ΠΕΔΟΜΕΤΡΟΝ

Newsletter of the Pedometrics Commission of the IUSS Issue 45, April 2020

From the Chair

Dear colleagues,

It has been a while since we have send you the Pedometron. Much has happened since the last one but now especially the COVID-19 is shaping our daily lives. I hope that you and your families are safe and not too much affected by Covid-19. The current circumstances demand flexibility, creativity and solidarity from us. Due to the severe travel restrictions, the majority of the 2020 conferences have been cancelled and consequently we miss opportunities to reconnect and collaborate in person. That is unfortunate but I hope that the Pedometron gives you a some support and helps us to remain connected in these difficult times.

In this issue we prepared for you the regular items to enjoy, including the Pedometrics Comic, Poetry and Pedomathemagica, 'What's new in R' and several conference reports. An important contribution in this issue is the 'Pedometricians Digital Mind—Mindfulness & Pedometrics' written by Sabine Grunwald. Not only is this an interesting and creative read, it may actually help you to find some peace of mind in these stressful days.

Finally, I would like to welcome you all to join us at the online European General Assembly 2020. On 8 May, we have a full day of Pedometrics talks and everybody can join the sessions for free. I hope to connect with many of you that day.

That is all for now! Happy reading and be inspired!

Titia Mulder
April, Wageningen, The Netherlands

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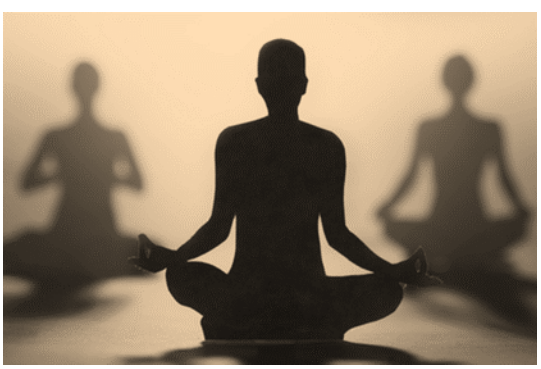
Mindfulness & Pedometrics

By Sabine Grunwald (sabgru@ufl.edu)

Ph.D., Professor University of Florida (UF), pedometrician, Director of the UF Mindfulness Program, and mindfulness practitioner

We love being pedometricians! We like to publish (congratulations—159 pedometrics papers published in 2019, Google Scholar), and the IUSS Pedometrics Commission has been one of the most active commissions with numerous conferences/workshops in digital soil mapping, soil spectroscopy, and pedometrics. As pedometricians we praise ourselves that our minds are attuned to quantify, not only to quantify soils but also many other things in our lives. The "bread and butter" of a contemporary pedometrician are machine learning, deep learning, advanced stats, mathematics, and coding in R. To excel in the 'metrics-part' of pedometrics brings accolades to successful pedometrician. What gives us a blast is to transfer soil knowledge into a digital format—pedometricians digital minds.

However, there is a shadowside to our profession, specifically in academia, that is also common to other STEM (science, technology, engineering and mathematics) disciplines. Pedometricians work in highly competitive work environments in the academy that impact researchers, teachers, and students alike. The growing costs are burn-out, depression, and high stress levels that have consequences for well-being, physical and mental health. There is a current mental health crisis in academia brewing with one of the highest incidences of mental illness when compared to other occupations according to a recent synthesis of various studies (Lau & Pretorius, 2019). According to Lau and Pretorius, the factors that have contributed to this health crisis entail the increasing pressure to compete for research funding and publish in high-impact journals, lack of work-life balance, isolation, increasing work demands with less resources, career and financial insecurity, interpersonal conflicts, and lack of support systems. The numbers tell a story. Data from a survey with 621 respondents of counseling center directors from U.S. universities paint a dire picture how stress has translated into health issues. Anxiety continues to be the most frequent concern among college students (48.2%), followed by stress (39.1%), depression (34.5%), suicidal ideation (25.2%), specific relationship concerns (22.9%), family concerns (21.2%), interpersonal functioning problems (18.8%), sleep problems (15.8%), and loneliness/social isolation (15.5%). One in two Ph.D. students have experienced psychological distress and one in three are at risk of a common psychiatric disorder (Levecque et al., 2017). Other stress-inducers are associated with multi-tasking and the heavy technology use for communication that focuses our attention away from the present moment experience due to a constant stream of incoming text messages and emails as well as flashy reminders and ringing tones from smart phones and other media devices that disrupt our attention.



Mindfulness has been identified to (1) counter stress, (2) enhance attention, well-being and health, and (3) help balance work and personal life. In a nutshell, mindfulness is paying attention in a particular way, on purpose, in the present moment, and non-judgmentally (Kabat-Zinn, 1994). Mindfulness has gained attention in U.S. higher education over the past decade concurrently with the unfolding mindfulness, wellness, and yoga movement in the U.S. (Barbezat, & Bush, 2014; Pickert, 2014). Evidence-based (empirical) mindfulness research studies have demonstrated its positive effects on health (e.g., reduction of anxiety, worries/rumination, and depression), well-being, cognitive appraisal (i.e., the personal interpretation of a situation that influences the extent to which a given situation is perceived as stressful), emotional resilience, physiological functioning, and self-regulation. Examples of several meta-analysis on mindfulness effects were provided by Grossman et al. (2004), Greeson (2009), Khoury et al., 2013), and Goyal et al. (2014). This kind of research has shown what mindfulness practitioners have known for centuries—that greater attention, awareness, acceptance, and compassion can facilitate more flexible, adaptive responses to stress, which, in turn enhances health and well-being (see Garland et al., 2015), work performance and collaboration (Good et al., 2016), and task performance (Dane, 2011). There is growing recognition in organizations and institutions that mindfulness is not something separate that is cultivated only weekends or when time permits (which mysteriously never materializes because of busyness and overloaded schedules), but it is considered a life skill that is best integrated into daily life and work.

One example how mindfulness is integrated into STEM and pedometrics programs comes from the University of Florida (UF), USA. The UF Mindfulness interdisciplinary program (https://mindfulness.ufl.edu/) offers training, practice mindfulness sessions, action events, workshops, and retreats related to mindfulness. This program was launched in 2015 and has since grown to infuse the university campus and curricula with mindfulness. The goal of the program is to co-create mindful campus culture.

Yes! it is possible for scientists and pedometricians to practice mindfulness at the workplace, integrate it into research and teaching, and reap the benefits that come from its practice. I am inviting pedometricians to try one of the mindfulness practices below. If you are an experienced 'mindful pedometrician' keep enjoying to practice. Ideas how to integrate mindfulness into your daily work life or one of the upcoming pedometrics conferences or workshops may inspire us to co-create a mindful pedometrics community that stays in the "green zone" without getting completely stressed-out ("red zone").

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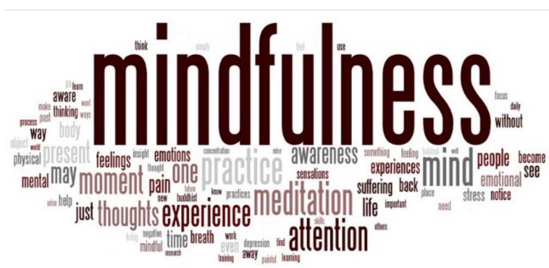
Mindfulness practices for novices	**Simple daily mindfulness practices**
https://www.mindfulnesscds.com/pages/videos-of-jon-teaching https://counterculturist.net/how-to-meditate-for-beginners/	• Practice 10 deep in- and out-breaths before you start work at your desk • Take a long outbreath before picking up your smart phone when it rings or vibrates • 10 minutes of guided mindfulness (get kick-started with one of the apps – Insight Timer, Headspace, Calm or other)
	
Practices for the experienced mindful pedometrician	**Ideas to co-create a mindful pedometrics community**
• https://openheartproject.com/open-heart-project/ • 1 hour meditation, yoga, tai chi or qigong	• 20 or 30 min. long mindfulness sessions in the morning and afternoon at a pedometrics conference (to destress and listen more attentively to more Power Point presentations) • Gentle body movement session • Offer once a month a group meditation at your workplace • Give yourself, your colleagues/fellow-students, mentees "breathing space" before pushing them to meet the next deadline
 University of Florida (UF) students	 UF Mindfulness Day (conference and workshops)

Showing that invalid variograms are indeed invalid

By Gerard Heuvelink
Wageningen University & Research

Those of you who haven't gone for machine learning all the way but still see the use of kriging for mapping soil properties, will know that in the variogram modelling stage one cannot just fit any function that one likes to the experimental variogram. A variogram model must be 'valid', meaning that any finite linear combination $\sum_{i=1}^{n} \alpha_i \cdot Z(x_i)$ for a random field $Z = \{Z(x) | x \in A\}$ must have non-negative variance, regardless of the choice of weights α_i and locations x_i in the geographical domain A. That is why we usually go for 'safe' variogram shapes, such as the exponential, spherical and Matérn models. These models have been proven to be valid.

To draw attention to this problem and make sure that students understand what it is all about, please see the exam question in the text box below. Please check yourself: can you answer this exam question?

<u>Exam question Wageningen University MSc-course 'Spatial Modelling and Statistics'</u>

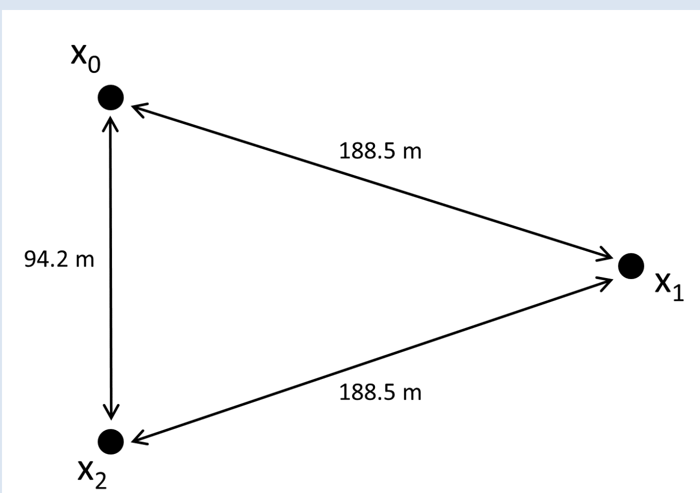
Based on 80 observations of the soil moisture content (g/kg) taken in the dunes near Zandvoort (the Netherlands), a researcher comes up with the following variogram (where h is distance in meters):

$$\gamma(h) = 200 \cdot \left(1 - \cos\left(\frac{h}{30}\right)\right) + 0.25 \cdot h$$

In this equation, 'cos' is a function that computes the cosine of its argument specified in radians.

a. Make a sketch of the variogram from h=0 to h=500 m, with units and measurement units along the axes. What is so special about it? Does the variogram have a sill?

Let the soil moisture be measured at two locations x_1 and x_{2}-, with measured values 34.7 g/kg and 52.0 g/kg, respectively. We wish to predict the soil moisture at location x_{0}-, see figure below.



Invalid variograms are indeed valid

1. Compute the ordinary kriging weights. Which observation has the largest weight? Can you explain this? Compute also the predicted soil moisture at x_0. Does the prediction make sense?
2. Compute the ordinary kriging variance at x_0. Does it make sense? Explain your answer. Compute also the ordinary kriging standard deviation, if possible.
3. The ordinary kriging prediction and ordinary kriging variance are unconventional, to say the least. What could be the reason of these odd results?

The exam question shows that we may get in serious trouble when using an invalid variogram. But problems may also arise in less extreme cases. For example, text books tell us that the linear-with-sill model is not valid in 2D and 3D and that the circular model is not valid in 3D. But I was never able to come up with examples that show that it goes wrong, while this would be so useful for my teaching. There must be cases where a particular choice of n, weights α_i and locations x_i leads to $Var(\sum_{i=1}^{n} \alpha_i \cdot Z(x_i)) < 0$ for a linear-with-sill variogram in 2D or a circular variogram in 3D. If anyone of you has such example or could derive it, then please share it with me!

Announcements

Pedometrics Best Paper 2019

Nominations are invited for the best paper in Pedometrics published in 2019. The Pedometrics Commission's Awards Committee will assess all nominations and prepare a shortlist for a public vote.
Papers must be:

I. Concerned with pedometrics, the application of statistical and mathematical methods to the study of the soil.
II. Published in a peer-reviewed international journal.
III. Published in 2019. This is the date that appears on the issue of the journal in which the paper is published, not the date on which it might be made available online.

Please send nominations before 30th June 2020 to the committee chair: R.M. Lark, murray.lark@nottingham.ac.uk with the subject heading "Best Paper in Pedometrics 2019"

Upcoming conferences and call for abstracts

4 – 8 May, 2020 **EGU2020**: Sharing Geoscience Online (#shareEGU20) brings part of the activities of the EGU General Assembly 2020 online. We hope that you will join us in sharing our research and discussing with colleagues. On 8 May 2020 (CEST) everyone can join us online for their favourite Pedometrics sessions, participation is for free. https://www.egu2020.eu/

14-18 December 2020, Goa, India. **2nd Joint workshop for Digital Soil Mapping and GlobalSoilMap** IUSS WGs https://sites.google.com/view/soilmapping2020

A Pedometrics PhD defence

Last August Alexandre Wadoux successfully defended his PhD at Wageningen University entitled 'Sampling design optimization for geostatistical modelling and prediction'. The thesis was supervised by Gerard Heuvelink and Dick Brus. Alexandre developed sampling techniques for mapping with geostatistics or machine learning, and applied them on case studies in hydrology and soil science. The defence committee was composed of Philippe Lagacherie (INRA, France), Marc Bierkens (Utrecht, NL), Alfred Stein (ITC, NL) and Arnold Bregt (WUR, NL). The thesis is available online and the video of the defence can be accessed by this link. Alexandre is now working in Sydney.

Errata in Conversation with Margaret Oliver

Some words missed out in two places.

What was your main motivation to do soil science
Original: I found a University science and geology.
New: I found a University with soil science and geology courses.

What makes the EJSS unique compared to other journals
Original: The EJSS is the oldest soil science journal
New: The EJSS is one of the oldest soil science journals

Soiling Tea Bags to promote soil health and citizen science in Australian schools

By Alex McBratney, Damien Field, Vanessa Pino, Edward Jones, Eugenia O'Brien1, Kim Chau Le
The University of Sydney

Soiling tea bags (green and rooibos) is the simplest, shortest and most standard method available these days for a better appreciation on how the soil processes the decomposition of organic materials under different environments and conditions and what would makes this soil function to be healthier.

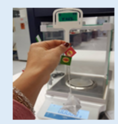
The so-called Tea Bag Index method (TBI) released in 2013 (Keuskamp et al., 2013) has become popular because is simple and fun for tracking experiments about soil decomposition in collaboration with a non-scientific community such students and citizen scientists.

This method shows us that the break down of the organic materials - such as those two tea types, i.e. green and rooibos - during the decomposition is a function of a range of cellulolytic enzymes that come from also a range of different soil microorganisms driven by their soil habitat. Therefore, by burying a pair of different tea bags at about 10 cm deep in the soil, leaving them for three months and then exhume them up, we can estimate the remaining tea as to whether the soil is microbially more or less efficient and active.

By digging as many pair of tea bags under all different soil types and land uses we could acknowledge the changes of this soil function across soil habitats due to differences in their microbial activity.

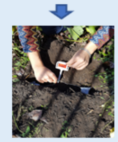
Tea Bag Index method

1. Measure the initial mass of the Green and Rooibos Tea bags.



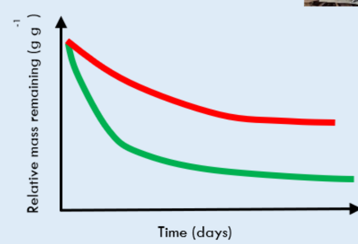
2. Bury both tea bags 15 cm apart and no more than 10 cm deep.

3. Keep teabags buried for 90 days.

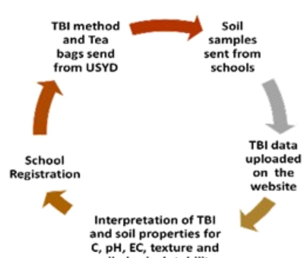


4. Recovery, dry and record the final mass.

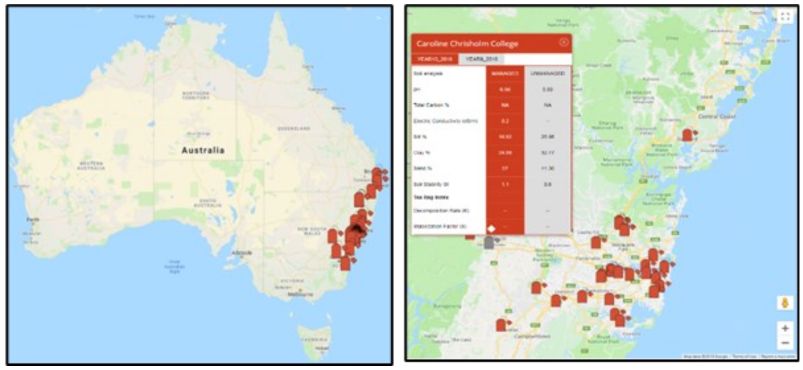
5. Calculate the k and S values where k is a measure of the decomposition rate from the rooibos tea and the stabilisation factor S is the fraction of green tea stabilised in the soil that was not released as CO_2.



To promote soil connectivity and awareness while creating a picture of soil health contributing to soil security in Australia, the University of Sydney has adopted the TBI method throughout the TeaComposition Project. This initiative aims to analyse the soil's ability to decompose organic materials by working with primary schools recording the simultaneous decomposition of the two tea types during three months experiments and for three consecutive years.



Soiling tea bags



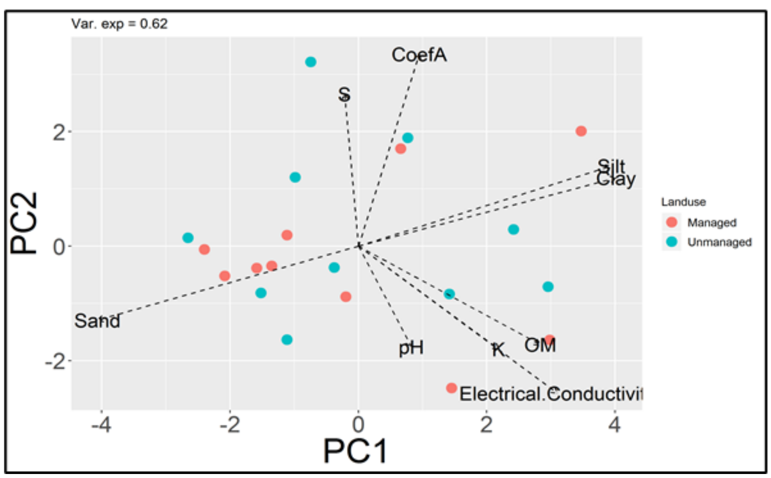
The University of Sydney workflow is currently available on a website (Fig. 2). Classes that engage in the experiments receive TBI materials and perform the experiment in their school. A soil scientist from USYD provides interpretation of data and may conduct visits to the schools to promote soil connectivity in the school community.

A total of 97 classes from 38 schools across NSW have participated in the experiment to completion. New regional schools participate as far north as Grafton and one in Queensland (Tweed Rivers). So far, more than 2,000 students have tested the decomposition ability of the soil on their school grounds. An interactive map from TeaComposition website show the distribution of schools locations across NSW and Queensland. TBI and soil data are available online to schools and visitors.

Results so far have shown a significant relationship between k and S with other soil properties such as organic matter (OM), soil pH and soil physical stability (coefA).

Disturbed soil conditions tend to increase k and decrease S. This would indicate increases in microbial activity that releases CO2 instead of storing C in the soil.

The TeaComposition Project aim to streamline the method to allow it to be used beyond this project to the wider community such as agricultural contexts and with regional communities.



Principal component analysis (PCA) between soil properties and TBI parameters k and S collected from the schools.

References: *Keuskamp, J.A., Dingemans, B.J.J., Lehtinen, T., Sarneel, J.M., Hefting, M.M., 2013. Tea Bag Index: A novel approach to collect uniform decomposition data across ecosystems. Methods in Ecology and Evolution 4, 1070–1075. doi:10.1111/2041-210X.12097 / ** https://teacomposition.sydney.edu.au/

In conversation with Wirastuti Widyatmanti

Wirastuti Widyatmanti is organizing the next Pedometrics conference in Indonesia. We ask her to introduce herself and to relate on her experience on practicing Pedometrics in Indonesia.

What motivated you to work in soil? What are your main research interests and why?

I have been working with soils since I undertook Physical Geography in my Undergraduate Program. After experiencing a tedious procedure of soil laboratory analysis, and then exploring more about soil mapping, I found that we can learn soil from a different perspective. Rather than focus on lab analysis, we can utilise remote sensing and geographic information systems (RS&GIS) to study and infer soil-ecological-landscape processes. This type of approach allows me to evaluate and monitor land quality from a multi-disciplinary perspective (soil, ecology, geography, geomorphology & remote sensing).

My geography background helps me in understanding the processes of soil development and how different elements of nature can influence soil formation spatially. This understanding equips me to apply various soil mapping methods with specific purposes, such as land evaluation, feasibility, and capability. Advanced technologies allow me to solve complex problems, such as using spatial statistics and modelling in the problems of scale conversion and accuracy assessment.

My main research interests are developing a multi-scale method for mapping peatland and coastal acid sulfate soil (ASSoils), and developing a framework for soil security in Indonesia. Indonesian peatland has been facing severe environmental challenges. More than 250,000 km^2 peatlands have been mapped using various methods, but none of them can create an integrated approach that can be applied in various environments in Indonesia.

Similar problems with the Coastal ASSoil mapping. Indonesia, with more than 17,000 islands, has one of the longest shore lines in the world. Indonesia has a massive problem with coastal soil management and mangrove conversion to anthropogenic functions. I have been developing a mapping method using RS and GIS to map some of the coastal ASSoils, however, there are still some limitations with the data and field and laboratory equipment which challenge me to develop a more robust method.

In conversation with Wirastuti Widyatmanti

What are the main research challenges for soil scientists in Indonesia

A common problem for soil scientists in Indonesia is the unavailability of comprehensive and complete data, at different scales. This is due to limitations in equipment, technology and accessibility to many remote areas in Indonesia. These problems lead to high data uncertainty, inappropriate method of quantifying accuracy, and data unavailability on a large scale, which is now urgently needed to support the soil and food security. Indonesian soil scientists should explore innovative but practicable methods to solve these problems. Nevertheless, things are improving, we have an One Map policy, meaning that all maps (related to land and resources) are now reconciled under one portal. We now have access to high-resolution satellite images and DEM throughout the country. While not perfect, it is a good start, and probably better compared to other developing countries.

Most of us do not know much about Pedometrics activities that are ongoing in Indonesia, can you briefly highlight some ongoing activities.

Pedometrics activity was started some 10 years ago by the support of many Pedometricians around the world through training, conference, and some research collaborations. Prof. Budiman Minasny is the one faithfully supporting and encouraging us to develop more Pedometric activities that involve more soil scientist in Indonesia and to promote digital mapping method using RS and GIS and spatial statistics.

In your opinion, what is the added value of the application of Pedometrics in soil research in Indonesia. Do you foresee particular challenges with respect to this?

Pedometrics is still considered new in Indonesia, and this conference can bring a new dimension not only to soil science but also to geographers and other environmental sciences.

Indonesia has unique, but vast tropical soils that vary among the thousands of islands. New methods and advanced technologies in developing soil spatial databases, and more accurate mapping are prominent; these could lead Indonesia to a better sustainable soil resources management, thus to the global soils.
We hope that the conference will enable us to provide some insights into new data analytical techniques and sensing technologies that enable the development of a clear understanding of the status of our land resources.

You are the next organizer of the Pedometrics conference. What was the main reason you decided to welcome us?

I believe that Pedometrics can contribute significantly to soil related problems in Indonesia. After more than a decade of Pedometrics development, many Indonesian soil scientists are still not yet aware of it. Only a small amount of research groups that actively contribute to Pedometrics development in Indonesia. Therefore, my colleagues from the Ministry of Agriculture, and other universities agree to welcome Pedometricans around the world to showcase their latest Pedometrics development in the 2021 Conference. We hope that soil scientists will learn how statistical and mathematical techniques can help soil management and mapping. Geographers can benefit from new modelling techniques and the creative use of remote sensing products. Environmentalists can know better the distribution of high conservation areas for protection. Land managers and government officials can benefit from having comprehensive information on their soil conditions to determine the best inputs and practices to be employed.

And more importantly, we want international scientists to experience our hospitality, food, culture, and soil. We picked Bali as a venue because it is widely known as the island of the gods, we have soils from volcanic mountains, karst landscape, down to paddy fields, mangrove, acid sulphate soils, and beaches.

During your presentation on Pedometrics 2021, you have introduced a theme to us. What does hosting Pedometrics 2021 mean for your country? Can you elaborate on this?

The theme of Pedometrics 2021 is “Pedometrics to support soil and food security in the tropical regions”.
The main issue in tropical regions, such as Indonesia, is food security, and to ensure food security, we need to secure its soil resources. Indonesia, as the fourth most populated country in the world, needs to meet its food security challenge with a shrinking arable land area.
We hope that pedometricians can show us ways of assessing soil functions for crop production to support soil security.

In conversation with Wirastuti Widyatmanti

Do you have a final message to your Pedometrics colleagues?

We hope the conference can provoke pedometricians to think about ways of mapping soil in remote and difficult to access areas. Also not just demonstrate the latest machine learning models to make soil maps, but think about how to link maps to soil functions, and socio-economic factors that can affect decisions regarding soil management and land use. And always remember that the soul of soil knowledge is on its nature of the formation process.

SteeDA conference

By Jeremy Prananto

Attending the SteeDA conference hosted by Sydney Institute of Agriculture was a very educational experience. At the conference I was given the chance to present my honours research on using portable NIRS device for a real-time nutrient analysis of cotton plants. It was a very good chance to test my public speaking skills. Moreover, I received different feedbacks and insightful questions from academics and professionals that have had experience in digital agriculture. No doubt this has broaden my horizon and added to my own knowledge on digital agriculture.

At the conference, I was fortunate to hear a variety of talks about ongoing research as well as new findings in the digital AG space. The topics presented included the use of sensors to predict different aspects of soil and plants, digital soil mapping for various purposes.

Alex McBratney opened the conference with a proposal on the need for decomoditisation for digital agriculture. I also learnt about other use of digital technology such as for marketing purposes in the form of block chains in the sugarcane industry.

Despite the optimistic nature of digital AG, the conference did highlight that we still have lots of challenges. Jessica Koch, a farmer and adopter of digital technology, told us that that the challenge is still the expensive soil analysis. Scientists also need to make their technologies and data analysis methods to be available for use. An Australian startup company FarmLab tried to do that by developing apps which translate scientific findings into practical use. The implementation and commercialisation of this wonderful technology on display in the conference should be focused on as the next step.

Socioeconomic factors also affect how digital agriculture can operate. There is a lot of discussion of data sharing, where farmers may not want to share their data if they don't see any value just for research. Scientists should have a sound value proposition. I also learned how human decision on risk aversion can distort statistical theory, we should be looking into prospect theory.

I gained not only from the talks, but also from the interaction with the professionals and academics that attended the conference. Listening from their experiences in the industry and their journey will definitely help me to forge my own in the future.

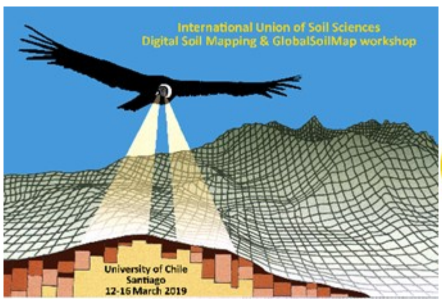
Overall, my experience attending the SteeDA conference was an amazing one with a splash of fun from the soil painting exhibit. The need of digital agriculture to push through the commercial barrier is imperative, especially with the need to improve the efficiency of our agricultural production to feed the ever growing population. With this, the age of the digital AG can take place and flourish.

Conference reports

Digital Soil Mapping workshop

Laura Poggio, Chair of the Digital Soil Mapping IUSS WG
Dominique Arrouays, Chair of the GlobalSoilMap IUSS WG
Osvaldo Salazar, Chair of the organizing committee of the conference

The IUSS Working Groups "Digital Soil Mapping" and "Global Soil Map" from the commission 1.5 Pedometrics, held a joint Conference "SOIL 2019" from 12 to 16 March in Santiago (Chile). This meeting was hosted by the University of Chile in Santiago, under the chairing of Prof. Osvaldo Salazar.



Opening Ceremony (below). From left to right : Osvaldo Salazar (University of Chile), Monica Antilén (President of Chilean Society of Soil Sciences), Carlos Muñoz (Vice-Dean Faculty of Agricultural Sciences, University of Chile), Dominique Arrouays (INRA) and Laura Poggio (ISRIC).

This conference gathered 65 participants from 19 countries. It included two keynote presentations, given by Laura Poggio and Axel Schmidt, 30 oral presentations and 12 poster presentations, and a final discussion about advances and remaining challenges concerning these two WGs. The first day (12 March) was devoted to training sessions, and the last day (16 March) to a field trip.

Soil field trip to the "*Rinconada de Maipú*" Experimental Station at the Faculty of Agricultural Sciences, University of Chile. Tour guided by Prof. Manuel Casanova and Prof. Marco Pfeiffer from the University of Chile.

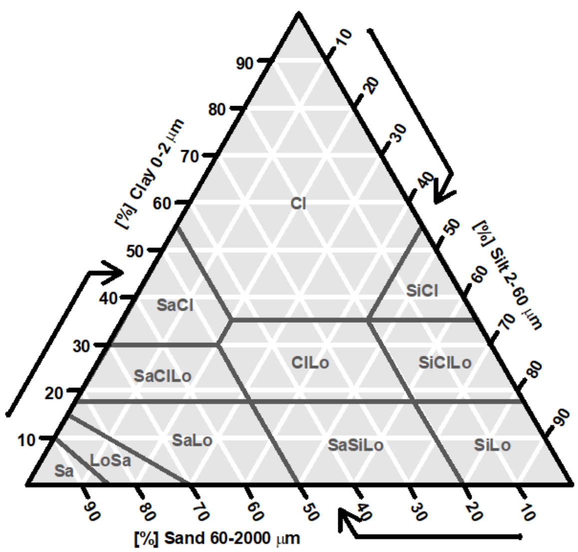
A virtual special issue of the journal "Geoderma Regional" is currently under edition and the deadline for submission was 15 January 2020.

Pedomathemagica

By Luc Steinbuch
Wageningen University & Research

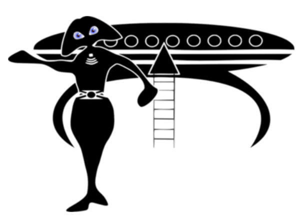
Alien Soil Triangle

Our alien colleague pedometricians from the icy planet Fitteddode (in the Woldundeng star system) asked for our feedback. In their equivalent of soil, three main fractions -- based on local chemistry rather than particle size -- define soil type: 1) *Hifil*, which looks like solid mercury; 2) *Smina*; best comparable to liquid nitrogen; and 3) *Pyxech* – a purple glowing, radio-active mineral. In a fraction over 70%, the latter gets critical and it will spontaneously explode, often indicated with an exclamation mark. With 3 main fractions always adding up to 100%, a so-called *ternary plot* can be used to illustrate the seven main Fitteddodeian soil types. We, earthling soil scientists, use something similar; see for example the soil triangle used by the *UK Soil Survey of England and Wales*:

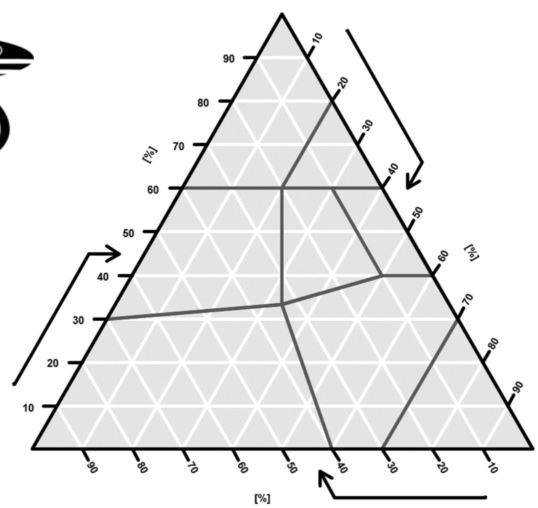


	abbr	name
1	Cl	Clay
2	SaCl	Sandy clay
3	SiCl	Silty clay
4	ClLo	Clay loam
5	SiClLo	Silty clay loam
6	SaClLo	Sandy clay loam
7	SaLo	Sandy loam
8	SaSiLo	Sandy silt loam
9	SiLo	Silt loam
10	LoSa	Loamy sand
11	Sa	Sand

With help of the R-package soiltexture, the Fitteddoders created their soil triange, and transmitted it to earth for peer review. However, during the transmission -- over several light years -- almost all symbols got lost. We received an empty graph (see next page) and the following descriptions: "Soiltype **Morath-Mizule** contains less *Hifil* than does both **Jovaphile** and **Ethosien; Ethosien contains a bit less *Pyxech* than Neoskizzle**, but always more *Hifil* than **Oonex**; **Oonex** has always some *Hifil*, and *Smina*, and *Pyxech*; **Yoyflen** contains none, or just a little, *Smina*; and **Ximble-Ximble** is always a bit warmer than its environment (bit still very cold) because of radioactive decay."



Using all available information, can you help out our colleagues far away, and recreate the complete soil triangle? And, according to alien rumours, there might be a hidden message inside the triangle. Can you find it?



Pedomathemagica—Answers from previous Pedometron

Answer to "A fragile ground radar"

1. Note that Reci thinks like a pragmatic engineer, not like a statistician looking for probability distributions. If a component on average breaks down once every 10 hours, it breaks down on average 0.1 time per hour. Thus two components, independent but each critical, will together on average break down 0.1 + 0.1 = 0.2 times an hour, or – in other words – have an MTBF of 5 hours.

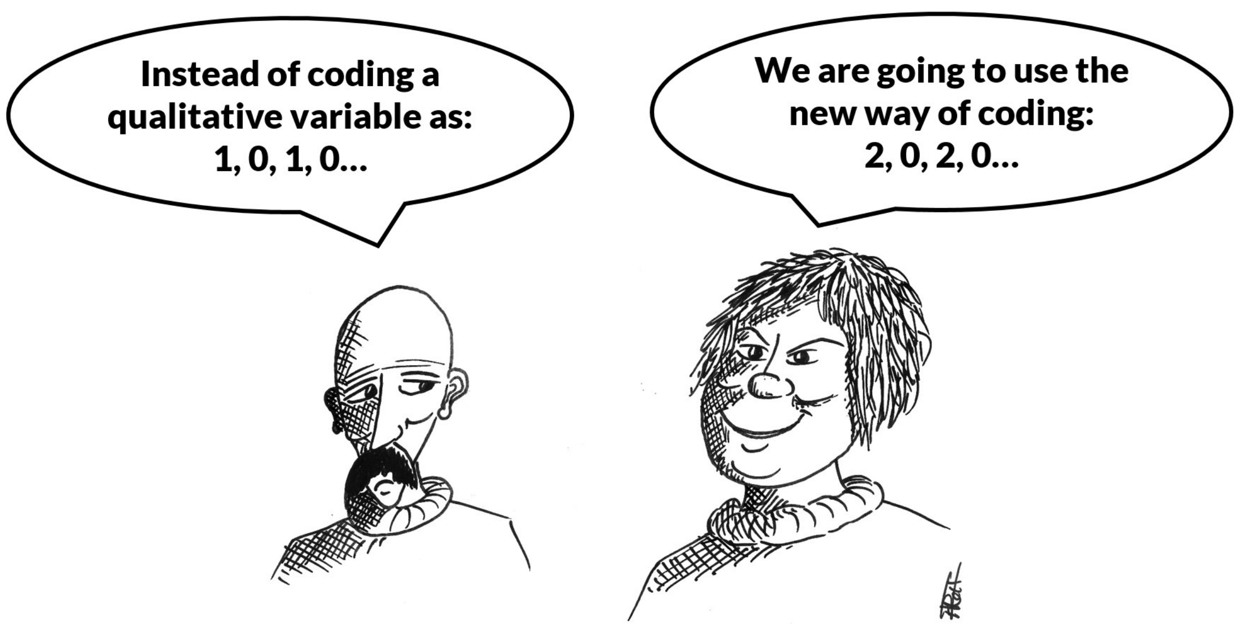
2. With the 3 components, the total MTBF becomes

$$\frac{1}{\frac{1}{10}+\frac{1}{10}+\frac{1}{8.4525}} \; ? \; 3.1416 \; ? \, hours$$

3. ...which by completely accident is almost equal to π, the ratio of a circle circumference to its diameter (and also playing its role in Fourier transformations). Therefore, we propose to call the upgraded ground radar "Pi".

A cartoon

By Anne Richer de Forges and Dominique Arrouays



PEDOMETRICS 2020 REVOLUTION

Particle size distribution

Visualising particle-size distribution

By Budiman Minasny and Alex McBratney

University of Sydney

Particle-size distribution is an important soil physical property. Soil scientists had been trying to convey particle-size distribution using graphs for a long time. But most graphical representations of soil particle-size distribution (psd) is a cumulative plot of mass fraction against the diameter of the particles on a log-scale, which was probably derived from geology. When a cumulative mass is plotted, it is not intuitive to comprehend the major size fractions of the soil.

We found a truly 'soily' way of visualising particle-size distribution. A USDA publication, *Tobacco Soils of the United States* (1898) authored by Milton Whitney, showed a unique way of presenting particle size. A physical soil histogram was used to illustrate the particle-size distribution of soil (Figure 1 below). Percent of gravel, sand, silt, and clay of 20 g of soil was presented. Each particle fraction was represented by a tube and the relative amount was filled with soil. We are not sure if the tube was filled on a mass or volume basis. We can easily visualise the actual soil and also the texture: sandy subsoil from Connecticut was dominated by fine sand (Figure 1) as compared to the sandy loam from Virginia or loam from Wisconsin (Figure 2).

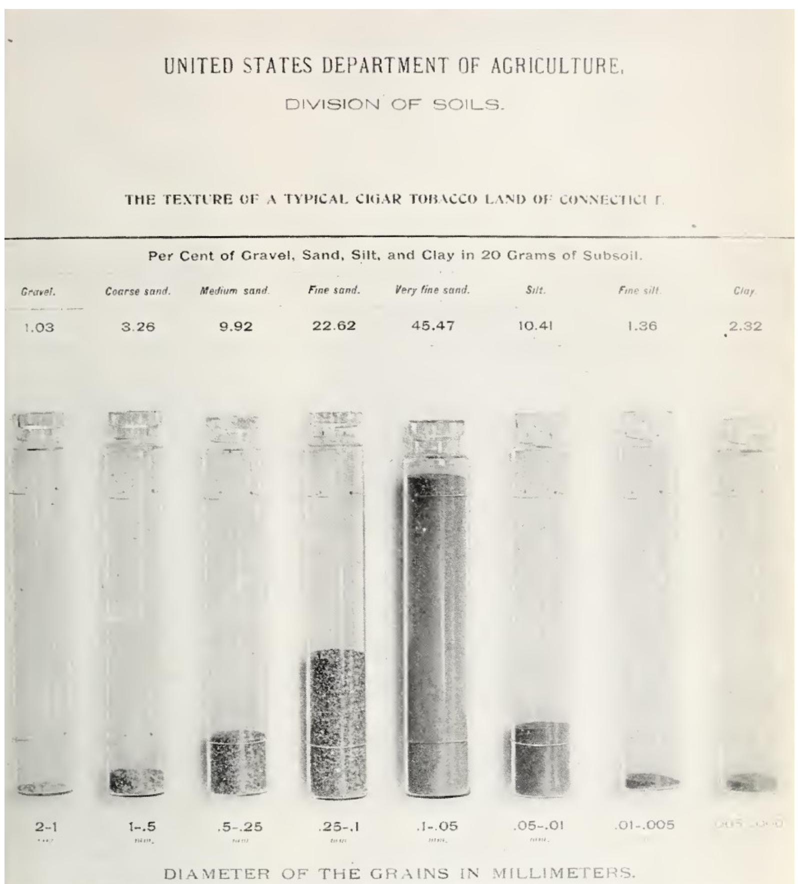


Figure 1. Particle-size distribution of a typical Connecticut soil (from Whitney, 1898).

Particle size distribution

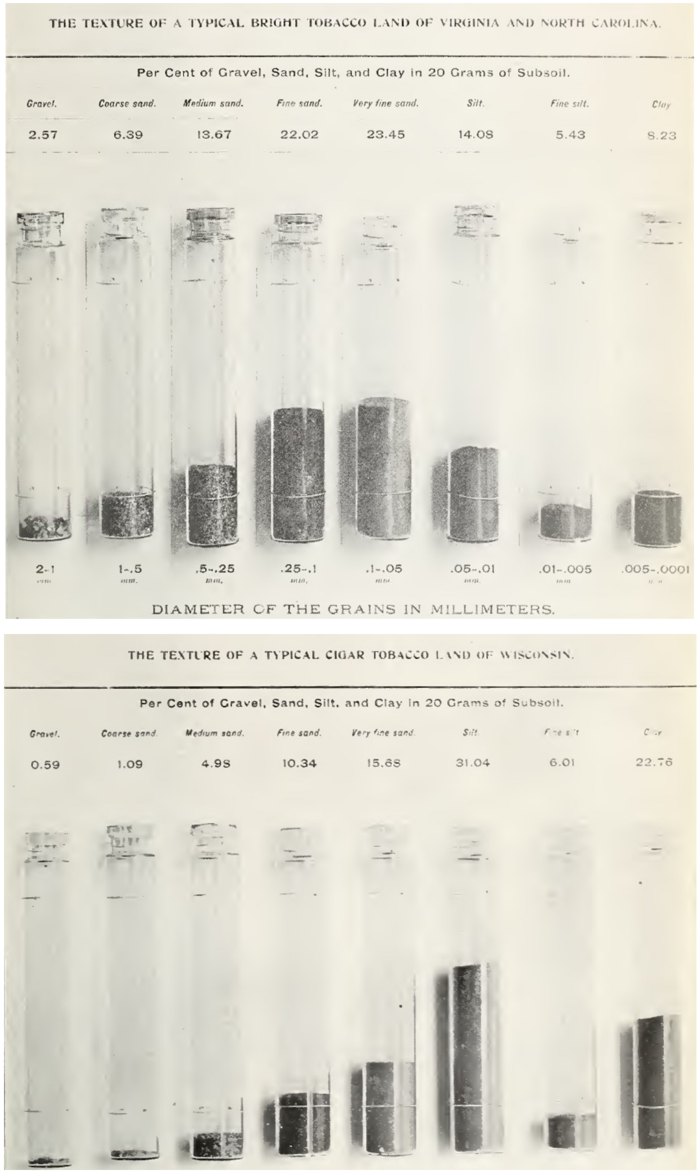


Figure 2. Particle-size distribution of tobacco soil of Virginia and Wisconsin (from Whitney, 1898).

Note that the particle-size fractions in that period is different from current practice. There were 8 fractions based on particle's diameter less than 2 mm, which decreases logarithmically:

- Gravel: 2-1 mm
- Coarse sand 1-0.5 mm
- Medium sand: 0.5-0.25 mm
- Fine sand: 0.25-0.1 mm
- Very fine sand: 0.1-0.05 mm
- Silt: 0.05-0.01 mm
- Fine silt: 0.01-0.005 mm
- Clay: 0.005-0.001 mm

Particle size distribution

Soil scientists should recreate this kind of intuitive graph!

Whitney devised the soil texture triangle 12 years later (Figure 3) in a 1911 USDA publication *The Use of Soils East of the Great Plains region*. The diagram is a user-friendly right triangle, with silt and clay percentage on the axes. This diagram appeared in the textbook *Soils their properties and management* by Thomas Lyon et al. (1915). France had its first texture triangle in 1906, see: Anne Richer-de-Forges' article http://www.pedometrics.org/Pedometron/pedometron29.pdf.

Whitney should be credited for his novel representations of soil particle-size distribution. Whitney considered soil texture as the most important soil property. Unfortunately, the psd distribution and texture diagram were later replaced by the more difficult to read cumulative psd plot and the ternary diagram, which were probably derived from geology. See Howarth (1996) for the history of ternary diagram.

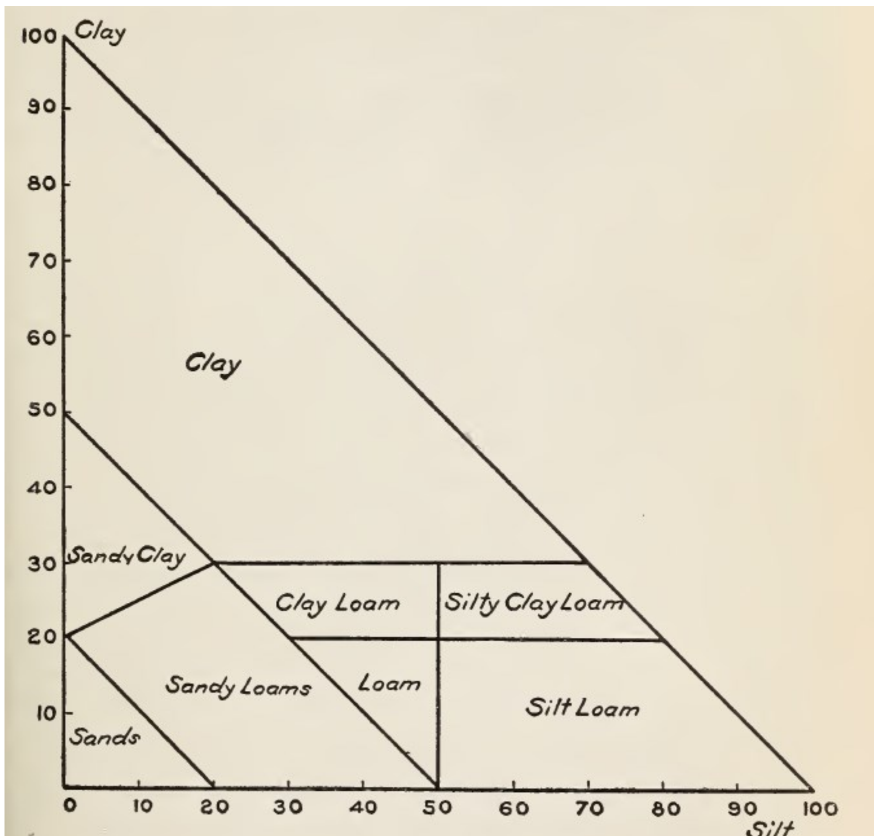


FIG. 1.—Diagram showing classification of soil material according to mechanical analysis.

Figure 3. Soil texture triangle by Whitney (1911).

Acknowledgements
We thank Anne Richer-de-Forges for sharing the information on the original texture triangle. BM is member of a consortium GLADSOILMAP supported by LE STUDIUM Loire Valley Institute for Advanced Studies through its LE STUDIUM Research Consortium Programme.

Particle size distribution

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By David van der Linden

Challenges

A brace or ten
Why not four score
And yet more?
Fellow-travelling
With our snouts?
Or squinting afar
Beyond the faddish vista?
Into the murky elements
The uncharted philosophy
And clenching this
Arduous menu
Noble and global
Doable and absurd
Grasping the iron gauntlet
With bodacious resolve
Banding our flanks
Adjudging fathoming
Erecting our destiny
Digit by painstaking paper
Ecstasy euphoria repercussion
The fainéants will opine
It's over demanding
All too patrician
Take a cursory peep
Over the dike
Where the data dredgers
Are dreamily trawling
Observe their aptitude
Imitate and simulate
It's a painless pilfer
And we'll journey
Nowhere nonchalantly

What's new in R?

simplerspec: streamlining spectral data processing and modeling for spectroscopy applications

By Philipp Baumann

philipp.baumann@usys.ethz.ch

Intro

Albert Einstein would probably not have felt the necessity for simplerspec, as he would have followed his quote *"Everything should be made as simple as possible, but not simpler"*. In line with this recommendation, I was told that spectral analysis in R is standard practice and straight forward using the famous partial least squares (PLS) regression when I started my MSc back in July 2015. I had the chance to sample and model both soils and yam plants from 20 fields in 4 landscapes across the West African yam belt (see here for details). Since I was both fascinated by R, statistics, soils, and their interplay with plants, I started my first scientific journey with the premise that I just had to deepen my R knowledge a bit.

There is a plethora of chemometrics and other statistical learning toolboxes, and many of them are available via CRAN, for example. Most of them are good at solving single tasks, but I somehow missed a clean common interface that interlinked the key steps required for spectral processing and modeling. Back then I thought streamlining all analysis tasks would produce a sustainable basis for model development and sharing with collaborators. In particular, simplifying repetitive boilerplate code was the motivation when I started building simplerspec step by step. The package aims to provide a rapid prototyping pipeline for various spectroscopy applications that share common tasks.

Hands-on

First, clone this repository to your local computer to reproduce the entire analysis in this hands-on. You can download a compressed archive manually, or use git to clone from this website:

```
# command line option
git clone https://github.com/philipp-baumann/simplerspec-pedometron-article.git
# or via RStudio: see https://happygitwithr.com/rstudio-git-github.html
```

For the installation of packages I would advise one of the two main procedures. Procedure one installs renv, which is then used to restore simplerspec and remaining versions of R packages as described `renv.lock` file in an isolated project library.

```
## Option 1 for installation
install.packages("renv"); renv::restore("renv.lock")
```

Procedure two below should also work, however comes without guarantee of identical package versions.

```
## Option 2 for installation
pkgs <- c("simplerspec", "here", "tidyverse", "data.table",
  "future", "doFuture", "remotes")

install.packages(pkgs)
remotes::install_github("philipp-baumann/simplerspec")
```

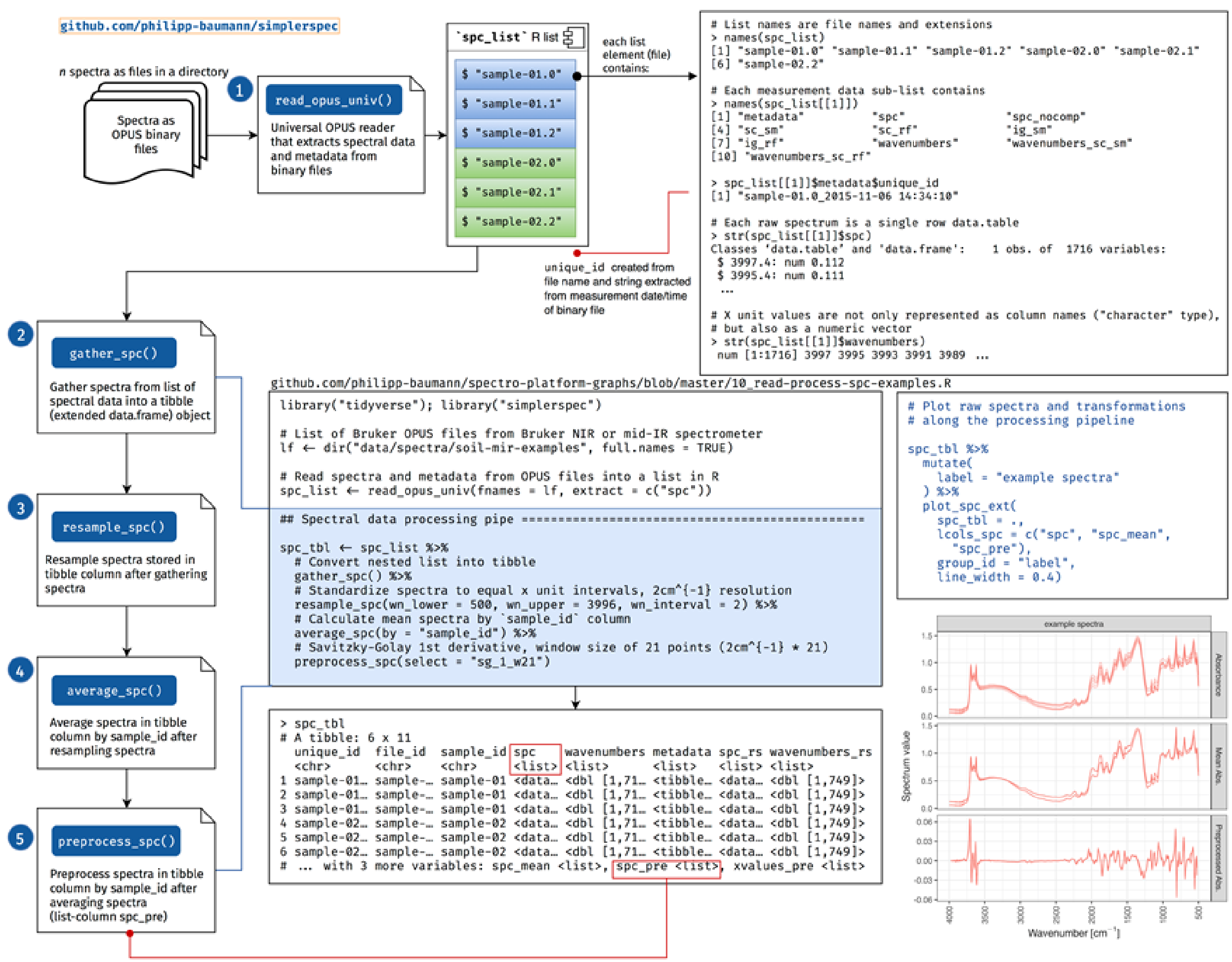
What's new in R?

We use the example data set from my MSc thesis. First, let's load required packages.

```r
# Package detection with "apply type" package load is not yet supported in renv
suppressPackageStartupMessages(
  xfun::pkg_attach("simplerspec", "here", "tidyverse", "data.table",
  "future", "doFuture", "remotes")
)
```

A typical simple spectroscopy modeling project has the following components:

1. Soil sampling and sample preparation
2. Spectral measurements
3. Selection of calibration samples
4. Soil analytical reference analyses
   - A) Calibration or recalibration
   - B) Estimation of properties of new soils based on new spectra and established models.



What's new in R?

Simplerspec focuses on the key tasks in spectral modeling and estimation (components 2 to 5 above), and provides user-friendly modules in the form of a standardized function pipeline. Simplerspec uses prospectr for key steps and data.table for simple operations. The following scheme summarizes the spectral processing steps.

We assume that spectral measurements are done before chemical reference analyses as the former are faster and cheaper to do. Here we read the data from a Bruker Alpha mid-Infrared spectrometer. Currently, the package is limited to Bruker and ASD devices. However, support for reading files from other devices and formats is planned within the package simplerspec.io.

```r
# multicore futures are not supported when using RStudio (stability reasons)
plan(multisession)
registerDoFuture()
# availableCores()

# files to read
files_spc <- list.files(
  here("data", "spectra", "example-yamsys"), full.names = TRUE)
# read the files
suppressMessages(
  spc_list <- read_opus_univ(fnames = files_spc, extract = c("spc"),
    parallel = TRUE)
)
```

Typically, list information is nicely ordered, however printing is really verbose (see the spectral processing scheme for details). Therefore, we can gather the list into a so-called spectral tibble (`spc_tbl`; data.frame extension).

```r
spc_tbl <- gather_spc(data = spc_list)
```

Instead of appending a matrix of spectra as a single column in a data.frame, spectra are represented as a list of `data.tables` split by rows, also forming a column (list-column; see scheme above).

In a nutshell, spectral data processing can be done in one pipeline. Resampling in this context refers to creating a new X-axis interval in spectra. Spectra are averaged because there are 3 replicate measurements for each soil sample. Preprocessing is done to reduce scattering and noise in the spectra.

```r
spc_proc <-
  spc_tbl %>%
  resample_spc(wn_lower = 500, wn_upper = 3996, wn_interval = 2) %>%
  average_spc(by = "sample_id") %>%
  preprocess_spc(select = "sg_1_w21") %>%
  group_by(sample_id) %>%
  slice(1L) # remove replicate spectra (averaged)
```

After preprocessing, we can read the final reference analysis data and merge it with the spectral tibble:

```r
# see data/reference-data/metadata_soilchem_yamsys.txt for further details
reference_data <- fread(
  file = here("data", "reference-data", "soilchem_yamsys.csv")) %>%
  as_tibble()
dim(reference_data) # number of rows and columns
```

What's new in R?

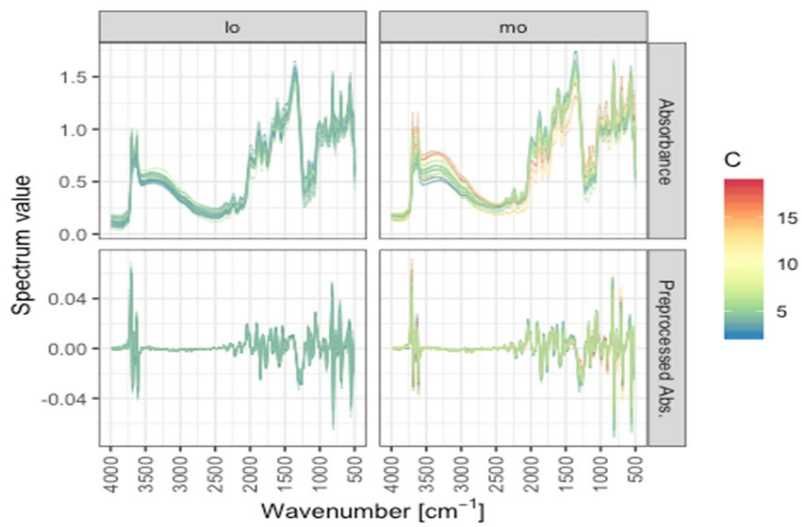
```
## [1] 94 36

spc_refdata <-
  inner_join(
    x = spc_proc,
    y = reference_data %>% rename(sample_id = sample_ID),
    by = "sample_id"
  )
```

We can explore the final processed spectra.

```
spc_refdata %>%
  filter(site %in% c("lo", "mo")) %>% # two landscapes in Burkina Faso
  plot_spc_ext(
    spc_tbl = .,
    lcols_spc = c("spc", "spc_pre"),
    lcol_measure = "C",
    group_id = "site")
```

After this, we proceed with selecting reference analytical samples based on Kennard-Stone.




```
spc_tbl_selection <- select_ref_spc(spc_tbl = spc_proc, ratio_ref = 0.5)
spc_ref <- spc_tbl_selection$spc_ref
spc_pred <- spc_tbl_selection$spc_pred
# PCA biplot
spc_tbl_selection$p_pca
```

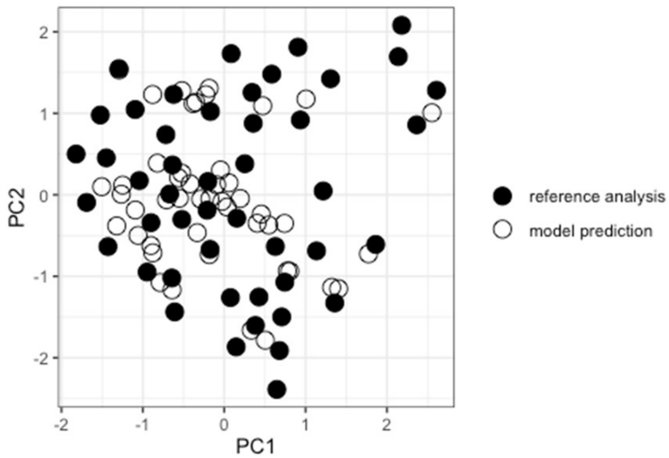
Lastly, we develop a partial least squares (PLS) calibration model for total Carbon (C), hypothetically assuming that we only have above selected 50% calibration data.

```
pls_carbon <- fit_pls(
  spec_chem = spc_refdata %>% filter(sample_id %in% spc_ref$sample_id),
  response = C, evaluation_method = "resampling", print = FALSE)
```

What's new in R?

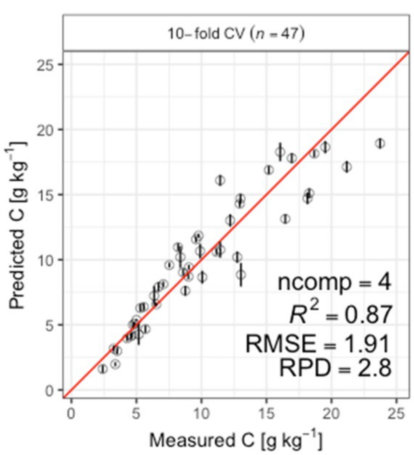
```
pls_carbon$p_model +
  xlab(expression(paste("Measured C [g", ~kg^-1, "]"))) +
  ylab(expression(paste("Predicted C [g", ~kg^-1, "]")))
```

What remains is the estimation of total C for the model prediction samples (component 5.ii) based on the model trained above (component 5.i) and the assessment thereof.




```
spc_ref_pred <- predict_from_spc(model_list = list("pls_carbon" = pls_carbon),
  spc_tbl = spc_pred %>% filter(sample_id %in% spc_pred$sample_id))
# Assess estimation of total C on prediction samples
assess_multimodels(
  data = spc_ref_pred %>% inner_join(spc_refdata %>% select(sample_id, C)),
  C = vars(o = "C", p = "pls_carbon"), .metrics = c("simplerspec"))

## # A tibble: 1 x 27
##   model     n   min   max  mean median  sdev    cv skewness_b1 kurtosis
##   <chr> <int> <dbl> <dbl> <dbl>   <dbl> <dbl> <dbl>       <dbl>    <dbl>
```



```
## 1 C        47     1  24.7  9.86   7.75  6.18 0.626       0.990  -0.0845
## # … with 17 more variables: rmse <dbl>, mse <dbl>, me <dbl>, bias <dbl>,
## #   msv <dbl>, sde <dbl>, mae <dbl>, r2 <dbl>, b <dbl>, rpd <dbl>,
## #   rpiq <dbl>, SB <dbl>, NU <dbl>, LC <dbl>, SB_prop <dbl>,
## #   NU_prop <dbl>, LC_prop <dbl>
```

Outro

The steps shown here using simplerspec are merely some first baby steps in a realm of possible spectral adventures. The package deals with simplifying standard tasks and currently mainly focuses on exploration and teaching purposes. As an example, the Congo spectral platform uses some of its functionality. Complex problems and professional spectroscopy applications require transfer learning (i.e., transferring knowledge from big spectral libraries into to new target set of soils) and spectral feature engineering (i.e., modifying spectra with operations that enable models to better discover predictor-response relationships) pipelines that tune automatically. If you have ideas to collaborate and develop new frameworks, just send me an email or interact via github.

GLADSOILMAP

The GLADSOILMAP consortium launched it's kick-off meeting in Orléans (France) from 25 to 29 November 2019

By Dominique Arrouays, on behalf of the GLADSOILMAP consortium (30/11/2019).

GLADSOILMAP

Effective soil management requires high-resolution data on their properties. However, until now, no global high-resolution map (i.e. on a grid size less than 250 x 250 m) of the world's soils has been released. Digital Soil Mapping (DSM) is one of the major approaches for generating soil property maps over large areas at fine spatial resolution. Two projects, GlobalSoilMap and SoilGrids, aim at delivering the first global high-resolution soil property maps, the first one by a bottom-up approach (from country to globe), the latter by a top-down approach (global). Through regular meetings organized in Orléans (France) the GLADSOILMAP consortium brings together scientific leaders involved in both projects.

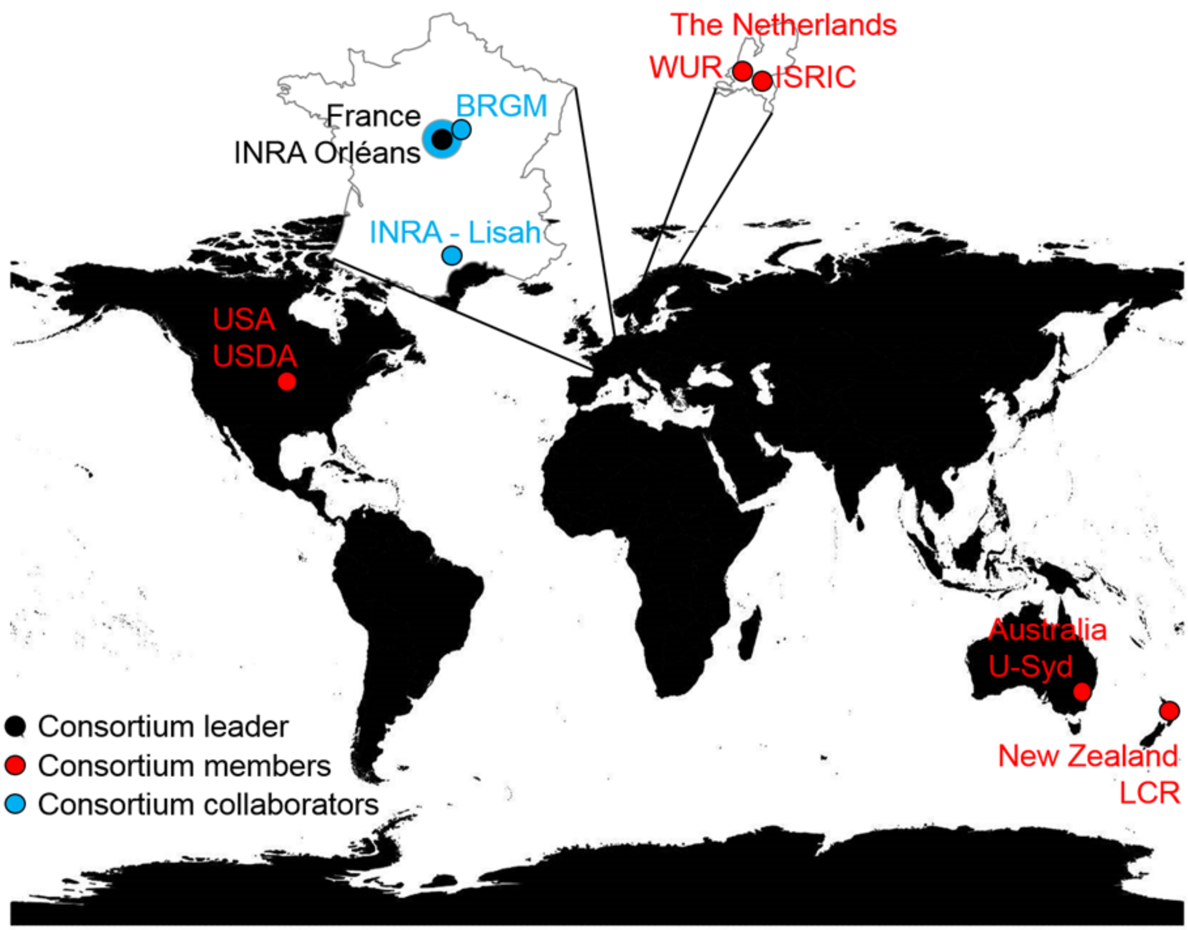
The GLobAl Digital SOIL MAP (GLADSOILMAP), consortium is funded by LE STUDIUM Lore Valley Institute (France) for Advanced Studies through its LE STUDIUM Research Consortium Programme.

It aims at **developing and transferring information and methods from the scientific community to (i) producers,** i.e. people in charge of soil mapping so that they can improve the prediction accuracy of soil properties and decrease the associate uncertainty and, (ii) **end-users, i.e. farmers, natural resource planners, modelers, policy makers**, etc., so they can support their assessments and/or decisions at the relevant scales.

The consortium is led by Dominique Arrouays (INRA Orléans France) and includes 5 main members:
Budiman Minasny (Univ. of Syney), Australia
Pierre Roudier (Manaaki Whenua - Landcare Research), New Zealand
Laura Poggio (ISRIC-World Soil Information), The Netherlands
Zamir Libohova (USDA-NRCS) USA
Vera Leatitia (Titia) Mulder (Wageningen University and Research), The Netherlands

GLADSOILMAP

The consortium also includes collaborators from INRA Orléans (France) (Anne Richer-de-Forges, Hocinne Bourennane and Manuel Martin), from INRA Montpellier (France) (Philippe Lagacherie) and from the French Geological Survey (BRGM, France) (Guillaume Martelet, Pierre Nehlig).



During this 5 day kick-off meeting an ambitious program for the next two years was discussed and agreed. The minutes of this meeting will be posted soon at https://www6.inra.fr/gladsoilmap-consortium/.