Title: Calibration and Simultaneous Monitoring of Soil Water Content and Salinity with Capacitance and Four-electrode Probes

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Abstract: Non-destructive monitoring of soil water content (W) and the electrical conductivity of the soil solution (ECw) has been desired for environmental evaluation and sustainable agriculture. Dielectric probes and four-electrode probes are widely used for the non-destructive determination of W and the soil bulk electrical conductivity (ECb), respectively. Since the output of dielectric probes is affected by soil salinity, the calibration for the effect is indispensable for accurate determination of W. Meanwhile, four-electrode probes require the W value for determination of ECw from ECb. We present an empirical calibration method for the salinity dependence of commercial capacitance moisture probes. A four-electrode probe was also calibrated to investigate the possibility of simultaneous monitoring of W and ECw by combining each calibration equation for capacitance and four-electrode probes. A laboratory experiment was conducted using a sandy soil to obtain probe outputs at various W (air-dry-near-saturation) and ECw (0-31.9 dS m^{-1}). The output of the capacitance probe exhibited strong, nonlinear dependence on ECw. The root mean square error (RMSE) between actual W and calculated W using the linear functions provided by the manufacturer was at a maximum of 0.162 m3 m^{-3}. A calibration equation, describing the probe output as a function of W and ECw, was developed using curve fitting approach. The RMSE between the actual and calibrated W by this equation was at a maximum of 0.011 m3 m^{-3}. The output of the four-electrode probe (ECb) was also expressed as a function of W and ECw. The calibration equations for each probe were combined and solved for W and ECw. Although both W and ECw were determined with acceptable accuracy, the combined calibration equation had multiple solutions for W. Development of the method to select optimal solutions will be needed for the practical application of this probe combination.