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A Concept for the Development of Spatially Resolved Measurements for Soil Moisture with TEM Waveguides

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Soil water content plays a leading role in delimitating water and energy fluxes at the land surface and controlling groundwater recharging. The information about water content in the soil would be very useful in overcoming the challenge of managing water resources under conditions of increasing scarcity in Southern Europe and the Mediterranean region.For collecting data about the water content in soil, it is possible to use remote sensing and groundwater monitoring, built wireless sensor networks for water monitoring. Remote sensing provides a unique capability to get the information of soil moisture at global and regional scales. Wireless environmental sensor networks enable to connect local and regional-scale soil water content observations. There exist different ground based soil moisture measurement methods such as TDR, FDR, electromagnetic waves (EW), electrical and acoustic methods. Among these methods, the time domain reflectometry (TDR) is considered to be the most important and widely used electromagnetic approach. The special techniques for the reconstruction of the layered soil with TDR are based on differential equations in the time domain and numerical optimization algorithms. However, these techniques are time- consuming and suffering from some problems, like multiple reflections at the boundary surfaces. To overcome these limitations, frequency domain measurement (FDM) techniques could be used. With devices like vector network analyzers (VNA) the accuracy of the measurement itself and of the calibration can be improved. For field applicable methods the reflection coefficient is mathematically transformed in the time domain, which can be treated like TDR-data and the same information can be obtained. There are already existed some experiments using the frequency domain data directly as an input for inversion algorithms to find the spatial distribution of the soil parameters. The model that is used represents an exact solution of the Maxwell's equations. It describes the one-dimensional wave propagation in a multi-layered medium, assuming the wave to be transverse electromagnetic (TEM). In the particular case of transmission lines with perpendicularly arranged layer transitions this assumption is very close to reality. Such waveguides and their frequency domain measurements in layered media are promising concerning a development ways working with soil moisture detection.