Agriculture Research and Development

Soil Moisture Mapping Using Multi-frequency and Multi-coil Electromagnetic Induction Sensors on Managed Podzols

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Project Objective

The overall goal of this study was to comparatively investigate the potential of multi-coil and multi-frequency EMI sensors and the various combinations of these instruments for agricultural systems on managed podzols. We aimed to develop a relationship between ECa, as measured by both instruments, and SMC measured using in-situ gravimetric and HD2-TDR. This allowed us to compare the performance between the ECa and SMC-based projections.

Background

Development of site-specific management (SSM) over large fields is the goal of precision agriculture (PA). PA encompasses the use of spatial and temporal information of soils to select the best agronomic practices. Different types of spatial information derived from EMI surveys can offer significant support to the development of accurate management decisions.

Apparent electrical conductivity (ECa) can be used to characterize the spatial variability of soil properties in support of management decision in PA.

PA provides a way to automate SSM using information technology, thereby making SSM practical in commercial agriculture. CMD Mini-Explorer is a multi-coil EMI sensor, which operates at 30 kHz and has one transmitter and three coplanar receiver coils with different distances (32, 71, and 118 cm). GEM-2 is a multi-frequency EMI sensor with one transmitter coil and a receiver coil separated by 166 cm, which can be operated in a frequency band between 30 Hz to about 93 kHz. Mapping of SMC at field scale required site-specific calibration to derive reasonably accurate models to predict SMC from EMI measurements.

Technical Details and Prelimary Results

The study was carried out at Pynn's Brook Research Station (PBRS) in Pasadena in 2016.

Soil samples (n = 7) analyzed for the study site revealed a gravelly loamy sand (sand = 82.0% (±3.4); silt = 11.6% (±2.4); clay = 6.4% (±1.2)) with an average bulk density of 1.31 g cm-3 (±0.07) and porosity of 51% (±0.03).

SMC was measured gravimetrically as the standard, and TDR as the most commonly used methods. ECa data were collected using CMD Mini-explorer and GEM-2. Both instruments provided promising results with respect to the variability of ECa and the estimated SMC.

A good relationship was found between measured ECa from CMD and GEM-2 at the study site. The plot of CMD and GEM-2 was observed to have similar values for the selected coil and frequency used in the study. Maximum, minimum and average measured and predicted (using ECa) SMC were Apparent electrical conductivity (ECa) can be used to characterize, respectively.

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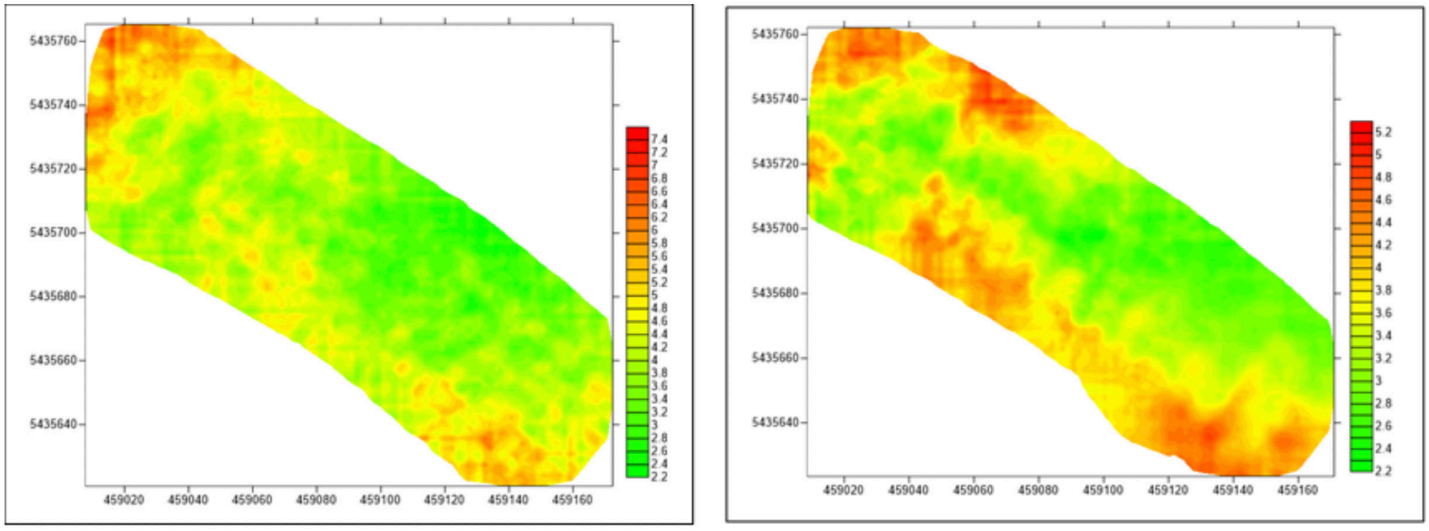

Figure 1: Spatial variability of measured ECa using CMD Mini-explorer using two different survey orientations covering grass, silage-corn and corn-soybean intercropping at PBRS.

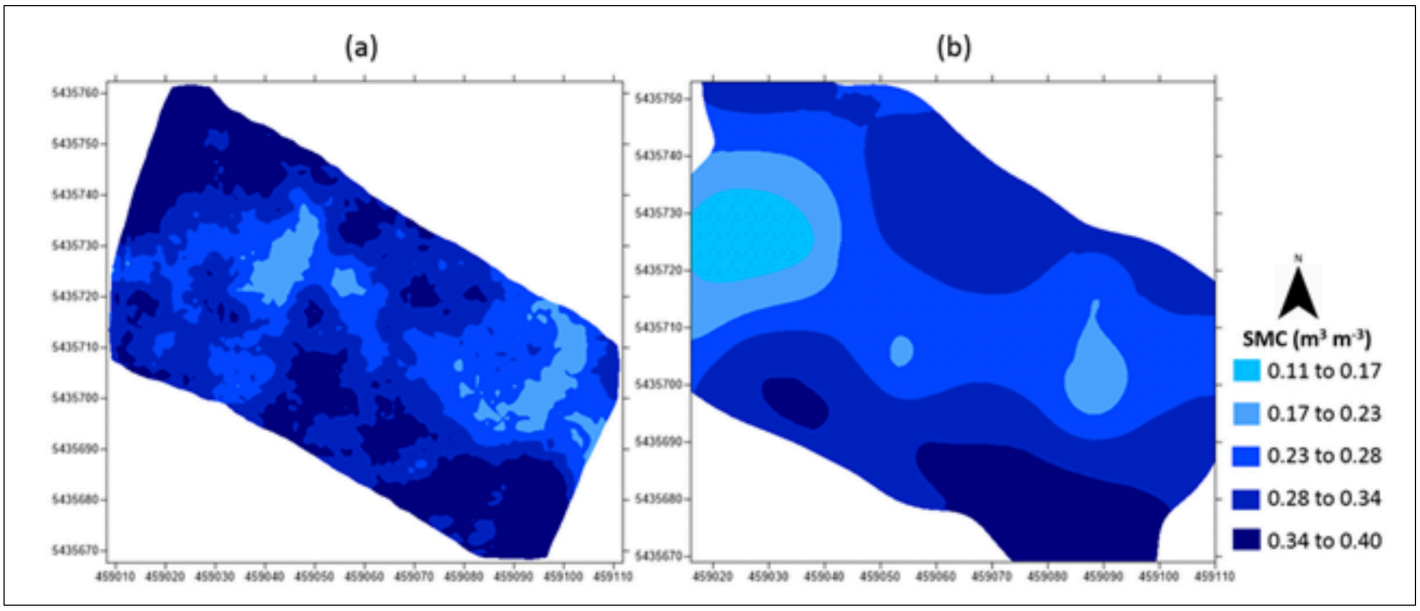

Figure 2: SMC variability maps for the large field study estimated using CMD Mini-explorer (a) and 27 geo-referenced point measurements (b).

The rapid assessment of spatiotemporal variability of soil physical and hydraulic properties will be useful in:

- identifying increasing threats on land and water resources due to climate change,
- efficient management of soil fertility and crop water in increasing agricultural productivity,
- reducing the potential for contamination of soil and water resources due to agricultural inputs, and
- protection of ecosystem sustainability and biodiversity.

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