PEDOMETRON

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Newsletter of the International Society of Soil Science Working Group on Pedometrics (PM)

Pedometrics Chair: Professor Alex B. McBratney; Secretary: Dr Jaap J. de Gruijter; Pedometron Editor: Dr Inakwu O.A. Odeh

From the (Dark Blue) Chair

(I've got a new one)

Alex McBratney, Chair, WG-PM

Since the last issue of Pedometron much has happened. First, a Special Issue on Fuzzy Sets in Soil Science has recently been published in Geoderma volume 77. This is the Proceedings of a Joint Symposium held by the Working Group and Division S5 of the SSSA in November 1995. Interest in this publication has been strong. The Proceedings of last year's Symposium on Soil and Water Quality at Different Scales jointly held by three working groups is soon to be published in Nutrient Cycling in Agroecosystems.

The major event I wish to report on here is the 2nd International Conference on Pedometrics (Pedometrics '97) held at the University of Wisconsin in Madison from August 18 to 20. Some 60 delegates from a dozen countries took part.

The program consisted of morning oral presentations with poster presentations and round-table discussions in the afternoon.

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Random spatial patterns of Pedometricians in a Wisconsin prairie after observing a soil pit during the post-Pedometrics '97 field trip (Photo: Courtesy of Zueng-Sang Chen)

Papritz and Webster win '95 best paper award

The 1995 PM best paper award has been won by **Drs Andreas Papritz** and **Richard Webster**. Their two-part paper published in the Volume 46 of the European Journal of Soil Science, entitled *Estimating temporal change in soil monitoring,* was voted as the best paper among three other papers which were earlier nominated by the eminent Soil Scientists **Prof. Dr. J. Bouma** and **Prof. Dr. A. Stein** both of the Agricultural University, Wageningen in the Netherlands. The abstracts of the two parts are re-presented below for the benefit of readers.

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From the Chair of PM

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The talks had two main themes. There were methodological reviews of familiar topics such as soil geostatistics and sampling and reviews of newer topics such as neural networks and fractals. The second major theme focussed on spatial prediction methods. It was clear that there were two (somewhat distinct) approaches to spatial prediction. The first is the geostatistical approach - using various forms of kriging. The second approach is what I call the "clorp(t)" approach, named from Jenny's equation. In this approach prediction of soil properties is made from other environmental variables, principally derived from digital elevation models. The synthesis of these two approaches was not really discussed. This will be an area for much further research in Pedometrics.

The poster and discussion sessions were excellent. The discussion was open, detailed and thought-provoking. I'd certainly recommend this format for future conferences. All in all the format of the Conference was a great success and much of that is due to **Kevin McSweeney**. Thanks Kevin. The final afternoon was spent in the field looking at soil profiles in a prairie environment, nitrogen modelling and ended up with a very pleasant visit to a vineyard.

The 25 or so papers from the Conference are currently being reviewed and will appear in a Special Issue of Geoderma in a year (and a bit).

In 1998 the Pedometrics WG will assemble in Montpellier. We're holding a One-day Symposium on Soil Geostatistics on August 18, prior to the World Congress of Soil Science. This has been kindly organised by **Marc Voltz**. Thanks Marc. Please send your abstracts as soon as possible to Marc by email to < voltz@ensam.inra.fr >.

The plans for the next two International Conferences are well in hand. The 3rd International Conference will be held in Sydney in late-September 1999. The 4th International Conference, organised principally by Marc Van Meirvenne, will be held in Gent in 2001.

I'd like to congratulate Andreas Papritz and Richard Webster on their being awarded the Best Paper in Pedometrics Award for 1995. Their papers really are a significant contribution to the rather difficult problem of environmental monitoring.

I'll conclude with the following poem from my Dutch friend. It essentially focuses on what we don't know about soil - the fundamental cause of the variability - is soil formation a divine process, or a chaotic process or is it just clorpt?

SOIL neSCIENCE

Soil variability –
A multiform jewel
Or a capricious pig
In a heterogeneous poke?
God tossing the dice
Across the earth's felt
Games and throws of craps
Since time was created
The crazy paving of
An unknowable artisan.
Or a nonlinear god
Toying with
Pedogenic parameters
Out on the edge?
Chaos realised
Over and again.
Or is it simply
Clorpting away
According to a plain
Old-fashioned determinism
With unknown factors
Yet to be revealed
By further understanding
And meticulous measurement?
And in this nescient state
Can we husband it
To a centimetre?
Or is the soil's diversity there
To protect us
– From ourselves?

- David van der Linden

'95 best paper award won

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The paper describes a very innovative approach to modelling temporal changes of spatially varying soil properties, an approach that will increasingly be used to monitor the effects of human and natural activities on the environment over a specific period of time. The paper is a pleasure to read.

Papritz, A. and Webster, R**.** 1995. *Estimating temporal change in soil monitoring:*
I. *Statistical theory.* Eur. J. of Soil Sci., 46: 1-12.

Detecting small temporal change of spatially varying soil properties demands precise estimation. Design- and model-based methods are compared for estimating temporal of soil properties over finite areas. Analytical expressions for the estimators and their variances are derived for the two approaches, and formulae for the expectations of the variances under the random-process model are developed. Among the randomized designs simple, stratified, and systematic sampling using the arithmetic mean as estimator have been studied. Pairing the sampling positions on different occasions increases the precision of deign-based estimation if the observations are positively cross-correlated. The relative precisions of the means of stratified and systematic samples depend on the spatial correlation. Neither is more precise than the other in all circumstances. The stratified design provides an unbiased estimator for the sampling error, which is not available from systematic samples. Theoretically, the geostatistical global estimator is more precise than the estimates derived from any of the classical designs when many realizations are repeatedly sampled at random. In practice, with only a single realization of the process, this is no longer relevant. Moreover, errors in estimating the variograms

It seems that only by sampling from large auto-correlated random fields can the precisions of the methods be compared in practise.

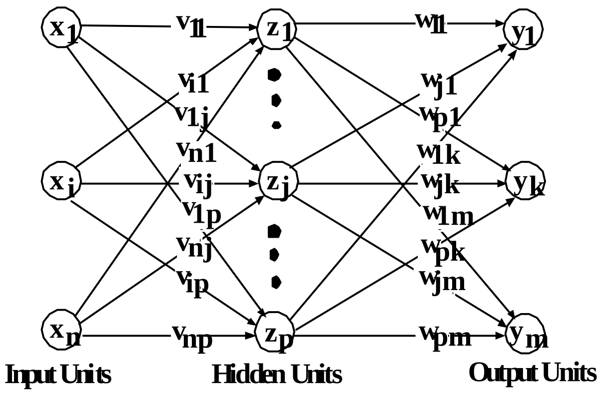
II. *Sampling from random fields.* Eur. J. of Soil Sci., 46: 13-27.
Design -based and model based methods of estimating temporal change of soil properties over a finite area have been compared. Two large fields of auto-and cross-correlated data were simulated, each representing the spatial distribution of a variable at one time. The fields were then sampled repeatedly. The means of stratified and systematic random samples and geostatistical global estimates were used to infer the mean difference between the fields. All estimators were unbiased, but their variances differed. Pairing the positions on the two occasions increased the precision of the design-based estimates. Systematic sampling was slightly more precise than stratified sampling. Kriging was less precise then both because some of the sample information must be used to estimate the variograms at short lags. Neither balanced differences nor the normal formula for simple random sampling predicted the estimation variances of small (*n*<50) systematic samples accurately. For larger samples the method of balanced differences performed well. If the spatial variation is unknown in advance and only small samples can be taken then stratified random sampling with two observations per stratum is the preferred design. It resulted in the best combination of precision and accuracy in predicting the sampling error.

On using Neural Networks in Soil Science

by Inakwu Odeh

During the recently concluded International Pedometrics Conference, two papers presented gives much for thought in the use of an emerging method in soil science, the artificial neural networks (ANN). The first by **Ellisa Levine** and **Daniel Kimes**, entitled: *Evaluating water holding capacity across the spatial scales with neural networks,* makes interesting reading. The abstract gives a brief description of, and the method of neural networks, and their advantages. An application to predicting available water holding capacity is briefly described. The capability of the method in extending the analytical process of the networks to complex relations in data sets at various scale level is highlighted.

The second paper by **Yakov Pachepsky** gives cautionary advice to potential users of ANN in soil science. The abstract humorously entitled: Neural *networks in soil science: a tool or just cool?* also gave a brief description of the principles of ANN. It emphasises that there are various approaches to ANN, with the multilayered feed-forward neural networks (MFNN) as the most popular. This popularity can often lead to misapplication, the paper further emphasised. A successful approach in using ANNs is to use them as task-specific problem solving algorithms, although this is by no means easy.



A hypothetical multilayered network. Note the layers of weights between the units. The multilayered networks are designed to solve more complex problems than the single-layered ones, perhaps the reason why they are popular in geoscience applications.

My addition in having a critical look at the ANN is due to its learning criteria which are beyond the control of the user. ANN can often "overtrain" in some situations as has been shown in the literature. When once this occurs, details that are not often essential in the model are overemphasised. One way to avoid this is to simplify the model by fuzzification prior to ANN analysis. This will have a refining effects that would make the ANN more robust and general. In other words, this would lead to an optimal trade-off between accuracy and generalisation. In fact algorithms that combine fuzzy sets and neural networks are now widely available. Also there are now coupled methodology that combines ANN with regression methods and thus takes on the added advantage of training possibilities in ANN.

I quite agree with Yakov that it requires a good knowledge of the ANN for it to be used correctly, and of course one needs to adjust/modify the algorithm for the task at hand, based on the user's heuristic experience. Like any other new methods that could potentially be adopted to model the soil, it only requires our imagination/intuition combined with inductive models to adopt this method in the most appropriate ways. These two papers, when published in full in Geoderma as being proposed, could perhaps provide us with the avenues to twinkle into this new and potentially popular method.

Nominations for '96 PM best paper

Nominations for the final selection of the best paper in Pedometrics for 1996 have been made by **Professor Marc Van Meirvenne** of the Department of Soil Management, University Gent, Gent, Belgium. In making these nominations, Professor Meirvenne took the extra pain to peruse through a host of Journals that publish Pedometrics-related papers. The 14 Journals perused are:

- European Journal Soil Science
- Soil Science Society of America Journal
- Soil Use & Management
- Geoderma
- Catena
- Soil Science
- Soil Technology
- Canadian Journa of Soil Science
- Australian Journal of Soil Research
- Water Resources Research
- International Journal of GIS
- Plant & Soil
- Environmetrics
- Nutrient Cycling in Agrosystems (formerly Fertilizer Research)

The abstracts of the pre-selected papers are presented below. **Readers should please read through the abstracts (or preferably the full papers) and vote on the ballot paper provided, before sending it to the Secretary of the WG-PM, Dr Jaap De Gruijter.**

S. E. Cook, R. J. Corner, G. Grealish, P. E. Gessler, and **C. J. Chartres**. *A Rule-based System to Map Soil Properties.* 1996. Soil Sci. Soc. Am. J. 60:1893-1900.
Abstract. Conventional soil mapping is limited in its capabilities in that it presents a summary of the soil surveyor's conceptual view of soil variation. As such, the method conveys little regarding what is known about the variation of individual soil properties, or the quantitative nature of their variation. We developed a new method for soil mapping, based on the concepts employed in the PROSPECTOR mineral exploration system, which builds on existing soil surveyor knowledge to construct quantitative statements about individual soil properties via the development of a network of rules. These rules operate within a system of Bayesian inference to assign the varying probability of occurrence of a soil property of interest within an area, given evidence that relates to it in a known way. Permissible evidence includes the range of attributes normally used by a soil surveyor, such as landform, vegetation, land use, or parent material, and can also include remotely sensed digital data. Evidence is weighted according to the uncertainty associated with it, and combined to produce a single estimate of probability of a given attribute. The relationship between the evidence and prediction is stated explicitly at each stage of the procedure and is thus repeatable in a consistent manner. The system has the advantage that while it does not discard the evidence and knowledge used in conventional soil survey, it produces quantitative estimates of the distribution of soil properties, which can be used for a wide range of applications. The data produced is amenable to storage in geographic information systems and related data bases. As such, it can be updated or enhanced as new information or knowledge becomes available.

Edith Perrier, Michel RieU, Garrison Sposito, and **Ghislain de Marsily**. 1996. *Models of the water retention curve for soils with a fractal pore size distribution*. Water Resources Research, 32: 3025-3031.
Abstract. The relationship between water content and water potential for a soil is termed its water retention curve. This basic hydraulic property is closely related to the soil pore size distribution, for which it serves as a conventional method of measurement. In this paper a general model of the water retention curve is derived for soils whose pore size distribution is fractal in the Ósense of the Mandelbrot number-size distribution. This model, which contains two adjustable parameters (the fractal dimension and the upper limiting value of the fractal porosity) is shown to include other fractal approaches to the water retention curve as special cases. Application of the general model to a number of published data sets covering a broad range of soil texture indicated that unique, independent values of the two adjustable parameters may be difficult to obtain by statistical analysis of water retention data for a given soil. Discrimination among different fractal approaches thus will require water retention data of high density and precision.

Ference Csillag, Milkós Kertésw and **Ágnes Kummert**. 1996. *Sampling and mapping of heterogeneous surfaces: multi-resolution tiling adjusted to spatial variability.* International Journal of Geographical Information Systems, 10: 851-875.
Abstract. Mapping by sampling and prediction of local and regional values of two-dimensional surfaces is a frequent, complex task in geographical information systems. This article describes a method for the approximation of two-dimensional surfaces by optimizing sample size, arrangement and prediction accuracy simultaneously. First, a grid of an ancillary data set is approximated by a quadtree to determine a predefined number of

homogeneous mapping units. This approximation is optimal in the sense of minimizing Kullback-divergence between the quadtree and the grid of ancillary data. Then, samples are taken from each mapping unit. The performance of this sampling has been tested against other sampling strategies (regular and random) and found to be superior in reconstructing the grid using three interpolation techniques (inverse squared Euclidean distance, kriging, and Thiessen-polygonization). Finally, the discrepancy between the ancillary grid and the surface to be mapped is modelled by different levels and spatial structures of noise. Conceptually this method is advantageous in cases when sampling strata cannot be well defined a priori and the spatial structure of the phenomenon to be mapped is not known, but ancillary information (e.g., remotely-sensed data), corresponding to its spatial pattern, is available.

D.J. Brus, J.J. de Gruijter, B.A. Marsman, R. Visschers, A.K. Bregt, A. Breeuwsma and **J. Bouma.** 1996. *The performance of spatial interpolation methods and choropleth maps to estimate properties at points: A soil survey case study.* Evironmetrics, 7: 1-16

Summary. A study was designed to compare the performance of six spatial interpolation methods to estimate soil properties at unvisited points. These methods were global mean, moving average, nearest neighbour, inverse squared distance, Laplacian smoothing splines and ordinary point kriging. These methods were also applied in combination with a choropleth map (soil map) by stratifying the area. The soil properties estimated were thickness of A1 horizon, maximum areic mass of phosphate adsorbed by soil, mean highest water table and mean lowest water table. The performance of the methods was measured by estimating the spatial means of the squared and absolute error (quality criteria not conditional on the sample of test points) by a stratified simple random sample of test points. The mean squared error was very large in proportion to the spatial variation over the total area for all methods and properties. Differences between methods were small. In general, no statistically significant stratification or weighting effects were found. The efrect of weighting plus stratification was usually not significant either. Overall, weighting with inverse squared distance was as satisfactory as weighting by ordinary point kriging. However, the latter was superior near data points. Also, when combined with soil map stratification, kriging was more reliable in the sense that it estimated all properties well. Estimates obtained using the means of six soil map units were better, although not significantly, than those obtained from unstratified kriging and as good as kriging within three map units.

Gerard B.M. Heuvelink. 1996. *Identification of field attribute error under different models of spatial variation.* International Journal of Geographical Information Systems, 1 0: 921-935

Abstract. Recent developments in theory and computer software mean that it is now relatively straightforward to evaluate how attribute errors are propagated through quantitative spatial models in GIS. A major problem, however, is to estimate the errors associated with the inputs to these spatial models. A first approach is to use the root mean square error, but in many cases it is better to estimate the errors from the degree of spatial variation and the method used for mapping. It is essential to decide at an early stage whether one should use a discrete model of spatial variation (DMSV-homogeneous areas, abrupt boundaries), a continuous model (CMSV-a continuously varying regionalised variable field) or a mixture of both (MMSV-mixed model of spatial variation). Maps of predictions and prediction error standard deviations are different in all three cases, and it is crucial for error estimation which model of spatial variation is used. The choice of model has been insufficiently studied in depth, but can be based on prior information about the kinds of spatial processes and patterns that are present, or on validation results. When undetermined it is sensible to adopt the MMSV in order to bypass the rigidity of the DMSV and CMSV. These issues are explored and illustrated using data on the mean highest groundwater level in a polder area in the Netherlands.

Meeting

There will be one-day Symposium on:

Advances in Soil Geostatistics

to be held just prior to the ISSS Congress

at Montpellier, France

Date: August 18, 1998.

Submit your abstracts by email to **Marc Voltz** (voltz@ensam.inra.fr) before December 31, 1997.

Deadline for the next issue is April 1, 1998.

Short articles could be sent by emailed to:

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