Characterizing Mass and Energy Transport at Different Scales

Multi-State Research Project W-1188
2008 Progress Report

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Flow of presentation

- **Research theme**
- Biological intensification in agriculture

- **Research project**
- Soil water balance and nitrate leaching for corn in kura clover living mulch

- **W1188-related component**
- Monitoring soil water storage

Biological intensification

- Occurs when the number and diversity of species in an agricultural system are intentionally increased

- Aims of biological intensification
  - Increase net agricultural productivity
  - Conserve and improve the soil
  - Create positive off-site environmental impacts

Integrated crop-livestock systems

Cattle and winter wheat, KS
http://flickr.com/photos/59526103@N00/137649071

Double cropping

Rye silage following corn silage, MN

Relay cropping

Soybean and winter wheat, NE
http://cropwatch.unl.edu/archives/2003/crop03-23.htm

Living mulch

Corn and kura clover, WI

Soil water balance and nitrate leaching for corn in kura clover living mulch

- Collaborators:
  - Ken Albrecht, Agronomy, UW-Madison
  - John Baker, USDA-ARS, St. Paul, MN
- Objectives:
  - determine if corn grown in kura clover living mulch is a viable option for biological intensification of agriculture in the Midwestern United States
  - determine the impact of a kura clover living mulch on the water balance and nitrate leaching under corn

Methods

- Plot experiment
  - Arlington, WI
  - No-till corn with and without living mulch

- Nitrate leaching
  - Soil nitrate storage to 1-m measured every 6 months
  - Nitrate in solution at 1-m depth sampled every 2 weeks with ceramic suction cups

- Water balance
  - Rain and snow measured daily by personnel at the research farm
  - ET modeled using FAO-56 Penman-Monteith method with dual crop coefficients (input data from Bill Bland)
  - Soil water storage to 1-m depth determined daily
  - Runoff negligible
  - Drainage estimated by difference

How?

W1188 Objective 2: **To develop and evaluate instrumentation and methods of analysis for characterizing mass and energy transport in soils at different scales.**

- Needed reliable method to measure soil water storage to 1-m depth at the plot scale

- Challenges
  - Perennial kura clover root system
  - 4 hour travel time to site
  - 2-3 year duration of experiment
  - 3 treatments of interest X 4 replications
  - Instruments must not interfere with planting and harvesting
  - Limited budget

- What would you do?

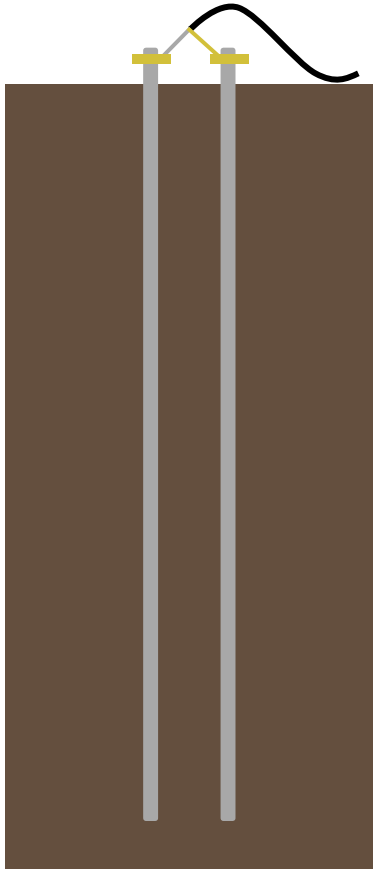
Coated waveguide pros and cons

- PVC coating increases the amplitude of the end reflection in the TDR signal

- Under homogeneous conditions the apparent permittivity is given by

$$K_m^{-1} = w_{ring} K_{ring}^{-1} + w_{soil} K_{soil}^{-1}$$

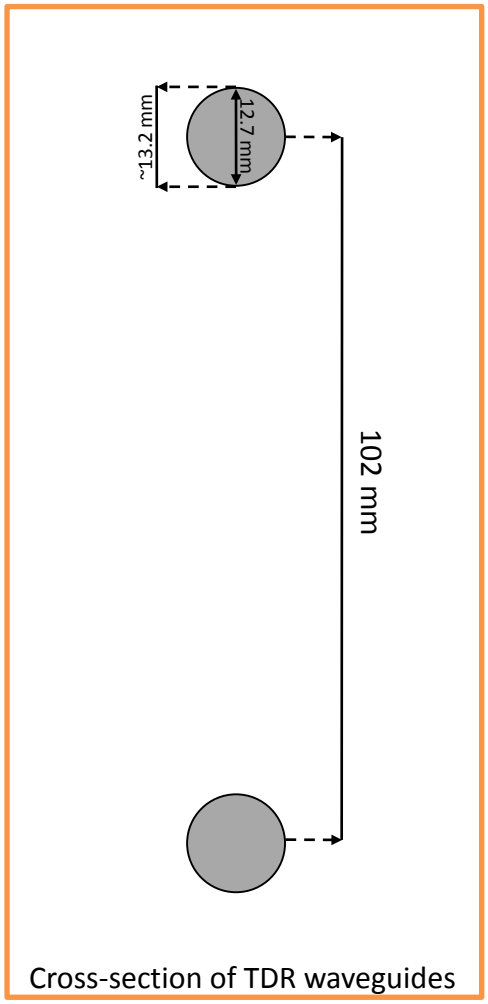
- Coated waveguides do not measure the true average water content when water content varies axially (Ferré et al., 1996)



Reasons for hope

- The error in the water content for non-homogenous conditions decreases as w_{ring} decreases
- For our sensors w_{ring} = 0.028
- The silt loam soil at the site does not have strong layering

Layer	Organic matter	Sand	Silt	Clay
cm	g kg^{-1}		%	
0-25	38.9	16	64	20
25-50	23.8	13	61	26
50-75	18.9	11	60	28
75-100	15.9	16	60	24

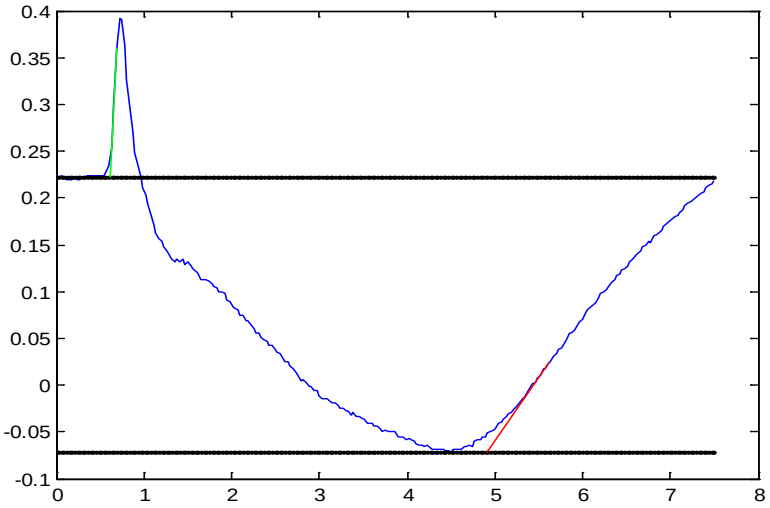


Cross-section of TDR waveguides

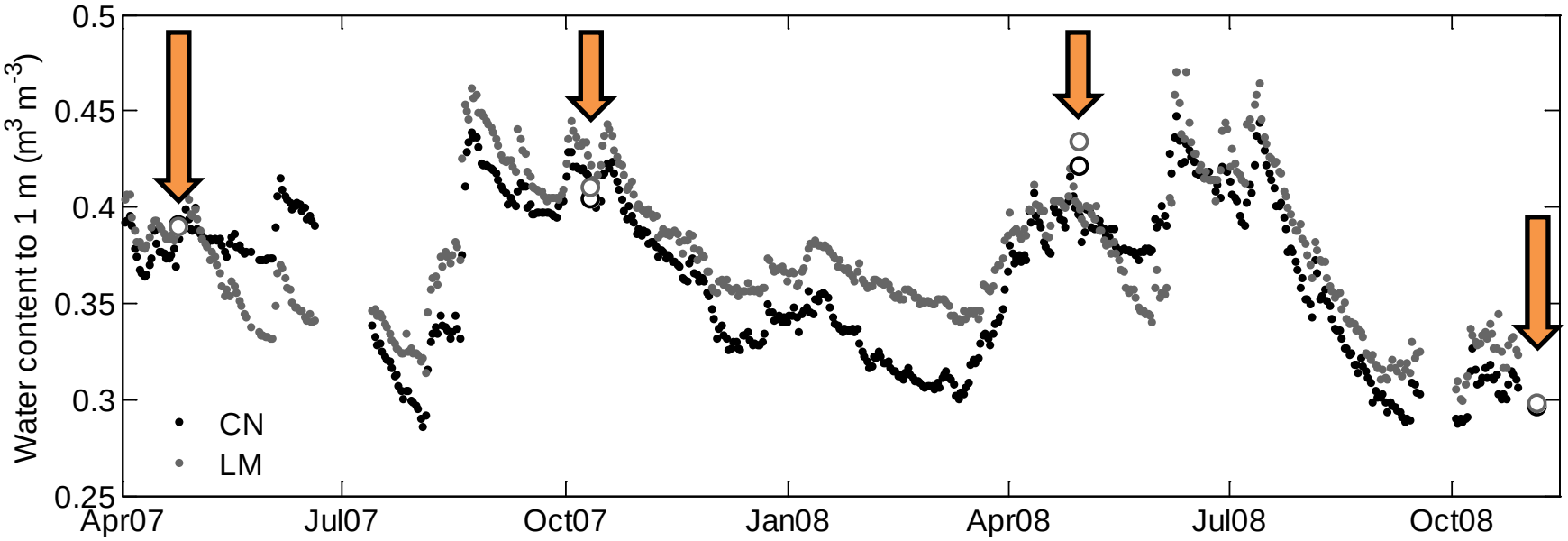
Implementation

- Materials
  - TDR 100, 8 channel multiplexer, CR10X logger
  - RG-6 coaxial cable
  - ½ inch x 1-m stainless steel waveguides
  - Heat shrink PVC coating
  - Grounding clamps
  - Installation kit

- Data processing
  - Dual tangent line analysis for L_a
  - L_a to K_m assuming 0.1 m offset
  - K_m to K_{soil} by Ferré et al. (1996)
  - $\theta = -0.176 + 0.115 * \sqrt{K_{soil}}$



Results



- The system provided consistent and plausible water content data
- The data agreed with soil sampling data to within ± 0.035 m^3 m^{-3}
- System advantages: easier install, fewer sensors, better spatial replication, less site disturbance
- The data provided valuable insights into the function of the living mulch cropping system

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Questions or comments?

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