Introduction

The measurement and characterization of soil physical properties at the field scale is increasingly important in agriculture and natural resource management. Changes in topography, parent material, management practices, erosion, etc., can influence the variability of the soil’s physical properties. The Geonics EM38 is a noninvasive geophysical sensor that is used to measure the soils apparent electrical conductivity ($E_C$, in milliSiemens/meter) through electromagnetic induction – primarily influenced by clay content, soil moisture content, and salinity. Soil moisture is a significant contributor to $E_C$, allowing the EM38 to be used to measure both the spatial and temporal variation in Available Water Content (AWC) across a landscape. This study combined detailed lab analysis of soil physical properties at 14 discrete locations, within the same field, with EM38 surveys to examine the ability of EM38 to quantify and map soils based on their physical properties and surface soil moisture (0-15cm) in the root zone.

Objectives

1. Determine the ability of an EM38 sensor to measure the spatial variability of soil physical properties at the field scale in coarse-textured/gravelly Piedmont soils of North Carolina and map characteristics using a Geographic Information System (GIS).
2. Calibrate and test the sensors ability to measure temporal variability of soil moisture in the root zone.

Significance

The ability of an EM38 sensor to perform real-time, on-the-go sensing of key soil properties, such as soil moisture, means high resolution maps can be developed that will significantly aid in our understanding and management of soils. These maps can be used to direct soil sampling, placement of soil moisture sensors, and the delineation of management zones/soil restoration areas.

Materials and Methods

Study site description:

- A 1.65 hectare field at the NCSU Lake Wheeler Road Field Laboratory (LWFL) in the Piedmont region of North Carolina (Fig. 2) was selected as the study site.
- The site was selected based on an initial EM38 survey, variable topography, input from LWFL superintendent, cropping rotation, feasibility of in-season research, and proximity to NCSU campus.

Materials:

- Geonics EM38 geophysical sensor (Fig. 1) and 1.5 m tall PVC calibration stand
- Trimble Nomad 9600 DGPS (Differential GPS) unit with Farmworks Mobile 6.1 Software
- Slide hammer soil core sampler with sampling head and core sleeves
- Soil Push Probe

Results

Soil Physical Properties:

- Particle size analysis indicates small range of textural variation (Fig. 3)
- Gravel fraction within cores varied from 5% to 50% of soil core mass
- Available Water Content varied by 8% between core samples (Fig. 7)

EM38 and Soil Physical Properties:

- Discrete readings of EM38 were highly variable within 2m² area ($\sigma$: 0.4 - 3.1 mS/m)
- 52% of $E_C$ value explained by the clay fraction of the soil matrix (Fig. 4)
- No significant relationship was observed between $E_C$ and bulk density
- Lack of droughty conditions limited ability to calibrate $E_C$ to soil moisture

Conclusions

- EM38 values are highly related to soil textural properties, particularly clay
- Maps can be developed to estimate soil water content using measured physical properties and spatial analysis
- EM38 is useful for measuring spatial variability of soil physical properties and has applications as a decision support tool to guide soil sampling, instrument placement, planting decisions, water management, etc.
- The resolution of EM38 data collected allows for further differentiation of soil physical properties beyond standard resolution soil surveys
- Variations in EM38 readings over small areas were significant, making interpretations difficult
- $E_C$ measurements reflect multiple soil properties (i.e. clay, moisture, etc.) and interactions between individual properties may confound data, making characterization difficult

Acknowledgements

Funding provided by NSF REU Basic and Environmental Soil Science Training (BESSST) Project 1358938. We appreciate support of C. Niewohner for guidance in lab analyses; J. Taylor and I. Holzer for field data collection; and NextGen Air Transportation (NGAT) for aerial imagery.