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ΠΕΔΟΜΕΤΡΟΝ

Newsletter of the Pedometrics Commission of the IUSS

ΠΕΔΟ METRICS

Inside this issue

From the Chair

Welcome to the 25th anniversary of Pedometrics.

25 years ago I just received my first soil science course and learned Jenny's factors of soil formation. I didn't anticipate that we can quantify Jenny's relationship and there is a discipline called Pedometrics.

Pedometrics start with a humble beginning, several young soil scientists eager to develop a new discipline within soil science. These pioneers formalised the subject of the application of the mathematical and statistical study of soil genesis and distribution. Formalising Pedometrics and recognising it as a discipline within soil science allows us to form an identity and a community where we can work and communicate effectively.

After a couple of decades, the discipline is now mature with several active working groups. This can be seen from the growing number of articles and also the rising of young scientists working in Pedometrics. The Pedometrics 2017 conference demonstrated the expansion and breadth of scientific information related to Pedometrics. Pedometrics tackle soil science problems from the micro-scale to the global scale using various mathematical and statistical models and utilising various proximal and remote sensors.

After 25 years, the dynamic of pedometrics research continue to be strong, and I hope that this conference will inspire much more new research. Keep the discipline growing and show more relevance in tackling real world problems.

Happy Silver Anniversary and I hope to see you again at the Gold anniversary.

Sydney, June 2017

Budiman Minasny

Chair of the Pedometrics Commission of the IUSS

Pedometrics took off: its first conference

Richard Webster

Pedometrics had its origins in disparate fields—initially in agronomy, later in engineering, and, with the advent of computers, in taxonomy and soil survey. Its practitioners were few and widely spread around the world, some in Europe, some in Australia, some in Africa and some in the Americas. They sought solutions to their problems largely from professional statisticians and applied mathematicians and the statistical literature rather than from one another. In the 1980s, however, they recognized their common interests and that it would help them to develop those interests more coherently if there were some formal organization for the purpose.

The opportunity to discuss matters arose at a conference on statistics in the earth and space sciences in Leuven in 1989. A dozen or more of us statistically minded soil scientists were there. We decided to form a working group which we hoped would be recognized by the International Society of Soil Science, now the International Union of Soil Science (IUSS). We elected as chairman Donald Myers, a mathematician in the University of Arizona, with a strong interest in soil, and as secretary Jaap de Gruijter, then in the Winand Staring Centre of the DLO in Wageningen. Our working group was recognized formally by the IUSS the following year, and henceforth we could hold meetings under the aegis of the Union. The stage was set. The first Pedometrics meeting was held in Wageningen in September 1992 with its theme, "Developments in spatial statistics for soil science". Some 80 participants attended, and 20 of the presentations were edited and published in a special issue of *Geoderma*, volume 62, in 1994.

Professor L. van Vloten-Doting, director of the Agricultural Research Depart- ment of the Dutch DLO, welcomed the participants. The scientific programme proper began with R. Webster's account of the history of pedometrics. Then came a review by D.E. Myers of spatial interpolation: deterministic methods including trend surfaces, kernel approximation and splines, and stochastic methods, in particular kriging based on spatial covariances. In one contribution M.F. Hutchinson and P.E. Gessler elaborated on the merit of splines and linked one particular class, the thin plate splines, to kriging. Several later speakers described further developments mainly as required for case studies, others simply described their applications of established technique in case studies.

In "The state of the art in pedometrics" P.A. Burrogh, J.Bouma and S.R. Yates brought the proceedings to a close. They summarized the statistical practice of the time as presented by the previous speakers, drew on the discussions that followed and looked to the future. They stressed the importance of understanding and quantifying soil variation for managing land and water resources, of mastering theory and of having available the computational tools for analysis, prediction and application.

Pedometrics has undoubtedly moved on in the 25 years since the first conference. The numbers of pedometric papers in journals of soil science have multiplied by many times, and the techniques developed and publicized by soil scientists have spread into related fields of endeavour. Some of the techniques described in 1992 do look dated. Others, on the other hand, are still "state of the art'" and might be better called "best practice". They now appear in several acclaimed text books.

Where is pedometrics now? What progress have pedometrcians made since 1992? Pedometrics 2017 provides the forum at which speakers will tell the world. I shall not be there, but I look forward to learning what you achieve.

Twenty five years and more

Jaap De Gruijter

Being asked to look back at the start of Pedometrics 25 years ago, I could not resist the temptation of looking back a bit further, not only because I have lively memories about what had happened in the years before the informal meeting in Leuven in 1989, but also because I believe that we should not forget such an impressive amount of pedometrical work avant-la-lettre.

It was in the seventies that Jaap Schelling of the Dutch Soil Survey Institute initiated the ISSS Working Group on Soil Information Systems. The first conference was organised by Schelling and Bie (secretary) in 1975 in Wageningen (Bie, 1975). The Working Group was extremely active. More conferences were held in 1976 in Canberra (Moore and Bie, 1977), in 1977 in Varna Bulgaria (Sadovski and Bie, 1978), in 1980 in Canberra again (Moore, Cook and Lynch, 1981), in 1981 in Paris (Girard, 1981), and in 1983 in Bolkesjø, Norway (Burrough and Bie, 1984).

The numerous papers presented during these conferences covered a wide range topics, falling in three categories: (1) "how do we collect soil information?" (methods of soil survey and sampling, quality of soil maps, techniques of data recording in the field), (2) "how do we get the data in a computer?" (architecture of soil information systems, automated cartography), and (3) "what can we do with the data once they are in a computer?" (a host of statistical techniques: regression analysis, ordination and classification, expert systems for land evaluation, geostatistical methods, to name just a few).

All this is what we now call *pedometrics*, the term coined by Alex McBratney.

Soon after the conference in Norway in 1983 it was decided to discontinue the working group. An unfortunate decision in my view, because the soil scientists who were actively interested in soil data acquisition and application of quantitative methods missed from then on the opportunity to come together for exchange of experiences and ideas. This went on for nine years.

In this period Alex McBratney and I started co-operative work on application of fuzzy logic. I had met him on the conference in Paris, and soon thereafter we began a series of working visits to each others institutes. During one of our discussions we concluded that we should have conferences again, Richard Webster agreed to cooperate, and the idea of a working group on pedometrics was born.

Alex wasn't able to attend the meeting in Leuven, but soon after the first Pedometrics conference in Wageningen he succeeded Donald Myers as chairman, and an amazingly active period began. I had never expected such an enormous success, and I'm very happy to see how full of life this enterprise still is, 25 years later.

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Pedometrics: how about the views of 25 years ago?

Johan Bouma
Emeritus Professor soil science, Wageningen University

Twenty-three years ago, Peter Burrough and others analysed the state of the art and future prospects of Pedometrics, based on the initial conference in 1992 (Burroughs et al, 1994). How many of our ideas materialized and how can we look at Pedometrics now at a time when social media and "post-truth" views seem to dominate the societal discourse? The societal context in which the scientific community operates has changed dramatically since 1992 particularly during the last decade. This analysis is timely as the 2017 Pedometrics conference in Wageningen (June 27 to July 1) is about to take place. Not having followed developments in the profession closely during at least the last decade I will refrain from general comments on the quality of pedometric research. But having been an active reviewer, not only of soil papers but also of agronomic and hydrological papers , some comments may be relevant. Let me briefly follow up on six arbitrarily selected comments made by Burrough et al (1994), adding some references for further clarification.

1. "*Work with other disciplines*", "include *data on quality and quantity of ground- and surface water and pay more attention for the time component regarding movement of water, nutrients and pollutants*". I don't see much interdisciplinarity in the 2017 program, which appears to be rather inward looking. I can, however, fully understand that a program involving hydrologists, agronomists and others would become too broad distracting attention from methodology development, the core mission of Pedometrics. But ultimate goals determine whatever pedometric methods will be most effective so never loose sight of goals and in my view the Sustainable Development Goals of the UN present perfect goals for all earth sciences. I have seen hydrologists and agronomists using soil data provided by soil scientists (but most of them don't contact soil scientists when modeling) without having any idea as to their meaning, significance and limitations. It pays to be involved and the many new soil monitoring and sensing methods (covered at Pedometrics 2017) make model validation and provision of data for modeling much more feasible than in the past, when the data-crisis reigned. Thus we can demonstrate convincingly and much better than in the past the crucial importance of soil data, characterizing dynamic soil behavior in a landscape context. This represents a paradigm shift as lack of data used to be a major problem as model use proliferated. The definition of Pedometrics is now restricted to "application of mathematical and statistical methods…." and should, I feel, be extended including physical, chemical, biological and – increasingly important!- optical and in-situ sensing methods.

2. The "*importance of soil management and land use*" as well as "*relations between pedology and land evaluation*" is mentioned and is gaining increased importance when addressing the SDGs. Modeling soil and landscape evolution is covered within Pedometrics and it is covered well. But modeling soil behavior when subjecting any given soil to different agronomic, hydrological, ecological and climatological scenario's (preferably in combination) is, in my perception, not receiving adequate attention. In these fields Pedometrics can provide essential data.

3. "*Convince colleagues, managers and decision makers that pedometrics is necessary and useful*" (see also topic 23 of Pedometrics 2017: use of uncertain soil information in policy and decision making and topic 5:citizen science, crowd sourcing). Here, basic problems remain. For example, in contrast to water, biodiversity and air quality, there is no legally binding soil guideline in the EU. Dutch manure regulations focus on amounts of manure applied without considering soil differences. In the current policy climate we can hardly afford to be so disconnected. More attention has to be paid to achieving effective communica-

tion practices, addressing policy and management issues (e.g. Bouma and Wosten, 2016).

4. Basic remarks were made about a central question in Pedometrics on "*measuring versus modeling*". For example, saturated hydraulic conductivity can be measured but also calculated, considering pore size distributions, pore continuity established by staining and pore-interaction models. This we did some time ago for clay soils but measurement is, of course, much quicker and cheaper producing more data. Soil physicists have tried for decades to model bypass flow in structured soils with macropores by trying to adapt Richards equation, developed for and successfully applied in homogeneous soils. No operational procedures could be developed so far and measurement of bypass flow is therefore more logical (see Bouma, 2016). The paradigm shift (see point 1) from modeling with little data to modeling based on many data, feeding and validating models, is of crucial importance for Pedometrics making it a very important, if not the most important, key activity of soil science in future.

5. "*Methods are needed to determine the appropriate level of detail for models and supporting information to achieve particular goals*". This is important when aiming at SDGs. Some problems can be solved with existing methods or techniques that can even be empirical and qualitative for some issues (e.g. Bouma et al, 2015). This appeals to the policy arena where the Pavlov reaction of scientists: "we need more money for research" causes irritation and resistance. New evermore sophisticated models or methods may not be needed to solve at least some problems but – let's be honest- are needed by scientists to advance their careers, publishing in international refereed journals. This is a self-inflicted problem that can only be solved by the scientific community itself.

6. "*Communication*" remains a key activity as well (see also point 3) . Listing 23 topics for Pedometrics 2017 could suggest to outsiders that this is a free-for-all activity. Of course, it is not but including a logical storyline in which the different topics are mutually related would be helpful. The recently proposed soil security concept is suitable in this context, distinguishing condition, capability, capital, connectivity and codification. The 23 topics fit in here when describing the research process for a given soil all the way from problem identification to implementation of research results.

Pedometrics 2017 excels in the way the conference was organized. Rather than the classical approach with a tiring succession of papers, emphasis is now on interactive workshops that allow joint learning of participants. This provides a very positive signal for the future.

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Digital Soil Mapping Working Group

Laura Poggio

When and How did the WG was formed?
The first Digital Soil Mapping (DSM) workshop was organised in Montpellier, France. The IUSS working group was formed following this first workshop. The working group met every two years in different locations. Previous workhops are 2016 – Aarhus (Denmark), 2014 – Nanjing (China), 2012 – Sydney (Australia), 2010 – Rome (Italy), 2008 – Logan (Utah, USA), 2006 – Rio de Janeiro (Brazil). There will be a joint meeting with all working groups of the pedometrics division in Wageningen (The Netherlands) for the 25th anniversary of Pedometrics. The idea of more GlobalSoilMap was launched at the meeting in Rio de Janeiro (Brazil, 2006)

Did you see the topic of the WG emerging 25 years ago ?
In order to answer this question a poll was sent to a subset of scientists involved in DSM since the beginning. Out of the ten replies, six answered "yes" and four answered "no" [most interesting is who answered no, but as the poll was anonymous I am afraid I cannot disclose this information]. For example, DSM 25 years ago was perceived as work on land evaluation using GIS and soil information, but also as "science fiction".

How were you involved in the WG?
I always like map, soils and computers, DSM seemed to be a good combination. When I moved to Aberdeen I had the chance to start "playing" with DSM. I was hooked and I tried to dig further into it. I started to attend some of the DSM meetings.

What is the highlight of the WG?
DSM developed a lot in the years since the WG was created. The paper of Minasny and McBratney (2016) provides a nice history of the topic and, partly, the WG. There were many great advancements, applications, new techniques. Too many to list all of them and too many to have a shortlist that makes sense and does not leave out something equally important from a different point of view. However, I think one of the main highlights of the Working Group in particular has been to make DSM operational and widespread and not only a research topic. DSM is now widely used (and mis-used) based on the availability of computer power, open data and open-source tools.
Another important general highlight is the application, not only to local cases (farms, field) but also to regional, national and global cases.

How do you see the synergies between Pedometrics and the WG?
I think Pedometrics and DSM are inherently interlinked. I see pedometrics as more methodological, while DSM is more applied. The two need and complement each other.

What is the research challenge of the working group in the next 5 years?
There are many challenges ahead, some more scientific, some more technical and some more social. I will try to summarise some of them, but I would like to hear what people think about this.

- Technical challenge(s): To develop methods that can deal with the amount of data out there, the increase in resolution of the input and output dataset, the increase in extents. Using a fashionable buzz word: DSM and big data.
- Research challenges:
  - ⇒ Do we really need/want to use all the information out there? How to best select the information available? How to make best use of it, once selected?
  - ⇒ What to do with the data produced? Carbon maps are nice, but what to do with them once they are produced.
  - ⇒ Uncertainty communication and propagation: a lot has been done on this, but maybe more is needed to make it more widespread and not only a research tool.
- "Social" challenges:
  - ⇒ How to advertise to other communities to use the data produced?
  - ⇒ How to communicate the limitations of a map? We can produce a 10m resolution of a national/continental/global map of a soil property, but is this meaningfully supported by the existing data?

The main reference on the history of DSM was Budiman Minasny, Alex. B. McBratney, 2016, Digital soil mapping: A brief history and some lessons, Geoderma: 264, 301-311.

I would be happy to collect further opinions, information, suggestions, answers, anecdotes especially on: 1) where was DSM 25 years ago?, 2) highlights of the WG/DSM? and 3) challenges in the next few years.

Proximal Soil Sensing Working Group

Zhou Shi

When and How did the WG was formed?
A proposal to establish the WG-PSS was discussed at the 1st Global Workshop on High Resolution Digital Soil Sensing and Mapping held in Sydney in 2008. As a result, a proposal to the IUSS was prepared by Raphael Viscarra Rossel and colleagues, for the establishment of the working group to sit within the IUSS Pedometrics commission in division D1: Soil in Space and Time and the commission of soil physics in division D2: Soil properties and processes. During the IUSS mid-term meeting in June-July 2008 held in Brisbane, Australia, the IUSS approved the establishment of the WG-PSS. A vote, supervised by the Chairman of Pedometrics Murray Lark, established Raphael and Viacheslav Adamchuk as the inaugural Chair and Vice-Chair of the WG-PSS .

Did you see the topic of the WG emerging 25 years ago ?
Yes, proximal soil sensing gained prominence in soil science in around the past 25 years, because of the realization that sensed data could provide good quality soil information more efficiently than laboratory methods of soil analysis, which can be expensive and time consuming. Some of the earlier reports using sensors to measure soil properties were colleagues in the USA who measured soil with spectrometers, electrical resistance sensors, EMI, penetrometers and capacitance sensors for measuring soil water. In the 1990s, the development and use of sensors for soil measurement gained momentum and various technologies were being reported; for example, GPR, microwave sensing, visible and NIR reflectance and the development of tine -mounted sensors, ISEs and ISFETs for measuring nutrients, mobile penetrometers, acoustic sensors, and odor sensors to determine soil air composition. Recognizing the increasing interest in soil sensing, Viscarra Rossel and McBratney (1998) used “proximal soil sensing” to describe measurement of soil properties with ground-based sensors. The development of PSS coincided with that of precision agriculture, which for some time appeared to be the application most suited to the use of proximal soil sensors. Interest in PSS is now more widespread, and currently a wide range of technologies can be used for it. By its own merit, PSS is now a new discipline and is a topic of considerable interest in the soil, agricultural and environmental sciences, and engineering communities. .

How were you involved in the WG?
I hosted the 4th global workshop of PSS in 2015 in Hangzhou. The workshop was well attended with 130 participants from 19 countries. I have been an active member of the WG-PSS and attended several workshops over the last ten years. An outcome from the 4th Global Workshop was a special issue called “Sensing soil condition and functions” in the journal of “Biosystems Engineering” published in 2016. Abdul Mouazen and Marc Van Meirvenne and I were the guest editors. Craig Lobsey and I were recently elected to take over from Marc Van Meirvenne and Robin Gebbers as the new Chair and Vice-Chair of WG. We will actively organize and lead the WG-PSS and its activities for the next term starting 2017.

What is the highlight of the WG?
A highlight of the WG is the interdisciplinary makeup of its members and linkages. The group fosters interaction between scientists and engineers working to develop and apply state-of-the-art sensing technologies to the study of soil processes and spatio-temporal soil variability. The group links key disciplines including agriculture, electronic engineering, mechatronics, spatial statistics, chemometrics, mathematics, geophysics and remote sensing as well as those interested in applied geosciences, archaeology and ecology. The working group also links strongly to the subdisciplines in soil science, including soil physics, soil chemistry, pedometrics and digital soil mapping.

How do you see the synergies between Pedometrics and the WG?
If we see from the synergy prospective, it is clear that Pedometrics and PSS are very complementary. You collect data using soil sensors and then map using various mathematical techniques as used in the mapping. Therefore, in explaining and quantifying soil spatial and temporal variability, the PSS and Pedometrics come along.
In the near future, PSS will provide more precise and quantitative data at fine spatial and/or temporal resolutions, and will help Pedometricians to better understand the soil as a phenomenon that varies over different scales in space and time.

What is the research challenge of the working group in the next 5 years?
The challenge for the research group is to continue to develop new sensing techniques, as well as improve the accuracy, robustness and application of existing techniques. The use of local versus global sensor calibrations is still our future topic. And we should focus on adoption of the multi-sensor and data fusion approach that include in particular the vis-NIR-MIR spectroscopy, electromagnetic induction, ground penetrating radar, Gamma-ray spectrometers etc. To explore more application of proximal soil sensors for digital soil mapping, soil monitoring, assessment of soil carbon, contaminated site assessment, and soil biogeochemistry modeling. Continued development of soil sensing and approaches will provide the data and measurements necessary to improve our understand of soil processes, and assist soil science in developing solutions to the food, water, energy and climate issues that we face.

Soil Monitoring Working Group

Ben Marchant

When and How did the WG was formed?

The Soil Monitoring Working Group officially came into existence during the 2010 World Congress after Dominique Arrouays, a multitude of soil scientists and I submitted a proposal. The idea had originally been mooted by Murray Lark at Pedometrics 2007 in Tubingen and a workshop on Statistical Aspects of Soil Monitoring was hosted by Rothamsted Research in 2008.

Did you see the topic of the WG emerging 25 years ago ?

Twenty five years ago I'd just completed my A Level exams in the UK and I was on holiday, vaguely aware that I'd be starting university in the autumn. My plans for an IUSS working group were not fully formed at this time.

How were you involved in the WG?

When the WG was established I'd already collaborated a fair amount with Dominique Arrouays and Nicolas Saby using geostatistics to analyse data from the Réseau de Mesures de la Qualité des Sols – the French national soil monitoring network. The WG was an opportunity to establish wider links with other monitoring networks.

What is the highlight of the WG?

The WG has organised a workshop, many colloquia and special sessions, a review paper and two journal special issues. Probably the most memorable contribution was the 'cucumber in a mask' describing the implementation and results of soil monitoring in France.

How do you see the synergies between Pedometrics and the WG?

The two are very much interlinked. Pedometrics is the broader topic whereas the WG is focussed on the challenges of measuring and analysing soil properties in space and time.

What is the research challenge of the working group in the next 5 years?

This is the question we're going to answer at our Business Meeting during the Pedometrics meeting in Wageningen, so please come along to have your say. A primary motivation for the creation of the WG was the proposal of a European Union Soil Framework Directive which required member states to implement national-scale soil monitoring networks. The WG was to facilitate research into the tools required to implement, analyse, interpret and communicate the findings of these soil monitoring networks. However, the directive was withdrawn in 2014 and is therefore no longer a driving force behind the activities of the WG.

Of course, the need for soil monitoring remains and this has been stressed by the Global Soil Partnership, by the Status of the World's Soils Resource report and the Revised World Soil Charter. Much recent focus has been on how soil carbon sequestration rates can be monitored to establish whether targets such as the COP21 '4 pour mille' initiative are being satisfied. Soil monitoring is also vital across the globe to confirm whether land management, and specifically agricultural, practices are sustainable.

To some extent, there has been a shift away from purpose-built soil monitoring networks towards the use of remotely sensed data or data obtained from citizen-science activities. These different data sources have required different statistical methodologies. The business meeting will discuss how the WG should react to these changes in the focus of soil monitoring and better integrate with other relevant activities such as the GlobalSoilMap and the Pillar 4 action plan of the Global Soil Partnership. The business meeting discussions will lead to a proposal for a new structure of the WG in time for the 2018 World Congress.

Soilscape Modelling Working Group

Peter Finke

When and How did the WG was formed?

The suggestion to have a working group on soilscape modelling comes from the Terrestrial Working Group of CSDMS (Community Surface Dynamics Modelling System), was taken up by Arnaud Temme and the undersigned. Quickly thereafter, Alex McBratney asked us to propose a WG for the IUSS, which was followed up and lead to the instalment of the IUSS-WG on modelling of soil and landscape evolution at the Jeju IUSS congress in 2014.

Did you see the topic of the WG emerging 25 years ago?

In 1992 soil modelling was restricted to rather topical models describing water balances, and leaching of some nutrients and biocides. There was already a trend towards integrating more processes in these models (e.g. the LEACHM-family of models) and combining soil, crop models but the temporal extent was limited to a few years. This was strongly driven by early research on model-assisted precision agriculture. Landscape modelling was still in its infancy, largely due to computational limitations, and mainly concerned (R)USLE-based erosion models. The combination of both was far away and only identified by a few visionaries (e.g. Kirkby, M.J., 1985. A basis for soil profile modelling in a geomorphic context. J. Soil Sci. 36, 97–121). In general one could say that some of the components for soilscape modelling were being developed 25 years ago, but that their combination was still beyond the horizon.

How were you involved in the WG?

The combination of mapping and modelling soil processes has infected me during my PhD on model-assisted precision agriculture (indeed, 25 years ago; thesis available at reduced price). Soil genesis modelling started on a whim in 2006, when a workshop on modelling of pedogenesis was held in Orléans and I decided to try out some long-term simulations with an adapted version of LEACHC (Hutson, 2003 version). The keynote at Pedometrics 2009 in Beijing made me think about the possible future of soil and landscape modelling. Later I was involved in distributed modelling of soil genesis, which made me recognize the need to include lateral interactions in some landscapes. At that point I was ripe for this WG and it was an easy decision to join the initiative mentioned above.

What is the highlight of the WG?

The major achievement of this WG is an increased exposure of its topic, as demonstrated by 2 excellent review papers by Minasny et al. (2015) and Vereecken et al. (2016), and by sessions in various conference sessions (EGU 2015, 2016, 2017; Pedometrics 2015, 2017) in the form of papers and model demonstrations.

How do you see the synergies between Pedometrics and the WG?

I think Soilscape modelling is an application in the wider field of Pedometrics. Soilscape modelling involves the combination of mechanistic and stochastic quantitative methods. Especially for the stochastic methods there is a rich “repository” in the Pedometrics community that can be used. On the other hand, the mechanistic process-based knowledge generated by the soilscape modelling community is increasingly being used in Pedometrics fields like Digital Soil Mapping.

What is the research challenge of the working group in the next 5 years?

Personally, I see the following challenges:

- To interact with the Critical Zone Network people: there is a huge overlap between the interests of both groups, but exchange of instruments and methods appears to be limited.
- To better combine soil modelling with landscape modelling (see Minasny et al., 2015).
- To better motivate choices of mechanistic/ process-based/empirical model components in light of applications, data availability and model application domain;
- To better validate and calibrate soilscape models.

Most of the above are personal observations and opinions and are subject to discussion. At forthcoming meetings we should have these discussions!

Digital Soil Morphometrics Working Group

Alfred Hartemink

When and How did the WG was formed?

The Working Group was formed in 2014, and approved by the IUSS Council at the World Congress of Soil Science Meeting in Jeju, Korea. There were various thoughts floating around and a small group of people founded the Working Group. The idea was that the Working Group focuses on the soil and the soil solely, and that tools developed and tested by, for example, the proximal soil sensing working group are needed to understand the soil.

Did you see the topic of the WG emerging 25 years ago ?

Some 25 years ago, I was describing soil profiles in Tanzania and Indonesia. I was a soil surveyor. Just like there was a subconscious sense of scientific dissatisfaction in the way we mapped soils, I thought the way soil profiles were described was a most modest creative attempt of a natural phenomenon that deserved better. I vaguely realised that soil horizons were somewhat equivalent to the mapping unit of a polygon map. A loose set of properties, definition of classes, a line is drawn – all that to the best of our knowledge. But the answer is no, I did not see the WG emerging 25 years ago. The technology wasn't there and I was clueless. Later on, I imagined and saw that pedometrics techniques can be used to investigate soil profiles. Do we need soil profiles to understand the soils of the world, yes, and I guess that is something that I may have realised 25 years ago. As long as we have soil, we will dig and study.

How were you involved in the WG?

A few of us got together, wrote an introductory paper, an outline for a Working group, and organized the inaugural global workshop. I was very fortunate to be part of those few that got together.

What is the highlight of the WG?

The highlight is always the next thing, so I trust that is the Pedometrics meeting in Wageningen in June 2017. But the Inaugural Global Workshop on Digital Soil Morphometrics in 2015 was quite an event too bringing together 70 people from 15 countries.

How do you see the synergies between Pedometrics and the WG?

Cleary, the Pedometrics Commission is a scientific breeding ground for several IUSS Working Groups. The Working Group on Digital Soil Morphometrics is no exception, but it is also rooted in the pedology community. So ideas are distilled and synthesised from different groups, and hopefully that continues to lead to synergies and some novelty.

What is the research challenge of the working group in the next 5 years?

The focus of digital soil morphometrics is on the soil profile or the two dimensional representation of the pedon – that is: the three dimensional soil body. It focuses on enhanced understanding on what we see and measure, and how we measure and model the soil profile. It treats the soil profile as a continuum (through depth functions and soil profile maps) and through soil horizons from which we have learned so much.

The challenges are to accurately and objectively describe and quantify a soil profile (soil pit, core, road cut, auger hole etc.) and deal with variation within and between soil horizons. Currently, that is mostly dealt with in the form of soil horizon boundaries and their topography, and few studies have aimed to quantify such variation using models and ideas tested in pedometrics. As pedon information is used in site assessment and digital soil mapping, it is important that we get the pedon information right. The information is also needed to increase our understanding of the soil itself. Lofty goals that keep us going.

About Andrey Nikolaevich Kolmogorov

By Joulia Meshalkina

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In this article, I would like to introduce Andrey Nikolaevich Kolmogorov. I have a deep affection to Prof. Kolmogorov. My father, Prof. L.D. Meshalkin, was his postgraduate student and then worked with him. Since childhood, I have lived in the charm of the personality of A.N. Kolmogorov

We mostly know the “Kolmogorov-Smirnov test” but his contribution is much more, including, Markov Chain, Information Theory, Spectral Analysis, Variogram and many others, which are commonly used in Pedometrics.

Andrey Nikolaevich Kolmogorov was one of the most eminent mathematicians of modern times. His name is as significant as the names of Poincare and Gilbert. Widely recognised by the international scientific world, Kolmogorov was a member of almost all the most respected scientific societies in the world and a member of honour in 21 of those.

In 1962 Andrey N. Kolmogorov was awarded the Balzan Foundation International Prize in Mathematics (an award established to celebrate achievements in areas not covered by the Nobel Prize), which was the most distinguished appreciation of Kolmogorov's contribution to the world science (Fig. 1).

Vladimir Arnold, who is best known for he Kolmogorov–Arnold–Moser theorem concerned with the stability of integrable systems, once said: "Kolmogorov – Poincaré – Gauss – Euler – Newton, are only five lives separating us from the source of our science".

A.N. Kolmogorov was born in 1903. His rare and versatile talent revealed itself quite soon: at the age of 7 he rediscovered the representation of squares of integers in the form of a sum of primes (1 = 12, 5 = 12 + 22, 13 = 32 + 22, 17 = 12 + 42), at 12 he started studying higher mathematics. He was oscillating while choosing a future job: he dreamed of becoming a forester, meanwhile being interested in history and mathematics. In 1920, he was admitted to Moscow State University, Faculty of Physics and Mathematics, and to the Metallurgical Faculty at Mendeleev Moscow Institute of Chemistry and Technology.

Fig.1. A.N. Kolmogorov in 1962 at the Balzan Prize award ceremony.

During his first student years, Kolmogorov shared his interest between mathematics and the history of Russia. He liked telling his students an anecdote about the end of the "career of a historian". After presenting his historical study at a scientific seminar, Kolmogorov was praised by the head of the seminar, Professor S.V. Bakhrushin. However, the professor pointed out that the conclusions of the young man may not claim to be final, since "in the historical science, every conclusion must be underpinned by several proofs". Later, mentioning this episode, Kolmogorov added: "And I decid-

Fig.2. One of the buildings of Moscow State University, where in 1920 there was the Faculty of Physics and Mathematics.

ed to go for the science, the final conclusions in which ask for one proof only." Thus history lost a brilliant researcher, and mathematics was granted one.

Kolmogorov's first scientific publications appeared in 1923 when he was twenty years old, and his last scientific work was published in 1983, when he turned eighty. 60 years of work lie between these 2 dates.

In June of 1922, Kolmogorov constructed an example of the Fourier series, diverging almost everywhere, and after it, an example of the similar series, diverging at each point. These results, wholly unexpected by the experts, made the nineteen-year-old student famous around the world [1].

In 1924, for the first time, Kolmogorov approached the probability theory. Both for this area of mathematics and for its applications to natural sciences it is the law of large numbers which has significant meaning. The best mathematicians had been working on its substantiating for decades, and in 1928 Kolmogorov succeeded in identifying and proving necessary and sufficient conditions for the validity of the law of large numbers. With his work "Foundations of the Theory of Probability", first published in German (Grundbegriffe der Wahrscheinlichkeitrechnung) in 1933 [2], Kolmogorov laid the foundation for the modern probability theory based on the theory of measure. In his monograph dated to 1933, he first defined and proved the basic theorems of infinite-dimensional distributions, which established a solid basis for later logically flawless construction of the theory of random functions and of sequences of random variables. The task of constructing the theory of probability as a complete mathematical theory was completed. Throughout his life,

Fig.3. Kolmogorov in the 1930s.

Fig.4. Bathing the Red Horse, Petrov-Vodkin. 1912. One of the favourite mathematician's paintings, a copy of which Kolmogorov had at home.

A.N. Kolmogorov regarded the probability theory as his specialty, though he was engaged in around 20 fields of mathematics.

In 1933, Kolmogorov developed one of the most important nonparametric tests of mathematical statistics - *Kolmogorov-Smirnov test*, used to test the hypothesis that the sample belonging to a certain distribution law.

In the 1930s, Kolmogorov also laid the foundations for the theory of Markov stochastic processes with continuous time. Turning to topology, in 1935, along with James Waddell Alexander II, he introduced the notions of a boundary operator and *cohomology*, where the latter is one of the key notions of modern topology.

Kolmogorov made a significant contribution to the development of the theory of dynamical systems by introducing a new invariant "entropy"; as well as to constructive mathematics, where his ideas of measuring the complexity of the object had various applications in information theory, probability theory and the theory of algorithms. In 1954 at the International Mathematical Congress Kolmogorov's contribution to the general theory of dynamical systems and classical mechanics was recognised as an important historical milestone in the development of science. In the theory of dynamical systems, Kolmogorov developed a new method that allows describing destabilisation of conditionally periodic motion, which is considered to be one of the greatest achievements of mathematics of the twentieth century. The Kolmogorov-Arnold-Moser method plays an important role in nonlinear mechanics. The Kolmogorov-Arnold theorem serves as the mathematical basis for neural networks.

Kolmogorov is credited for the most important results in information theory related to the approaches to the definition of the concept of the amount of information and entropy, which allow to build it up as a rigorous mathematical science (as opposed to a purely technical discipline studying the problems of information transfer). Unlike Shannon's Information theory, based on the concept of probability, Kolmogorov's theory does not use this concept. On the contrary, it allows to render the basic laws of probability theory in a new language and even to provide a strict mathematical defini-

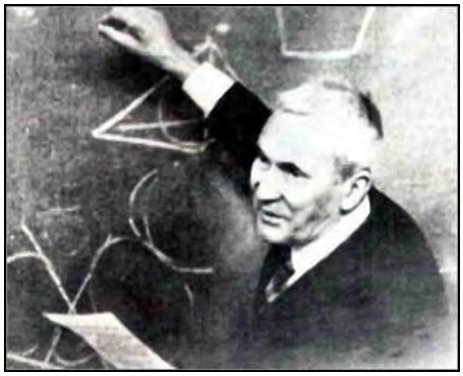

Fig.5. Kolmogorov in the 1970s.

tion of an individual random object, which traditional probability theory is incapable of. Kolmogorov offers the definition of the random nature of an individual object in terms of algorithms.

The variogram was introduced in the 1940s by Kolmogorov for the study of turbulent flow [3]. To determine the characteristics of random processes with stationary increments, Kolmogorov introduced functions, called *structural*, which were studied by his students A.M. Yalom, V.I. Tatarsky, A.F. Romanenko, and others. It is demonstrated that covariance functions are a particular case of structural functions. From a mathematical perspective, geostatistical methods are based on the section of probability theory, known as the "theory of random functions". The foundations of this theory were laid by the works of A.N. Kolmogorov (1941) and N. Wiener (1950) on the interpolation and filtration of stationary random processes. Kolmogorov arrived at these works in connection with works on turbulence.

At least 30 concepts bear the name of A.N. Kolmogorov. When asked why some feats didn't have his name, he answered: "It is not possible to call everything after me".

In 1931 Kolmogorov became a professor at Moscow State University. In 1935 Kolmogorov founded the Department of Probability Theory at the Faculty of Mechanics and Mathematics at Moscow State University and was its Head until 1965. Kolmogorov was the Head of the departments of the theory of mathematical statistics (since 1976), mathematical logic (since 1980). During 1954-1958 he held the position of the Dean of the Faculty of Mechanics and Mathematics.

Fig.6. Kolmogorov among students of the Boarding school of Physics and Mathematics .

In 1960, to further develop the work on practical applications of probability-theoretic and statistical methods Kolmogorov established a Laboratory of Statistical Trials at the department of Probability Theory. In 1967 the Laboratory received a new status and turned into the Interfaculty Laboratory of Statistical Methods. In fact, it was a small (130 people) statistical institute. Kolmogorov identified the following main research areas: theory of optimal control and statistical decision making, reliability theory, experiments design, statistics and linguistics, statistics in medicine, statistics in geology, nonlinear spectral analysis. V.V. Nalimov, who

Fig.7. Moscow State University, where Kolmogorov worked (on the 15th floor) and lived since 1953. Faculty of Mechanics and Mathematics takes 5 floors from the 12th to the 16th in the central part of the building. In the wings of the building, there are student dormitories and apartment for the teachers.

worked as Kolmogorov's deputy in this laboratory for many years, tells in his book "The Ropewalker" about issues brought up for discussions. For example, how educated mathematics-wise a non-mathematician who wants to employ probabilistic-statistical methods in his work should be? This issue is getting acute due to the fact that the wide development of computer technology allows completely not trained people to use programs. The following danger is that applied mathematics is still a deductive science. A model can not be obtained purely from experimental data, without relying on the premises brought in by a researcher. You need to understand that there is always some uncertainty in the results of cluster analysis - they depend on the metrics of the space designed by a researcher". This led to the discussion about the need to introduce a new interdisciplinary specialty: mathematically oriented biologists, soil scientists, psychologists, etc. Such a specialist could act as a consultant supporting at a proper level the process of bringing mathematics into science disciplines that traditionally were evolving without engaging mathematical knowledge. It bred the task of creating own mathematized language for the construction of axiomatized theories, similarly to how it worked in physics.

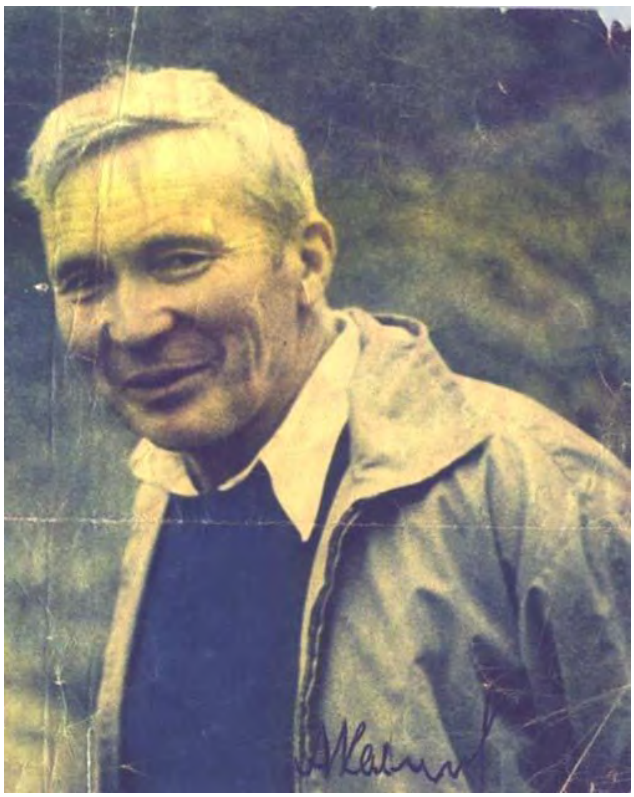

Fig.8. Kolmogorov in the late 1970s.

Fig.9. Kolmogorov skiing in the mountains.

Kolmogorov left a mark on the methodology and history of mathematics, the theory and practice of its teaching. In 1963, Kolmogorov initiated opening of a Boarding school of Physics and Mathematics at Moscow State University (Fig. 6). Gifted children from all the republics of the former USSR were admitted to it. Since 1989, this school bears his name.

The money from the Balzan prize was used to purchase foreign books on probability theory and mathematical statistics, a collection developed in a library opened in 1966. This library is still open and boasts a unique collection of professional literature on probability theory, mathematical statistics and their applications, accessible to all interested readers, starting with students.

According to people who knew him, Kolmogorov was seeing people and the surrounding reality as if through special magic glasses, in a better light than it was in reality. This, as a rule, yielded positive results, especially in the case with his students: they all wanted to match that perfect image Andrey Nikolaevich Kolmogorov had, everyone was growing, improving ...

Not granted strong health, Kolmogorov began to keep fit, skiing, became good at swimming and in 1924 he first went hiking with students to the Crimea. Since then, summer hikes belonged to his life. A few days before his sixtieth birthday, on April 14, Kolmogorov, together with his students, made a five-hours ski trip after which he bathed in the snow (Fig. 9).

And a month before his seventieth birthday, in March 1973, Kolmogorov swam in the mountain lake Sevan with his clothes laid on snow-covered rocks. Approaching 80, when his eyesight was deteriorating, Kolmogorov was bothered more by the fact that he could not see the track rather than by the difficulties with reading.

Andrey N. Kolmogorov died on October 20, 1987 and was buried at Novodevich cemetery, where the most famous Russian people are buried (Fig. 10).

V.M. Tikhomirov in his essay "The Genius Who Lived Among Us" wrote: “Without any doubt A.N. Kolmogorov belonged to the most remarkable mathematicians of the 20th century, he was the Educator, the creator of a massive scientific school, one of the patriarchs of Moscow University, the reformer of mathematical education, a philosopher and historian of science ... Andrey Nikolaevich always emanated lots of ideas, nourishing students working beside him. Kolmogorov ... was sharing challenges, hypotheses, ideas, methods - during lectures, during walks, and while having tea in Komarovka ... These were always problems with a long-

range vision, they were not purely mathematical, but had a general scientific (or philosophical) mystery. And if a person stepped on some path, then further he moved forward independently and could never say that everything has already been done ... ".

Fig. 10 The monument to A.N. Kolmogorov at the Novodevichy cemetery in Moscow .

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Interview:
Dominique Arrouays talks about 4 per mille

Tell us about the soil carbon 4 per mille initiative?

The 4 per mille (or 4 per 1000) was launched during the COP21 meeting in Paris by The French Minister of Agriculture Stéphane Le Foll. The 4 per mille initiative aspires to increase the global soil organic carbon stocks by 0.4 percent per year as a compensation for the global emissions of greenhouse gases by anthropogenic sources. It was supported by almost 150 signatories from representatives of countries, regions, international agencies, private sectors and NGOs. The official title is "4 per 1000 - Soils for food security and climate".

What is the significance of the number 4 per mille (4 per 1000)?

The official 4 per 1000 website (http://4p1000.org/understand) said: "A 4‰ annual growth rate of the soil organic carbon stock would make it possible to stop the present increase in atmospheric CO_2". Based on the Global Carbon Budget, then the objective would be to mitigate the annual increase in CO_2 in the atmosphere, around 4.3 Gt C. Taking a global SOC stock of 1500 Gt C (to 1 m depth) and multiply it by 0.4%, we get 6 Gt C, which is larger than the annual CO_2 increase.

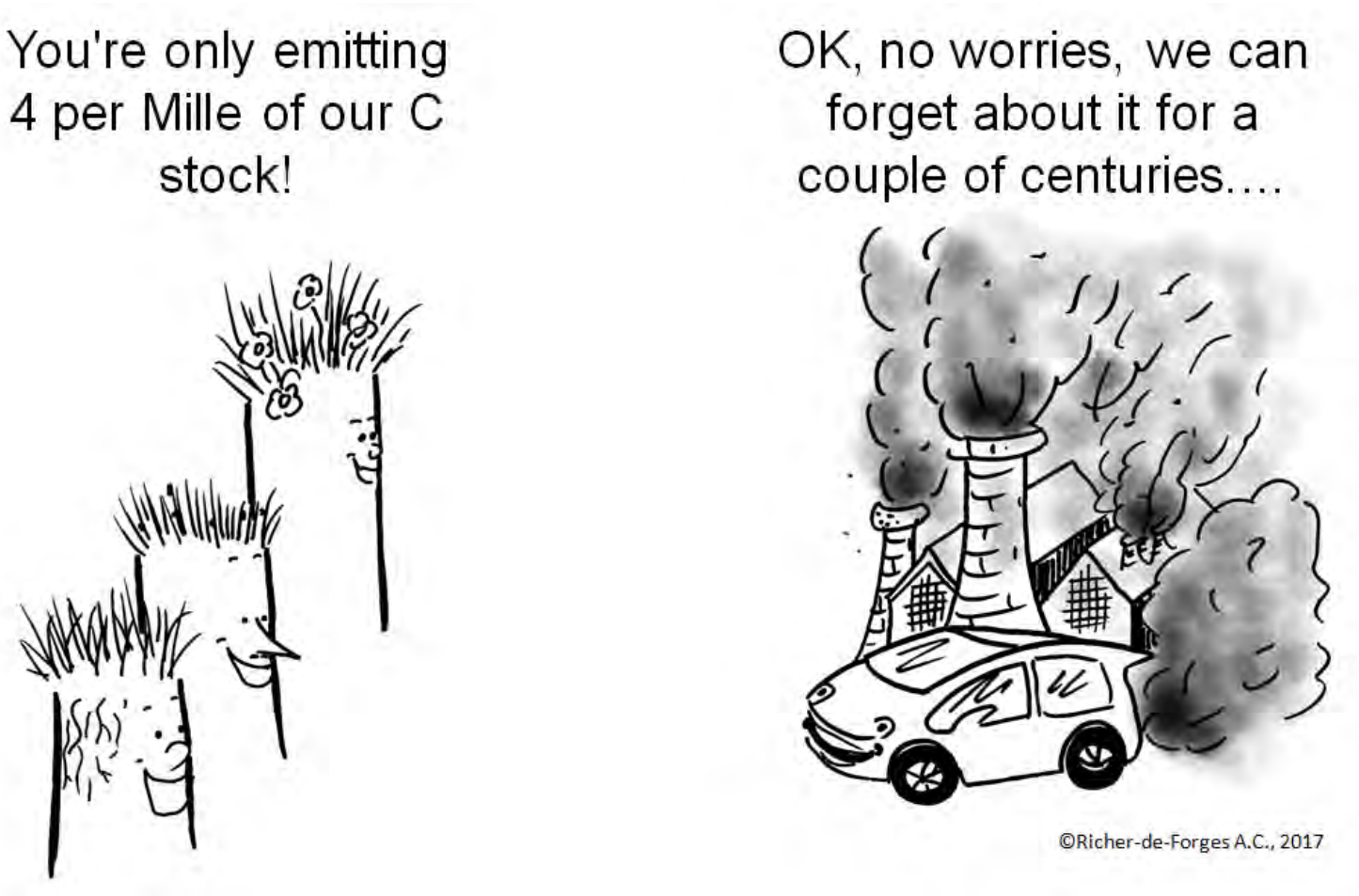
But according to a publication by Ademe (2015): "An annual 4 per 1000 (0.4%) increase in organic matter in soil would be enough to compensate the global emissions of greenhouse gases". If we take the global SOC stocks of 2400 G t C (to 2m depth) and only consider CO2 emitted by fossil fuel combustion which is estimated at 8.9 Gt C, then the ratio 8.9/2400 is 0.0037, or around 4 per mille figure. Actually, it should be 9.6/2400 = 0.4%.

Amazingly, Balesdent and Arrouays (1999) who proposed 4 per mille for the first time in the literature, wrote (in French) 'A relative increase of total SOC stocks by 0.4% would mitigate the global fossil fuel emissions'. We used an estimate of global SOC stock of 1600 Gt C (to 1 m) which, if multiplied by 0.4% gives 6.4 Gt C, close to the annual fossil fuel emissions during the 1990s. Since then, the estimates of SOC stocks have been refined to 2400 Gt down to 2 m, and the emissions have increased in a similar proportion, and thus the 0.4% figure does not change.

Now, if we quote Soussana et al. (2015) "Over a meaningful depth for carbon sequestration, i.e. 0-40 cm, the 4‰ target would result in a carbon sequestration that could peak at 3.5 billion tons C per year (Gt C yr^{-1}) when considering soils from all biomes. Agricultural soils have a technical carbon sequestration potential between 0.7 and 1.2 Gt C yr^{-1}, while the potential from all other land uses (including forests and integrated systems like agroforestry) could reach 2.5 Gt C yr^{-1}." Indeed, if we sum 2.5 Gt C and the average of the range 0.7-1.2 Gt C, we come to 3.45 billion tons C per year, which fits the target especially when combined with halting deforestation.

Tell us a bit more on the Balesdent and Arrouays paper.

The Balesdent and Arrouays paper (1999) was written in the framework of a French research programme on agriculture and greenhouse gases emission. In that paper, we produced a first rough estimate of changes in French SOC stocks linked to changes in Land Cover during the 20th century. In particular, we saw the evidence that the bare-soil fallow period from the Euro-



pean CAP had been a catastrophe. We were looking for a way to emphasize that SOC stocks were enormous if compared to anthropogenic GHG fluxes to the atmosphere and thus getting a small relative change of the stocks can have a significant effect. We did a approximate calculation and came up with the 4 per Mille ratio between world's soil carbon stocks and C-CO_2 emissions. Actually, we wrote that if such a relatively small change of soil C stock were to occur, it would offset GHG emissions. We did not elaborate whether it was plausible to achieve that rate.

Is 4 per mille a magic number?

As I explained earlier, no matter how the calculation is made, 4 per mille is the result which is claimed. But I don't believe it is a magic number. 4 per mille is a well-intentioned aspirational target that has also become a slogan in helping the promotion of sustainable soil management.

Is there a scientific discussion behind the 4 per mille?

Of course, there are discussions that took place before and during the launching of this programme (http://newsroom.unfccc.int/lpaa/agriculture/join-the-41000-initiative-soils-for-food-security-and-climate/). The 4 per Mille initiative includes a proposal for a research programme which is guided by a scientific committee (http://www.agropolis.fr/pdf/actu/4-per-1000-comite.pdf). The 4 per Mille initiative was also discussed under the auspices of the International Union of Soil Sciences (IUSS).

Isn't the C sequestration target of 4 per mille too optimistic?

There have been various estimates of potential soil carbon sequestration potential from agricultural and manage lands ranging from 0.5 to 2.5 Gt C yr^{-1}. If we only stay to currently managed soils and rely only on

atmospheric deposition and fertilizers for nutrient management, then the potential is low. If we believe, that there is a large technical potential in soils that are currently not managed or poorly managed and new technologies were developed, then the 4 per mille aspiration is realistic.

Some said that it is implausible to upscale experimental results of SOC sequestration to the global scale because of nutrient limitations.

I agree that some limitations to C sequestration may occur because of lack of nutrients such as N and P. However, we should not fully rely on chemical fertilizer and N deposition to solve this nutrient issue. Nutrient management may be improved by many techniques, such as the use of legumes, grazing management, agroforestry, etc.. In many parts of the world, crop residues are not well managed and frequently burnt. There is also an enormous potential for waste recycling, especially from large cities. SOC sequestration should be the outcome of improved farming practices that increased productivity, which in turn build up organic matter. The main feedback of N fertilization is through increased crop yields. However, the relationship between fertilizer N and SOC is also not direct. The missing argument from this is that increased SOC has a positive feedback on soil quality and crop productivity. A recent study by Sanderman et al. (2017) demonstrated that the management system which returns more carbon in the soil increases its SOC, which in turn, supplies more nutrients back to the crop, and increases crop production. This positive feedback thus eases the nitrogen dilemma.

In many places, organic amendments are not considered as sequestration.

Many would exclude organic amendments as C sequestration, as it assumes that it is merely transferring C material from one place to another. It is right in cases such as farmyard manure in intensive cattle production systems. However, when managed properly, this may lead to sequestration. More importantly, a large part of potential organic amendments in the world is largely under-utilized, such as for instance urban wastes and sewage sludges and thus have the potential for a true contribution to abating GHG.

But true abatement should consider net changes in all the GHG.

Yes, that is true, we need to work further on this topic. But there are also examples where reduced or no-till systems lead to a lower fuel consumption, and the reduction in N fertilizer application when legumes are used in crop rotation.

There is a limit of C sequestration with time?

Correct, the capacity of soils to sequester carbon is time constrained, in the paper of Minasny et al. (2017) , studies from France, New Zealand and Chile showed some constraint. Some countries reported that a new equilibrium will be reached (e.g., UK, Canada) and some others indicate that for some soils the maximum has already been attained (e.g., Scotland, New Zealand, Chile, USA, Belgium) and that the main challenge for these soil is not to lose the accumulated carbon. We also need to be aware that soil carbon sequestration is reversible.

Some simulation studies show that climate change (increasing temperature) can enhance soil C lost.

Increase temperature may have adverse effects on soil carbon storage, especially in the extreme conditions, by accelerating mineralization in the cold climates (permafrosts, northern hemisphere peats) and by reducing net primary production in hot-and-dry areas. However, in the intermediate situations, which are areas where increasing SOC is practicable, the effect of rising temperature is still under debate. The effect is convoluted by the fact that not only temperature but precipitation and extreme events will change, and also changes in land use may have larger effect on C stocks. Several regional studies for instance in China, Italy, and Korea found that management practices superseded the increase in temperature. The overall effects of land use and soil management will be much more important for the next decades.

Where SOC sequestration should be targeted?

Restoring degraded soils by management is indeed one of the main challenges of the developing world.

We acknowledge that the sink related to unmanaged rangeland or degraded soils, because of their relative large areas within the cultivated lands category, deserves more scientific attention in order to decrease current uncertainties. SOC sequestration can also be seen as a way to improving the resilience of the soil to future climate change, that is, improving adaptation rather than mitigation. In some parts of the world where food security is threatened, the benefit of soil carbon management for adaptation should be stressed more than for mitigation. This is the reason why the 4 per mille initiative explicitly includes food security.

You prefer to be optimistic?

I believe it is better to be optimistic with an aspirational target and use the best empirical evidence to achieve this rather than being pessimistic, refuse to do anything, and lament that it is unachievable. The paper by Minasny et al. (2017) list potential and challenges from 20 counties and regions worldwide, representing many biomes and landuses. We conclude that 4 per mille sensu lato is a challenge worth pursuing. Optimised practices for enhancing soil carbon will be region and site-specific and will raise new questions and generate new soil knowledge. The economic and social aspects need further investigation and hope that the initiative will create the opportunity to join these scientific communities to the soil science one.

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Interview with Brendan Malone on Using R for Digital Soil Mapping

What led up to this DSM "cookbook"?

Things really kicked off in 2010 when I was invited with Budiman and Alex to prepare a digital soil mapping training course to a number of Australian government scientists and soil scientists. Digital soil mapping was becoming operationalised in Australia around this time with initiatives such as the GlobalSoilMap and the Australian Soil and Landscape grid all being newly established. We needed to build the DSM capacity in the country. Subsequent to this there have been a number of workshops and training courses related to DSM in Australia and around the world. The course materials evolved significantly from 2010 and have been extended somewhat. Right at the beginning we were using a smorgasbord of software throughout the course, but it has been streamlined a fair bit and its now exclusively given using the R statistical software.

Why do you choose R ?

R is very popular. It has its limitations of course, but I like it for all the obvious reasons of being free and open source and having a very extensive help support. I had never been exposed to scripting until the beginning of my PhD in 2009 where Budiman encouraged me to learn R. What actually helped with my learning was translating some of Budi's Matlab code to R! A very cathartic exercise that was I might say. But anyhow, R is quite easy to learn, it is intuitive, and I like how you can develop complete workflows of a statistical analysis. This is good for reproducing your work and effective in a teaching context too.

You travelled around the world giving this DSM course?

I have! It is definitely one of the perks of the job I might say. I won't list them all, but a general observation from all my international training experiences are that soil scientists are a friendly bunch of people. Our workshops attract all skillsets. We have had seasoned pedologists, fledgling undergrad and postgrad

students, government scientists, private consultants and professionals. Furthermore, peoples experience with scripting and R has been equally diverse. This makes our workshops pretty fun. As facilitators of the courses we have to be on our toes too. I don't think anyone workshop is the same really, so we have to be prepared for anything and improvise often. Ultimately this creates quite nuanced experiences for the participants, which is why I suppose we have not had too many complaints yet! Ultimately, I think this type of high intensity training environment has been really good for us in honing our training materials over time.

How long did it take to write the book?

The book materials have taken some time to develop. There have not been extended periods of writing it though, just bits and pieces here and there. I did do a fair bit of writing for in in 2015 though once we had established the publishing contract with Springer. I migrated everything to LaTeX and knitr in 2013 to give the seamless integration between script and text. That was a rather fiddly exercise but worth it I think.

Which part or chapter of the book do you enjoy most?

Are you implying this book is not a masterpiece! There is not a single part, but I would say I quite like the parts where a particular method for addressing a

question is elaborated upon. For example I like the chapters about soil map disaggregation and the 2-stage DSM. I also like the section about estimating soil homologues too. There was actually quite a bit stuff going on behind the scenes for this book too which I am quite happy with too. These are namely to development of a number of R packages which included ithir, which has all the data that is used in the book. Also there is the dsmart R package (soil map disaggregation) and the fuzme R package, which does fuzzy k means and fuzzy kmeans with extragrades.

Do you get feedbacks from readers?

No I think we have stunned everyone to silence. No seriously, there has been quite a few personal congratulatory emails that I have found very satisfying. I can't say I have fielded any sharp criticisms (yet). Ultimately the book is not for seasoned DSM people, but rather for new students and practitioners wanting an entry point to our science.

Can we get all the R codes from the book?

Yes you can. We are setting up a book website (www.digitalsoilmapping.com) that will have all the R scripts. I also have most of the R scripts up on my Github repo "USYD_DSM". Anyone can get the data by getting hold of the ithir R package I have developed.

Isn't a DSM cookbook precarious? Anyone without the knowledge of soil can now make soil maps from few lines of codes.

Well the flip side of your argument is that if we shroud our workflows in mystery and jargon, then nobody will get on board. Part of the reason why DSM is operationalised, for example in Australia is because this book and our courses have made it accessible. I don't think we are dumbing it down, but rather we have partially designed a pedagogical framework needed to build capacity in DSM around the world. So let's get it out there I say.

I do believe in the book we have gone to lengths about the importance of validation, and covered different approaches for how to go about doing this. Also the chapter on uncertainty quantification is integral to the workflow of DSM. Evaluating the quality of our outputs via communicating the uncertainties is a strong characteristic for the DSM community, and probably sets us apart a bit from other communities where geospatial science is undertaken.

What would you like to see in the future edition of this book?

A future edition of the book would be one that stays up to date with what is going on in the R GIS space and the spatial modeling space. I think I would also like to see the book in digital form, complete with interactive scripting. There are some other unborn ideas bubbling away too. As a start though, what would you (meaning the DSM community) like to see in a future edition? I would like to see what other people think about this too you know.

Margaret Oliver Award, 2017

The Pedometrics Commission of the International Union of Soil Sciences (IUSS) is pleased to announce the first recipient of the Margaret Oliver Award for Early-Career Pedometricians The award goes to Dr. Tom Orton, currently a postdoctoral scientist at the University of Queensland, Australia.

Dr Tom Orton obtained his PhD: "*Accounting for sample support in geostatistical analyses of soil properties*", from the University of Sydney in 2016. Dr Orton's research focuses on developing methodological for modelling and mapping soil variables.

Dr. Orton has shown that he has a profound knowledge of advanced statistical methods. He not only applies these methods in soil science, but is also capable of developing new methods. His work on the use of data on variable spatial support, both in horizontal and vertical directions as well as location uncertainty and various compositing strategies, in geostatistical mapping is really innovative and of great importance to digital soil mapping. He has also been active in the use of Bayesian methods and process models.

Tom Orton has published 29 papers in international journals. One of his recent papers won the Best Paper in Pedometrics 2015.

Tom Orton publishes both academic papers in the fields of statistics and Pedometrics, and in thematic journals where he develops applications demonstrating the use of Pedometrics. By doing that, he demonstrates that he is not only excellent in statistics and pedometrics, but that he is also keen to transfer scientific advances to applied fields. In this way, he can be considered as an 'Ambassador' of Pedometrics. His works apply to a wide range of soil parameters or soil-related issues such as soil carbon, soil nitrogen, soil contaminants, soil texture, water sediments, grain yield, and soil-climate change interactions.

He regularly presents his works at the Pedometrics Conferences (2009, Beijing; 2011, Trest; 2013, Nairobi and 2015, Cordoba) and he is a member of the scientific committee for the Pedometrics 2017 Conference. He also contributed to Pedometron. He has been invited to give oral presentations to many National and International Conferences to present his works and he published papers in reviewed Conference proceedings.

Thomas Orton worked in UK (Silsoe Research Institute and Rothamsted Research Institute), Japan (Yokohama University), France (INRA Orléans) and Australia (Univ. Sydney – Univ. Queensland). He also developed a network of collaborations with other institutes.

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Can you complete this series?

This number series, due to Nob Yoshigahara is quite unique as it is circular.