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BOOK OF ABSTRACTS

Block A

Session A3

Innovation and methods for data aquisition

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A3 Innovation and methods for data aquisition

Session Description

Involved projects: STEROPES, ProbeField, Sensres

Conveners: Emmanuelle Vaudour (INRAE), Johanna Wetterlind (SLU), Luboš Borůvka (CZU)

The session will consider communications dealing with i) how accurate spectral approaches can be from varied observational scales: lab, field, airborne and/or spaceborne sensors, be they multispectral or hyperspectral, point or imaging measurements ; ii) to what extent a sensed soil property can be either mapped, or timely monitored or even spatially timely monitored. Special consideration will be given to soil organic carbon and stocks and in how degree to the disturbing factors (atmospheric conditions, soil moisture, texture...) intervene in such approach for diverse agroclimatic zones and agroecosystems. The session raises the accuracy that can be reached spectrally according to diverse ancillary factors, algorithms, spatial scales and time scales and the various sources of uncertainty that spectral approaches accordingly underlie. It will also consider the use of soil spectral libraries in combination or not with remotely sensed images.

Abstracts of Oral Presentations

Stimulating novel Technologies from Earth Remote Observation to Predict European Soil carbon - STEROPES

Emmanuelle Vaudour (INRAE)

Conventional high-detail soil maps are static and often based on obsolete data in relation to the time of use. STEROPES intends to overcome these limitations putting the use ofsatellite time series forward, to test their potential to predict cropland soil organic carbon content over various pedoclimatic conditions and cropping systems across Europe.

First, models will be constructed from the reflectance image spectra of optical satellite series, notably Sentinel-2 (ESA), based on a number of diversified areas for which soil organic carbon samples are already available.

The second phase of the project will be dedicated to analysing the influence of various factors on SOC prediction performance: soil moisture, texture, dry vegetation due to management practices, salinity.

Then, for the sites where satellite information may not enable to derive acceptable predictions, other ancillary data will be considered at a more detailed scale, using geophysical proxies to reduce the uncertainty associated with these predictions.

A novel protocol for in-field monitoring of soil carbon stock, based on proximal sensors and soil spectral libraries – ProbeField

Luboš Borůvka, CZU

Quick and simple soil analyses directly in the field through proximal sensing have the potential to substantially gear up the number of samples analysed. To meet the growing demand for fast and cheap analysis of soils, ProbeField will focus on visible and near infrared spectroscopy (vis-NIRS) as an alternative tool to expensive and time-consuming conventional methods. The vis-NIRS technique has many advantages required for field analyses of soil properties. There are, however, drawbacks to be overcome. In contrast to lab spectroscopy, variable moisture and structure in the field will hamper reliability of analyses. ProbeField will test and suggest the most optimal physical and mathematical procedures to manage these problems. A wide range of soil properties will be analysed and 3D mapping will be performed to estimate for example carbon stocks. A best practice protocol will be produced.

The presentation will introduce the objectives, structure and methodological approaches of the project. The work and achievements so far will be presented. The methods and their applications and results will be shown on example of selected fields in the Czech Republic and other participating countries. A novel tool for field spectra measurement SoilPro developed by prof. Eyal Ben Dor in Israel and preliminary results of its application will be also presented.

Apparent electrical conductivity across classes of soil drainage and survey conditions: what performance can we expect from EMI sensors' response revealing soil parameters?

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The use of proximal soil sensors revealing apparent electrical conductivity (ECa) through electromagnetic induction (EMI) is increasingly being considered to produce high spatial resolution soil maps for precision agriculture. However, predicted values from linear regression models between ECa and main soil physical properties (i.e., clay, sand, EC, and coarse fragments) sometimes may show inconsistency. We hypothesized that different soil drainage classes (i.e., SDC) and survey season could influence the performance of EMI sensors revealing soil properties, and thus a specialized knowledge to correctly interpret the EMI output is required. The aim of this work was to study the effect of varying soil parameters and survey conditions over seven SDC on ECa data (ms m^{-1}) collected during the last fifteen years within the Italian territory (up to sixty-five soil surveys and up to one thousand soil profiles). We used a step-by-step modelling of data, starting from the classical relationships (i.e., correlations, RMSE, and R^2). First, we identified the better correlation between soil properties and ECa. Second, we scaled survey points (i.e., EMI outcome) using the Bray-Curtis distance based on SDC, using non-metric multidimensional scaling (i.e., NMDS). Then, we applied a PERMANOVA to identify which variable of those identified in the first step was influencing the more ECa. Last step was to apply a generalized additive model (i.e., GAM) using NMDS coordinates as random factor to study the spatial dependency of ECa, together with soil properties, SDC, and survey season.

Our results show that i) more variability of ECa is associated with well-drained soils and winter surveys as indicated by NMDS and PERMANOVA statistics; ii) clay content was the best correlated parameter (R^2=10%) after the soil drainage (R^2=22%), still residuals of the PERMANOVA were up to 50%; iii) unsignificant influence of physical parameters on ECa was found with the GAM (R^2=97%), which relates an important portion of variance of data with NMDS coordinates. This reveal a spatial dependence of ECa and SDC, which is influenced by the survey season and marginally by soil properties. In particular, well-drained soils surveyed in humid seasons accounted for the highest effect on ECa. Lower influence of moisture and drainage on ECa was identified in poorly drained soils due to drier survey conditions. Such fact allows the identification of better relationships with clay, sand, EC, and coarse fragments.

From such results, we infer that knowledge of hydrological characteristics of soils is mandatory to obtain a better interpretation of EMI outcomes, because ECa dependency on soil moisture and drainage would mask relationships with other soil parameters. Thus, we would recommend the use of more techniques and the measurement of auxiliary variables for surveys carried out in soils with high drainage in humid seasons.

Keywords: electromagnetic induction; performance metrics, soil properties, survey season, soil drainage

SANCHO'S THRIST, the effects of cover crops on multiple ecosystem services in woody crops of semiarid areas

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Woody crops (vineyards and olive groves, for example) are usually located in marginal areas, on poor and sloping soils. This fact, together with its intensive use, has led to degraded soils, with little organic matter and very prone to erosion. This scenario is typical of southern European countries. The current Common Agricultural Policy tries to mitigate this situation by financing agri-environmental measures or eco-schemes, for example, the use of cover crops to improve organic carbon and moisture content and prevent erosion and desertification. However, in dry areas, this type of sustainable management is not welcomed by farmers, who fear competition for water and nutrients.

In this project we want to study the effects of cover crops compared to tillage, in vineyards and olive groves, in Spain and Italy, using experimental farms and private farms (30 to 40 farms). The objectives can be grouped into large groups. The first is based on the study of the effect of cover crops, or ground covers, on the quantity and quality of organic matter, on the availability of water, and on the microorganisms involved in carbon metabolism. The second is the ability to remotely monitor the changes produced by this management, incorporating elements such as soil roughness, and the type of clay or iron oxides, which can interfere with the interpretation of satellite time series. The third is the efficiency of carbon sequestration by studying the 13C and/or 15N isotopic signature on bulk soil fraction. The fourth is the effect on productivity and costs of this management, as well as the socio-environmental aspects that are crucial to achieving acceptance by farmers. A set of ecosystem services indicators will be established for different domains: production, socio-economic and environmental aspects, and thresholds for favorable and unfavorable for each indicator will be established.

This project will try to evaluate to what extent woody crops in semiarid areas can be managed with cover crops. We will consider a wide set of pros and cons, including the production of grapes and olives, soil health, carbon sequestration, and other ecosystem services. The results will be modeled to establish future scenarios of business as usual compared to the long-term use of cover crops. We will improve the interpretation of satellite imagery to better monitor carbon sequestration in agricultural areas as spectral and spectral-spatial models will be made for soil organic carbon, with clay and iron oxides as covariates. A synthetic ecosystem service index will be calculated and compared with the tilled woody crop for each cover crop system. The final objective is the dissemination of results through small meetings with farmers, notes on social networks, and the production of a high-quality documentary that can be broadcast on television and the internet.

Keywords: ground covers; woody crops, carbon sequestration, satellite imagery

Monitoring soil salinity and using proximal sensing to map soil salinity and soil texture

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Temporal series of soil salinity were obtained for ten drip-irrigated commercial orchards, located in Roxo' irrigation district, southern Portugal, from May 2019 to May 2021. Secondary salinization has long been reported in this irrigation district, due to the use of saline-prone irrigation water and the existence of poorly structured soils. The crops were almond groves, olive groves, citrus, and pomegranates, having different tolerances to soil salinity. The soils were Luvisols, Cambisols, Regosols, Planosols and Vertisols. Soil samples were taken at different depths (soil surface to a maximum of 80 cm) and the electrical conductivity of the soil saturation paste (ECe) was measured (indicator of soil salinity). Twenty campaigns were carried out. The average electrical conductivity of irrigation water was 0.72 dS/m. Soil salinity varied over time, but without reaching values of concern. In salt-sensitive crops (almond and citrus), there were occasional situations in which ECe presented values above the tolerance. At the end of the monitoring period, ECe values were very close to the initial ones. In addition to the quality of the Roxo water indicating an improvement compared to previous studies, the precipitation that occurred from 2019 to 2021 (1200 mm) also contributed to the removal of salts that eventually accumulated in the rootzone.

During the monitoring period, electromagnetic induction (EMI) surveys were conducted, to measure the apparent electrical conductivity (ECa) of the soil. The objective was to use a fast and non-invasive methodology, that allows covering large areas quickly, to map soil salinity. However, ECa does not represent the actual electric conductivity (EC) variation with depth (is a depth-weighted average conductivity measurement). Inverse modelling can be applied to ECa data to obtain 3D electromagnetic conductivity images (EMCI) of EC of soil horizons or layers. EC is influenced not only by soil salinity but also by other soil properties, such as clay content. To evaluate the potential use of EMI inversion models for mapping soil salinity and other soil properties, EC values were related to soil data collected during an extra survey at the same time as EMI measurements. Sampling locations were selected based on the observed ECa variation in each study site. Most samples were collected in the almond, citrus, and super-intensive olive grove fields due to higher ECa values observed, suggesting potentially higher soil salinity. Soil samples were analysed for ECe and texture. Soil salinity was extremely low at the time of EMI measurement since all samples from the different locations had ECe lower than 2 dS/m (non-saline soil), and no correlation between ECe and EC was found. However, higher correlations (R2>0.60) were found between EC and sand and clay content in almond and citrus fields. In the absence of high salinity, clay content can dominate the EMI signal and be used to map soil texture. A linear regression (LR) between EC and soil texture, in Almond and Citrus fields, was established. Results showed that it is possible to establish LRs between EC and clay and sand content, allowing to convert EMCI into these texture classes and generating sand and clay 3D maps in depth.

Keywords: soil salinity, electrical conductivity, electromagnetic induction, inversion modelling, soil texture mapping

Sentinel imagery capability in digital SOC mapping in two agricultural regions in France

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Soil organic carbon (SOC) is the target attribute with the largest number of studies in digital soil mapping in the frame of global initiatives such as *GlobalSoilMap* that aim to provide maps of key soil properties at national scales. Previous studies have considered terrain-derived variables and other soil properties such as clay to map SOC. Nowadays with the free availability of satellite imagery the mapping of SOC using remote sensing data is being more widely envisioned. However, the capability to predict SOC via satellite imagery in conjunction with soil and terrain data is still unknown in many agricultural regions. In order to map top SOC content over croplands, this study was carried out in the framework of the STEROPES project in two regions in France, Beauce (4838 km^2) and Pyrenean piedmont (22177 km^2), addressing: (i) for both areas, the use of Sentinel-2 single date images and/or soil moisture maps derived from Sentinel 1 and 2 data (ii) for Beauce only, the constructing of temporal mosaics of bare soil images, the inclusion of Gamma-ray images and terrain-derived covariates in prediction models and the map uncertainties.

In both study areas, the prediction performances were influenced according to the date of image acquisition, surface soil conditions (e.g., soil moisture and soil roughness) and the historical context. In Pyrenean piedmont based on a purely spectral method (i.e. using only spectral data from S2 images) using single date images it was possible to predict high SOC contents in specific soil types. In Beauce considering a mixed method (i.e. using S2 spectral data and terrain-derived variables as covariates in the prediction models) using S2 temporal mosaics of bare soil (S2Bsoil) it was possible to determine the most relevant variables in that area and the best periods to elaborate S2Bsoil for predicting SOC.

Keywords: Soil organic carbon; digital soil mapping; Sentinel-1/2; bare soil; map of uncertainties

Estimation of soil salinity using the electrical conductivity of the saturated soil paste from soil:water extracts in a 1:5 ratio

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Soil salinity mapping requires the input of soil data depending on the method used. Soil indicator-based methods are considered more demanding in the need for soil data input to provide evidence of the occurrence of salt problems in the soil. Soil salinity indicators are used to quantify the intensity of salt problems in the soil and to calibrate other methods (remote and proximal sensing) for mapping salt-affected soils.

Electrical conductivity (EC) is one of the most widely used parameters to diagnose soil salinity and estimate soil ion concentration. The determination of soil EC can be carried out in the saturation extract of a saturated soil paste (ECe) or in aqueous soil extracts with different soil:water ratios. The first method is considered ideal for estimating soil salinity and better at assessing plant response to salinity. However, it is time consuming and requires greater investment in equipment. Moreover, the dynamic nature of soil salinity due to the influence of management practices (such as irrigation) and physical factors (soil permeability, water table depths, micro-topographic conditions, water use, rainfall, and salinity of groundwater) leads to the need of repeated measurements. Soil:water extracts are less time consuming and more economical and are therefore often used to assess soil salinity. The most commonly used soil:water ratios are 1:1, 1:2.5 and 1:5. The latter extracts are also used for the measurement of soil pH (ISO 10390) thus making EC analysis more expeditious. The aim of the present study was to determine the relationships between ECe and EC1:5 of soil:water extracts of several agricultural soils of the southern region of Portugal. It is an ongoing study and preliminary data is presented. A total of 749 soil samples from 27 different sites belonging to the irrigation perimeters of Lezíria, Vigia, Campilhas and Alto Sado, Roxo and Alqueva were used for the measurement of the EC of saturated soil pastes (as developed by USDA, 1954) and soil:water extracts (m:v) in 1:5 ratio. The ECe of the soil samples varied between 0.13 and 13.53 dS m-1. The soil samples presented varied textures, with greater predominance of silty-clay and sandy-loam textures with 26 and 22%, respectively. Of the total number of soil samples, 689 were used to establish the regression and the remaining 60 to validate the estimation of ECe from EC1:5. The results showed a linear regression between ECe and EC1:5 with $R^2 = 0.89$. The set of 60 samples for independent validation showed that the slopes of the regressions between ECe estimated from EC1:5 measurements and direct ECe measurements were close (ME= 0.0783 dS m^{-1}, RMSE= 0.76 dS m^{-1}, PBIAS= 0.1085 % and $R^2 = 0.89$), indicating that the equation found in this ongoing study can be used to reliably assess soil salinity.

Keywords: soil salinity, electrical conductivity, saturated soil paste, soil:water extracts

A3 Innovation and methods for data aquisition

Block B