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Evaluation of a low-cost water content sensor for wireless network applications

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Wireless sensor networks are a promising new in-situ measurement technology for monitoring soil water content changes with a high spatial and temporal resolution for large areas. In the framework of the SFB Transregio 32 "Patterns in Soil-Vegetation-Atmosphere Systems: monitoring, modelling and data assimilation" soil water content sensor networks at the small basin scale (about 1200 sensors for an area of 25 ha) will be set up. In order to realize such a large measurement system, the costs for a single sensor have to be minimized. Furthermore, the sensor technique has to operate with a low energy consumption to achieve a long operation time of the network. This paper evaluates a low-cost capacitance probe (ECH2O Probe model EC-5, Decagon Devices Inc., Pullman, WA) using laboratory as well as field experiments. The field experiment features a comparison of water content measurements of a forest soil at 5 cm depth using TDR and EC-5 sensors. The laboratory experiment is based on a standardized sensor characterization methodology proposed by Jones et al. (2005), which uses solutions with predefined volumetric amounts of deionized water and 2-isopropoxyethanol or dioxane to obtain liquids with a known dielectric permittivity. The results of the laboratory experiment showed that the EC-5 sensor has good output voltage sensitivity below a permittivity of 40, but is less sensitive when permittivity is higher. The experiments also revealed a distinct dependence of the sensor reading on the applied supply voltage. By fitting a high order polynomial function to the permittivity - applied voltage - sensor reading data, a function was obtained that allows the permittivity to be determined from the sensor reading and the supply voltage. Due to the higher frequency of the EC-5 sensor, conductivity effects were less pronounced compared to the older EC-20 sensor (also Decagon Devices Inc.). However, the EC-5 sensor reading was significantly influenced by temperature changes, which was also observed in the field experiment. Furthermore, the field experiment showed differ-

ences between the EC-5 and the TDR sensor readings, which are mainly attributed to the difference in sampling volume. However, the relative soil water content changes were similar for both sensors.