Experimental quantification of bulk sampling volume of ECH_2O soil moisture sensors

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Abstract. Soil moisture is one of the critical parameters needed in analysis and modeling associated with many applications in hydrology, irrigation, and environmental engineering. Sensors that rely on the relationship between the dielectric constant and water content are used extensively in the laboratory and in the field. Since the "universal" relationship between dielectric constant and water content for various types of soils measured using time domain reflectometry (TDR) was published (Topp et al. 1980), the characteristics of TDR probes and the dielectric properties of soils have been investigated extensively. For the probes/sensors to be installed properly, sampling volume has to be known. A number of experimental studies followed by numerical investigations have been performed on this issue and sampling volume of TDR probes are now well understood. Recently developed, relatively low-cost, ECH_2O soil moisture sensors (Decagon Devices, Inc.) have received considerable attention by both laboratory and field scientists. These dielectric sensors typically comprise plus and ground prongs, where the sensitivity of the plus prong is higher than that of the ground prong. Moreover, the sensor head in which the circuitry is embedded has some sensitivity. It is not straightforward to incorporate these asymmetric characteristics and sensor head sensitivity into numerical analysis of the sampling volume. Therefore, we re-visited the "classic" experimental approach for quantifying the *bulk* sampling volume of the sensors. Our experimental procedure was: 1) obtain sensor readings under varying distances between the sensor and a water-air interface, and 2) determine bulk sampling volume when the sensor readings start to show an "abrupt" change. Firstly, we tested two TDR probes (CS-640 and CS-630, differ in electrode length and spacing, Campbell Scientific, Inc.) and showed that the experimental procedure yielded results that were consistent with the results in the previous studies. Secondly, we examined four ECH_2O soil moisture sensors that differ in design (EC-5, TM, 5TE, and 10HS). The results showed that: 1) the sensitivity of the plus prong was generally higher and the contribution of the ground prong varied depending on if the ground prong was in air or under water, 2) the sampling volume was roughly about 1-2.5 cm from the plus prong, and 3) the sensor head can affect the output readings by 3-5 % for EC-5, TM, and 10HS, and 34% for 5TE. Since the experiments were performed in air and under water, where soil moisture conditions are in between these extreme conditions, the measured bulk sampling volumes of the sensors should be applicable for measurement of water content in soil.

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