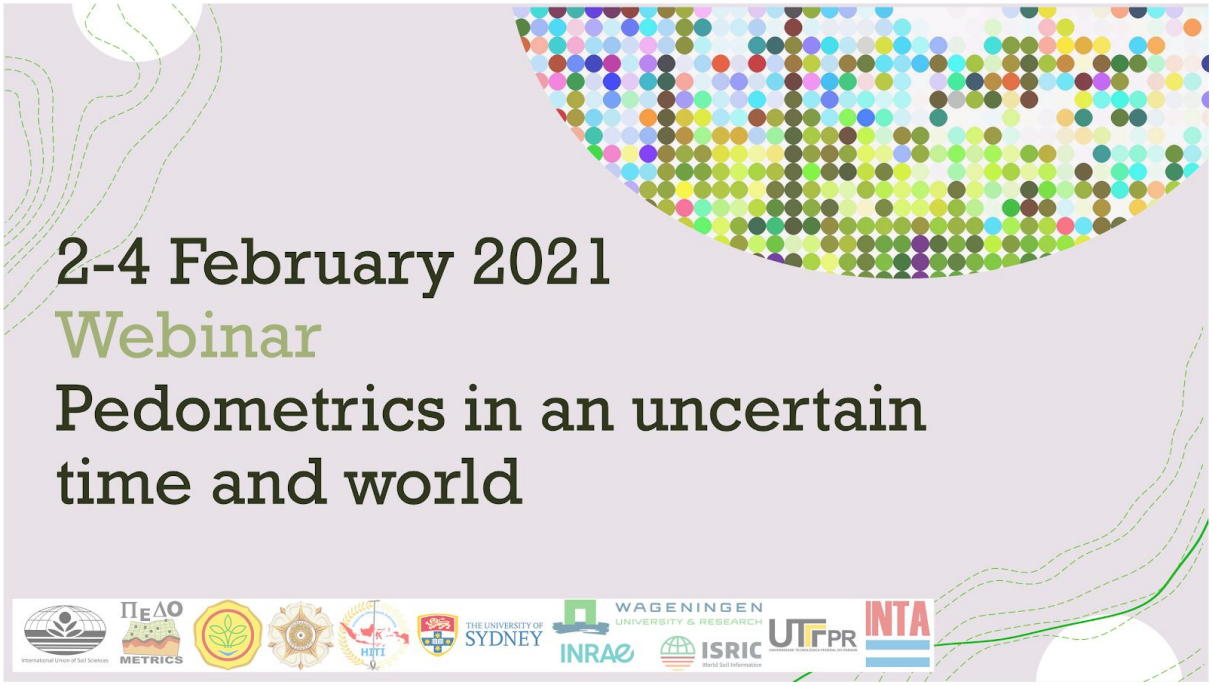

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Overview Presentations 2 February

Geographic region: Americas
Session moderators: Alessandro Samuel Rosa, Federal University of Technology - Paraná, Brazil; Marcos Angelini, Instituto Nacional de Tecnología Agropecuaria, Argentina

Presenter	**Affiliation**
Mario Guevara	Centro de Geociencias-Universidad Nacional Autonoma de Mexico, Mexico
Jingyi Huang	University of Wisconsin-Madison, USA
Andres Felipe Rodrigues Vasquez	Unidad de planificación Rural Agropecuaria, Colombia
Daniel Saurette	University of Guelph, Canada
Preston Sorenson	University of Saskatchewan, Canada
Maria Eliza Turek	Federal University of Paraná, Brazil
Hunter Winsor	New Mexico State University, USA
Chengcheng Xu	Duke University, USA
Yakun Zhang	University of Wisconsin-Madison, USA
Maiara Pusch	Universidade Estadual de Campinas, Brazil

Soil moisture and vegetation productivity across the green gold belt in central Mexico (2001-2018)

Guevara Mario[1,*], Gutierrez Sebastian[2] , Delgado Tzitzi[1], Tarin Tonantzin[1], Kolb Melanie[1], Vazquez Lule Alma[3], Mariano Torres[1], Luis Miguel Morales Manilla[4], Equihua Julian[5], Cardenas Raul[4], Pablo Alarcon[1], Gomez-Tagle Alberto[4]

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Abstract. Mexico is the largest avocado producer in the world (around 33% of the world´s total avocado production) and the state of Michoacan (central Mexico) is the largest avocado producer in the country, reaching around 914,530 tons of avocado per year (e.g., 2018-2019 cycle). We analyze the impact of avocado plantations on ecosystem drivers, such as soil moisture and vegetation primary productivity, and quantify trends between 2001 and 2018 using remote sensing and *in-situ* information for delineating avocado plantations. We observe negative trends in soil moisture (-0.038 [$CI_{95\%}$ -0.06, 0.01] $m^{-3}m^{-3}$ d^{-1}), but increasingly positive trends of vegetation productivity (105.4 [$CI_{95\%}$ 1.4, 203.8] g C m^{2} d^{-1}) that are associated with the industrialized avocado plantations. The analysis reveals that negative trends of soil moisture and positive trends of primary productivity are associated with low vegetation density and bare soil conditions (e.g., 2018) where avocado is produced. We integrate our results in a land degradation index on a municipality basis that we use to assess trends of soil moisture and plant productivity across avocado production areas. Our results suggest that if avocado production conditions continue to be the same and regulations regarding land use change in the state are not enforced, the temperate forest region in Michoacán will face severe hydrological -and consequently, social- problems associated with soil security in the near future.

Keywords: *Soil moisture decline, plant productivity, avocado orchards, trend detection.*

Retrieving heterogeneous surface soil moisture at 100 m across the globe via fusion of remote sensing and land surface parameters

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Abstract. Successful monitoring of soil moisture dynamics at high spatio-temporal resolutions globally is hampered by the heterogeneity of soil hydraulic properties in space and complex interactions between water and the environmental variables that control it. Current soil moisture monitoring schemes via in situ station networks are sparsely distributed while remote sensing satellite soil moisture maps have a very coarse spatial resolution. In this study, an empirical surface soil moisture (SSM) model was established via fusion of in situ continental and regional scale soil moisture networks, remote sensing data (SMAP and Sentinel-1) and high-resolution land surface parameters (e.g., soil texture, terrain) using a quantile random forest (QRF) algorithm. The model had a spatial resolution of 100m and performed well under cultivated, herbaceous, forest, and shrub soils (overall R^2 = 0.524, RMSE = 0.07 m^3 m^{-3}). It has a relatively good transferability at the regional scale among different soil moisture networks (mean RMSE = 0.08–0.10 m^3 m^{-3}). The global model was applied to map SSM dynamics at 30–100m across a field-scale soil moisture network (TERENO-Wüstebach) and an 80-ha cultivated cropland inWisconsin, USA.Without the use of local training data, the model was able to delineate the variations in SSM at the field scale but contained large bias. With the addition of 10% local training datasets (“spiking”), the bias of the model was significantly reduced. The QRF model was relatively insensitive to the resolution of Sentinel-1 data but was affected by the resolution and accuracy of soil maps. It was concluded that the empirical model has the potential to be applied elsewhere across the globe to map SSM at the regional to field scales for research and applications. Future research is required to improve the performance of the model by incorporating more field-scale soil moisture sensor networks and assimilation with process-based models.

Keywords: *Soil moisture, quantile random forest, remote sensing.*

The simulation in the land evaluation and climate change for planning of the agricultural sector

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Abstract. Land evaluation is an agricultural planning tool. For Colombia, the government for Colombia, the government through the Rural Agricultural Planning Unit (UPRA, Unidad de Planificación Rural Agropecuaria) is using the national scale farmland evaluation. Land evaluation is being used to plan for 20 years the climatic effects of potential areas of different productive systems. Land evaluation was used to plan the action of 20 years in the future, with the climatic effects in the potential areas of different productive systems. It is evaluated physically with the spatialization of the scenarios of climate change for RCP 2.6, RCP 4.5 y RCP 8.0 and the variability historical climate for ENOS. As a result, a zoning of climatic effects is carried out at different levels to take action by 2040. The methodology is applied with a spatial approach, for the crops of dry rice, technified corn, potatoes and pastures. The greatest effects are seen for climatic variability in ENOS, with potential reductions of up to 20%. For the scenarios of climate change, the potential reductions of up to 10%. Some areas improved their fitness, this is because the availability of surface water resources was not evaluated.

Keywords: *Land evaluation, climate change, planification.*

Sample Size Optimization Techniques for Predictive Digital Soil Mapping

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Abstract: A key underlying assumption in digital soil mapping (DSM) is that the variability in the target soil property can be explained by the environmental covariates. Machine learning algorithms (MLAs) are commonly leveraged in DSM and are a data-driven approach to modelling; the resulting model is inextricably linked to the data being used to build the model. Likely the most used algorithm for sampling design is the conditioned Latin hypercube sampling (cLHS) approach, designed to optimize the sampling locations within feature space, ensuring adequate coverage of the environmental covariates from which the model will later be developed. Despite the advances in sample site selection, one critical component of a sampling design which has received considerably less attention is the optimal number of samples, and this question has yet to be adequately addressed in the literature. Few techniques have been proposed to address this gap. In this study, we evaluate the use of five techniques: normalized variance approach, the Kullbach-Liebler Divergence (D_{kl}), Kullbach-Leibler Divergence for continuous variables (D_{klc}), the Jenson-Shannon Divergence (D_{js}), and the Jensen-Shannon Distance ($Dist_{js}$) to determine an optimal sample size. We test these techniques for a 26-hectare study site near Guelph, Ontario, using an increasing number of environmental covariates (4, 6, 8, 10 and 12). For each combination of covariates, we used the cLHS to generate 400 unique sampling designs, including 10 replicates of sample plans at 40 different sampling intensities increasing from 10 to 400 in steps of 10. The techniques could be sensitive to data binning, a requirement for comparing the sample plan to the population, therefore the calculation of the divergence metrics was tested across a range of bin sizes from 15 bins to 50 bins in steps of 5. Across all techniques and bin sizes, the $Dist_{js}$ consistently resulted in the largest sample size, while the D_{klc} resulted in the smallest sample size. The number of covariates used to create the sample plan had no effect on the optimal sample size, where sample size increased marginally as the number of covariates increased. For example, sample size determined using the $Dist_{js}$ increased from 185 with four covariates to 189 with 12 covariates. On the other hand, the number of bins used to compute the metrics had a significant effect on sample size. For all techniques we saw a strong linear relationship between bins and sample size with regression slopes typically ranging between 2 and 3 sites per additional bin. For example, the sample size determined using $Dist_{js}$ with four covariates increased from 183 using 15 bins to 278 using 50 bins. This comparison of different techniques to determine an optimal sample size provides some new tools that can be added to the DSM toolbox, but also reveals substantial challenges that remain for resolving the issue of optimal sample size. Future work will look to use the sample plans to create predictive models and determine the optimal sample size based on achieving peak model performance.

Keywords: *Sample size, optimization, divergence.*

Distribution Mapping of Soil Profile Carbon and Nitrogen With Laboratory Imaging Spectroscopy

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Abstract. Conversion of arable cropland to forage crops has been proposed as a potential method to increase soil organic carbon (SOC) stocks to sequester carbon and improve soil quality. In this study, intact soil cores were collected from long-term boreal forest soil research plots established in 1980 consisting of: a mixed arable crop and forage agroecological rotation (AE), continuous forage (CF), and continuous grain (CG) rotations. These cores were analyzed using a SisuROCK automated hyperspectral imaging system in a laboratory setting collecting shortwave infrared reflectance data. Samples were then analyzed for SOC and total nitrogen (TN) contents by dry combustion to prepare a training data set. Predictive models were successfully built for SOC and TN using a combination of wavelet analysis and Bayesian Regularized Neural Nets. The CF rotation was found to have the highest SOC and TN contents compared to AE rotation for only the top 3 and 4 cm, respectively. These two rotations had comparable contents for both parameters for the rest of the topsoil, which was greater than the SOC and TN contents in the CG rotation to depths of approximately 12 cm. Increases in both SOC and TN were associated with increased spatial aggregation at fine spatial scales. These results indicate that adding forages to rotations in boreal forest soils increases SOC and TN, however these changes were concentrated in the surface depths.

Keywords: *Imaging spectroscopy, crop rotation, soil organic carbon, nitrogen.*

Estimation and Mapping of Field Capacity in Brazilian Soils

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Abstract. Modeling soil water dynamics is important to support decisions in planning and management policies. Field capacity (FC) is an important parameter in this context and its proper determination allows the use of simple models to assess soil water balance components. In this study we aimed estimation and mapping of FC in Brazilian soils based on available soil global data and pedotransfer functions (PTF). Soil basic data were obtained from the SoilGrids system in a 0.05×0.05° spatial grid covering the Brazilian territory, with a resolution of approximately 5 km. Soil saturated hydraulic conductivity (K_s) and water retention curve (SWRC) were estimated by PTFs and used as input in the agro-hydrological model SWAP to simulate an internal drainage experiment without evapotranspiration, until the drainage at the bottom profile reached negligible flux density values (q_{fc}) of: 0.25, 1.0 and 4.0 mm d^{-1}, considered to correspond to FC. Simulations were performed considering three soil depths (z_{fc}) of 30, 60 and 100 cm. FC was classified according to major soil textural and pedological classes. Uncertainty was evaluated by the sensitivity of the model to the soil hydraulic properties and the grid cell size. The highest soil matric potential at FC (h_{fc}) was observed for loam texture while the lowest h_{fc} was observed for sandy loam texture. Between soil pedological classes, Gleysols presented the lowest h_{fc}. The results showed that FC estimation is sensitive to z_{fc} and q_{fc}. Spatial agreement between patterns of K_s, FC and soil class were observed according to the evaluated database. The q_{fc} value of 4.0 mm d^{-1} presented reasonable results for estimating FC in Brazilian soils, in agreement with expected drainage time following saturation, with average values below 4 days for the evaluated depths and h_{fc} around −30 cm. Estimation of FC with PTF showed underestimation of h_{fc} varying from double to almost fourfolds times. The usually adopted h_{fc} of −330 cm does not represent the FC for Brazilian soils. Furthermore, a q_{fc} lower than 1.0 mm d^{-1} did not yield usable values for FC.

Keywords: *Hydraulic properties, SoilGrids, available water.*

Recreating Soil Systems in North Carolina

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Abstract. Soil systems are areas which have repeating patterns of soils that occur from a stream center to an interstream divide. Soil scientists delineated soil systems in North Carolina, USA based on their expertise and field observations [Daniels et al, 1999]. We wish to recreate their descriptive maps with a quantitative and generalizable method. We demonstrate a methodology to recreate soil systems using a High-Resolution Hydrography Dataset, elevation data, and SSURGO soil data. This involved identifying soil map unit delineations adjacent to streams, evaluating map unit elevation, and walking the selection uphill until reaching a local maximum. The resulting dataset is clustered and then mined for soil sequences using association rule mining. The soil sequences can be plotted to create a general pseudo-soil block diagram for each soil system. Soil block diagrams are useful for pedologically-based assessment of digital soil mapping predictions. In the future we plan to apply this method to the southwestern USA to discover soil systems outside of North Carolina.

Keywords: *Mapping, soil, co-occurrence.*

Towards POLARIS 2.0: Spatial Prediction of Soil Taxonomy over Selected Regions of the United States at a 10-meter Spatial Resolution

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Abstract. Recent soil data maps have illustrated the potential for Digital Soil Mapping (DSM) to improve the description of soil information within Earth system models. Among these DSM products, POLARIS is a hyper-resolution probabilistic soil classification and properties system over the Contiguous United States (CONUS). POLARIS provides a field-scale representation of soil information at a 30-meter resolution over the CONUS. One of the important deficiencies of POLARIS was the relatively low accuracy score prediction of soil classes — which were then used to create the soil hydraulic property maps. In this presentation, we will illustrate how we are addressing this weakness in POLARIS by rethinking the algorithm used to assemble the spatial predictions of soil classes. More specifically, using ten representative 100 km by 100 km regions over the CONUS, we will introduce a new soil taxonomy prediction algorithm called Watershed-based algorithm that is being made for use over continental extents at field scales. POLARIS 2.0 is being built using the National Soil Information System (NASIS), the Soil Survey Geographic Database (SSURGO), Sentinel data, USGS Digital Elevation Models, and relevant environmental covariates. This method employs the national-wide Watershed Boundary Dataset to disaggregate the US into sub-basins. Local predictive models (Random Forests) are generated for distinct regions featured with different environmental characteristics. Initial soil class predictions soil at 10 meters are pruned using SSURGO to fully leverage the century's worth of soil survey. This new approach (Watershed-based algorithm) will eventually both increase the spatial resolution of POLARIS down to a 10-meter spatial resolution and also will appreciably reduce soil taxonomy predictive misclassification errors.

Keywords: *Digital Soil Mapping, watershed-based algorithm, accuracy.*

Spectral signatures of soil horizons and soil orders – an exploratory study of 270 soil profiles

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Abstract. Soil mid-infrared (MIR) spectra contain absorption features related to soil physical, chemical, and biological properties. In this study, we explored the use of soil MIR spectra (7,500 to 600 cm^{-1}) to characterize and classify soil horizons and soil orders and identified the important features in the MIR spectra. The dataset consisted of 1,167 soil samples collected from soil horizons of 270 soil profiles encompassing eight soil orders across 12 National Ecological Observatory Network (NEON) domains in the USA. The spectral features of the soil samples were qualitatively explored on the five master horizons (O, A, E, B, and C) and five B horizons (Bhs, Bs, Bk, Bt, and Bw). Random forest models were developed to investigate the predictability of soil MIR spectra on the soil master horizons and B horizons. Organic soils had different absorption features in the MIR spectra compared to mineral soils. Many absorption features in the MIR spectra were caused by organic functional groups, clay minerals, quartz, and carbonates in soils. The random forest models had an overall accuracy of 0.74 and 0.72 in classifying the five master horizons and the five B horizons for the validation, respectively. Hierarchical clustering analysis was applied on the concatenated topsoil (averaged from O and A horizons) and subsoil (averaged from E, B, and C horizons) MIR spectra of the 270 soil profiles to investigate the similarity of soil profiles in the spectral space. The MIR spectra of Spodosols had strong features of O horizons and Bhs and Bs horizons and thus Spodosols were well distinguished from other soil orders. Mollisols, Ultisols, Aridisols, and Inceptisols were not easily differentiated using MIR spectra. The random forest model to classify eight soil orders had an overall accuracy of 0.72 in the validation. The Alfisols, Aridisols, and Spodosols were fairly well classified by the MIR spectra, whereas the MIR spectra could not be used to differentiate Entisols, Inceptisols, Mollisols, and Ultisols. Soil MIR spectra can be used for characterizing and classifying soil horizons and soil orders when there are distinct spectral features in the soils. Soils with similar features cannot be easily distinguished using soil MIR spectra.

Keywords: *MIR spectra, soil classification, random forest.*

Auxiliary variables in the sample design optimization and prediction of chemical soil properties in precision farming

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Abstract. The management of fertility at variable rates requires continuous maps of soil attributes. Soil heterogeneity in agricultural fields provides complex systems that are difficult to characterize, as they combine the variability from landscape processes and the variability caused by anthropic soil management. This PhD project aims to assess the added value of using auxiliary variables that represent these processes in spatial sampling optimization and spatial trend modelling for producing digital maps of chemical soil properties for precision farming. Two experiments are being carried out in four study sites located in southeastern Brazil, using auxiliary variables provided by remote and proximal sensing and field management variables. In the first experiment we evaluated whether the use of multiple auxiliary variables, in a robust linear-mixed modeling framework, improves the prediction of chemical soil properties (K, P, CEC, and base saturation) whose distribution was contaminated with extreme values. We observed that the inclusion of auxiliary variables in robust methods improved accuracy of spatial predictions of soil properties in the presence of outliers, but this did not occur for all situations. In agricultural systems, besides the variables that represent soil formation factors, such as relief characteristics, auxiliary variables that describe some kind of area management may be effective in improving chemical soil properties mapping. This is because the management auxiliary variables represent the secondary processes of variation that cause the outliers. The experiment evaluates strategies for allocating sample points, defined by spatial simulated annealing using two criteria: first is to ensure the spatial coverage (MSSD); second is using a multi-objective function, that search a distribution and correlation between the auxiliary variables, the mean squared shortest distance and distribution of point-pairs contributing to each lag-distance class of semivariogram. We will use as predictor methods: robust multiple linear regression, robust ordinary kriging, robust universal kriging, random forest, and random forest-kriging to evaluate the performance of predictions in both sample configurations as we add information in the modeling of the existing variation of soil properties.

Keywords: *Robust methods, management variables, soil digital mapping.*

Overview Presentations 3 February

Geographic region: Australasia
Session moderators: Alexandre Wadoux, The University of Sydney; Wirastuti Widyatmanti, Universitas Gadjah Mada, Indonesia

Presenter	**Affiliation**
Noviyanti Listyaningrum	Universitas Gadjah Mada, Indonesia
Andree Nenkam	SIA, SOLES, University of Sydney, Australia
Ho Jun Jang	SIA, SOLES, University of Sydney, Australia
Nagarjuna Reddy	Agricultural and Food Engineering Department, Indian Institute of Technology Kharagpur, WB 721302, India
Sativandi Riza	University of Brawijaya, Indonesia
Sasirin Srisomkiew	Tokyo Metropolitan University, Japan
Syintianuri Intan Wijayanti	UPN "Veteran" Yogyakarta, Indonesia
Peipei Xue	The University of Sydney, Australia
Dongxue Zhao	University of New South Wales, Australia

Integrating Ethnopedology and Geomorphology in Detailed Soil Mapping

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Abstract. Soil is a geomorphological component that comes as content material. Technical knowledge on soils requires conventional surveys with various variables on testing its characteristics. It would take longer time, much power, as well as cost and consequences, that it has rarely been done in geomorphological mapping. Ethnopedology comes as an alternative in detailed geomorphological mapping, as a simple local soil knowledge could accommodate information on local scale through participatory soil survey. Bompon watershed in Magelang, Indonesia, is a rural and remote area, that the community local knowledge is yet available and can be used. This study aims to identify geomorphological or land mapping unit, identify local soil unit, and analyse local soil mapping unit in a hillslope of Bompon watershed. The data collected is a digital elevation model (DEM) and local soil knowledge which contains information of soil name, characteristic, and local distribution. The DEM and its derivative are used to obtain land mapping units, and validated through a field survey. The soil participatory survey is conducted to build interpretation keys of the initial local soil characteristic, followed by field survey and grid-based soil sample tests, resulting in local soil units. Data processing is done by calculating the local soil unit composition within the land mapping units to generate local soil mapping units. This study depicted the land mapping unit in the hillslope consists of morphoarrangement of ridge, upper slope, mid-slope, lower slope, foot slope and plain. The local soil units in the hillslope comprise *abrit*, *cabuk*, *gesik*, and *lincat*, are identified based on the structure, color, consistency, and texture. There are five soil mapping unit within the hillslope, namely consociation of *cabuk*, complex of *cabuk abrit*, complex of *cabuk abrit lincat*, complex of *cabuk lincat abrit*, complex of *lincat cabuk*, and consociation of *lincat*. The soil mapping unit generally forms a geographic pattern of consociation of cabuk in residual zone (the ridge), complex in erosional zone (the slope), and consociation of lincat in depositional zone (the plain).

Keywords: *Ethnopedology, participatory soil survey, local soil mapping unit.*

Using the Homosoil concept to enrich the soil data infrastructure of sparse soil data environments: A case study in Mali

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Abstract. Soil is an essential factor driving crop productivity, crop health and consequently food security. Numerous research studies rely on soil data to assess environmental health or food security related issues, for example in soil degradation mitigation, soil fertility improvement or soil carbon. However, in Africa, most countries suffer from relatively sparse soil data availability hindering the successful implementation or adoption of the results of these studies. The objective of this study is to populate the soil data infrastructure of a sparse soil data environment like Mali, West Africa, using the concept of homosoil. A homosoil is a soil in the world which shares similar soil forming factors than the soil of a target area. First, the concept of homosoil based on a multi-factorial distance model was used to identify homosoil areas of Mali. Large areas in India, Southern Africa, Northern Australia, Brazil, Mexico are within the environmental conditions of the Sahelian band in Africa and are considered as homosoils. Second, we used the relationship between the available soil data and the soil forming factors of the homosoils to generate a digital soil mapping rule, and finally we applied the mapping rule on Mali's soil covariates to populate its soil database. Comparisons of the new soil database are made with publicly-available gridded digital soil mapping products based on the available (sparse) data. The approach developed here provides the opportunity to populate relatively sparse soil data infrastructures and moreover to transfer agronomic experimental results practices from homosoil areas.

Creating a soil parent material map digitally using a combination of manual interpretation and statistical techniques

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Abstract. In this study, a map of soil parent material is created to support the delineation of soil properties and classes of the Narrabri Shire, NSW. Current parent material maps that are available in this study area are geological and lithological maps at a scale of 1:250,000 to 1: 1 million. These maps are not detailed, and the description in some areas is not accurate. Thus, this study created a new parent material map using information from the geological and lithology information, barest earth satellite imagery, gamma radiometric, topography, prior soil map, and digital soil texture maps (clay and sand content). Based on manual interpretation and parent material observations, eighteen parent material classes were delineated in the area. The eighteen classes were then modelled using Linear Discriminant Analysis using DEM, Slope, TWI, Gamma K and Th, and Ratio K to Th and soil VIS and NIR (created using RGB and NIR bands) as covariates. This modelling process was iterated 50 times, and the most frequently predicted class was assigned to each of the 90 m by 90 m pixel throughout the study area. A map of the frequency of the predicted classes was also created to assess modelling uncertainty. The new parent material map consists of sedimentary residuals (sandstone), volcanic materials (basalt), alluvium, and colluvium. The alluvium can be distinguished into six classes according to slope, soil information from satellite images and soil texture. The colluvium consists of three classes with a characteristic of high clay content (smectitic) and brown in colour (kaolinitic). Using similar approaches such soil parent material or substrate maps could be developed for different regions in Australia. This method generated unique soil parent material classes combining stratigraphy, lithology and geomorphology.

Estimation of Soil Organic Carbon Stock in Different Agro-Ecological Regions of India using Legacy Soil Data and Digital Soil Mapping Approach

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Abstract. Soil organic carbon (SOC) stock plays a vital role in soil health and global carbon cycle. Recently, a 3-D regression kriging approach was used to estimate SOC contents at 500 m resolution to a depth of 2 m as per the GlobalSoilMap specifications using soil legacy data for 1707 profiles across India. Because estimation of SOC stock requires information on soil bulk density (BD) and soil BD data are typically sparse in nature, we collated a soil BD dataset by combining data from published literature (n = 3156) and those measured in our laboratory (n = 801) to develop a national BD map using the digital soil mapping (DSM) approach. A pedotransfer approach was first used to estimate soil BD for all the 1707 profiles with the available soil physical and chemical properties. We followed the 'model-then-calculate' approach to calculate the SOC stocks for different agroecological regions (AER) of India. Such an approach showed that the national SOC stocks range from 11.83 Gt for top 0.3 m to 34.63 Gt for top 1 m of the soil profile. The AER-specific SOC stock results showed a higher stock for the Deccan plateau – semi-arid (1.14 Gt at 30 cm and 3.70 Gt at 100cm), and central highlands (1.03 Gt at 30 cm and 3.06 Gt at 100 cm) where there is dense forest cover whereas relatively lower stocks (0.17 Gt at 30 cm and 0.58 Gt at 100cm) are found in the deccan plateau – arid region. These estimates can be useful in implementing the management strategies to improve the deficit carbon stocks in the different AER.

Modeling Soil Textures Using Hyperscale Terrain Attributes

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Abstract. Analysis of the spatial distribution of soil properties is essential. A soil map is needed to represent this information, which is a type of graphic representation useful for transmitting information about the spatial distribution of soil attributes. Digital soil mapping (DSM) is a highly developed science, and the use of a hyperscale for the modeling of soil properties is an important aspect of such work. Hyperscale analysis, as a further development within the DSM framework, is a process wherein a topographic parameter is sampled at more than one scale, represented by the spatial resolution, to identify the optimum scale for characterizing the topography. This study aimed to develop a prediction model for estimating the soil particle size fraction by using a hyperscale terrain analysis approach and determining the proposed prediction model's accuracy. We used hyper-scale DEM, soil samples, statistical analyses, and local morphometric variables (LMV) for creating the prediction model of a watershed area within the city of Malang, Indonesia. The primary data used to conduct hyperscale modeling are DEM data and 407 topsoil samples contained varying soil textures (sand, silt, and clay) in the upper 10 cm. We used univariate stepwise MLR, in which there is only one dependent variable, and all three PSFs were modeled separately. The proposed combined hyperscale-LMV approach with a simple statistical analysis such as stepwise MLR shows good performance and is comparable to previous research. Moreover, this MLR also can be used to easily understand soil terrain interactions rather than an advanced statistical method. The LMV parameters included in the model provided an overview of the topography and its influence on the hydrology and flow forming factors. Our model indicated that, besides the parent material, the flow direction in the landscape had a controlling effect on soil texture's spatial distribution.

Keywords: *Hyperscale modeling, digital soil mapping, soil textures.*

Prediction of soil properties by digital soil mapping with limited soil data from the Thung Kula Ronghai region, Thailand

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Abstract. Prediction of soil chemical properties and their spatial distribution is important for sustainable food production and land management in Thailand but remains a challenge in vast areas with limited soil data. The digital soil map (DSM) technique can provide the spatial soil information from field surveys and laboratory analyses combined with numerical spatial prediction methods that have been found to alleviate cost and time-consumption. The TKR region is an essential source of production of good quality jasmine rice and has been successfully registered by the European Union as a Protected Geographical Indication (PGI) (2010). However, the rice yield in this region is lower than those in other regions in the country. The main objectives of this study are to (1) identify the important spectral and terrain indices for predicting various soil properties, (2) create digital soil maps of various soil properties using the multiple linear regression (MLR) model, and (3) assess the soil nutrients level in the TKR region of Thailand. In this study, a total of 186 surface soil samples were collected and analyzed for nutrients. A digital elevation model with 5 m resolution was used to derive the terrain variables of the study area. Landsat-8 images collected at bare soil conditions with 30 m resolution were used to determine the soil and vegetation indices. Models developed to predict soil properties using MLR were evaluated in terms of the coefficient of determination, root mean square error and normalized root mean square error. The results show that the spectral indices of brightness, saturation, coloration, normalized difference water, and moisture stress were the important predictor variables and were significantly correlated with various soil properties. The results of this study further demonstrated that the DSM technique successfully produced digital soil maps of various soil properties using the MLR model equations. The MLR model exhibited high accuracy for most of the soil properties, except for electric conductivity, available K and Fe. The government can use this soil information for land-use planning, decision-making support to improve soil fertility, and monitoring soil conditions for long-term trends. Soil information from these digital maps can help farmers determine the extent of crop nutrient deficiencies and increase the soil nutrients to enhance the rice yield and maintain the PGI standard for jasmine rice in the TKR region.

Keywords: *Multiple linear regression, remote sensing, Protected Geographical Indication.*

Study on the LIDAR Application for Land Potential Mapping: Study in Geragai Village Tanjung Jabung Timur Jambi

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Abstract. LIDAR (Light Detection And Ranging) is a system of active remote sensing technology using laser light that has an infrared as an invisible wave that can penetrate the narrow space interleafs to produce topographic characteristics of land surface information. The present research was to study an application of LIDAR technology on determining the land potential classes and its interpretation of agricultural land uses. The present research area was located on Pandan Makmur village in Jambi Regency, Jambi Province, Sumatera Island. Acquisition of LIDAR technology was carried out at each predetermined GPS point. The data needed in this study were DEM (Digital Elevation Model) data that has been processed and used for parameters of land potential classes, i.e.: slope, drainage, maps of rocks, and soil type, and land use. Orthophoto data is used to simplify digitizing and cross checking field conditions with remote sensing. The land potential was obtained based on scoring on each parameter of land potential, then overlaying all parameters were conducted to get a land potential map. The results showed that the potential of land were 3 classes: 1) land without limiting factors as class I was the dominant area (17.854 ha:75,74%), 2) land with limiting factors of drainage as class II (3.254 ha:13,8%), 3) and land with limiting factors of drainage and land use as class III (2.464 ha:10,45%). Land potential in the study area is dominated by class I, which shows that the research area is very well used for agricultural use. All the study areas also showed relation with performance of oil palm plantations.

Keywords: *DEM, potential land, LiDAR, map, oil palm.*

Land-use affects soil microbial co-occurrence networks and functions in both top- and subsoils

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Abstract. Soil organisms have an essential role in soil global biogeochemical processes and ecosystem functioning. Soil microbial interactions are crucial in performing ecosystem functions. The microbial co-occurrence network could shed a new understanding of microbial functioning performances as affected by land management. Current studies on microbial community interactions mainly considered surface soils, while microbial activities also thrive below the surface. We investigated the soil bacterial and fungal network from undisturbed remnant forests and disturbed cropping (vineyard) in topsoils (0-25 cm) and subsoils (40-100 cm) in the Hunter Valley region, New South Wales, Australia. In addition, we also characterise bacteria in performing nutrient cycling. We found that agriculture activities had changed the microbial network for both the topsoil and subsoil. Cropping shifted a widely connected bacterial network found in forest soils to a highly centralized structure not only in the topsoils but also in subsoils. Although the connections within those network clusters were enhanced in cropping soils, the connections between the clusters decreased or even isolated. In terms of the bacterial functions for element cycling, cropping decreased the variability of C cycling bacteria for both surface and below layers, and reduced the amount of C cycling bacteria in the topsoils. Additionally, soil bacterial co-occurrence network clusters were found to be correlated with microbial functioning pathways, which demonstrated the significant influences of microbial network structure for the microbial biological functions.

Keywords: *Co-occurrence Network, bacteria functions, land use, top- and subsoils.*

Soil exchangeable cations estimation using Vis-NIR spectroscopy in different depths: Effects of multiple calibration models and spiking

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Abstract. Due to the high rate of nutrient removal by cotton plants, the productive cotton-growing soils of Australia are becoming depleted of exchangeable (exch.) cations. For long-term development, data on exchangeable calcium (Ca), magnesium (Mg), potassium (K) and sodium (Na) throughout the soil profile is required. However, traditional laboratory analysis is tedious. The visible-near-infrared (Vis-NIR) spectroscopy is an alternative; whereby, spectral libraries are built which couple soil data and Vis-NIR spectra using models. While various models have been used to predict exchangeable cations, their performance was seldom systematically compared. Moreover, most previous studies have focused on prediction of topsoil (0–0.3 m) exch. cations while the effects of depth on applicability of topsoil spectral libraries are rarely investigated. Our first aim was to determine which model (i.e. partial least squares regression (PLSR), Cubist, random forest (RF), or support vector machine regression (SVMR)) produces the best prediction of topsoil exch. Ca, Mg, K and Na. The second aim was to evaluate if the best topsoil model can be used to predict subsurface (0.3–0.6 m) and subsoil (0.9–1.2 m) cations. The third aim was to explore the effect of spiking on the prediction in subsurface and subsoil. The fourth aim was to see if combining all depths to build a profile spectral library improved prediction. Based on independent validation, PLSR was superior for topsoil exch. cations prediction, while Cubist outperformed PLSR in some cases when spiking was applied, and the profile spectral library was considered. Topsoil PLSR could be applied to predict exchangeable Ca and Mg in the subsurface and subsoil, while spiking improved prediction. Moreover, a profile spectral library achieved equivalent results with when topsoil samples coupled with spiking were considered. We, therefore, recommended to predict exchangeable Ca and Mg throughout the profile using topsoil spectral library coupled with spiking approach.

Overview Presentations 4 February

Geographic region: Europe-Africa
Session moderators: Laura Poggio, ISRIC World Soil Information, The Netherlands; Nicolas Saby, INRAE Infosol, France

Presenter	**Affiliation**
Christopher Chagumaira	University of Nottingham, United Kingdom
Ozias Hounkpatin	Swedish University of Agricultural Sciences, Sweden
Gábor Szatmári	Institute for Soil Sciences, Centre for Agricultural Research, Hungary
Konrad Metzger	NUI Galway, Ireland
Alexander Russ	Landesbetrieb Forst Brandenburg, Germany
Margot Peluchon	INRAE UMR SAS Rennes, France
Abdelhakim Zidi	University of Ouargla, Algeria
Sayed Roholla Mousavi	University of Tehran, Karaj, Iran

Stakeholder interpretation of probabilistic representations of uncertainty in spatial information: an example on the nutritional quality of staple crops.

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Abstract. There is interest in implementing interventions to address human micronutrient deficiencies by reference to spatial information on the nutrient content of staple crops. Interventions will be recommended where predicted concentrations are below some threshold. Because the variable concerned is predicted from partial data, it may be useful to map the probability that the threshold is exceeded to communicate the uncertainty in the spatial information. We examined how nutritionists and public health specialists, or soil scientists and agronomists interpret such probabilities when making a decision about interventions to address human selenium (Se) deficiency, given the probability that Se concentration in local staple grain falls below a nutritionally significant threshold. We found no evidence for differences in the responses between locations (Ethiopia and Malawi). Study subjects who were presented information with negative framing (probability that the grain Se content is inadequate) responded differently to those presented with a positive framing (probability that the grain Se content is sufficient). There were also differences according to professional groups, although responses were more consistent when the framing was negative. Negative framing led to more conservative decisions; intervention is recommended at a smaller probability that the grain Se is inadequate than if the question were framed positively. This approach could be used in other settings to elicit threshold probabilities which represent the preferences of stakeholder communities and assist in decision making. The framing of the question is critically important, and this should be done consistently in any elicitation.

Digital soil mapping of soil fertility index for agricultural lands in tropical environment

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Abstract. Indicators of soil production function such as soil fertility index can potentially be a key decision tool in spatial planning for sustainable land management. The establishment of such soil fertility index requires basic soil properties which can be modelled for spatial mapping. The objective of this study was to take advantage of the soil legacy data of Benin to produce a digital soil map of soil fertility index at a national scale based on 8 soil properties (soil organic carbon matter, nitrogen, pH, exchangeable potassium, assimilable phosphorus, sum of base, cation exchange capacity and base saturation). Specific research aims were: (1) to model and develop digital soil maps; (2) to identify important factors influencing soil nutrients; (3) to establish soil fertility potentials using digital soil maps. For each soil property, modelling procedures involved the use of different covariates including soil type, topographic, bioclimatic and spectral data along with the comparative assessment of the Cubist and Quantile Random Forest model. Results revealed that apart from N and exchangeable K, significant models can be produced for most of the soil properties with R-square varying between 28% and 72% with the Quantile Random Forest presenting a more accurate prediction interval coverage probability. The analysis revealed that the distance to the nearest stream has strong predictive ability for all the soil properties along with the bioclimatic variables. Visualisation of the soil fertility map showed that most of the soils in Benin have low fertility levels suggesting that the use of fertilizers and organic materials will be critical in sustaining crop productivity. A limited number of high and average fertility level soils were found in the low elevation areas of southern Benin and policy could advocate for their sole use for agriculture purpose as well as promote sustainable management practices.

Estimating soil organic carbon stock change at multiple scales using machine learning and multivariate geostatistics

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Abstract. Soil is the largest terrestrial pool of organic carbon, which is highly important not just because soil organic carbon (SOC) directly or indirectly influences various soil related properties, functions and services but it is also a double-edged sword, as soil can be either a net sink or a net source of greenhouse gases. Therefore, there is an increasing demand on the knowledge of how SOC stocks vary not just in space but also in time. In this presentation we address how SOC stock change for a given time period may be estimated by applying a digital soil mapping approach to SOC data from the beginning and end of the period considered. Nowadays, stakeholders are highly interested in information on SOC stock change referring to an area or region that is larger than the support of the SOC stock observations, an issue which is commonly referred to as change-of-support in geostatistics. Our study focused on two methodological issues associated with the estimation of SOC stock change at multiple aggregation levels. First, data on SOC stocks is frequently found to be lognormally distributed, which could pose difficulties in spatial modelling especially when change-of-support is targeted. This can be attributed to the fact that the spatial average of lognormal variables is neither lognormal or normal. Second, it is reasonable to assume that there is an interdependency between the SOC stock observations not just in space but also in time, and this should be taken into consideration in spatial modelling in order to gain a coherent estimate of SOC stock change and the associated uncertainty. These issues and a proposed solution are presented on the example of estimating SOC stock change between two years (i.e., 1993 and 2010) in Hungary at multiple aggregation levels using a combination of machine learning and multivariate geostatistical techniques.

Keywords: *Change-of-support, geostatistical cosimulation, uncertainty assessment.*

Mid-infrared spectroscopy as an alternative to laboratory extraction for the determination of lime requirement in tillage soils

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Abstract. Lime is a crucial soil conditioner to bring agricultural soils to optimum pH values for nutrient availability. Lime recommendations are typically determined in laboratory extractions, the most common being the “Shoemaker-McLean and Pratt” (SMP) buffer method, that requires carcinogenic reagents soon to be abolished under the EU legislation. As an alternative to wet chemistry, mid-infrared (MIR) spectroscopy has shown to be a cost-and time effective method at predicting soil properties. The capability and feasibility of diffuse reflectance infrared spectroscopy (DRIFTS) to predict lime requirement (LR) in tillage fields is examined. Samples from 41 cereal tillage fields (n=655) are used to build a calibration for DRIFTS using partial least squares regression (PLSR). The samples were split into a calibration set (31 fields, n=495) and validation set (10 fields, n= 160). After pre-processing with trim, smoothing and standard normal variate, a calibration model using 6 latent variables, provided R^2 of 0.89 and root mean square error of cross-validation (RMSECV) of 1.56 t/ha. Prediction of all fields from the validation set resulted in R^2 of 0.76 and root mean square error of prediction (RMSEP) of 1.68 t/ha. The predictions of the single fields ranged from R^2 values of 0.41 to 0.72, RMSEP of 0.48 to 4.2 t/ha and ratios of performance to interquartile distance (RPIQ) of 0.45 to 3.56. It was shown that the signals of soil constituents having an influence on the LR were picked up in the spectra and were identified in the loading weights of the PLSR. While the error is too high to predict the variability of LR within the field, MIR prediction using field averages provided a viable alternative to current laboratory methods for blanket spreading of lime on tillage fields.

Keywords: *Soil spectroscopy, lime requirement, SMP buffer, MIR DRIFTS, chemometrics.*

Three-Dimensional Mapping of Forest Soil Carbon Stocks Using SCORPAN Modelling and Relative Depth Gradients in the North-Eastern Lowlands of Germany

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Abstract. Nowadays regional data on forest soil properties are increasingly demanded for various questions concerning forest management practices like tree species selection, liming, harvest intensity or the detection of risk areas. Thus data related to climate change and its site specific drought effects on one hand and current soil nutrient status on the other is especially required to support decision making. Besides soil texture, soil organic carbon is one of the most important key factors controlling soil nutrient status (eg. cation-exchange capacity) and soil water storage (e.g. field capacity) in the glacial deposits of north eastern lowlands. In contrast to soil texture, which can be considered as stable over periods relevant to practical forest management, for mapping soil organic carbon and its distribution throughout the soil profile a more dynamic regionalization approach considering contemporary measurements is needed. For this purpose, data on contemporary soil organic carbon stocks is taken from the second National Forest Soil Inventory and additional regional sampling points in Brandenburg (Germany). Potential covariates representing the soil forming factors: parent material, organisms (vegetation), age, relief and climate are obtained with high spatial resolution from forest site mapping, forest inventory, digital terrain analysis and climate models. The proposed regionalization approach captures the concepts of SCORPAN modelling and depth functions. While for estimation of carbon stocks in the entire soil solum stepwise regression analysis and geostatistical techniques are involved, the methodology to derive and map relative depth functions is based on cluster analysis and classification tree approach. The intended benefits by splitting regionalisation into plot level and relative vertical depth gradients are to ensure consistency of solum stocks and single soil depths and to avoid the construction of artificial depth gradients. Furthermore, the procedure allows a straightforward interpretation of covariates in the sense of pedogenetic processes, which: (a) supports variable selection and exclusion of spurious covariates during model development and (b) may provide direct decision support regarding environmental and management effects on soil organic carbon. The obtained statistical models contain covariates related to all five soil forming factors. But, the conducted analyses especially point towards high influences of depth to groundwater table and mean slope of catchment area on soil organic carbon storage. Invoking geostatistical techniques shows no remaining variation, to be explained by spatial position and thus don't improve overall model performance. Cluster analysis of relative depth gradients results in five Clusters of acceptable heterogeneity. The highest differences between the clusters are observed across the portions of carbon stored in the forest floor. Relative depth gradients are especially distinguished by tree species composition and stand age.

Evaluation of SLAKES, a new smartphone technology for measuring aggregate stability: a case study in silty loam soils with contrasted managements

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Abstract. The measurement of aggregate stability is widely used to evaluate soil condition being an important indicator of soil quality. The SLAKES mobile app, implemented in Australia, is an alternative tool to measure soil aggregate stability avoiding high-cost experiments and using simple equipment. It provides aggregate stability measurements through Slaking Index (SI) in only 10 minutes. SI close to 0 suggests a high stability and values above 7 indicate minimum stability. As SLAKES has proven its efficiency in previous studies, the app could be very attractive for scientists and no-scientists. This study was conducted to determine whether the SLAKES mobile app could be adapted to French soils and spread out. Indeed, it then could be an alternative to the Mean Weight Diameter (MWD) method, a method normalized in France (ISO 10390). More specifically, this study explored three main objectives: (i) determining whether the aggregate stability measurements depend on the phone used for the experiment, (ii) estimating the number of measurements necessary to get reliable results, (iii) determining whether the app has the ability to detect the effect of contrasting soil managements (effects previously shown with the MWD method). We measured SI for 24 silty loam samples from EFELE (Effluents d'Elevage et Environnement) experimental site at le Rheu (Brittany, France) which is part of the French "Organic waste products" research observatory (SOERE PRO). The experimental scheme combines two different tillage practices (conventional tillage and shallow tillage) with two fertilization treatments (mineral and farm effluent: cattle manure) randomly replicated three times. Soil samples, at both 0-15 cm and 15-25 cm depth, were collected in March 2017 from the 12 plots. Four different mobile devices (phones) of the same brand and generation were used. The SI was measured on three aggregates simultaneously. This process was repeated 15 times for each sample providing 45 SI per sample. Before statistical studies, outliers above SI=11 were removed. First, the device used did not affect the SI measurements. This was demonstrated by analyses of variance applied on 3 results from three contrasted samples in terms of SI. The SLAKES results were comparable with the results obtained by the MWD method regarding significant separation of means ($p < 0.0001$) between each soil management. According to the results of an analysis of variance, SI was significantly lower in reduced tillage than in conventional tillage condition (p-value = 2.10^{-16}). These results indicate a higher soil stability in reduced tillage. Yet, no effect of fertilization was observed on the SI (p-value = 0.28), confirming the previous findings obtained with the MWD method. This study proved that some effects of soil management practices can be

detected with a mobile app and a relatively simple experimental system, with similar performance than the MWD method. This conclusion was reinforced by the existing correlation between the SI and the MWD index (p-value = 0.00059, R^2 = 0.39). Since we studied samples with identical texture, we recommend performing similar tests in other pedological and soil management contexts, taking at least 15 measures per soil sample.

Mapping soil surface states in the Sahara desert using optical and radar remote sensing. Case of the Guerra Region (Algeria)

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Abstract. Digital soil mapping is very important for the development of agricultural potentials, especially in desert areas where there is a lack of works and basic documents. The progress made in remote sensing today offers the possibility of mapping large areas from images with increasing accuracy. The development of high-performance classification algorithms also makes it possible today to create more coherent and reliable maps. This work aims to study soil surface characteristics of the municipality of Guerrara by remote sensing using satellite data. The research area is situated in the northern Sahara about 600 km south of the capital of Algiers (Algeria). The Guerrara region (32.790278°N, 4.492222°E and 303m Elevation) is characterized by a hyper-arid climate and by alluvial soils of great agronomic potential and very high quality, as compared to other soils in the Sahara desert. For this purpose, a total of 19 classification schemes have been experimented, resulting in the conclusion that the combination of Random Forest and Maximum Likelihood is the most suitable classification method to carry out a mapping of surface states in the region of Guerrara, using Landsat 8 data - Sentinel-2 - spectral indices and VV polarization of Sentinel-1. Thus, the supervised classification of soil pixels by Random Forest was performed under the Orfeo ToolBox (OTB) platform using data from previous work and basic documents used for model learning. The Kappa index and overall accuracy are used to evaluate the performance of the classification. We obtained as a result 36% of the sandy surface state, wish involved sandy glacis to coarse sand and gravel, 13% of the sandy surface state: involved sand dune massif to fine sand, 11% of the limestone reg surface state of the continental Pliocene and 1% of the silty surface state. The combination of satellite data (Landsat 8, Sentinel-2 and Sentinel-1) allowed an overall accuracy of 99.82%. This justifies the choice of this combination for soil mapping in the region.

Keywords: *Soil surface states, remote sensing, soil map, modeling, Guerrara, Sahara desert.*

Digital mapping of land suitability index of the major horticultural and irrigated crop by machine learning models in west Iran

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Abstract. Increasing pressure on soil resources due to population growth, development of urban and industrial areas has led to a decrease in agricultural land area, therefore, the optimal and sustainable use of soil and land resources seems necessary. So, the present study aims to digital land suitability evaluation for irrigated horticultural products (grapes, pistachios, and olives) and crop (wheat, barley, and saffron) in the vicinity of Badreh city by using machine learning (ML) algorithms in an area with 1840 ha. A total of 80 soil profiles location were designed by conditional Latin hypercube (clhs) method, dug, describe, and sampled. After that, all of the soil samples were transferred to the laboratory to measure soil physio-chemical properties. Based on laboratory analysis, the average of soil properties was determined by considering the depth weighted coefficient up to 100 and 150 centimeters for annual and perennial crops, respectively. Then, the soil characteristics of each profile were matched with the land criteria requirement table and the climatic characteristics required with the climatic requirement tables of different crops. Then, final qualitative land suitability classes were determined using the square root- parametric method. In order to spatially model and predict the classes and sub-classes of land suitability evaluation, two ML models of boosted regression tree (BRT) and classification decision tree (DTc) were used. The variance inflation factor (VIF) was used to feature selection. The applied models were calibrated with 80% of data (n=64 soil profile) for training and 20% of data (n=16 soil profile) for validating. Overall accuracy (OA) and Kappa index were used for evaluating model performance. The feature selection results obtained that, 12 covariates ie., included slope length, midslope position, geomorphons, modified catchment area, vertical distance to channel network, convergence index, clay index, wind effect, analytical Hillshading, normalized difference vegetation index, and multi-resolution valley bottom flattens index (MRVBF) as a representative of topography and RS factors were selected by VIF method among a total of 53 environmental variables. The results of spatial modeling indicated that the BRT method for the class and subclass land suitability of the selected crops based on OA statistical index for wheat, barley, and saffron (85%, 75%, 75%) and (66%) (59%, 70%) and for horticultural crops of grapes, olives, and pistachios (85%, 91%, 89%) and (74%, 67%, 60%), respectively, and provided higher accuracy than the DTc method. In general, based on both models, the OA and kappa index values had a decreasing trend from class to subclass level. Also, among the environmental variables predicting irrigated crops horticultural land suitability classes and subclasses are wind effect indices, MRVBF, analytical Hillshading, vertical distance to distance channel network, slope length, and carbonate index, and for crops had the highest relative importance in comparison to other variables. Generally, the use of the BRT ML algorithm in relation to environmental variables, is well and able to predict class and subclass land suitability map of strategic crops included wheat, barley, saffron, grapes, pistachios, and olives in the study area with high accuracy.
Keywords: *Boosted regression tree, Decision tree classification, Digital mapping, environmental covariates, Land suitability evaluation.*