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Local and profile soil water content monitoring: A comparison of methods in terms of apparent and actual spatial variation

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Although many soil water sensors are now available, questions about their accuracy, precision and representativeness still abound. This study examined down-hole (access tube profiling type) and insertion or burial (local) type sensors for their ability to assess soil profile water content (depth of water in a given depth of soil) and local volumetric water content data. Downhole sensors were compared with data from volumetric/gravimetric sampling and field-calibrated neutron probe (NP) measurements. Insertion and burial type sensors were compared with a time domain reflectometry (TDR) system that was calibrated specifically for the soil; and temperature and bulk electrical conductivity measurements were also made to help elucidate sensor problems. The capacitance type down-hole sensors were inaccurate using factory calibrations, and soil-specific calibrations were not useful in a California Central Valley soil and a U.S. Great Plains soil. In both soils, data from these sensors exhibited pseudo spatial variability that did not exist as determined by gravimetric and NP measurements, resulting in large errors in the interpretation of spatial variation in soil water content and plant available water content. Some of the local sensors that could be buried or inserted into the soil reported water contents larger than saturation using factory calibrations. The sensors that reported more reasonable water contents were also the least temperature sensitive. The poorly performing sensors also exhibited daily water content variations due to temperature of $>= 0.05$ m^3 m^{-3} water content, and they tended to exhibit larger unexplained sensor to sensor variation in a uniform medium. Errors were related to the temperature-dependent bulk electrical conductivity of this non-saline but clayey soil. Pseudo spatial variability of water content exhibited by capacitance sensors calls into question our ability to deduce spatial patterns of water content and infer spatial patterns of plant water uptake and evaporation from the soil.