Water Content Reflectometer Calibration and Field Use S.D. Logsdon

Introduction

Soil water flow patterns: landscape - water table interaction
• Preferential flow to water table
• Sub-surface lateral flow (Anderson and Burt, 1990)
• Upward movement from water table (Allmaras te al., 1975)
• Plant water uptake at capillary fringe (Reicosky et al., 1972)

Soil water variability: landscape position effect
• Neutron probe: temporal sample points
• Automated TDR: coaxial cable effects
• Newer soil moisture sensors, no coaxial cable
• Newer soil moisture sensors: lower frequency
• Newer soil moisture sensors: measurement volume

Preliminary study (Logsdon and Hornbuckle, 2006):
• Less spatial variability for CS616 than other probes
• Possible temperature effect for CS616
• Consistent, low-noise data

Objectives:

The purpose of this study was to determine in CS616 can be calibrated and used to determine soil water movement patterns in a field with zones that have shallow water table depths.

Methods

Soybean year of corn / soybean rotation
• Three positions
  o shoulder 313.43 m MSE, 3.08% slope
  o backslope 313.09 m, 3.28% slope
  o toeslope 312.85 m, 0.83% slope
• CS616 probes: 0.3, 0.5, 0.7, 0.9 m, angled
• Neutron access tubes
• Wells: manual and automated

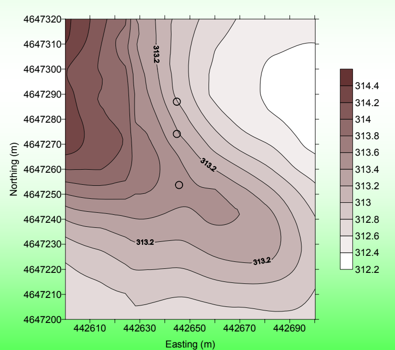

Figure 1. Field contour and location of sites.

The CS616 output was converted to square root of apparent permittivity as described by Kelleners et al. (2005):

$$\varepsilon_a^{1/2} = \frac{(t-2t_d)c}{4L} \qquad [1]$$

where *L* ~ 26 cm (probe length), *td* ~ 5.4 X 10-9 s, *c* is speed of light (3.0 X 108 m s-1), *t* = *P*/*St*, *St* = 1024, and *P* is the period instrument output (s).

Undisturbed soil cores collected in PVC tubes (10.2 cm inner diameter) for laboratory calibration:
• Shoulder, backslope: 0.3, 0.5, 0.7 m
• Footslope: 0.3, 0.5 m
• Range of water contents
• Temperature gradations 4 to 22ºC

Field calibration
• Calibrated against neutron probe data
(which had been calibrated for Clarion and for Webster)
• Seasonal temperature correction
• Not corrected for diurnal temperature fluctuations

Rainfal: tipping bucket
Evapotranspiration: Eddy covariance
(Curtesy of Tim Hart, John Prueger, Jerry Hatfield, Tom Sauer)

Results

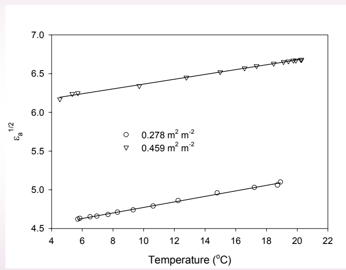

Figure 2. The linear laboratory temperature effect for CS616

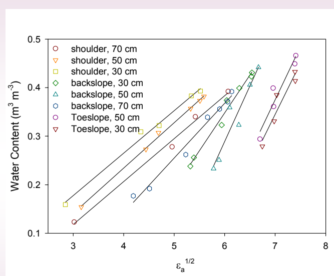

Figure 3. Laboratory calibration of CS616 - all different.

Table 1. Laboratory columns bulk density and sorbed water.

Site	Depth (m)	ρ_b (Mg m-3)	θ_{sorb} (m3 m-3)
Shoulder	0.3	1.24	0.040
Shoulder	0.5	1.37	0.056
Shoulder	0.7	1.45	0.051
Backslope	0.3	1.29	0.066
Backslope	0.5	1.41	0.063
Backslope	0.7	1.48	0.046
Toeslope	0.3	1.42	0.084
Toeslope	0.5	1.42	0.077

Laboratory calibration (Figs. 2, 3, Table 1)
• Linear temperature effect
• Different calibration for each site and depth
• Related to soil properties (not shown)

Table 2. Temperature (*T*) correction term (c) or laboratory data and for seasonally corrected field data: θ = a + b$\varepsilon_a^{1/2}$ + c*T*

Site	Depth (m)	Lab c	field c
Shoulder	0.3	-0.021	-0.0054
Shoulder	0.5	-0.026	-0.0083
Shoulder	0.7	-0.037	0
Backslope	0.3	-0.038	-0.0058
Backslope	0.5	-0.045	-0.0126
Backslope	0.7	-0.042	0
Toeslope	0.3	-0.057	-0.0096
Toeslope	0.5	-0.052	-0.0103

Why?
• Rate of *T* change too rapid in lab
• Range of T in lab appropriate for season change
• Range of T in lab much greater than diurnal fluctuations at these depths
• Vapor movement in lab?

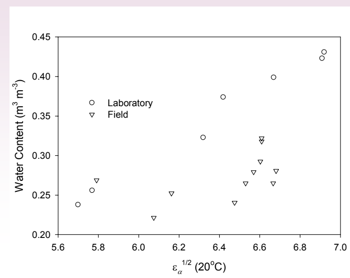

Figure 4. Laboratory and field calibration (temperature corrected) for sideslope position at 0.3 m depth.

• Field calibration offset to higher εa1/2 values than lab calibration.
• If drier field water included, showed nonlinear structure effect (Miyamoto et al., 2003, 2005; Blonquist et al., 2006; Logsdon, 2006).
• First point matched lab data, then soil settled around probe after rain.
• Similar data for other sites / depths (not shown).

Why?
• electrical field extending outside of lab sample
• field water distribution less uniform than in lab ?
• effect of confining PVC cylinder (lab) vs confining overburden (field) ?

Because of uncertainties in CS616 calibration and field temperature corrections, it is not a good idea to use nighttime soil water data (Nachabe et al., 2005) to distinguish vertical and lateral soil water movement unrelated to evapotranspiration.

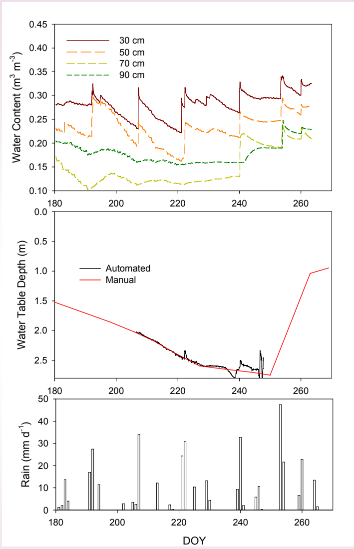

Fig. 5. Shoulder position soil water content, water table depth, and rain.

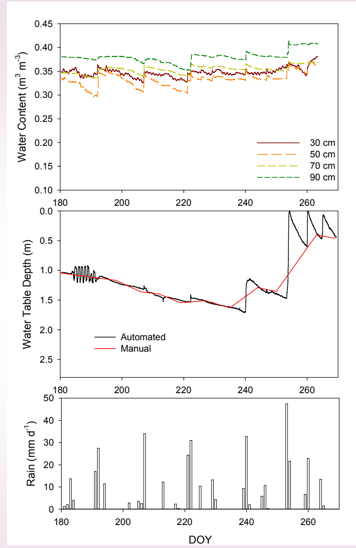

Fig. 7. Toeslope position soil water content, water table depth, and rain.

Seasonal soil water patterns at three landscape positions
• Greater soil water variation for shoulder (Fig. 5) and backslope (Fig. 6) positions than for toeslope position (Fig. 7).
• Not much rain water redistribution below 70 cm until rain day 240 for shoulder and backslope positions
• Not much water table rise until day 250 for shoulder / backslope
• Water table rose later in season when roots no longer intercepting drainage water
• Daytime soil water loss pattern similar to evapotranspiration
• Early season, soil water losses also above depth of measurement
• Late season, soil water losses also below depth of measurement

Instead of using nighttime soil water changes for lateral / upward flow
• Compare soil water changes with ET and rain
• Assume positional ET varies in relation to plant growth
• Or assume uniform ET across landscape positions
• Gap between soil water changes and ET: lateral and upward flow
• Inadequate depths for soil water in this study

Summary

• Laboratory calibration not valid for field data
• Uncertain temperature effects on CS616 complicate analysis
• Soil water net effect of:
  o Precipitation
  o Evapotranspiration
  o Drainage loss below root zone
  o Upward movement from below root zone
  o Soil water retention
• Night change in soil water inadequate to describe soil water patterns
• Difference between change in soil water and measured ET better indication of upward / lateral soil water additions / losses.

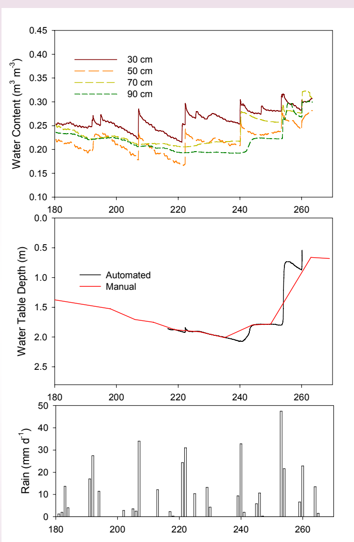

Fig. 8. Backslope position soil water content, water table depth, and rain.

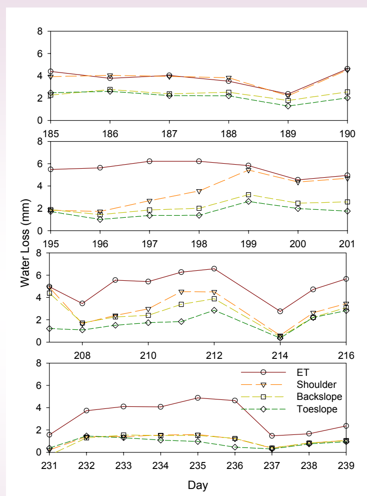

Fig. 8. Daytime (7-19 h) evapotranspiration and soil water loss (0.2 to 1.0 m) for certain days between rainfall events.

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Sally Logsdon
Research Soil Scientist
USDA-Agricultural Research Service
National Soil Tilth Laboratory
2150 Pammel Dr.
Ames, IA 50011
(515)294-8265
sally.logsdon@ars.usda.gov

Due to conflicts, I am unable to be at my poster at the scheduled time.