Proximal sensing of soil properties using VisNIR Spectroscopy and Bulk Electrical Conductivity

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⚠ “**Warning**: Soil map **may not be valid at this scale**. You have **zoomed in beyond the scale** at which the soil map for this area is intended to be used.…The **soil surveys** that comprise your AOI were **mapped** at **1:24,000**.…”

Soil Mapping Tools

Coarse Spatial Resolution (Km)

- Coring and lab characterization
- Costly
- Extensive labor
- High quality data

Fine Spatial Resolution (m)

- Proximal Sensors
- Fixed Costs
- Faster
- Relative Information

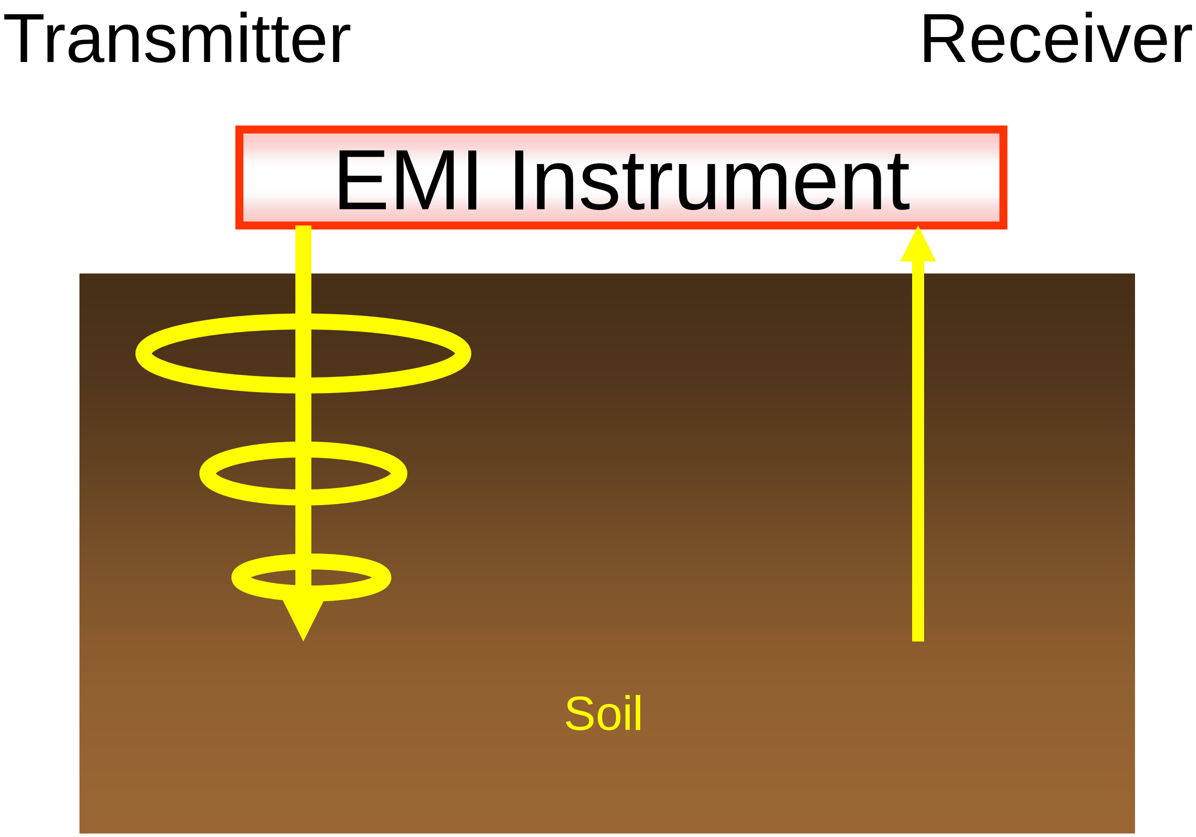
Proximal Soil Sensing

- Bulk Soil Electrical Conductivity (ECa)

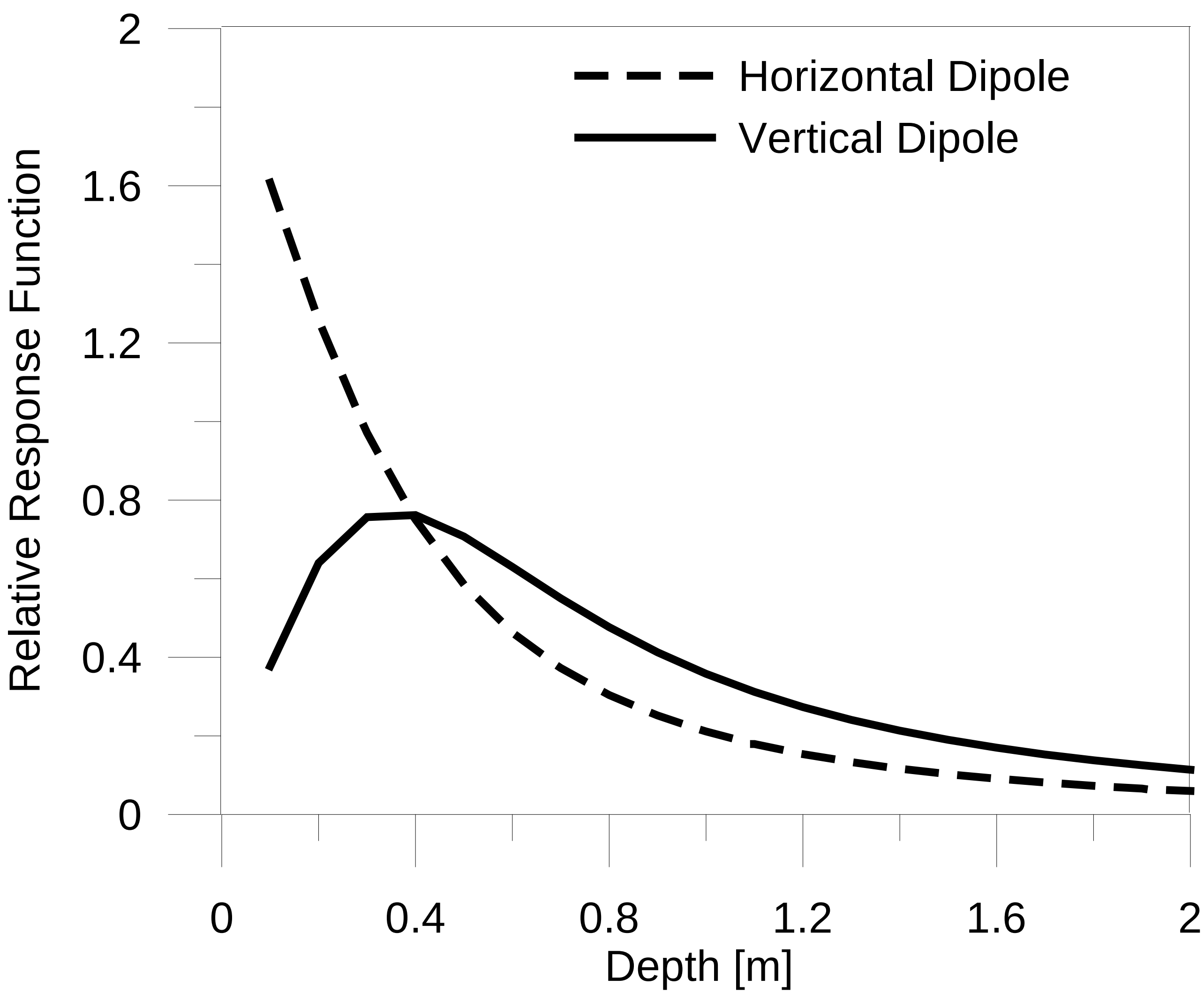
- Provides high resolution spatial information
- 1 to 20 m scale
- Relative Information

EC_a Survey Equipment

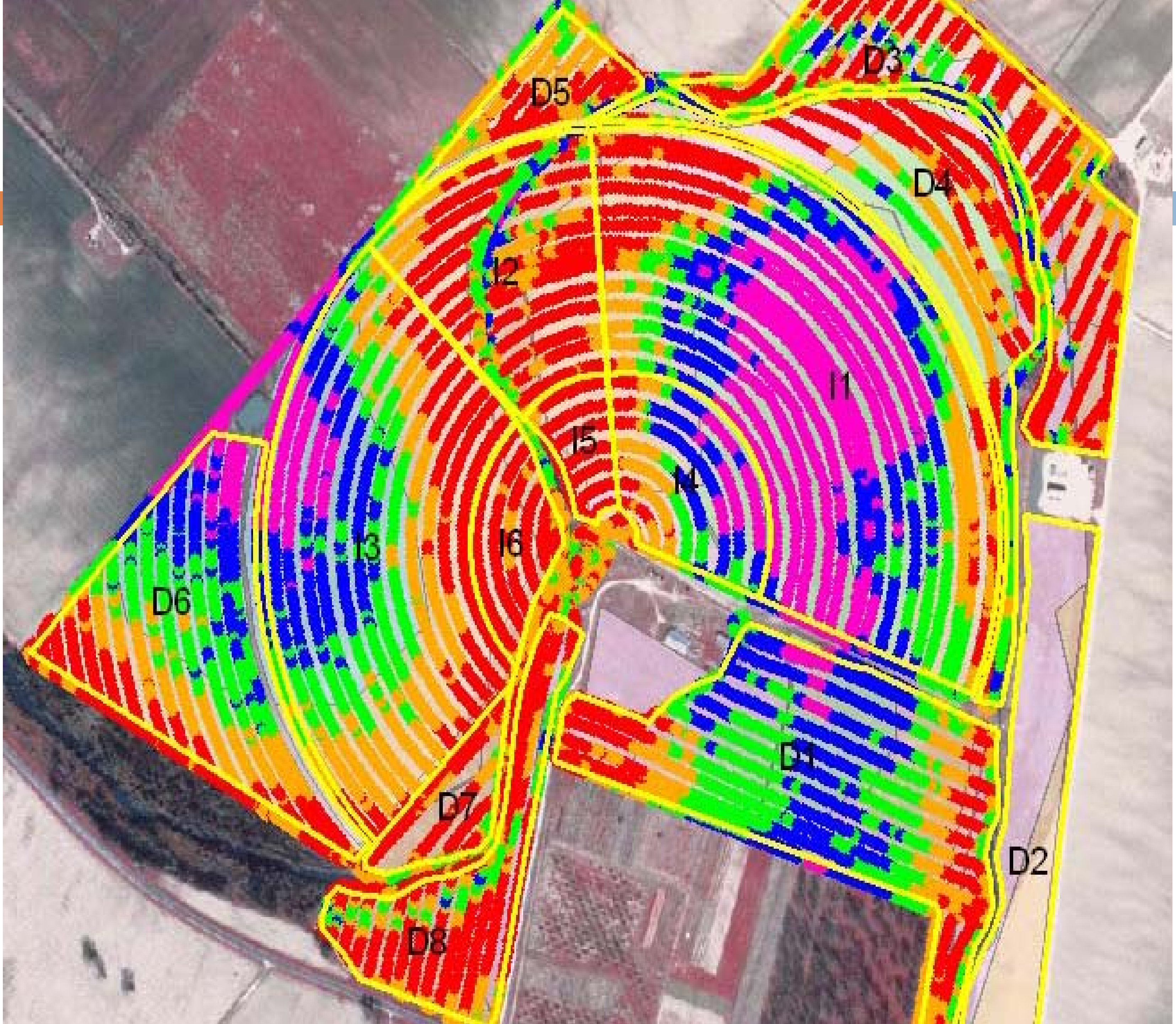
How EMI Works



EMI Depth Response Function



McNeill, 1980


D5
D3
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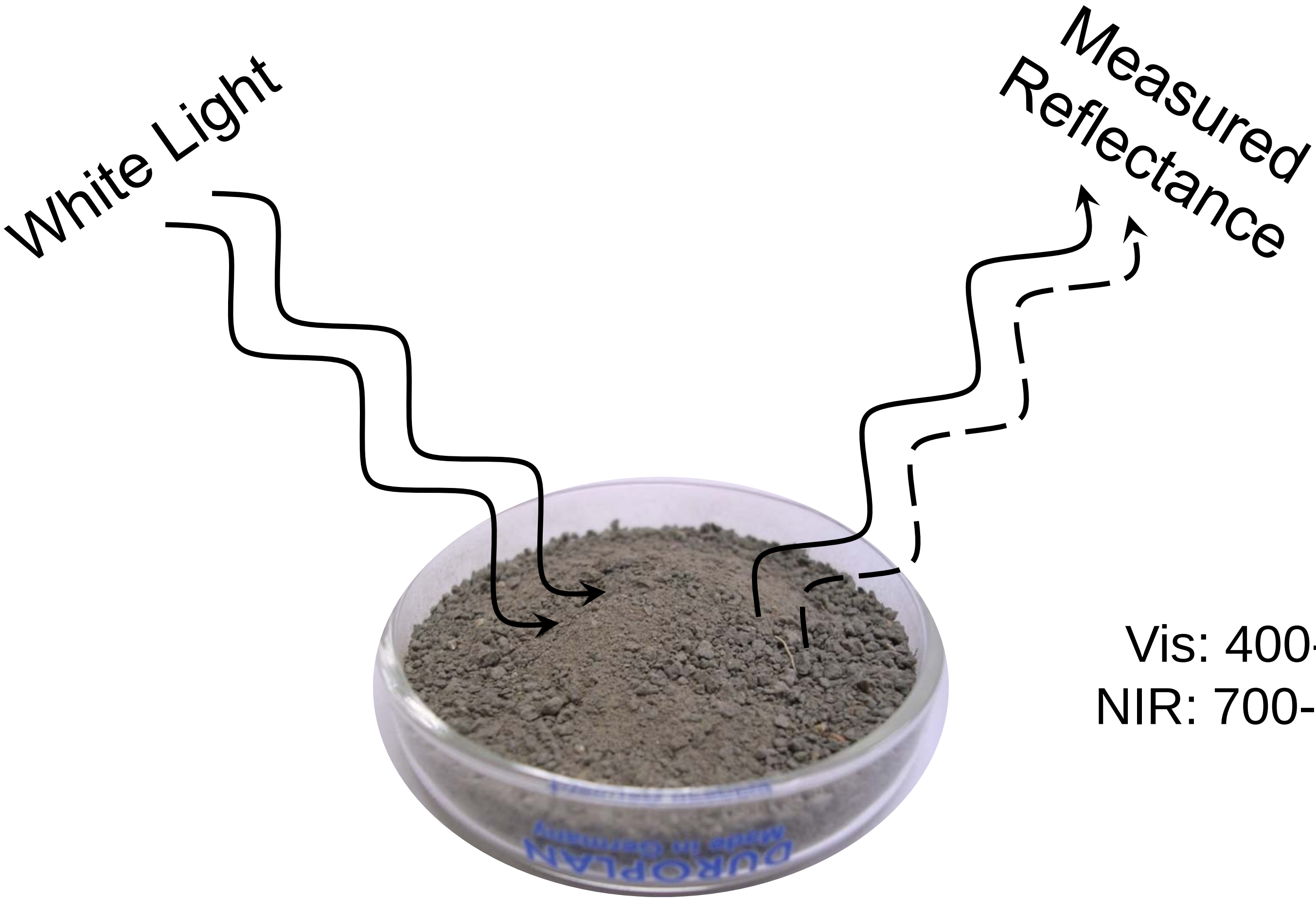
D8

Proximal Soil Sensing

- Visible and near infrared diffuse reflectance spectroscopy (VisNIR-DRS).

- Provides high quality soil profile characterization.
  - Faster than traditional soil coring and lab analysis.
  - Compliments high-resolution data provided by EC_a.

Principle of VisNIR-DRS



air-dried, ground soil sample

Vis: 400-700 nm
NIR: 700-3000 nm

Principle of VisNIR-DRS

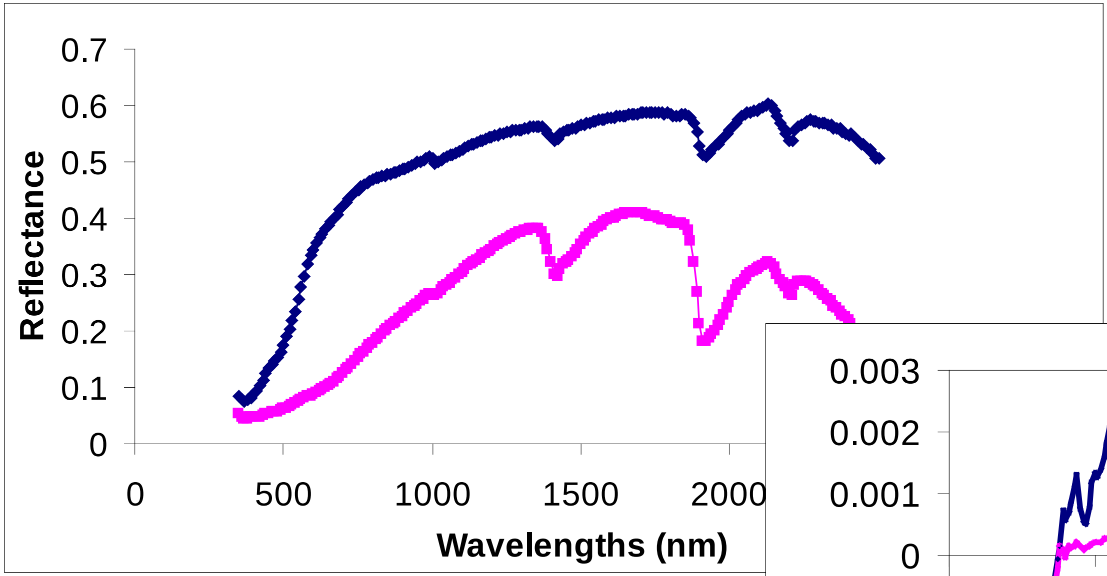
- Absorption features based on molecular overtones and vibrations.

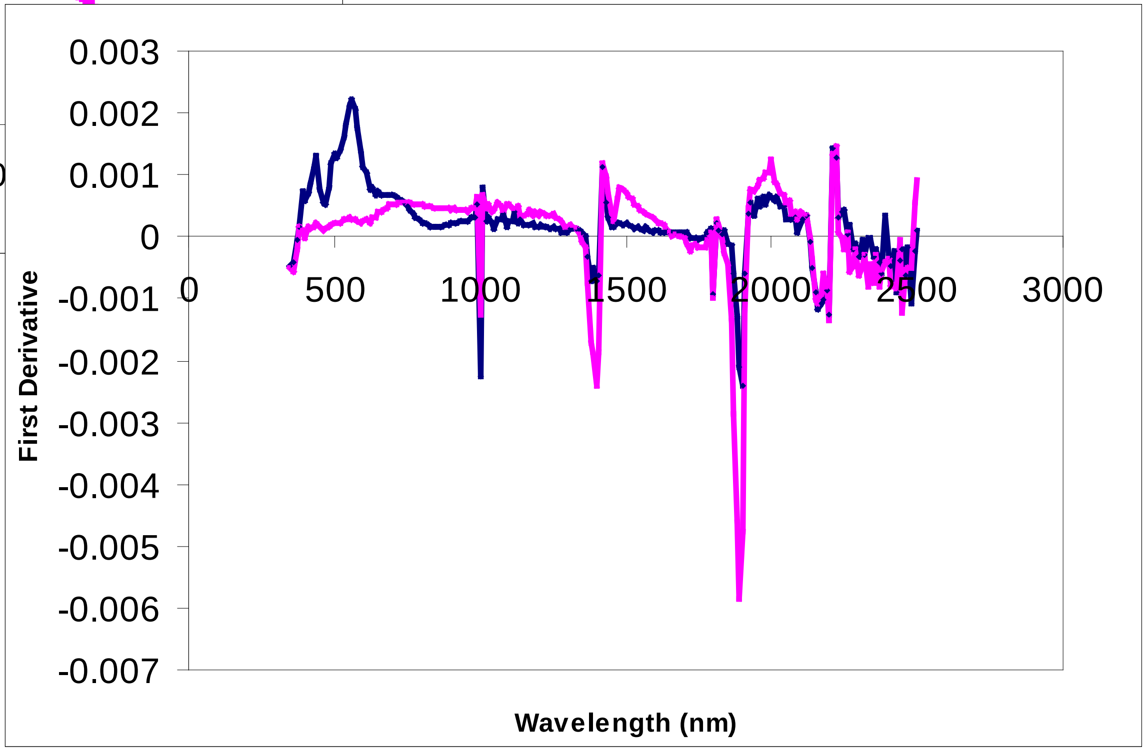
- **Clay-sized particles**
  - *Kaolinite, illite*, and *smectite*
  - Overtones and combinations of H_2O and CO_2

- **Organic carbon**
  - Active bonds of O-H, C-N, N-H, and C=O

- **Inorganic carbon**
  - *Calcite* and *dolomite* have distinct adsorption features (CO_3^{2-})

VisNIR Spectral Data





Laboratory use of VisNIR-DRS

- Predicts soil properties of air-dried, ground soils.

Soil Property	Total Clay	Organic Carbon	Inorganic Carbon	Total Sand	Total Silt
	Standard Error of Prediction (SEP), %				
Waiser et al., 2007; Morgan et al., 2009	6.2	0.46	0.73	x	x
Brown et al., 2005	5.4	0.79	0.56	x	x
Shepherd and Walsh, 2002	7.5	0.31	x	10.8	4.9

In situ use of VisNIR-DRS

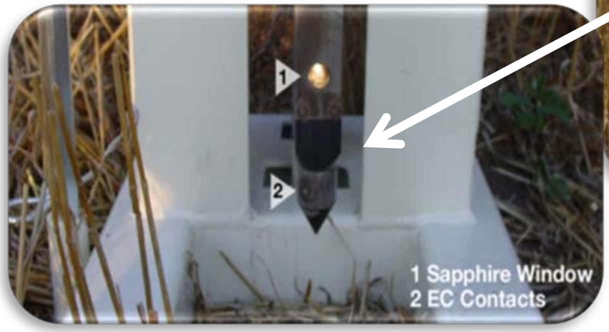
- VisNIR-DRS has been tested on intact cores.
- Cores were removed and scanned in the lab.

	Air dried, ground	Intact core
	SEP, %	
Total Clay	6.2	6.1
Organic Carbon	0.46	0.54
Inorganic Carbon	0.73	0.87

Waiser et al., 2007 and Morgan et al., 2009

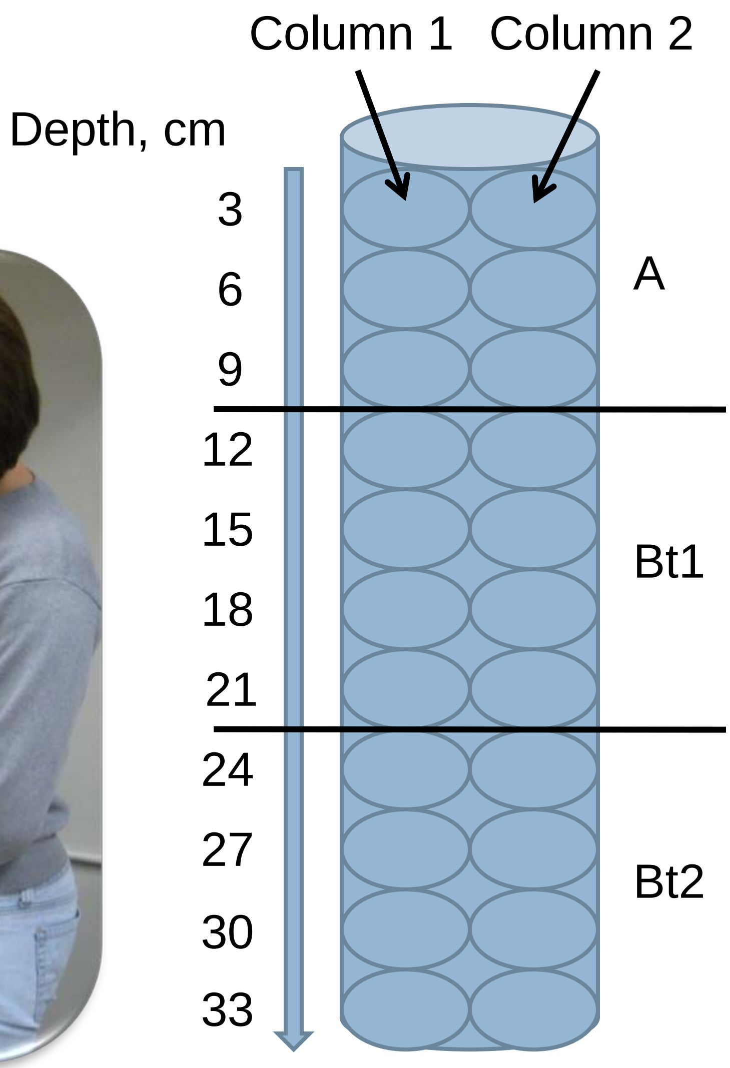
VisNIR-DRS on a Penetrometer

- Field predictions can be problematic.
  - Varying range of water content
  - Field heterogeneity
  - Regionalism of calibration models
  - Statistical techniques for predictions



Veris® Technology P4000 VIS-NIR EC-Force Probe

Scanning and Lab Analysis



Recent Research Objectives
Katrina Wilke M.S. thesis

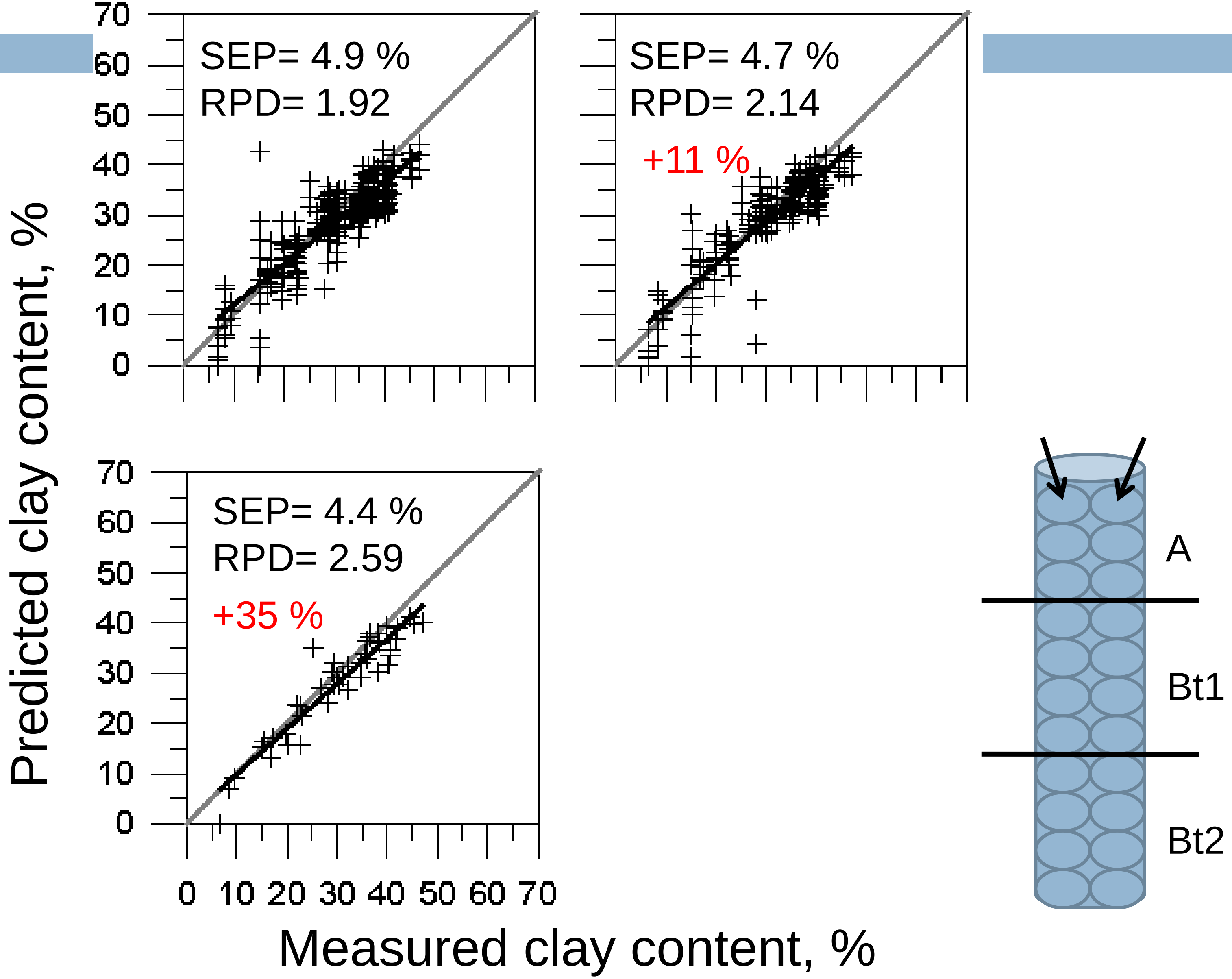
1) Is there a benefit for scanning at uniform moisture?

2) How does the estimation of prediction change when spectra from multiple scans are averaged?

3) What is the gain in prediction accuracy by boosting an in situ spectral library with local samples?

4) How do quantitative and categorical classification of soil series using VisNIR-DRS compare?

Effect of Continuous Scans



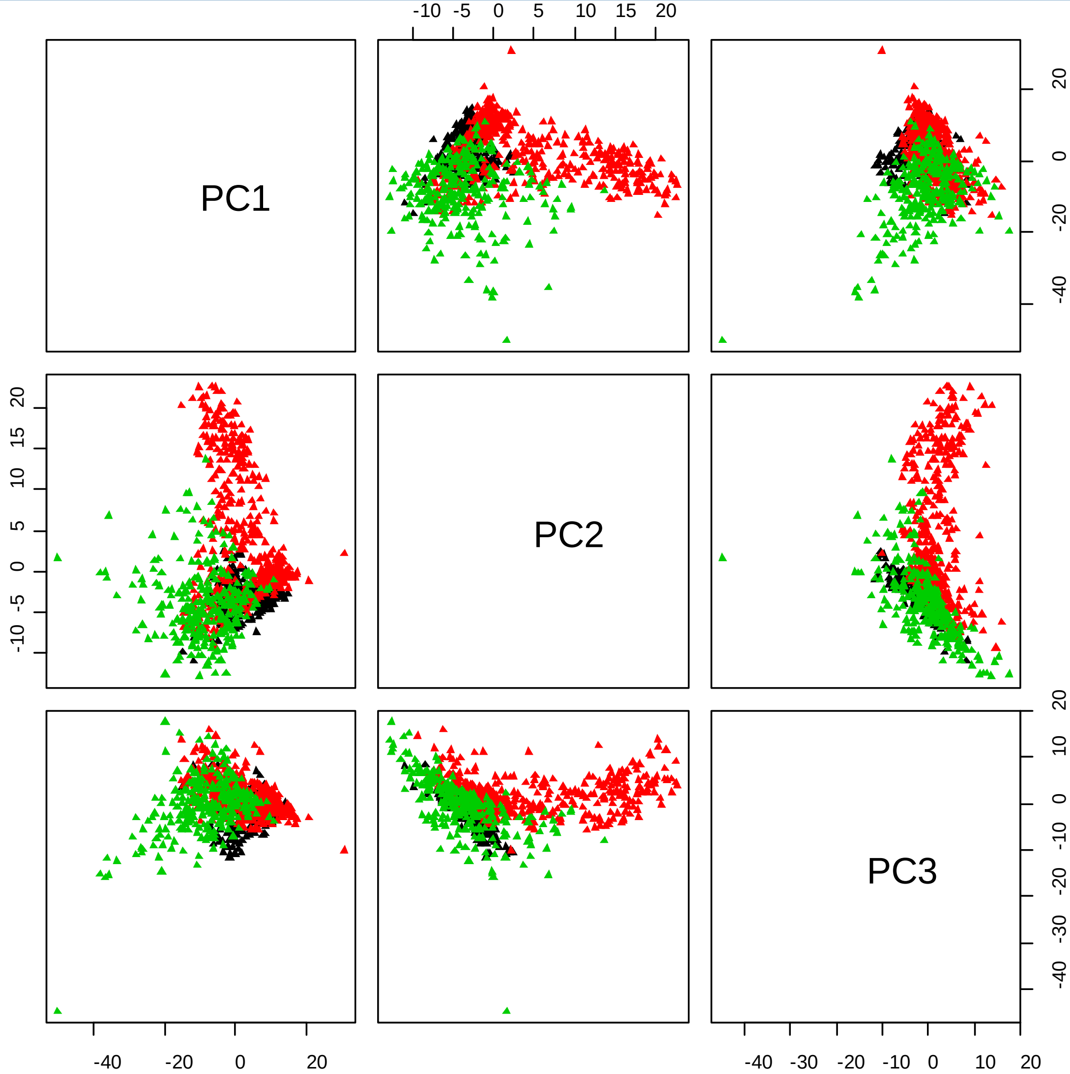
Boosting the Calibration with a Library

	SEP, %	RPD
Central Texas, Boosted		
Field 100		
Clay	6.8	0.88
Field 200		
Clay	7.9	1.50

+80 %

+34 %

Series- Field 100
Series- Field 200
Series- Central Texas



Classification of Soil Series

- **Quantitatively, by first predicting Clay Content**
  - 19 of the 27 (70 %) cores were classified correctly

- **Categorically, directly categorizing into series**
  - 19 of the 27 (70 %) of the soil series classified correctly

Conclusions

- *Overall*, VisNIR-DRS can classify soil series

  1) Uniform moisture improves prediction accuracy

  2) Multiple scans at each horizon illustrates within horizon variability

  3) Boosting a library with local samples improves predictions

  4) Classifying soils into soil series using clay content profiles performed similar to a direct statistical classification into profiles

Future Work

- Methodology needs to be developed for:
  - Creating larger regional and global intact, whole-profile spectral libraries.
  - Calculating the minimum number of local samples required for boosting prediction accuracy.
  - Using multivariate techniques for selecting soils to be include in the spectral libraries.