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Rapid Percolation of Water through Soil Macropores Affects Reading and Calibration of Large Encapsulated TDR Sensors

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The electromagnetic soil water content sensors are invaluable tools because of their selective sensitivity to water, versatility, ease of automation and large resolution. A common drawback of most their types is their preferential sensitivity to water near to their surfaces. The ways in which the drawback manifests itself were explored for the case of large Time-Domain Reflectometry (TDR) sensors Aqua-Tel-TDR (Automata, Inc., now McCrometer CONNECT). Their field performance was investigated and compared with the results of field and laboratory calibration. The field soil was loamy Chernozem on a carbonate-rich loess substrate, while the laboratory calibration was done in fine quartz sand. In the field, the sensors were installed horizontally into pre-bored holes after being wrapped in slurry of native soil or fine earth. Large sensor-to-sensor variability of readings was observed. It was partially removed by field calibration. The occurrence of percolation events could be easily recognised, because they made the TDR readings suddenly rising and sometimes considerably exceeding the saturated water content. After the events, the TDR readings fell, usually equally suddenly, remaining afterwards at the levels somewhat higher than those before the event. These phenomena can be explained by the preferential flow of water in natural and artificial soil macropores around the sensors. It is hypothesised that the percolating water which enters the gaps and other voids around the sensors accumulates there for short time, being hindered by the sensors themselves. This water also has a enlarged opportunity to get absorbed by the adjacent soil matrix. The variance of TDR readings obtained during the field calibration does not differ significantly from the variance of the corresponding gravimetric sampling data. This suggests that the slope of the field calibration equation is close to unity, in contrast to the laboratory calibration in quartz sand. This difference in slopes can be explained by the presence or absence, respectively, of gaps around the sensors. A typical percolation event and dry period records are presented and analysed. Sensors of this type can be used for qualitative detection of preferential flow and perhaps also for its quantification. The readings outside the percolation events indicate that the sensor environment imitates the native soil reasonably well and that the field-calibrated sensors can provide us with quantitative information about the actual soil water content.