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How accurate are soil moisture profile sensors? – Results from a multi-sensor evaluation using a sandbox experiment

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Many precision farming applications rely increasingly on the near-real time provisioning of accurate root zone soil moisture measurements to enable the efficient and economical use of limited freshwater resources. Besides the established sensor manufacturers who have been around for decades, new companies are entering the market, often with a portfolio of sensors especially designed for agricultural applications. These so-called soil moisture profile sensors (SMPS) exhibit a high potential for agricultural use. Their elongated shape and the ability to measure simultaneously in different depths make them especially suitable for frequent changes of location as required during cultivation of field crops. These sensors measure the volumetric soil water content (VWC) by exploiting the highly different dielectric permittivity of the solid and liquid soil compounds.

I this study we use a sandbox experiment to determine the measurement accuracy of different SMPS under controlled moisture conditions. The sandbox is a 2 x 2 x 1.5 m container filled with well-characterized fine sand which is sealed watertight to all sides. The sandbox is equipped with a 20 cm drainage layer and the water level inside the sandbox can be controlled by pumping water in or out using piezometer tubes, which are open at the bottom in the drainage layer. The SMPS were installed into the sandbox and the measurements were compared against reference measurements using CS610 TDR probes connected to a TDR100 (Campbell Scientific) and SMT100 (TRUEBNER) measurements installed in triplicate at six different depths. The measurement accuracy of 10 different sensors were evaluated, with each sensor being tested in triplicate. Most SMPS performed with reasonable accuracy under very dry and very wet conditions. However, strong variation was observed with respect to slope, offset and spread of the measurements and non-linear behavior was observed with some SMPS in the intermediate soil moisture range. The high variability of the measurement accuracy (RMSE: 1.2 – 6.5 vol. %) highlights the importance of choosing a suitable sensor, especially for precision farming applications, where it is crucial to have accurate field data to make the best management decisions without the need for soil specific calibration.