Comments on “Field Calibration of Water Content Reflectometers”

Chandler et al. (2004) tried to evaluate and improve the performance of the commercial soil moisture sensor CS-615 (Campbell Scientific Inc., Logan, UT). The authors should be complimented for their devoted efforts to provide growers with an accurate yet inexpensive tool for monitoring water content (WC), a critical parameter in agricultural production. Practically, the authors propose a three-phase campaign:

1. Extensive use of low cost but problematic sensors;
2. An upgrade, by one way or another, of the factory-supplied sensor calibration; and
3. Use of time domain reflectometry (TDR) technology to intermittently verify water content reflectometer (WCR) calibration stability under field conditions.

My following comments intend to show that: (i) the calibration strategy offered and discussed by the authors may be problematic, (ii) the measurement frequency gap is unbridgeable, (iii) the selected experimental site is not a typical agricultural example, and (iv) it is worth checking if a simple and cheap electrical resistance measurement could not bring the same benefit for a fraction of the price.

The authors assume that “TDR is a reliable, most widely accepted electrical technique for measuring soil WC”; it is desirable to identify a substitute for the TDR technique due to its high price; and Campbell Scientific’s Water Content Reflectometer (WCR, CS-615) is a suitable candidate because, similarly to the TDR it measures soil dielectric properties, differing only in the measurement frequency (15–45 MHz, compared with the 1000–1450 MHz of TDR).

Contrary to the superlatives used for describing TDR, the characteristics of the WCR presented in the article include (verbatim): “WCR-determined volumetric WC (VWC) is more sensitive to soil type, because the effects of EC are strongly temperature dependent … WCR data are also temperature (T) dependent for high EC soils.” For three of the four soils tested, the authors report, “there were substantial deviations from the factory calibration and substantial T effects.” The authors also stated, “at present there are insufficient data to know, a priori, how much the calibration for a given WCR application might deviate from the factory calibration, however it appears that the calibration will vary with soil properties, with deviation tendency to increase with clay content, and that it may vary with each individual sensor, and in addition, it is difficult to account for individual sensor variability, which may vary with site characteristics.” Sensors’ production seems also to have contributed to the error, as was indicated by the trends between individual sensor pairs (TDR-WCR), and the error in the overall relationship is primarily due to variability between the TDR and WCR sensors. The site-specific regressions show a difference in accuracy as stated. This hypothesis is based on the following reasoning: Bulk EC (ECa) of a medium depends on the product of its ionic concentrations (C) and the effective suction water volume (WC). The effective water volume is sensitive, hints that the soil’s galvanic component affects measured WC far more than does the soil’s dielectric properties, namely that WCR measurements reflect medium’s changes in resistance. The site-specific regressions show a difference in accuracy as stated. This hypothesis is based on the following reasoning: Bulk EC (ECa) of a medium depends on the product of its ionic concentrations (C) and the effective suction water volume (WC). The effective water volume is sensitive, hints that the soil’s galvanic component affects measured WC far more than does the soil’s dielectric properties, namely that WCR measurements reflect medium’s changes in resistance.

WC_{TDR} − WC_{WCR} relations, conveniently denote multiple types of disparity: partly or fully biased, systematically shifted, and a wide range of scatter, all relative to factory calibration. To improve the correspondence between the sensors, the authors have applied different forms of averaging, apparently without considering whether the dual TDR-WCR installation can change the inherent properties of the sensor or calibration manipulations.

More specifically, it is given that the CS-615 measures T, EC, and the soil WC, which are continuous during the season, and that undistinguishable interactions exist. Extensive use of low cost but problematic sensors; … the complicated, nonlinear, multi-interdependence on T, texture, and salinity. Field measurements obtained by the authors yield doubtful results, for only the texture content (WC), a critical parameter in agricultural production. More specifically, it is given that the CS-615 measures T, EC, and the soil WC, which are continuous during the season, and that undistinguishable interactions exist.

A. Is it reasonable to expect that potential users would be able to internalize the meaning of the recalibration of the factory calibration, to distinguish between a real TDR and its imitation, or will the authors maintain that their WCR-reported data are as reliable as those of a true TDR? Would the average user (ranch manager, extension person, research technician, or engineer) be able to understand, perform, analyze, apply, and supervise the recalibration procedure? And from where could the average user get the TDR be “occasionally” borrowed?

B. An inner contradiction arises, in that the authors praise the TDR as the most widely accepted tool for measuring soil WC that is also reliable and accurate, they also attribute a limitation in their production method to the TDR’s poor performance in high salinity media. Sensor rods can be shortened to solve this problem. The authors’ list of parameters to monitor is sensitive, hints that the soil’s galvanic component affects measured WC far more than does the soil’s dielectric properties, namely that WCR measurements reflect medium’s changes in resistance.

C. The authors’ rationale for avoiding the recalibration indicate a lack of experience. Recently (Blake et al., 2003; Jones and Or, 2004; 2004; Zhang et al., 2004) have reported WCR measurements in high salinity media. Sensor rods can be shortened to solve this problem.

D. The authors’ long list of parameters to monitor is sensitive, hints that the soil’s galvanic component affects measured WC far more than does the soil’s dielectric properties, namely that WCR measurements reflect medium’s changes in resistance.