionally, a large spiral of optical fiber (with a total length of thirty meters) has been installed in the shallowest meter of soil passing very close to standard sensors. Four tests have been realized heating the optical fiber for 120 seconds. From the recorded temperature evolution during and after the heating the spatial variation of soil thermal properties (thermal conductivity and heat capacity) are inferred, and from them the spatial variation of soil water content is obtained. The accuracy of the DTS technique to monitor soil-water content is evaluated by comparison with the measurements provided by the other sensors.