Novel Flying EM Sensor for Agricultural Research

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Information on soil properties is of vital importance for crop development but very difficult to obtain from the online data stores such as satellite imagery repositories and digitized soil maps. Only the information about top soil is possible to derive from the imagery of the bare soil, and agricultural land is covered with crops most of the time. Soil profiles are complex and agronomical properties vary not only in the topsoil but also with soil depth. Collecting and analyzing soil samples to fully characterize soil spatial variability impacting crop productivity is not only time consuming but in most cases cost-prohibiting. While there are numerous on-the-ground geophysical sensors measuring soil electrical parameters, such as electrical conductivity and resistivity, most of them still require walking or driving agricultural machinery on the field.

Previously developed sensors were thoroughly tested on agricultural fields to provide detail interpolated map of important agrophysical soil properties at multiple depths. Figure 1 shows example of using combination of resistivity mapping, vertical electrical sounding, and reduced soil sampling to map soil clay content, water field capacity, and filtration coefficient at different depths.

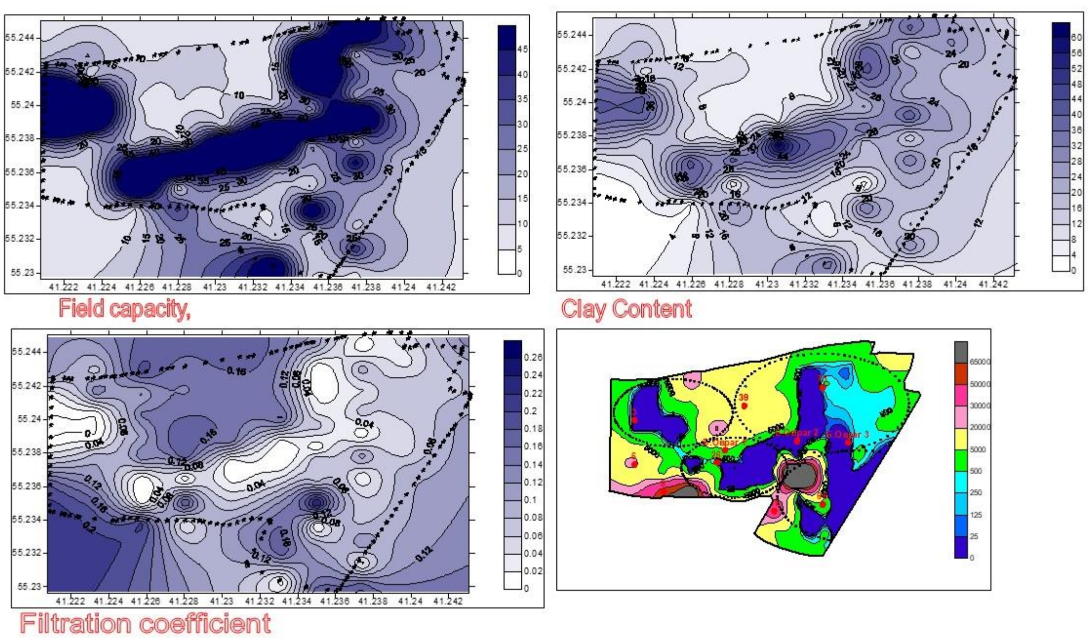

Fig. 1. The soil physical properties maps at 16 feet inverted from electrical resistivity measured at the surface with contact DC methods.

Even faster farm filed characterization is possible with electromagnetic inductions instruments developed by various companies. SiberGeo has two multi-frequency EMI instruments, AEMP-14 (14 frequencies, ~8 m depth) and Geovizor (3 frequencies, ~3 m depth), which were thoroughly tested in many applications and was mounted on various vehicles for faster data acquisition.

Generally, the electrical resistivity measured with non-contact EMI instruments correlates well with the more traditional DC methods of resistivity measurements and can show different textural layers in soil profile, outlining both lateral and vertical variability continuously (Fig. 2).

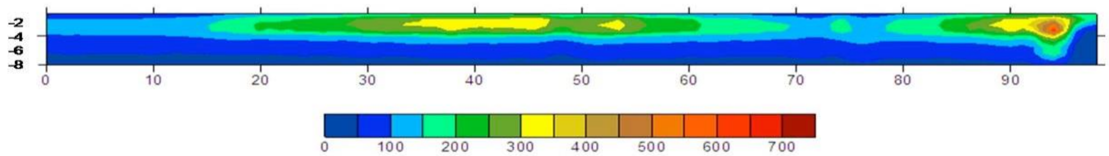

Fig. 2. Continuous profile of electrical resistivity measured with EMI instrument showing top sand and bottom clay layers and groundwater at 3.5 m depth.

Such fast and detail data acquisition is unvaluable in agricultural research to plan field trial layouts, obtain detailed data on soil properties at multiple depths for breeding analysis, especially for developing stress-resistant (salinity, drought) and nutrient-efficient (N fertilizer utilization) crop varieties.

Although fast, most existing EMI sensors are big, heavy, and awkward to handle, since transmitter and receiving coils have to be physically separated by several meters to penetrate deeper. When mounted on the machinery they have to be placed on non-conductive platform and separated from the machine far enough to avoid signal interference. Those drawbacks limit their usefulness to monitor soil condition during crop growth.

To address those challenges we have developed a new mobile universal soil EC sensor (EM) as payload on the octocopter UAV to be able monitor soil conditions on and off growing seasons, without use of the machinery. The weight of the existing Geovisor instrument was further reduced, the balancing harness and flying protocol for DJI Matrice UAV was developed, and the data acquisition and output files suitable for interfacing with other sensors and crop data were provided to the research collaborators.

Fig. 3. New EMGeoDrone test flight and parameters**.**

- Generator diameter: 300 mm
- Number of turns in generator coil: 21/2
- Pump supply voltage: 8.5 V
- Receiver diameter: 50 mm
- Number of turns in receiving coil: 42
- Preamplifier gain total: 2000
- Total weight of the device without handle and footrest: 3328 g.

The device flights at precise height 20-40 cm, measuring EC at 3 frequencies, corresponding to 3 depths, approximately 0.5, 1.0 and 2.0 m. The precise height stability is obtained by lidar sensor usage. Electric resistivity measurement can be shown as maps of resistivity at various frequencies (depths) and various height of flight.

Disclaimer: the EMGeoDrone sensor was developed with the support of EU HORIZON 2020 research and innovation program, PARSEC Consortium, under grant agreement #824478 “Crop Predictions Take Flight – Linking Genomics and Geophysics”.