The 4th Global Workshop on Proximal Soil Sensing (Hangzhou, China)

Automated On-the-Spot Analysis of Physical, Chemical and Biological Soil Properties

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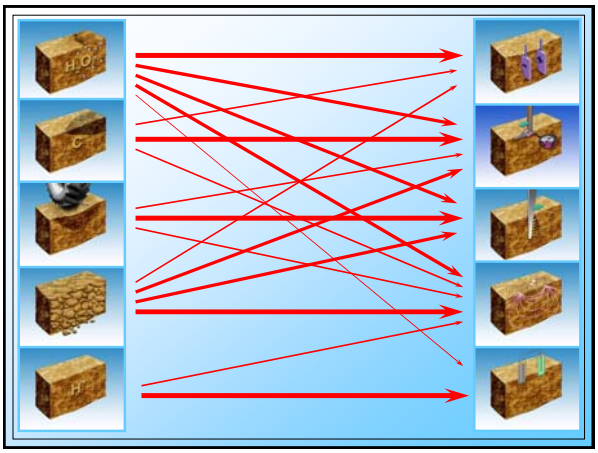
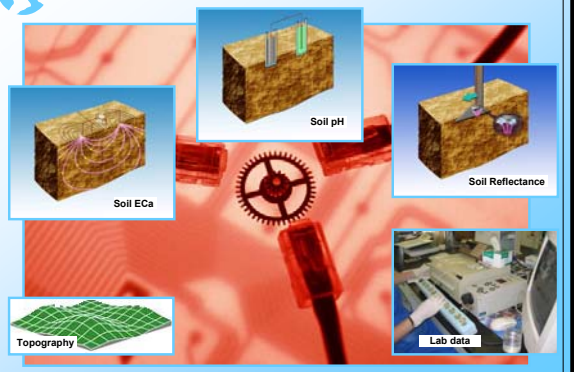
McGill University

May 13, 2015

McGill

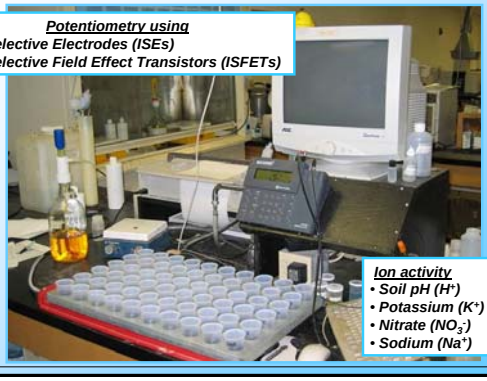


Sensor Fusion



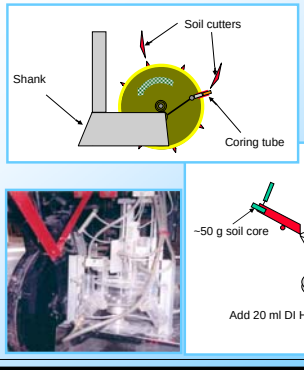
Electrochemical Sensors

Potentiometry using
- *Ion-Selective Electrodes (ISEs)*
- *Ion-Selective Field Effect Transistors (ISFETs)*

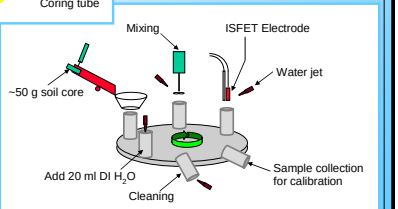


Ion activity
- *Soil pH (H^+)*
- *Potassium (K^+)*
- *Nitrate (NO_3^-)*
- *Sodium (Na^+)*

Automated Soil Testing



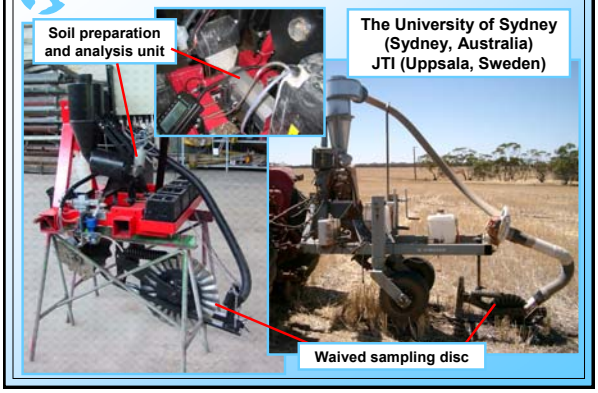
Purdue University
(West Lafayette, Indiana)
1993-1996



Soil/Buffer pH Mapping On-the-Go

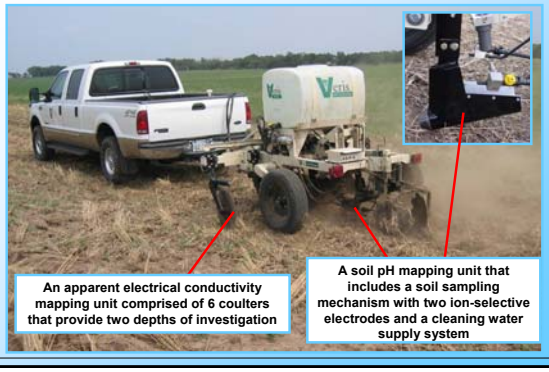
Soil preparation and analysis unit

The University of Sydney (Sydney, Australia)
JTI (Uppsala, Sweden)



Waived sampling disc

Veris® MSP

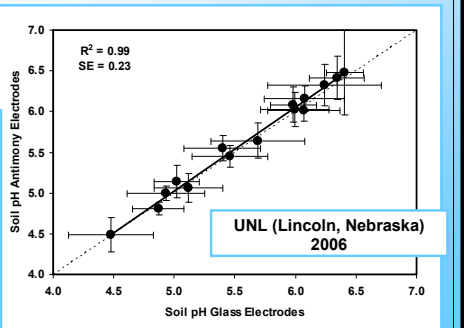


An apparent electrical conductivity mapping unit comprised of 6 coulters that provide two depths of investigation

A soil pH mapping unit that includes a soil sampling mechanism with two ion-selective electrodes and a cleaning water supply system

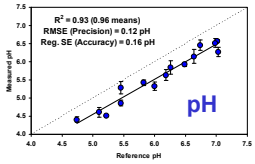
Antimony Electrode

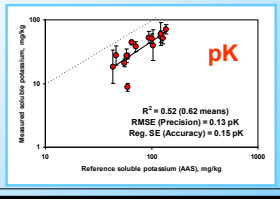
Sandy and stony soils

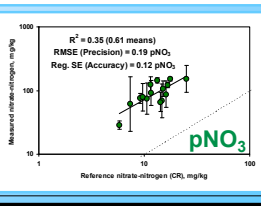


Integrated Direct Soil Measurement

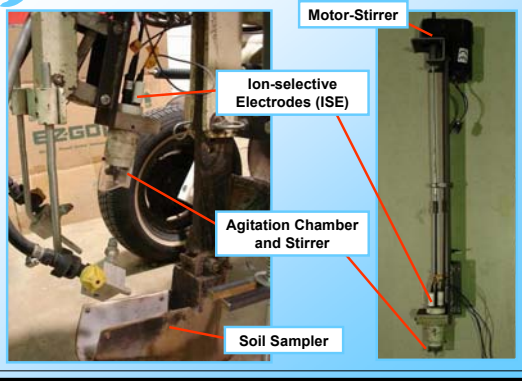
UNL (Lincoln, Nebraska)







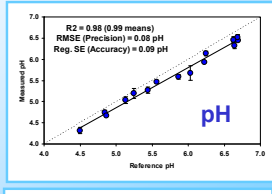
Agitated Soil Measurement

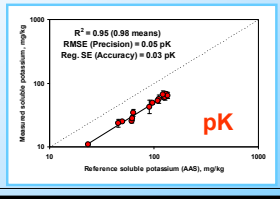


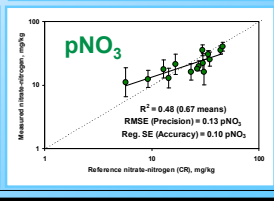
Agitates Soil Measurement

Reference tests:

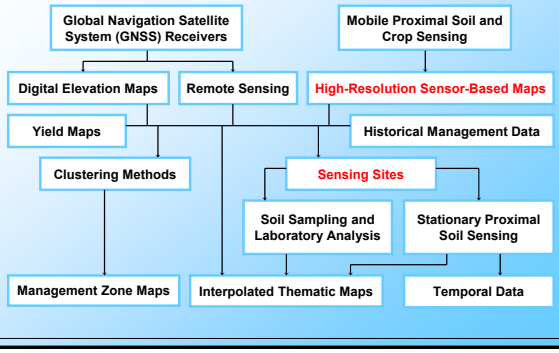
- **Soil pH**
  - glass ion-selective electrode
  - RMSE = 0.05 pH
- **Soluble potassium**
  - atomic adsorption spectroscopy (AAS)
  - RMSE = 0.01 pK
- **Residual nitrate**
  - cadmium reduction (CR)
  - RMSE = 0.02 pNO_3





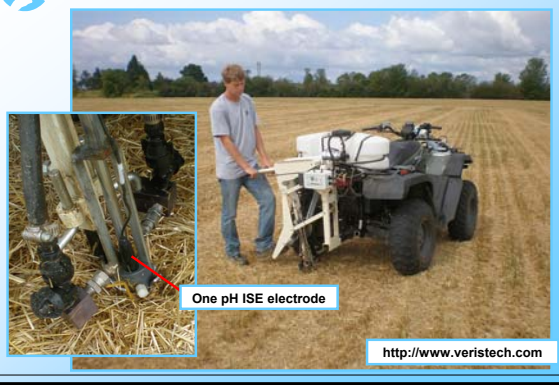


Data Integration



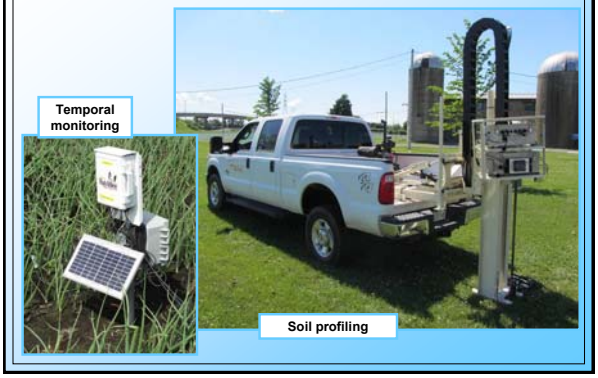
Portable Probe

Veris® pH Detector



Semi-Automatic Soil Sampling

Point Measurements

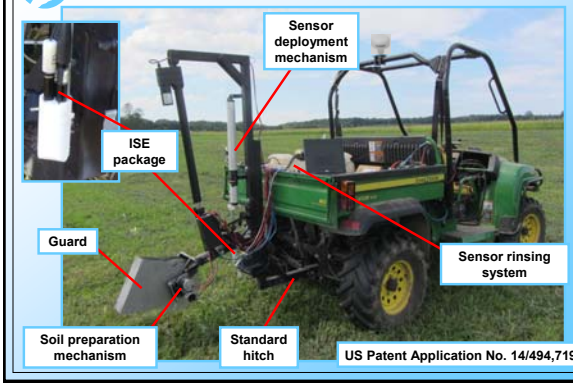


On-the-Spot Soil Analysis

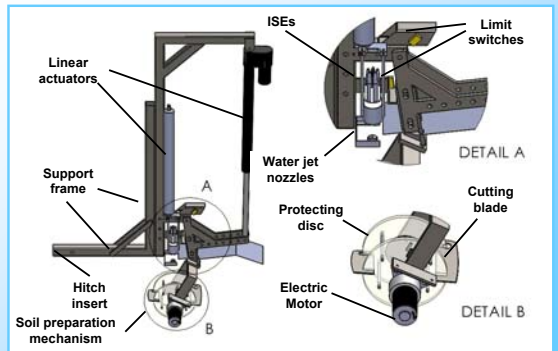
- *In situ* measurement
- Predefined depth near soil surface
- Preconditioned surface
- Sensor integration
- Autonomous operation
- Vehicle versatility
- Low cost

http://static.guim.co.uk/sys-images/Guardian/Pix/audio/video/2012/10/14/1350228832501/Mars-Curiosity-rover-test-012.jpg

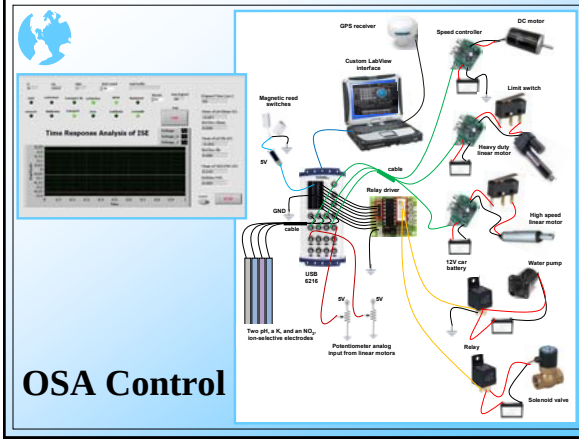
On-the-Spot Analyzer (OSA)



Principle of OSA



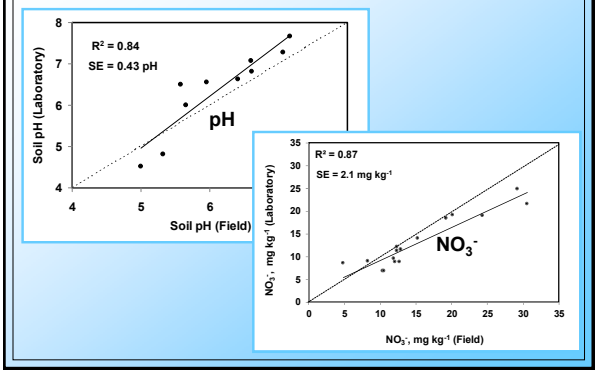
OSA Control



Sensor Package Options

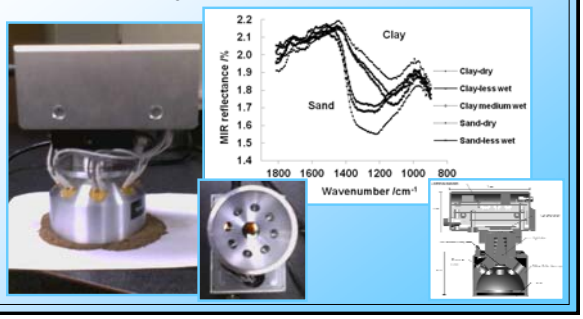
- **Ion-Selective Electrodes**
  - pH (antimony) and ions (PVC)
- **Mid-Infrared Spectroscopy**
  - 2 780 to 5 096 or 5 500 to 10 800 nm
- **Microscopy**
  - 2 µm resolution RGB imagery
- **Biological Activity**
  - substrate-induced CO_2 emission
- **Physical Conditions**
  - moisture (capacitance) and temperature (IR)

ISE Electrodes

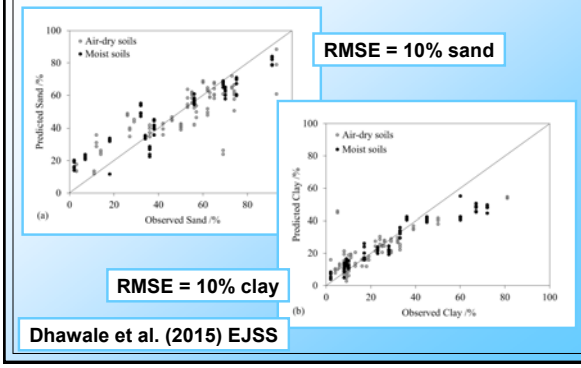


MIR Spectroscopy

Diffuse Reflectance Variable Filter Array Mid-Infrared (MIR) spectroscopy (2 780 – 5 096 or 5 500 – 10 800 nm



MIR Spectroscopy

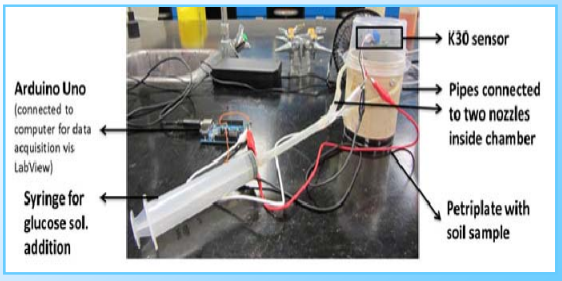


RMSE = 10% sand

RMSE = 10% clay

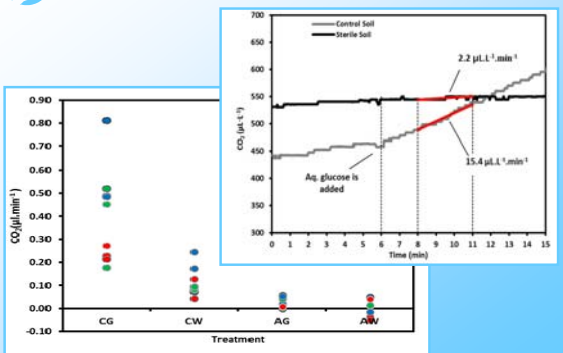
Dhawale et al. (2015) EJSS

Substrate-Induced Soil CO_2 Emission Sensor System

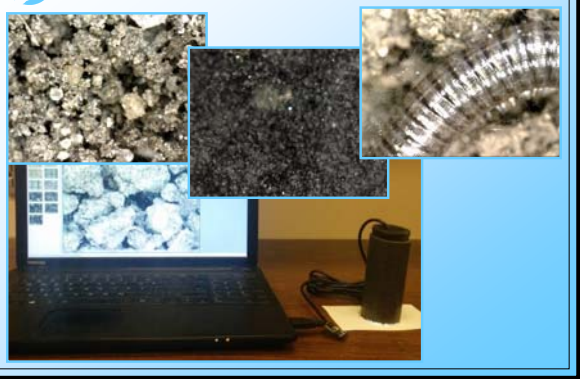


Kaur et al. (2015) Sensors 15: 4734-4748

Sensing Soil Bioactivity

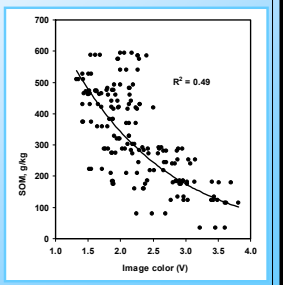


Soil Microscopy



Soil Microscopy

- Color transformation
  - RGB vs. HSV
- Geostatistics
  - Variograms
- "Watershed" modeling
  - Void ratio
- Wavelet transformation
  - Particle size distribution
- ???



Biswas et al. (2015) GWPSS

OSA Highlights

The system was designed in such a way that it can be operated from the standard hitch of a pickup, an all-terrain vehicle, or another platform.

Measurement locations and density can be either predefined or adjusted in real time to respond to the quality and variability of the measurements already obtained at a given site.

The low destruction approach makes this method applicable to specialty and perennial crop environments.

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