

On-the go soil surveying

Figure 1. The Multi-sensor platform at The University of Sydney. This system is capable of measuring EC_a at 0-30cm, 0-90cm and 30-90cm using the Veris 3100, EC_a to 1.5 m using the Geonics EM38 (vertical mode), EC_a to ~5m using the Geonics EM31, topsoil pH with the Veris pH sensor, elevation with the Omnistar Carrier-phase GPS and several regions of interest in the gamma radiometer spectra in one pass over the field.

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Research into combining apparent electrical conductivity (EC_a) and gamma-radiometric data has shown that the accuracy of mapping and predicting the texture in the topsoil can be improved compared with predictions from EC_a data alone. The Australian Centre for Precision Agriculture is currently investigating issues with operating multi-sensor platforms including system set-up, sensor calibration, data collection, data analysis and interpretation.

The EC_a signal (see breakout) is governed by several different soil properties including texture, clay mineralogy, soil moisture, salinity, organic matter and temperature, to name a few. The signal is generated over a given depth. As a result it is usually impossible from a single sensor to extract information on an individual soil property, e.g. clay mineralogy or soil moisture, or split the signal into multiple depths, eg. topsoil and subsoil response.

If repeated EC_a measurements are taken overtime and done with the sensor at different heights above ground level then some of the soil property and depth information can be extracted. The newer EC_a

sensors on the market are capable of measuring to several different depths simultaneously, allowing topsoil and subsoil response to be separated with a single-pass operation. However, these newer sensors are still unable to separate the signal into individual soil properties.

Combining information from multiple sensors could improve the prediction of soil properties

As well as EC_a sensors there are several other types of soil sensors that are suitable for on-the-go mapping. In fact, the opportunities and applications of many of these sensors in soil science are still being investigated in the research domain. The advantage of other sensors is that they may be able to provide information that enhances the EC_a information. Combining information from multiple sensors may allow users to extract and map soil property information, such as soil moisture, rather than map the signal response, like EC_a .

Some examples of alternative soil sensors that can be used on-the go include;

- Gamma-radiometers are available for vehicle-mounting to map the naturally occurring (non-hazardous) background radiation emissions from the top 40cm of the soil profile. The radiation data provides information about the texture and mineralogy of the topsoil.
- Laser and radar imaging is being used to characterise the roughness of the soil surface to assist growers to manage seedbed preparation and germination rates.
- Mechanical resistance sensors (dynamometers) are being coupled with moisture sensors to map soil strength and adjust tillage operations.
- Ground-penetrating radar, which identifies differences in the density of soil layers, is being used to try and map subsurface features, eg. clay pans, and to assist mapping soil moisture.

Advances in soil data collection

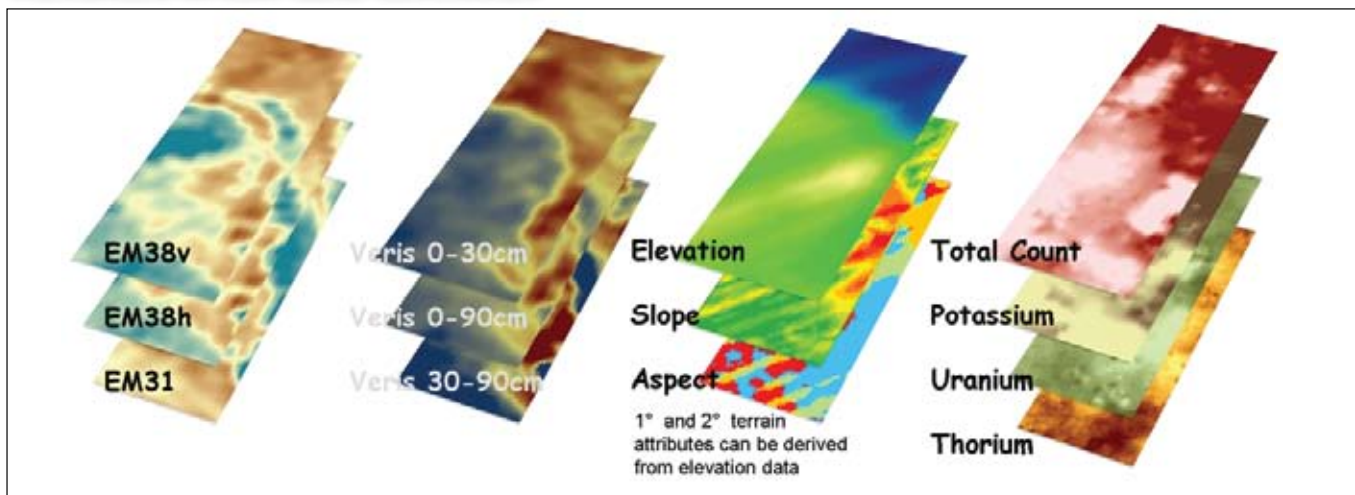


Figure 2. An example of the different data layers that can be obtained from the multi-sensor platform. From the left: EC_e data from the Geonics sensors, EC_a data from the Veris 3100 sensor, elevation and terrain attributes from the carrier-phase GPS and the region of interests from the gamma-radiometer. Some of the data show similar patterns (eg. the Geonics and Veris 31000, which both map EC_e) and some show different patterns (eg. the gamma-radiometrics and EC_e data). These differences and similarities can be used to help identify underlying soil properties and processes.

- On-the-go electrochemical sensors are now commercially available for mapping topsoil pH but are not currently widely used. There are other electrochemical sensors under development for soil ions such as N, P and K.

All the sensors listed can be mounted on a vehicle and run on-the-go in a field. Therefore, since different soil properties can be inferred from the different sensors, it makes sense to run multiple sensors on the one vehicle when conducting an on-the-go soil survey.

Figures 1 and 2 illustrate the multi-sensor platform produced for the project and the type of data layers that can be produced after one pass of the platform.

There is no doubt EC_a data is valuable and has had a dramatic impact on the way growers look at their soils and soil spatial variability. However, it is important to understand that EC_a is not the complete answer. In the coming years more and more real-time on-the-go soil sensors will be available and commercially used. This will help growers attain an even greater understanding of the productivity of their soil systems.

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Confused terms

The terms EMI (electromagnetic induction) EM38 and soil EC_a (apparent electrical conductivity) are often used interchangeably but are not the same. The term, EM38, only refers to data collected by an instrument made by Geonics Ltd, Canada (www.geonics.com), which measures the third term, EC_a , to a depth of about 1 to 2m. While the Geonics EM38 is the most common instrument used for EC_a surveys, it is by no means the only one.

On-the-go EC_a surveys are possible with a variety of instruments from several different manufacturers including DUALEM (www.duallem.com), GEM (www.geophex.com), Geocarta (<http://geocarta.sa.free.fr>) and Veris Technologies (www.veristech.com). It is worthwhile having a look at these web pages to see the different approaches and depths of penetration of these systems.

Four key factors influence soil EC_a

- 1) Moisture content – soil with a high moisture content will have a higher EMI/ EC_a than the same soil with a lower moisture content;
- 2) Salt content – just as salty water is a better conductor than fresh water, a soil with a high salt content will have a higher EMI/ EC_a than the same soil with a low salt content;
- 3) Clay content – soils with a high clay content have a higher EMI/ EC_a than sandy soils due to:
 - a) high charge holding capacity of clay particles,
 - b) higher total porosity,
 - c) generally higher water holding capacity;
- 4) Bulk density – soils with a higher bulk density generally have a higher EMI/ EC_a than soils with a lower bulk density.