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Spatial TDR a new approach for observing 4d- soil moisture dynamics at the field scale: promise, progress, problems

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Time Domain Reflectometry (TDR) is frequently used to assess soil moisture data at the point scale. TDR and capacitance methods depend on probes to guide the signal into the soil of interest. Both methods usually have made use of parallel rods inserted into the soil from the surface to serve as transmission line. Most TDR instruments launch a fast rise voltage step along the transmission line in the soil. The TDR step pulse travels to the end of the probe reflects back to the instrument where it is detected. Pulse velocity is determined from the measured travel time for one round trip and converted to an average electrical permittivity /average water content along the transmission line. Spatial TDR (STDR) is an advanced method, which allows the retrieval of the soil moisture profile by means of simulating the TDR signal using the Telegraph equation and optimising the capacitance profile along the transmission line. An STDR cluster, which consists of up to 40 sensors that are connected via a mutlti-plexer to a single sampling TDR, allows observation of the 4d soil moisture pattern at an extend of to 1000 m2 and a temporal resolution of 10 min. Hence, in principle STDR technology allows representative sampling of soil moisture data, which is crucial for understanding small scale soil moisture variability, or how initial soil moisture determines runoff response or for a reasonable ground truthing of remote sensing data.

However, the inversion of the TDR signal requires a relationship between the capacity

and the electric conductivity along the transmission line, that has to be calibrated for the soil of interest. Additional error sources in natural soils reconstruction are furthermore a) deviations from the ideal parallel geometry of the TDR rods, b) vertical in bulk densities, b) the presence of solids (stones, wood) close to the TDR rods and in d) a higher clay fraction in the soil. The objectives of this study are threefold. First, to present most recent laboratory and field experiments that shed light on how these error sources contaminate soil moisture measurements in natural soils. Second, to present moisture data from two STDR clusters installed in a small headwater catchment in Germany to shed light on the question how much we we may learn about 4d soil moisture patterns from this technology. And third, to compare soil moisture data derived from GPR observations at the same site to the STDR data and discuss the feasibility of combining both technologies for assessing representative spoil moisture data.