SAGEEP - 2011 (Charleston, South Carolina)
April 13, 2011

Mapping Vertical Profiles of Apparent Electrical Conductivity in Soils Using Angular Scanning Approach

Viacheslav I. Adamchuk
McGill University
(Ste-Anne-de-Bellevue, Quebec)

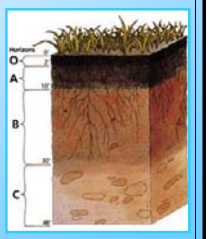
Ahmad S. Mat Su
University Putra Malaysia
(Selangor, Malaysia)

Roger A. Eigenberg
USDA-ARS
(Clay Center, Nebraska)

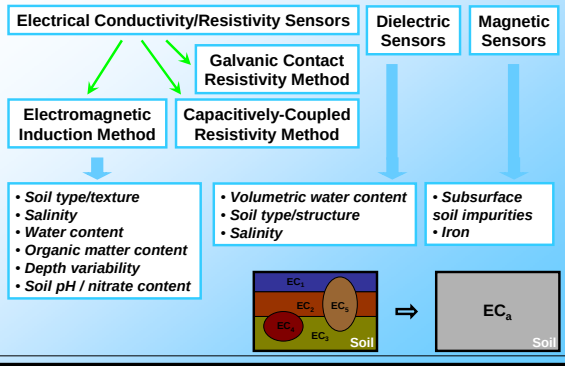
Richard B. Ferguson
University of Nebraska-Lincoln
(Lincoln, Nebraska)

Problem Statement

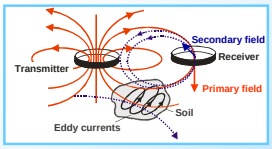
- Soil apparent electrical conductivity (EC_a) can be related to a number of properties that affect crop growing conditions
- Soil spatial variability has been evaluated using one or several different EC_a data layers
- Change of EC_a with depth can be related to the ability of soil to drain and accumulate water as well as to store nutrients to satisfy crop demand



Electrical end Electromagnetic Sensors



Electromagnetic Induction Method



Geonics Limited
(Mississauga, Ontario)
http://www.geonics.com

Geonics EM-38
horizontal – 0.75 m
vertical – 1.5 m

Dualem, Inc.
(Milton, Ontario)
http://www.dualem.com

DUALEM – 1S
co-planar – 0.4 m
perpendicular – 0.95 m

Vertical Sounding Techniques

- Using multiple receiving coils at different distances from the transmitting coil
- Using multiple operation frequencies
- Using vertical, horizontal, or hybrid (one coil vertical and one horizontal) modes of operation
- Raising the instrument to different heights above the ground

Angular Scanning

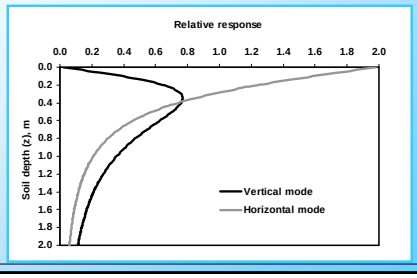
Research Objectives

- To develop an instrumented platform for an automated angular EC_a scanning using an electromagnetic induction (EMI) sensor
- To evaluate the system development in a field with different soil EC_a profiles

Instrument Response Function

$$EC_a = \int_0^{\infty} \phi(z)\sigma(z)dz$$

$$\phi(z) = \begin{cases} 2 - \dfrac{4z}{(4z^2+1)^{1/2}} & \text{for horizontal operation} \\ \dfrac{4z}{(4z^2+1)^{3/2}} & \text{for vertical operation} \end{cases}$$

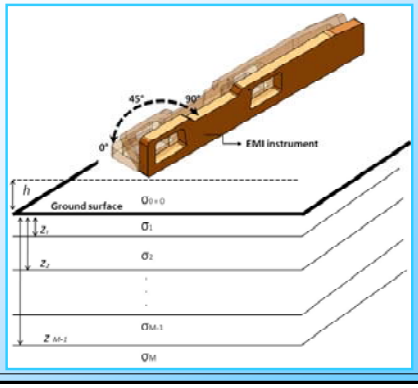


Raising the Instrument Effect

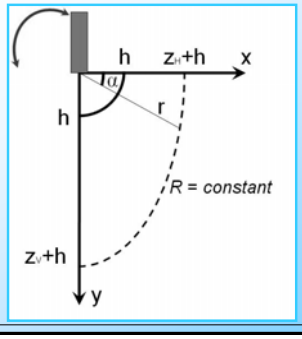
$$m(h) = \int_0^{\infty} \phi(z+h)\sigma(z)dz$$

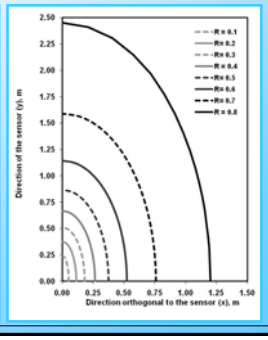
$$\phi(z+h) = \begin{cases} 2 - \dfrac{4(z+h)}{(4(z+h)^2+1)^{1/2}} & \text{for horizontal operation} \\ \dfrac{4(z+h)}{(4(z+h)^2+1)^{3/2}} & \text{for vertical operation} \end{cases}$$

Principle of Angular Scanning



Ellipsoid Representation of Cumulative Response Function



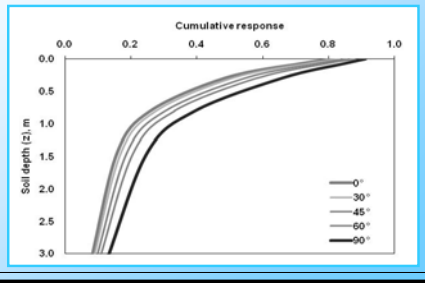


Cumulative Response Function

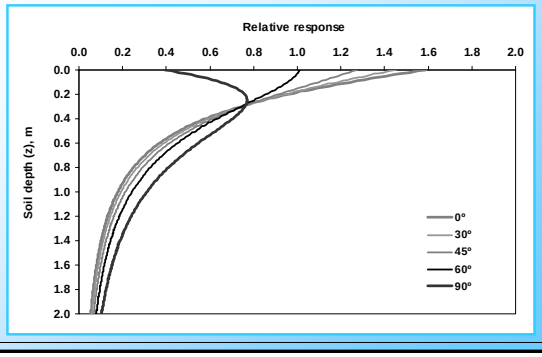
$$R = \sqrt{\frac{-B+\sqrt{B^2+4A}}{2A}}$$

$$A = -1 - 4(z+h)^2 \sin^2\alpha$$

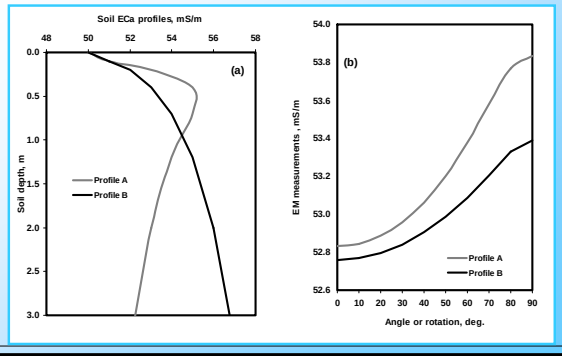
$$B = 2 + 4(z+h)^2 \sin^2\alpha + 16(z+h)^2 \cos^2\alpha$$



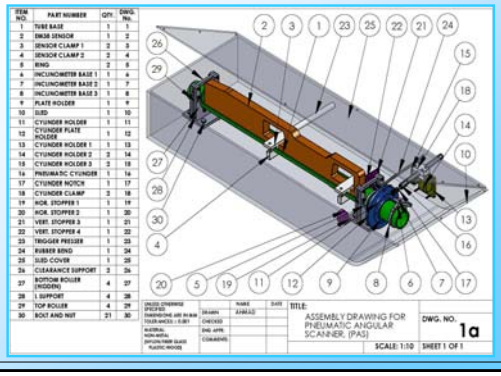
Relative Response Function



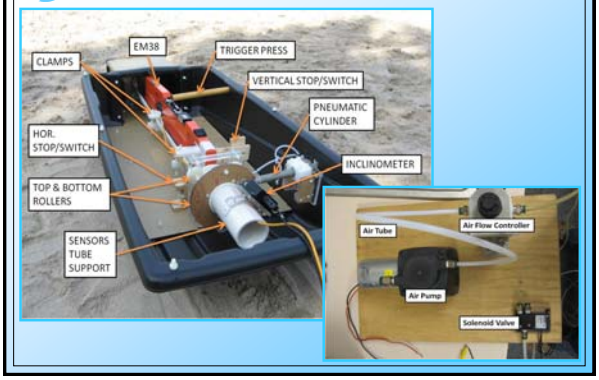
Effect of Soil Profile on Angular Scans



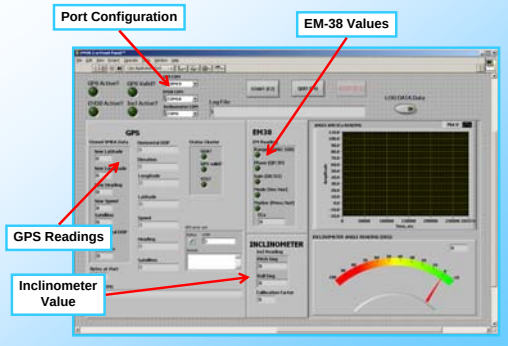
System Development



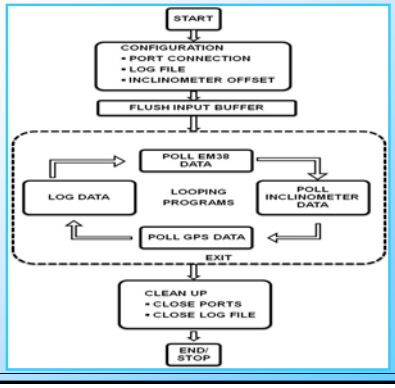
Pneumatic Angular Scanning System



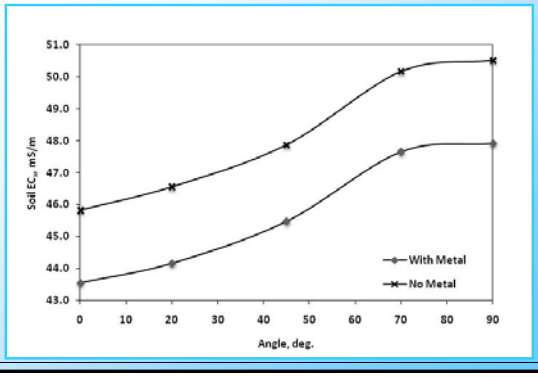
User Interface



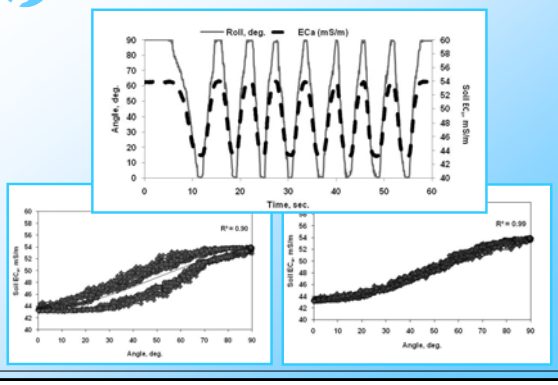
Software Logic



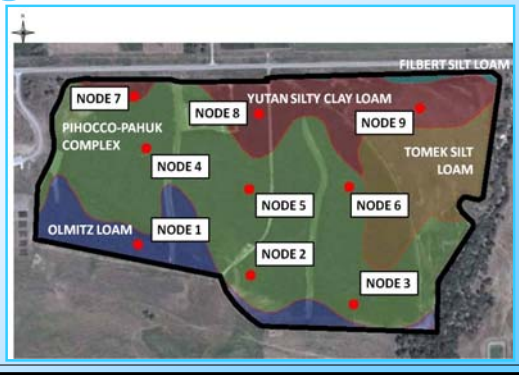
Influence of Metal Parts



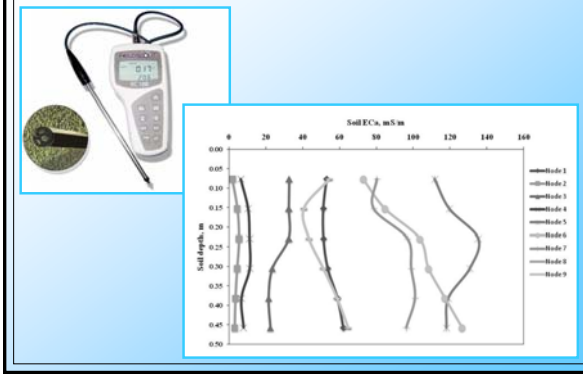
Instrument Lag



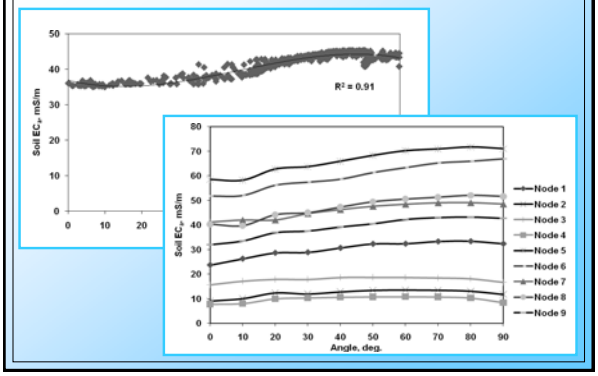
Field Evaluation



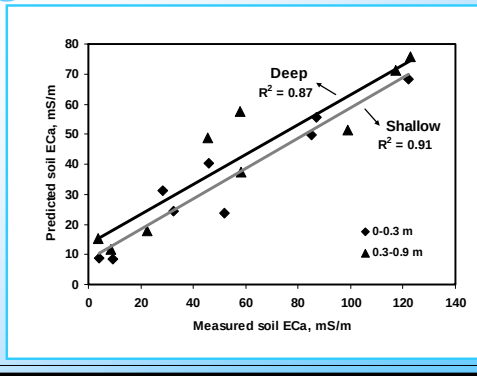
Measurement Validation



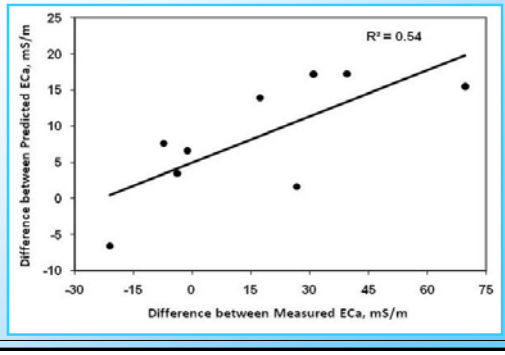
Angular Scans



System Evaluation (2x2 Matrix)



System Evaluation (2x2 Matrix)



Conclusions

- The Pneumatic Angular Scanning System (PASS) was developed to measure EC_a when continuously changing the mode of operation of an EMI sensor from vertical to horizontal and back
- At this time, the inversion technique was applied to only two hypothetical soil layers (0-0.3 m and below 0.3 m)
- Development of a more complex inversion solution and stated improvements in the data acquisition process should allow potential users to predict a set of parameters indicating the change of soil EC_a with depth at each field location, which ultimately would lead to 3-D soil modeling

http://bse.unl.edu/adamchuk
E:mail: vadamchuk2@.unl.edu