ΠΕΔOMETRON

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Commission 1.5 Pedometrics Div. 1 of the International Union of Soil Sciences (IUSS)

Chair: Gerard Heuvelink **Vice Chair & Editor: Sabine Grunwald**

1. From the Chair

Dear Pedometricians!

It is less than two months before we will have our bi-annual Pedometrics conference. This time we will meet in Naples, Florida. A detailed program of the meeting is presented in this issue of Pedometron. Recently, someone pointed out to me that our meeting is scheduled right in the middle of the hurricane season, so with some luck we will have a very exciting event.

In the previous Pedometron, you will have read the report about the Digital Soil Mapping workshop in Montpellier. Shortly (I hope!) a book will come out based on the papers presented at the workshop. Perhaps it will be published even before the long-awaited 'Environmental Soil-Landscape Modeling' book edited by Sabine, let's see which book makes it first. There is a lot of activity taking place on DSM right now. The next meeting will be in 2006 in Brazil, just before the World Congress of Soil Science. You will find more information about both meetings under 'Upcoming Meetings'. We are delighted that the importance of DSM has also been recognized by the IUSS Bureau, which last month has formally approved a proposal to establish a Working Group DSM within the IUSS. The new working group will function under the umbrella of the Soil Geography and Pedometrics commissions, so this is an excellent opportunity for soil scientists from the two commissions to get to know each other better and start collaborations.

With Pedometrics 2005 just ahead of us, we might forget that the deadline for abstract submission for the WCSS in Philadelphia next year is September 15, 2005!!! It will be difficult to submit an abstract from an airboat right in the middle of the Everglades, so I urge all of you not to wait until the final day but submit your abstracts well in time. This is the first time that the Pedometrics commission has been given the chance to organise a symposium at the WCSS (we have two symposia, in fact!), and it is important that we make these symposia a success. We want to be visible and reach out to other soil scientists. The WCSS is the perfect place to do just that. I hope that many of you will visit the WCSS website (http://www.colostate.edu/programs/IUSS/18wcss/index.html) and submit an abstract.

See you soon in Florida!

Gerard

INSIDE THIS ISSUE

2. Separating Random and Deterministic Spatial Components in Soil Data with REML

R.M. Lark & R. Webster

Rothamsted Research, Harpenden, Hertfordshire AL5 2JQ, Great Britain
E-mail: murray.lark@bbsrc.ac.uk; richard.webster@bbsrc.ac.uk

Embracing geostatistics was perhaps the most significant step we pedometricians ever took. It required an act of imagination to treat spatial variation in soil as if it were random, the outcome of stochastic processes. After all, we had been led to believe that the soil at any one place was determined by five soil-forming factors and that the laws of physics must hold. Instead, we discovered that we could treat many sets of data as deriving from second-order stationary random processes. These are ones with constant means and variances and with spatial covariances that depend only on lag and not on absolute position. If it seemed unreasonable to assume a constant mean then at least Matheron's intrinsic stationarity would hold and we could work with simple variograms. Numerous research papers and case studies in the last 20 years attest to the success of these models of stationarity, with ordinary kriging as the 'work-horse' for spatial prediction and interpolation.

However, not all variation in soil is as simple. In many situations there is evident trend in addition to what seems to be random fluctuation, and if we try to estimate covariance functions or variograms directly from raw measurements we shall get misleading results. The variogram can properly describe only the random component and not the combination of random and deterministic components. So, somehow we have to model such variation as that combination.

Georges Matheron (1969) elaborated kriging to cope with the combination so as to predict values at unrecorded sites and larger blocks. The technique, which he called 'universal kriging', uses the variogram of the residuals from any trend in augmented sets of equations that include terms for the trend. An attractive feature of universal kriging is that you do not have to know precisely what the trend is at any place, only its general form: linear, quadratic or some other. But, as above, you do have to know the variogram of the residuals from the trend, and estimating that is difficult.

If you estimate the trend by the once-popular trend surface analysis, which is straightforward multiple regression on the spatial coordinates, then you obtain a surface from which the residuals are autocorrelated; the variances of the predictions are not minimized therefore. Furthermore, the variogram of the residuals is biased. If your data are on a regular grid or transect then you can obtain an estimate of the variogram of the residuals by a structural analysis, corrected for the bias; Ricardo Olea (1975) spelled out the procedures in a series of algorithms. If the data are from irregularly scattered sampling points then this is not an option.

An alternative to universal kriging, also proposed by Matheron (1973), was to model variation as intrinsic random functions of order *k*, IRFk, with $k > 0$. Analysis then proceeds by looking effectively at successive differences in neighbouring data and computing generalized covariances. Functions of these are then used for kriging predictions. As for the structural analysis, sampling must have been at regular intervals on grids or transects.

So, where there is trend and sampling has been irregularly scattered, which is usual in soil surveys, there is a problem; you cannot estimate the trend with assurance because you do not know how the random residuals are distributed, and you cannot estimate the variogram of the residuals without bias because you do not know the trend. The solution to the problem is to use residual maximum likelihood, REML.

Residual maximum likelihood was first proposed by Patterson & Thompson (1971) to estimate variance components. We can recall that around that time pedometricians were also interested in variance components. They estimated these from designed samples, and computed intra-class correlations of soil properties to evaluate the effectiveness of soil classifications. Statistical geneticists compute intra-class correlations for traits in plants and animals the classes of which are genetically uniform lines. They call the correlations 'heritabilities', and REML is the tool they choose for their estimation. Now pedometricians are turning to REML to solve problems arising in the geostatistical methods which we took up as an alternative to the analysis of variance!

We can use REML in geostatistics as follows. We obtain from our data a new random variable that is independent of a specified trend model and which has a covariance matrix derived from a known form of covariance function for the residuals from the trend. We apply maximum likelihood to estimate the parameters of that function. For the familiar spherical or exponential functions these are the nugget and sill variances and the distance parameters (the range in the case of the spherical function). Note that REML is in this sense a generalization of the IRF*k* method, since in IRF*k* the differences of order *k* are combinations of the original data independent of a trend model.

Once the parameters of the covariance function have been estimated they can be used to compute the covariance matrix of our observations, which in turn enables us to obtain minimum-variance estimates of the parameters of the trend component by generalized least squares. We can now compute at target points best linear unbiased predictions (BLUP) of the variable of interest from our data. We call them 'E-BLUP' predictions, in which the E, for empirical, means that the variogram is an empirical estimate of the assumed underlying function.

The E-BLUP estimate has two separate parts. One part is the estimate of the trend component, derived from the assumed form of the surface, its estimated parameters and the covariances among the data and the target point. The other is recognizably a kriged term embodying the same covariances and the data. The parts simply add together to give the final predictions. E-BLUP is directly equivalent to universal kriging. What REML has allowed us to do is to estimate the requisite covariance parameters without bias, and using all the data, not just paired comparisons that we assume are unaffected by the trend.

We have recently re-analysed data on the Sub-Upper Chalk surface beneath the Chiltern Hills of southeast England. The values are the heights of this surface above sea level at 238 places, irregularly scattered. The data were originally analysed by Moffat et al. (1986) who separated out a regional quadratic trend by ordinary least squares regression and the random residuals from it with a spherical variogram. They then kriged the random residuals and added back the trend to obtain their final predictions. As above, the results were not minimum-variance predictions, and the variances of the predictions would have been underestimated.

In our new analysis by REML we assumed that the forms of the two components were broadly correct, i.e. we could represent the surface as a quadratic trend plus random residuals with a spherical variogram. We used the simulated annealing algorithm of Lark & Cullis (2004) to maximize the log-likelihood and thereby obtain the REML estimates of the variance models. These were put into the final equations for the E-BLUP predictions at numerous points on a grid, and the whole grid was then contoured.

Our results will be reported in full elsewhere, and here we can give only a glimpse. Figure 1 shows two variograms; the lower one is the experimental variogram of the residuals from the ordinary least squares (OLS) regression surface, the upper one is the variogram estimated by REML. Note that near the ordinate the two almost overly one another, but that as the lag distance increases the discrepancy between the two increases, with that from the OLS residuals consistently underestimating that from REML. This accords with theory (see Cressie, 1993).

Figure 2 is a contour map of the surface. It follows the general regional dip of the surface from northwest to southeast with flexures approximately perpendicular to the dip. This map is indistinguishable from the one made by Moffat et al.. Our final figure (Figure 3) is an isarithmic map of the prediction variances. It has the same general pattern as the map of the kriging variances made by Moffat et al., but with substantially larger values. Not only does it incorporate the large contributions from the kriging, it also includes the variances for the trend, which were absent from the map of Moffat et al.

So, geostatisticians have in REML a piece of technology that enables them to estimate the separate variance parameters of any trend and of the residuals from the trend. They can use it to obtain minimum-variance unbiased predictions at unsampled places by combining the trend predictors with the random variation in universal kriging.

References

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Moffat, A.J., Catt, J.A., Webster, R. & Brown, E.H. 1986. A re-examination of the evidence for a Plio-Pleistocene marine transgression on the Chiltern Hills. I. Structures and surfaces. Earth Surface Processes and Landforms, 11, 95–106.

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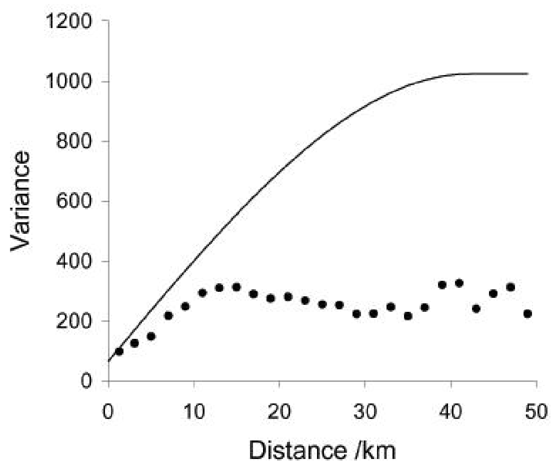

Figure 1 Variograms of height of Sub-Upper Chalk surface. The black discs form the experimental variogram of the residuals from the quadratic surface fitted to the data by ordinary least squares regression, the continuous line is the variogram estimated by REML.

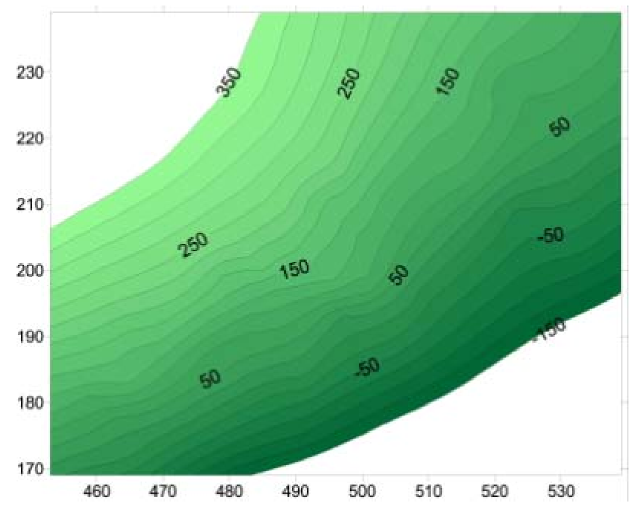

Figure 2 Contour map of the Sub-Upper Chalk surface made by universal kriging. Units are meters, the co-ordinates are in kilometers.

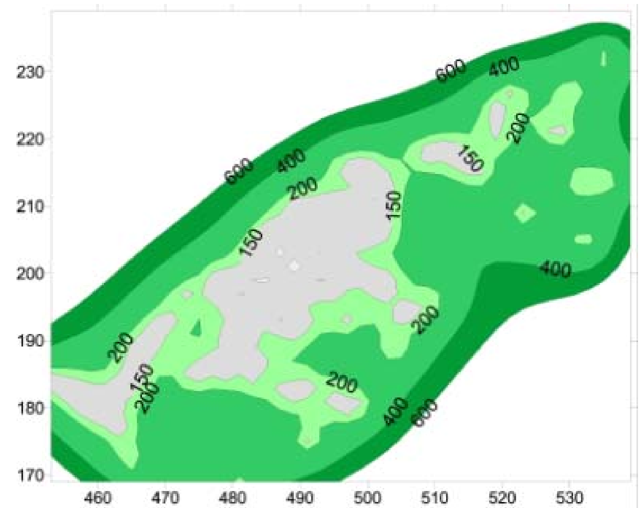

Figure 3 Isarithmic map of the universal kriging variances.

3. Working Groups

Several working groups have been proposed to work under the umbrella of Commission 1.5 Pedometrics to focus on specific themes. The first one “Digital Soil Mapping” was initiated at the Global Workshop on Digital Soil Mapping in Montpellier in 2004. A proposal to formalize this working group has recently been accepted by the IUSS. The idea for a second working group “Proximal Soil Sensing” has been initiated by Dr. David Brown, Montana State University, Bozeman, USA. A third proposed working group is spearheaded by Dr. Annamaria Castrignanò – the Italian group of Pedometrics.

3.1 Working Group "Digital Soil Mapping"

The Working Group operates under the auspices of the Commissions on Pedometrics and Soil Geography

Proposal Prepared by
Alex. McBratney, Marc Voltz, Janis Boettinger,
Thomas Scholten, Thorsten Behrens, and A Xing-Zhu

A shortened version of the proposal:

EXECUTIVE SUMMARY

Given the relative dearth of, and the huge demand for, quantitative spatial soil information, it is timely to develop and implement methodologies for its provision. We suggest that digital soil mapping, which can be defined as the creation, and population of spatial soil information systems by the use of field and laboratory observational methods coupled with spatial and non-spatial soil inference systems, is the appropriate response.

1. BACKGROUND TO THE CASE

With the great explosion in computation and information technology has come vast amounts of data and tools in all field of endeavour. This has motivated numerous initiatives around the world to build spatial data infrastructures aiming to facilitate the collection, maintenance, dissemination and use of spatial information. Soil science potentially contributes to the development of such generic spatial data infrastructure through the ongoing creation of regional, continental and worldwide soil databases, and which are now operational for some uses e.g. land resource assessment and risk evaluation.

Unfortunately the existing soil databases are neither exhaustive enough nor precise enough for promoting an extensive and credible use of the soil information within the spatial data infrastructure that is being developed worldwide. The main reason is that their present capacities only allow the storage of data from conventional soil surveys which are scarce and sporadically available.

The main reason for this lack of soil spatial data is simply that conventional soil survey methods are relatively slow and expensive. Furthermore, there is a worldwide crisis in collecting new field data in general which leads some to be very pessimistic about future developments in conventional soil surveying. Others believe technologies, such a hand-held field spectrometers, will come to the rescue.

To face this situation, we think that the current Spatial Soil Information Systems have to extend their functionalities from the storage and the use of digitised (existing) soil maps to the production of soil maps *ab initio*. This is precisely the aim of *digital soil mapping,* which can be defined as *the creation, and population of spatial soil information systems by the use of field and laboratory observational methods coupled with spatial and non-spatial soil inference systems.*

The development of digital soil mapping methods has been a growing activity for the past decades. It is moving inexorably from the research phase of the early 1990's to production of maps for regions, catchments and whole countries. Moore's Law is a scaling law developed in the 1970's, stating that electronic device feature sizes would decrease by a factor of 0.7 every three years or the processing power of microchips doubles every eighteen months. Although this empirical law has attracted various kinds of critics, this prediction has proven to be accurate enough that it has become well-established within the computer and information technology industries. Because digital soil mapping is underpinned by information technology one might speculate a relationship between the size of DSM project that might be tackled and time. Taking data on the number of pixels described or predicted from the earliest projects up until the present day we can observe an exponential growth with time. The fitted line describes a ten-fold increase every 7.1 years, or a doubling in the number of pixels every 26 months – slightly slower than Moore's law. The scaling model predicts that we should be able to have a 10-metre resolution digital soil map of the world by 2040, but we must not sit back and believe it will just happen!

This evolution is contemporaneous with the increasing development of spatial data infrastructures which provide more and more exhaustive mapping of soil-forming factors e.g. DTM, remotely sensed images. Meanwhile, the classical toolbox for observing and characterising soils in the field (codified observations of auger hole and pits and laboratory chemical analysis) is more and more integrated within GIS thanks to new tools such as GPS or PAD observation forms. It is also complemented with new field observation techniques able to hasten and objectify the collection of soil data e.g., geophysics and visible-NIR spectrophotometry. In parallel, a body of research work in geographical Information science heralds the evolution from classical raster or vector GIS, tools limited to the collection and storage of all kinds of spatial data, to more sophisticated systems able to represent more complex spatial models, and to embed spatial reasoning procedures such as inductive learning, or hierarchical reasoning. Therefore, a perspective now exists to integrate in modernised GIS packages all the computational work on digital soil mapping which has been done so far outside the framework of simple raster or vector GIS. In this perspective, we feel it is timely to develop a general intellectual and operational framework for digital soil mapping which can integrate the recent developments in numerical soil mapping techniques in the light of the knowledge on soil cover which has been accumulated for a century or so by soil surveyors.

The proposed working group sees the realization of digital soil mapping worldwide as its key goal. We are aware in order to achieve this we need a focused group of scientists willing to discuss and collaborate, and willing to help others in capacity building.

3.2. Working Group "Proximal Soil Sensing"

Within the US soil science community—and particularly within the subdisciplines of pedology and soil physics—there has been a growing interest in a range of proximal soil sensing technologies and their application to quantify soil temporal and spatial variability. To stimulate discussion and interaction among a diverse group of scientists, I have written, informally distributed for comments, and revised a draft abstract on Proximal Soil Sensing (PSS). Assuming that there is as much or more interest internationally, I provide the draft abstract and logo below with the goal of stimulating international discussion. I welcome comments, additions, constructive criticism, and proposed revisions.

The response I have received to date has been overwhelmingly positive. There are a large number of researchers working with specific technologies that fall under the wider concept of PSS. However, there is limited interaction between scientific groups focused on different technologies, and therefore not as much synergy as might be possible. Researchers I have contacted in the US are excited about the idea of enhancing cross-technology and cross-disciplinary communication.

There is immense interest in PSS, and we just need to insert a "seed" to start the crystallization process. There are a number of directions that we can take to develop PSS as a coherent and connected research focus: (i) designate PSS as a focus area for the Naples '07 Pedometrics meeting; (ii) emphasize PSS as a topic of interest for the "high-resolution" Digital Soil Mapping (DSM) meeting in '08; (iii) organize special sessions at national soil science meetings (e.g. SSSA, '07); and (iv) seek IUSS "working group" status. I propose that those of us interested in PSS pursue all of these initiatives.

David Brown
Montana State University - Bozeman

<u>Proposed Mission Statement</u>:
Proximal Soil Sensing (PSS) is an emerging, cross-cutting research nexus focused on the rapid, inexpensive and often *in situ* acquisition of physical, chemical, and mineralogical soil properties through the use of mechanical, electromagnetic, biological or spectroscopic sensors. Sensor readings can be georeferenced using global positioning systems (GPS)

to provide high resolution geospatial data. PSS techniques are defined by: (i) sensor proximity to interrogated soil (from direct contact to within a few meters); and (ii) non-destructive characterization of whole and intact soils, as distinct from conventional laboratory methods which involve treating, separating, or extracting soil materials prior to analysis. Within PSS, constituent areas of investigation include sensor engineering, mathematical and statistical modeling, and basic research into the science of soil-sensor interactions. Examples of relevant technologies include penetrometers, time-domain reflectometry (TDR), ground-penetrating radar (GPR), electromagnetic induction (EMI), biosensors, diffuse reflectance spectroscopy (DRS) (ultraviolet, visible, near-infrared, and mid-infrared), Raman spectroscopy, laser-induced breakdown spectroscopy (LIBS), inelastic neutron scattering (INS), and nuclear magnetic resonance imaging (NMRI). As every soil sensing technology has strengths and weaknesses, successful soil characterization and monitoring will ultimately depend upon the development of integrated multi-sensor arrays. The articulation of Proximal Soil Sensing as a new research focus provides a vehicle for greater interaction and collaboration between scientists and engineers with a common interest in applying state-of-the-art sensing technologies to the study of soil processes and spatio-temporal variability. To comment on the proposal to form the working group "Proximal Soil Sensing" and to become involved in their activities please contact:

David Brown <djbrown@montana.edu>

4. National Geospatial Development Center

in Morgantown West Virginia, USA

In Fiscal Year 2004, the U.S. Department of Agriculture-Natural Resources Conservation Service received funds to establish a new technology center in cooperation with the Department of Geology and Geography of the Eberly College of Arts and Sciences at West Virginia University (WVU). The National Geospatial Development Center will compliment existing Natural Resource Conservation Service (NRCS) technology centers to further facilitate the innovative use of geographic information systems (GIS) and geo-technology tools to support NRCS business needs and those of the partners. The Center will collaboratively develop and integrate tools, methods and procedures to ensure delivery of useful and high quality resource information to the NRCS community.

The Center will facilitate the innovative use of geographic information systems and related technologies to support business processes including but not limited to, data collection, archiving, access, dissemination, analysis and interpretation. The Center will explore technologies that deliver NRCS resource information to both the internal and external community in a usable and meaningful format. The Center will work closely with existing NRCS and USDA technology centers to ensure adherence to required agency policy and planning.

The Center will identify and integrate advanced technologies to bring soil data and natural resource information to the user community in a format that is easily accessed and readily understood and consistently reliable.

The Center is staffed by Co-Directors Jon Hempel, NRCS and Dr. Trevor Harris, West Virginia University. Staff expertise includes network administration, web programming, landscape/soil modeling, spatial/GIS analysis, database analysis, computer modeling and remote sensing. The staff is a combination of NRCS and WVU employees as well as graduate and undergraduate students.

The Center will work cooperatively with other Land Grant Institutions to further the advancement of geospatial technology for NRCS through the Cooperative Ecosystem Study Unit Network (CESU). The Center will use the CESU to formalize collaboration and partnerships, define deliverables and identify milestones relating to research projects.

The Center is also interested in working with the international community particularly for the advancement of digital soil mapping.

Center contacts are:
Jon Hempel-Co-Director, Jon.hempel@mail.wvu.edu
Trevor Harris-Co-Director, Trevor.harris@mail.wvu.edu
157 Clark Hall Annex
P.O. Box 6301
Morgantown, WV 26508
304-293-8232; 304-293-8185 (fax)

5. Pedometrics 2005 Meeting

Biannual Meeting of Commission 1.5 Pedometrics, Div. 1 of the IUSS
September 12-14, 2005
Naples, Florida, USA

Activities for the upcoming Pedometrics 2005 Meeting in Naples, Florida, USA are ongoing.

A total of 68 abstracts for oral and poster presentations were submitted by researchers and scientists from the following countries: Australia, Belgium, Brazil, Canada, China, Croatia, Czech Republic, Denmark, France, Germany, Iran, Italy, Kenya, Netherlands, Russia, Spain, South Africa, Uganda, United Kingdom, and USA.

The conference features three outstanding keynote speakers that will provide stimulating talks on the following topics:

Dr. Jay Bell, Professor in the Department of Soil, Water, and Climate at the University of Minnesota, USA.
Keynote Talk: Dynamic Soil Mapping: Adding the Temporal Dimension.

Dr. Harold M. van Es, Professor in the Department of Crop and Soil Sciences at Cornell University, USA.
Keynote Talk: Spatially-Balanced Experimental Designs for Field Experiments

Marc Van Meirvenne, Professor in the Dept. Soil Management and Soil Care, Faculty of Bioscience Engineering, Ghent University, Belgium.
Keynote Talk: Pedometrics in Transition: From too few to too many Data?
Information about registration, lodging, and more is available at:
http://conference.ifas.ufl.edu/pedometrics/.

Questions related to the meeting should be send to:
Sabine Grunwald (SGrunwald@ifas.ufl.edu) or
Sharon Borneman, Office of Conferences & Institutes University of Florida/IFAS (SPBorneman@ifas.ufl.edu).

Pre-Conference Workshop
Time: Sept. 9-10, 2005.
Location: University of Florida, Gainesville, Florida.

Theme: Quantitative Visible and Near-Infrared Diffuse Reflectance Spectroscopy (VNIR-DRS) for Soil Characterization.

Instructors: Dr. David Brown (Montana State University, Bozeman, MT; djBrown@montana.edu) and Dr. Fred McClure (North Carolina State University, Raleigh, NC).

Workshop Outline:
Theory

- Introduction
- Infrared Spectrometry Beer's Law
- Diffuse Reflectance
- Physical Chemistry of Infrared Absorptions
- Spectroscopy of Soil Minerals and Materials

Instrumentation

- Introduction
- General Spectrometry
- NIR Spectrometry
- Energy Sources
- Wavelength Selectors
- Dispersive vs. Fourier Transform
- Operating Modes
- Detector/Sample Configuration
- Electronics
- Detector Circuits
- Spectrometer Performance
- Trends: Where is NIR Going?

Analyses

- Pre-Processing
- Calibration – Validation
- Empirical Modeling Techniques (Step-wise multiple linear regression; principal components regression; partial Least Squares Regression; and boosted regression trees)
- Model Performance Statistics
- Trends and Futuristic Concepts

5.3. Post-Conference Field Trip
Time: Sept. 15, 2005
Location: Greater Everglades, Florida, USA.

Instructor: Dr. Mark Clark, Soil and Water Science Department, University of Florida (clarkmw@mail.ifas.ufl.edu).

Field Trip Itinerary

The post conference tour will take you to some of the natural communities prominent to the Greater Everglades Ecosystem. Much of the Everglades is inaccessible and luckily so to keep it as minimally impacted as possible, but our trip will take you to one of Florida's more unique State Preserves where extremely rare plants, orchids and a lush old growth cypress strand is accessible by board walk. Then experience the thrill of an airboat ride through the River of Grass while seeing first hand what the heart of the Everglades looks like. We will also get a bird's eye view of the Everglades from a xx ft. tower along the West side of the Park and a good opportunity to see the more common wildlife in the area.

Depart Hotel in vans
8:00am

Travel
8:00-8:45am

Fakahatchee Strand State Preserve
9:00am-10:00am

The Fakahatchee Strand is the major drainage slough of southwestern Big Cypress Swamp and the largest and most unusual of the strands. Although logging, drainage and other human actions have had a serious impact on the swamp, it is still one of the state's most unusual natural features.

The natural values of the Fakahatchee Strand may be greater than those of any area of comparable size in the state of Florida. It contains the largest stand of native royal palms and largest concentration and variety of orchids in North America, as well as other species of plants that are extremely rare. The unusual wildlife of the Fakahatchee Strand includes some threatened or endangered species. The Florida panther, wood stork, Florida black bear, mangrove fox squirrel and the Everglades mink have all been documented within the preserve area.

A 2,000-foot long boardwalk at Big Cypress Bend, meanders through the old growth cypress and will be our destination at this site.

Travel to Everglades Safari Airboat Tours
10:00am-11:00am

Airboat tour of Everglades
11:00am-12:30pm

The Everglades is a relatively inaccessible area due to limited roads and the types of vehicles that can operate in wetland conditions. Transport by airboat offers an unusual but effective way to get around in this environment. We will take a one hour airboat ride into the heart of Shark River Slough in the southern Everglades. This Stop on the tour will give you a unique look at a relatively undisturbed area of the Everglades.

Travel (7 miles west on Tamiami Trail) eat lunch in vans
12:30pm-1:00pm

Shark Valley: Everglades National Park
1:00pm-3:00pm

There are few opportunities to get a bird's eye view of the Everglades, but the tower at Shark Valley gives you a good look from above. In addition to the Tower, a Tram ride on a 15 mile loop road that juts about 7 miles into the Everglades will give you a good look at much of the wildlife common to the Everglades and a feel for the transitional zone between the longer hydroperiod sawgrass marshes to the east and the mixed cypress and marl prairies to the west.

Travel back to Naples
(with a possible stop at Big Cypress National Preserve - *time and weather permitting.*)
3:00pm-5:00pm

6. Best Pedometrics Paper Awards

Every two years the members of the Pedometrics Commission select the best papers in Pedometrics of the previous two years. The election is done by secret ballot during the Pedometrics meeting. The winners of this prestigious award are announced, celebrated and receive a framed certificate at the conference dinner. This year, Dr. **Peter Finke** (University of Ghent, Belgium) and Dr. **Neil McKenzie** (CSIRO, Canberra, Australia) nominated the papers for 2003 and 2004, respectively. The nominated papers and their abstracts are listed below, but we strongly advise that you read the full papers before casting your vote. So please spend a few days on reading the papers, it will be time well spent!

The election proceeds as follows:

a) Only pedometricians on the mailing list and registered participants of Pedometrics 2005 are considered as eligible voters.
b) Each vote must consist of a ranking of all 5 papers for 2003 and 2004, respectively. Rank 5 for the highest preference to 1 for the lowest preference.
c) The votes will be collected during Pedometrics 2005.
d) Pedometricians on the mailing list that are not attending Pedometrics 2005 may cast their votes by sending an email with their ranking to Sabine (SGrunwald@ifas.ufl.edu).

Nominations 2003

Gorssevski, P.V., P.E. Gessler and P. Jankowski, 2003. Integrating a fuzzy k-means classification and a Bayesian approach for spatial prediction of landslide hazard. J Geograph Syst 5, 223-251.

Hengl, T., D.G. Rossiter and A. Stein, 2003. Soil sampling strategies for spatial prediction by correlation with auxiliary maps. Australian J. of Soil Res 41, 1403-1422.

Lark, R.M. and H. C. Wheeler, 2003. A method to investigate within-field variation of the response of combinable crops to an input. Agron. J. 95, 1093–1104.

Metternicht, G.I., 2003. Categorical fuzziness: a comparison between crisp and fuzzy class boundary modelling for mapping salt-affected soils using landsat TM data and a classification based on anion ratios. Ecological Modelling 168, 371-389.

Walter,C., R.A. Viscarra Rossel and A.B. McBratney, 2003. Spatio-temporal simulation of the field-scale evolution of organic carbon over the landscape. Soil Sci. Soc. Am. J. 67, 1477–1486.

Gorsevski, P.V., P.E. Gessler and P. Jankowski, 2003. Integrating a fuzzy k-means classification and a Bayesian approach for spatial prediction of landslide hazard. Journal of Geographical Systems 5, 223-251.

A robust method for spatial prediction of landslide hazard in roaded and roadless areas of forest is described. The method is based on assigning digital terrain attributes into continuous landform classes. The continuous landform classification is achieved by applying a fuzzy k-means approach to a watershed scale area before the classification is extrapolated to a broader region. The extrapolated fuzzy landform classes and datasets of road-related and non road-related landslides are then combined in a geographic information system (GIS) for the exploration of predictive correlations and model development. In particular, a Bayesian probabilistic modeling approach is illustrated using a case study of the Clearwater National Forest (CNF) in central Idaho, which experienced significant and widespread landslide events in recent years. The computed landslide hazard potential is presented on probabilistic maps for roaded and roadless areas. The maps can be used as a decision support tool in forest planning involving the maintenance, obliteration or development of new forest roads in steep mountainous terrain.

Hengl, T., D.G. Rossiter and A. Stein, 2003. Soil sampling strategies for spatial prediction by correlation with auxiliary maps. Australian J. of Soil Res 41, 1403-1422.

The paper evaluates spreading of observations in feature and geographical spaces as a key to sampling optimisation for spatial prediction by correlation with auxiliary maps. Although auxiliary data are commonly used for mapping soil variables, problems associated with the design of sampling strategies are rarely examined. When generalised least-squares estimation is used, the overall prediction error depends upon spreading of points in both feature and geographical space. Allocation of points uniformly over the feature space range proportionally to the distribution of predictor (equal range stratification, or ER design) is suggested as a prudent sampling strategy when the regression model between the soil and auxiliary variables is unknown. An existing 100-observation sample from a 50 by 50 km soil survey in central Croatia was used to illustrate these concepts. It was re-sampled to 25-point datasets using different experimental designs: ER and 2 response surface designs. The designs were compared for their performance in predicting soil organic matter from elevation (univariate example) using the overall prediction error as an evaluation criterion. The ER design gave overall prediction error similar to the minmax design, suggesting that it is a good compromise between accurate model estimation and minimization of spatial autocorrelation of residuals. In addition, the ER design was extended to the multivariate case. Four predictors (elevation, temperature, wetness index, and NDVI) were transformed to standardized principal components. The sampling points were then assigned to the components in proportion to the variance explained by a principal component analysis and following the ER design. Since stratification of the feature space results in a large number of possible points in each cluster, the spreading in geographical space can also be maximized by selecting the best of several realizations.

Lark, R.M. and H. C. Wheeler, 2003. A method to investigate within-field variation of the response of combinable crops to an input. Agron. J. 95, 1093–1104.

Precision agriculture is based on the hypothesis that the optimum rate of inputs to a crop varies spatially within fields. Evidence for this hypothesis is scarce due to the practical and theoretical difficulties of designing appropriate experiments. This paper proposes a procedure for testing the hypothesis of precision agriculture for crops that may be harvested with a combine harvester equipped with a yield monitor. An input is applied according to a randomized block design. Yield monitor data may be treated as a convolution of yield with a function that characterizes the smoothing effect of processes in the combine on the mass flow rate at the sensor. The input rates, determined by the experimental design, are transformed using the combine's smoothing function and a pre-selected yield response function. The parameters of the response function for the whole field or a local neighborhood can be estimated from these transformed rates and the yield monitor data. A null hypothesis, that the spatial variation in one of these parameters (that determines the local optimum rate) , may be attributed to random yield variation about a uniform response function, may be tested. A wheat crop (*Triticum aestivum* cv. Consort) was treated with varying rates of N fertilizer in a case study in the south of England. Analysis of the yield data showed that the observed variation in the response could not be explained as random fluctuation around the field-scale response function. The economic optimum rate of N varied from zero to greater than 200 kg ha^{-1}.

Metternicht, G.I., 2003. Categorical fuzziness: a comparison between crisp and fuzzy class boundary modelling for mapping salt-affected soils using landsat TM data and a classification based on anion ratios. Ecological Modelling 168, 371-389.

This paper investigates whether the use of fuzzy, instead of crisp class salinity boundaries, improves the accuracy on the detection of salt types from remote sensing data. To this end, a classification of salt types based on anion ratios, and a supervised maximum likelihood classification technique, where the membership grades of the saline fuzzy classes are incorporated as prior probabilities to classify a Landsat TM image acquired over a salt-affected area of Bolivia are applied. The classification system based on anion types has been developed by Russian soil scientists (Plyusnin, 1964). In this approach, salt-affected soils are classified on the basis of salt types, in terms of chloride, sulphate and carbonate anion ratios present in the soil saturation extract. It is of interest to test this approach because not all salts are equally harmful, and do require different reclamation and management measures. Consequently, it is valuable to know the spatial distribution of salt-affected soils and their composition. Fuzzy modelling of the information categories and the incorporation of certainty factors during the classification procedure allowed overcoming low accuracy results. Identification accuracies improved by as much as 44% for chloride-sulphate and sulphate-chloride soils with similar proportions of both anions. Higher accuracies were achieved for soda-sulphate soils, as compared to the sulphate-chloride types. This is attributed to the fact that carbonates and sulphates used in the ratio for deriving soda-sulphate soils, have absorption features in the infrared and thermal ranges of the spectrum.

Walter,C., R.A. Viscarra Rossel and A.B. McBratney, 2003. Spatio-temporal simulation of the field-scale evolution of organic carbon over the landscape. Soil Sci. Soc. Am. J. 67, 1477–1486.

The spatial or temporal variability of soil has been extensively considered in the literature using either experimental or modeling approaches. However, only a few studies integrate both spatial and temporal dimensions. The aim of this paper is to present a method for field-scale simulations of the spatio-temporal evolution of topsoil organic C (OC) at the landscape scale over a few decades and under different management strategies. A virtual landscape with characteristics matching part of Brittany (France) was considered for the study. Stochastic simulations and regression analysis were used to simulate spatial fields with known spatial structures: short-range, medium range, and long-range variability. These were then combined using an additive model of regionalization. Agricultural land use was simulated considering four different land uses: permanent pasture, temporary pasture, annual cereal crops, and maize (*Zea mays* L.). Land use evolution over time was simulated using transition matrices. Evolution of soil organic matter was estimated each year for each pixel through a rudimentary balance model that accounts for land use and the influence of soil waterlogging on mineralization rates. This spatiotemporal simulation approach at the landscape level allowed the simulation of several scales of soil variability including within-field variability. Spatial variability decreased drastically over time when only the influence of land use was considered. This effect on soil variability over the landscape may have implications for site-specific soil management and precision agriculture. The presence of redoximorphic conditions was found to maintain soil spatial variability.

Nominations 2004

Finke, P.A., D.J. Brus, M.F.P. Bierkens, T. Hoogland, M. Knotters and F. de Vries, 2004. Mapping groundwater dynamics using multiple sources of exhaustive high resolution data. Geoderma 123, 23–39.

Hengl, T., G.B.M. Heuvelink and A. Stein, 2004. A generic framework for spatial prediction of soil variables based on regression-kriging. Geoderma 120, 75–93.

Lark, R.M., A.E. Milne, T.M. Addiscott, K.W.T. Goulding, C.P. Webster and S. O'Flaherty, 2004. Scale- and location-dependent correlation of nitrous oxide emissions with soil properties: an analysis using wavelets. European Journal of Soil Science 55, 611–627.

D'Or, D. and P. Bogaert, 2004. Spatial prediction of categorical variables with the Bayesian Maximum Entropy approach: the Ooypolder case study. European Journal of Soil Science 55, 763–775.

Zhu, J., C.L.S. Morgan, J.M. Norman, W. Yue and B. Lowery, 2004. Combined mapping of soil properties using a multi-scale tree-structured spatial model. Geoderma 118, 321–334.

Finke, P.A., D.J. Brus, M.F.P. Bierkens, T. Hoogland, M. Knotters and F. de Vries, 2004. Mapping groundwater dynamics using multiple sources of exhaustive high resolution data. Geoderma 123, 23–39.

Existing groundwater table (GWT) class maps, available at full coverage for the Netherlands at 1:50,000 scale, no longer satisfy user demands. Groundwater levels have changed due to strong human impact, so the maps are partially outdated. Furthermore, a more dynamic description of groundwater table dynamics representative for the current climate is needed. A mapping method to obtain a large set of parameters describing groundwater table dynamics was developed. The method uses time series analysis and well-timed phreatic head measurements to obtain a data set at point support. This point data set is correlated to groups of exhaustive high-resolution ancillary data by stratified multiple linear regression. Finally, simple kriging is applied to interpolate the residuals of the regression model. The method was applied in a 1,790,000 ha area and its performance was measured in 10,000 and 179,000 ha test areas. The relation between higher sampling density, mapping cost and map quality was explored. Validation results show that reasonable to good quality maps of various aspects of groundwater dynamics can be obtained by this method, at much lower cost than traditional survey-based mapping methods. The method includes the quantification of uncertainty at the actual sampling density and allows the a priori estimation of uncertainty at other sampling densities. Future research aims at identification of the effect of sources of error in ancillary data and how to diminish these.

Hengl, T., G.B.M. Heuvelink and A. Stein, 2004. A generic framework for spatial prediction of soil variables based on regression-kriging. Geoderma 120, 75–93.

A methodological framework for spatial prediction based on regression-kriging is described and compared with ordinary kriging and plain regression. The data are first transformed using logit transformation for target variables and factor analysis for continuous predictors (auxiliary maps). The target variables are then fitted using step-wise regression and residuals interpolated using kriging. A generic visualisation method is used to simultaneously display predictions and associated uncertainty. The framework was tested using 135 profile observations from the national survey in Croatia, divided into interpolation (100) and validation sets (35). Three target variables: organic matter, pH in topsoil and topsoil thickness were predicted from six relief parameters and nine soil mapping units. Prediction efficiency was evaluated using the mean error and root mean square error (RMSE) of prediction at validation points. The results show that the proposed framework improves efficiency of predictions. Moreover, it ensured normality of residuals and enforced prediction values to be within the physical range of a variable. For organic matter, it achieved lower relative RMSE than ordinary kriging (53.3% versus 66.5%). For topsoil thickness, it achieved a lower relative RMSE (66.5% versus 83.3%) and a lower bias than ordinary kriging (0.15 versus 0.69 cm). The prediction of pH in topsoil was difficult with all three methods. This framework can adopt both continuous and categorical soil variables in a semi-automated or automated manner. It opens a possibility to develop a bundle algorithm that can be implemented in a GIS to interpolate soil profile data from existing datasets.

Lark, R.M., A.E. Milne, T.M. Addiscott, K.W.T. Goulding, C.P. Webster and S. O'Flaherty, 2004. Scale- and location-dependent correlation of nitrous oxide emissions with soil properties: an analysis using wavelets. European Journal of Soil Science 55, 611–627.

This paper shows how the wavelet transform can be used to analyse the complex spatial covariation of nitrous oxide (N2O) emissions from the soil with soil properties that are expected to control the evolution of N2O. We use data on N2O emission rates from soil cores collected at 4-m intervals on a 1024-m transect across arable land at Silsoe in England. Various soil properties, particularly those expected to influence N2O production in the soil, were also determined on these cores. We used the adapted maximal overlap discrete wavelet transform (AMODWT) coefficients for the N2O emissions and soil variables to compute their wavelet covariances and correlations. These showed that, over the transect as a whole, some soil properties were significantly correlated with N2O emissions at fine spatial scales (soil carbon content), others at intermediate scales (soil water content) and others at coarse spatial scales (soil pH). Ammonium did not appear to be correlated with N2O emissions at any scale, suggesting that nitrification was not a significant source of N2O from these soils in the conditions that pertained at sampling. We used a procedure to detect changes in the wavelet correlations at several spatial scales. This showed that certain soil properties were correlated with N2O emissions only under certain conditions of topography or parent material. This is not unexpected given that N2O is generated by biological processes in the soil, so the rate of emission may be subject to one limiting factor in one environment and a different factor elsewhere. Such changes in the relationship between variables from one part of the landscape to another is not consistent with the geostatistical assumption that our data are realizations of coregionalized random variables.

D'Or, D. and P. Bogaert, 2004. Spatial prediction of categorical variables with the Bayesian Maximum Entropy approach: the Ooypolder case study. European Journal of Soil Science 55, 763–775.

Categorical variables such as water table status are often predicted using the indicator kriging (IK) formalism. However, this method is known to suffer from important limitations that are most frequently solved by ad hoc solutions and approximations. Recently, the Bayesian Maximum Entropy (BME) approach has proved its ability to predict categorical variables efficiently andin a flexible way. In this paper, we apply this approach to the Ooypolder data set for the prediction of the water table classes from a sample data set. BME is compared with IK using global as well as local criteria. The inconsistencies of the IK predictor are emphasized and it is shown how BME permits avoiding them.

Zhu, J., C.L.S. Morgan, J.M. Norman, W. Yue and B. Lowery, 2004. Combined mapping of soil properties using a multi-scale tree-structured spatial model. Geoderma 118, 321–334.

Accurate maps of various key soil properties on fine spatial resolutions play an important role in precision modeling of agricultural systems. Recent development of alternatives to soil coring enables us to collect multiple sources of data, but data quality and spatial resolutions may differ greatly from one source to another. In this article, we use a multi-scale model for combining all data sources, despite varying resolutions and accuracies, to produce soil maps. We demonstrate that the method gives accurate results via computer simulations. Using the multi-scale method, we combine soil coring, penetrometer, and topographic data to map the depth-to-till on a 10-m resolution in an Arlington, Wisconsin field, and combine soil coring and soil electrical conductivity measurements to map field capacity on a 20-m resolution in a Waunakee, Wisconsin field. The proposed mapping technique has several advantages: (1) it is computationally fast and hence is well suited for landscape modeling; (2) it provides a means to combine more than two sources of data; and (3) it provides a way to accommodate prior knowledge of spatial dependencies associated with various data sources.

7. Student Award

A student award for an excellent paper presented at the Pedometrics Meeting will be identified. The award entails a small cash price and waived registration fees for the Pedometrics 2007 meeting.

8. Courses

Short Course "Geostatistical Analysis of Environmental Data"
When: August 8-12, 2005
Location: University of Florida, Gainesville, USA
Instructor: Dr. Pierre Goovaerts
http://conference.ifas.ufl.edu/soils/geostats/index.html

Introduction Course to the Bayesian Maximum Entropy (BME) Approach
When: September 14-16, 2005
Location: Université catholique de Louvain in Louvain-la-Neuve, Belgium
Tutors: Dr. Partick Bogart, Dr. Dimitri D'Or, Dr. Roland Froidevaux, and Dr. Marc Serre.
http://www.enge.ucl.ac.be/BMEcourse

9. Upcoming Meetings

ASA-CSSA-SSSA Annual Meeting
http://www.asa-cssa-sssa.org/meetings/acs/
Salt Lake City, Utah, USA, Nov. 6-10, 2005.

2nd Global Workshop on Digital Soil Mapping DSM for Regions and Countries with Sparse Spatial Data Infrastructures
To be held by Embrapa Solos, Rio de Janeiro, Brazil, 4 -7 July 2006 under the auspices of IUSS.

A workshop aiming to review and discuss the state of the art of soil spatial data infrastructure development in different countries and regions, and the use and availability of soil data and information for the purpose of Digital Soil Mapping.

Some topics to be discussed at the Workshop:

- What data do we need for DSM? What data do we have?
- What new technologies are available for gathering data for DSM?
- What models and applications? Does DSM answer the need of soil information for some regions where predictor data is scarce?
- Are DSM requirements helpful in organising worldwide soil databases?
- Soil data and politics
- Economics of DSM
- Validation of DSM

…

Scientific Committee:

Alex. McBratney – University of Sydney, Australia
Alfred Hartemink – Wageningen University and Research Centre, Netherlands
A-xing Zhu – University of Wisconsin, USA

David Brown – Montana University, USA
David Rossiter – ITC, Netherlands
Elisabeth Bui – CSIRO, Australia
Endre Dobos – Uni-Miskolc, Hungary
Florence Carré – ISPRA, Italy
Gerard Heuvelink – Wageningen University and Research Centre, Netherlands
Inakwu Odeh - University of Sydney, Australia
Janis Boettinger – Utah State University, USA
Jay Bell – University of Minnesota, USA
Javier Tomasella – CPTEC, INPE, Brazil
Jon Hempel – USDA NRCS, USA
Marc Voltz – INRA, France
Maria de Lourdes Mendonça-Santos – EMBRAPA Solos, Brazil
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Alex. McBratney – University of Sydney, Australia, Co-Chair
Sílvio Crestana – EMBRAPA, Host
Celso Manzatto – Embrapa Solos, Host

Please send your expressions of interest in attending the 2nd Global Workshop on Digital Soil Mapping and suggestions for the topics to be discussed, to Dr. Maria de Lourdes Mendonça Santos: loumendonca@cnps.embrapa.br

World Congress of Soil Science (WCSS)
http://www.18wcss.org
Philadelphia, Pennsylvania, USA, July 9-15, 2006.
Abstracts due Sept.15, 2005.

Symposia (co)organized by the Pedometrics Commission:

(1) Diffuse Reflectance Spectroscopy, Soil Sensing, Remote Sensing and Image Analysis
(2) Soil Sampling in Space and Time
(3) Interdependency of Soils and Soilscapes

IAMG "Quantitative Geology from Multiple Sources"
http://www.geomac.ulg.ac.be/iamg06/
in Liège, Belgium, September 3-8, 2006.
Abstracts due: February 1, 2006

10. Next Issue

If you like to write a small contribution (MS Word; no PDFs !) please send your material to the editor – Sabine Grunwald (SGrunwald@ifas.ufl.edu).

I highly encourage our young pedometricians to make a contribution. Don't be shy and get involved.