

Report of the
EUFAR FP7
N4EWG-mtg04

“Quantitative Applications of Soil
Spectroscopy”

In collaboration with ISPRS VII/3 WG

15-16 April 2010 – Potsdam, Germany



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2. List of attendees

- **Attendees:**

Name (Institute number, Institute short name)

	Name	Surname	Institution
1	Barthes	Bernard	IRD-Eco& Sols, France
2	Bartholomeus	Harm	Wageningen University, The Netherlands
3	Bayer	Anita	DLR-DFD-LA, Germany
4	Ben-Dor	Eyal	Tel-Aviv University, Israel
5	Ben-Haim	Mordehai	Tel Aviv University, Israel
6	Böttcher	Kristin	Finnish Environment Institute, Finland
7	Bourguignon	Anne	BRGM – REM, France
8	Buzzi	Jorge	Geological Survey, Spain
9	Brodsky	Lukas	University of Prague, Czech Republic
10	Carrere	Véronique	University of Nantes, France
11	Chabrilat	Sabine	GFZ Potsdam, Germany
12	Cudahy	Thomas	CSIRO, Australia
13	Dematte	Jose A.M.	São Paulo University, Brazil
14	Eisele	Andreas	GFZ Potsdam, Germany
15	Förster	Saskia	GFZ Potsdam, Germany
16	Garcia-Melendez	Eduardo	University of León, Spain
17	Gerighausen	Heike	DLR, Germany
18	Gläßer	Cornelia	University Halle, Germany
19	Gomez	Cécile	IRD-LISAH, Tunisia
20	Gubler	Andreas	University of Bern, Switzerland
21	Guerrero	César	University Miguel Hernández, Spain
22	Hueni	Andreas	University of Zurich, Switzerland
23	Jarmer	Thomas	University of Osnabrueck, Germany
24	Jung	András	University Halle, Germany
25	Kaufmann	Hermann	GFZ Potsdam, Germany
26	Kopačková	Veronika	Geological Survey, Czech Republic
27	Kuśnierek	Krzysztof	University of Poznan, Poland
28	Larsen	Anders	Q-Interline, Danmark
29	Müller	Andreas	DLR, Germany
30	Nocita	Marco	DLR/ Wageningen University
31	Packer	Robert	PerkinElmer, GB
32	Palacios-Orueta	Alicia	University of Madrid, Spain
33	Pinet	Patrick	Midi-Pyrenees Observatory, France
34	Rawlins	Barry G.	British Geological Survey, GB
35	Riaza	Asuncion	IGME, Spain
36	Schmid	Thomas	CIEMAT, Spain
37	Schwartz	Guy	Tel Aviv University, Israel
38	Stenberg	Bo	University Agricultural Sc., Sweden
39	Stevens	Antoine	UC Louvain, Belgium
40	Terhoeven-Urselmans	Thomas	ICRAF Nairobi, Kenya
41	vanWesemael	Bas	UC Louvain, Belgium

42	Verpoorter	Charles	ULCO Wimereux, France
43	Viscarra-Rossel	Raphael A.	CSIRO, Australia
44	Vukovic	Ivana	University of Zagreb, Croatia
45	Westad	Frank	Camo Software, Oslo, Norway
46	Winkelbauer	Jennifer	TU München, Germany

- **Excused:**

We had NO no-show cases at the meeting

3. Meeting report

3.1. General

The workshop took place as part of the "*Hyperspectral Applications for Soils*" Expert Working Group activity within the EUFAR project and as part of the activity of the ISPRS WG VII/3 "*Information Extraction from Hyperspectral Data*" that is chaired by Eyal Ben Dor and co-chaired by Sabine Chabrillat and colleagues.

A call for the workshop was issued amongst the EWG EUFAR list (total of 54) and also in the EUFAR website. The maximum participants allowed were 44 and we had to reject some. All participants were active and had to submit abstracts (and give talks) which underwent a comprehensive review by the workshop chairs.

There were 46 registered persons (two observers from GFZ and DLR) from 17 countries and 5 continents. 36 presentations were given in six oral sessions and one technical discussion that summarized the workshop with setting some future notes into the activity of the soil spectroscopy group.

The workshop was composed of five sessions of oral presentations, most of them unpublished results of recent work in quantitative soil spectroscopy and one demonstration session that presented state of the art instrumentations in soil spectroscopy either in the laboratory (Agriquant) or in the field (SpecTool). Also, available softwares, free and commercial (SPECCHIO, TSG, Unscrambler) that can handle large soil libraries spectra and analyze quantitatively its information were shown in the demonstration session.

<p>Action 1: Title: Session Summary Responsible: Sabine Chabrillat, Eyal Ben Dor Deadline: 16 April 2010 Deliverable number: as approved by EUFAR</p>

3.2. Session summary

Session 1: Soil Mapping: Potential and Constrained (invited session) – Chair Eyal Ben Dor

The session starts with a comprehensive overview of the "global soil spectral library" (GSSL) activity given by Raphael Viscarra Rossel. The GSSL initiative started in 2008 by several colleagues as a result of a special soil session led by Raphael in the IGU Vienna. Since then more than 10,000 spectra and their attributes worldwide was gathered and processed to show interesting spatial view of the world soil status. Raphael praised the cooperation and wellness of many colleagues to contribute and mentioned that we need to still need to fill many gaps on the globe. A following presentation given by Jose Dematte demonstrated the need to whole profile information for soil survey, especially for determining soil orders according to the USAD nomenclature system. He reported the constraints in EO mean to provide undersurface spectra information and suggested solutions to that end. The next talk was given by Tom Cudahy from CSIRO who demonstrated that the Hyperspectral Remote Sensing technology is capable to extract useful quantitatively information about the surface mineralogy and reviewed some future missions for that. The final talk of Antoine Stevens showed that although the HSR technology is promising it still has problem for assessing soil attributes remotely as dependent on sampling procedure, BRDF effects signal to noise and stability of the constituent in question. He particularly discussed the role of soil organic matter sensing by HSR technology.

Session 2: NIRS-HSR Problems and Solutions – Chair Tom Cudahy

Session 2 titled “NIRS-HSR Problems and Solutions” and Chaired by Tom Cudahy (Australia) comprised seven papers. Four of these [papers presented by Bottcher (Finland), Jarmer (Germany), Nocita (Germany) and Bayer (Germany)] covered the use of PLSR on NIRS soil data for extracting soil properties, especially soil carbon. Key issues described by these presentations included: the benefits of pre-processing treatments; stratification based on the geology to assist with soil analysis; the inability to apply PLSR models established for one area (training set) to another area; selection of appropriate wavelengths; and up-scaling laboratory measurements of field samples to EnMap satellite opportunities. Two other papers described others methods for analysing reflectance data, including those by: Gomez (France) who described an unmixing approach that predicts clay and carbonate contents in the presence of vegetation in hyperspectral imagery; and Verpoorter (France) who presented an “Automated Modified Gaussian Model” (AMGM) method for spectral deconvolution which included a model for different types soil moisture (saturated, free, adsorbed). With all of these methods, it was noted that grainsize and water complicated the accurate extraction of target soil information. The final paper by Rianza (Spain) described the use of unmixing methods on airborne hyperspectral imagery for mapping acid mine drainage along drainage systems. Unexplained absorption centred at 0.69 microns is a characteristic of affected “wet” areas.

Session 3: Soil Models and Effective soil attributes – Chair Jose Alexandre Dematte

In this session we started looking at the importance of neural network on spectral quantification. Also, it was observed the necessity to take care with the bias that many statistic methods can have, thus showing good data where does not exist. The importance on transformation of data from one type of sensor to another, so data can be shared and compared between users is also an important approach. It was stated the importance of the parent material to analyse spectral data of soils. Other information about pre-processing data before getting into models where observed. Another approach was the monitoring of carbon on soils, although this element continues to be a very difficult one. The stratification of methods to improve models was also mentioned. The main message on the session was that we have to take more attention and studies on the physical properties of soils and spectra, and not only on statistics, thus with the mission to take us forward.

Session 4: Tradition soil spectroscopy, pre-treatment – Chair Antoine Stevens

Session 4 illustrated the diversity of applications that soil spectroscopy can address. The two first speakers (T. Schmid and H. Gerighausen) demonstrated that spectroscopy can be useful to monitor land degradation processes in semi-arid and temperate environments. The characterization and quantification of soil organic carbon attract also a lot of research as shown by the presentation of V. Kopačková and I. Vukovic. B. Barthès showed evidences that Mid-Infrared spectroscopy was not, as often claimed, outperforming Near-infrared spectroscopy for the quantification of soil organic carbon and other biological properties of tropical soils. A. Palacios-Orueta used a Modified Gaussian Deconvolution of reflectance spectra as a physical-based approach to estimate the chemical composition of soil. The last talk (L. Brodsky) presented an initiative aimed at the creation of a spectral library of Czech soils which will be exploited in the future in a digital soil mapping framework.

Session 5: Demonstration (sensor methods) – Chair Sabine Chabrilat

Session 5 was an interactive session dedicated to the demonstration of new developments in sensors and softwares for soil spectroscopy. There were 3 softwares demonstrations (Hueni, Westad, Cudahy) and 2 sensors demonstrations (Anders, Schwartz). The session began with an interactive demonstration of the potential of the SPECCHIO spectral database (A. Hueni) to store and handle field campaign database, with metadata editing, exporting and pre-processing options. The next paper (F. Westad) summarized calibration, validation and sampling techniques related to Partial-Least-Squares (PLS) regression and showed new developments in the Unscrambler commercial software from Camo. Then, common mistakes during the processing chain from field sampling to representative spectroscopic laboratory analyses were discussed (A. Larsen). T. Cudahy presented the TSG -The Spectral Geologist- software from CSIRO, that allows to interactively derive maps of soil properties based on hyperspectral imagery or on core loggers samplers. The session ended with live demonstration of 2 sensors: G. Schwartz showed the successful use of NIR spectroscopy for quantitative assessment of petroleum hydrocarbons using ANN and PLS methods and demonstrated in outdoor operation a new instrument the SpectraTools from the Tel-Aviv University, measuring soil spectroscopy along a soil profile until 1m depth with video and photos recording. A. Larsen showed a special commercial instrument AgriQuant from Q-Interline that measures and analyzes soil powder in the laboratory simultaneously

Session 6: Soil Spectroscopy Stability and Models – Chair Raphael Viscarra Rossel

Prof. Ben Dor proposed a simple approach to normalize visible-near infrared (vis-NIR) spectra collected measured with different instruments using a gray reference standard. The standardisation technique is going to be published and interested parties should contact Prof. Ben Dor for details. The technique appears to be useful and easy to implement. Dr Chabrilat showed that in our attempts to extract information from vis-NIR soil spectra we have gone a full circle: starting with physically based techniques, then adopting empirical approaches, taking advantage of advances in statistical methods and now we are once again trying to improve our understanding of soil spectroscopy by investigating physically based techniques. We hope that there is an upward and forward trend in the cycle! Sabine also introduced the software tool HySoma and called for the formation of a software developers group for people using soil spectroscopy.

Dr Stenberg described the effects of water and texture on spectroscopic calibrations of his Swedish vis-NIR spectral library. He showed that these interactions are complex and implied that more fundamental research is needed to better understand spectroscopic response. Bo showed how investigating ones data could enhance empirical modeling! Dr Terhoeven-Urselmans presented a comparison between vis-NIR and mid infrared (mid-IR) for predictions of various soil properties using the ISRIC and an African soil spectral library. His results showed that generally, the mid-IR produces better calibrations than the vis-NIR. He also showed that support vector machines produce better predictions than partial least squares regression. Dr Terhoeven-Urselmans described some of the operational aspects of using soil spectroscopy in Africa. Dr Guerrero showed that potentially the techniques of spiking and weighing in soil spectral libraries could extend the range of multivariate calibrations and improve their predictions. These techniques should be useful to also spike laboratory-collected spectra with spectra collected at field conditions so as to improve the predictions of soil properties from spectra collected in situ. Dr Jung reported on a project ongoing project to look at the reliability of spectral measurements – Reference Tour 2009. He called for the development of standards and more training for users of the techniques. He encouraged people to participate to make the project an international one. This final presentation provided with us with a good end to the session.

Technical Session: Chairs Raphael Viscarra Rossel and Eyal Ben Dor

A special technical session on future activity of the group evolved in this workshop and on the progress of the "global soil spectral library" was organized at the end of the workshop. It was agreed that the global soil spectral library is a very important issue and that it has to move from a voluntary basis activity to a funding based program, as its importance to the EO and other missions is invaluable. Funding sources to that end were suggested as well as establishing a lobby activity. It was mentioned that CEOS has never considered the soil arena to be an important targets as water, atmosphere, minerals and vegetation, and that we need to put our activities on the radar screen of all decision makers and funding entities. The new ESA call for developing new environmental based monitoring system was presented and the group has decided to support the DLR activity to submit a proposal to ESA that will be dedicated to develop a special mission to monitor soil in general and soil organic matter in particular from EO means.

4. Advice to users

4.1. General

An old / new community for soil spectroscopy is emerged. We still have many problems to solve (BRDF, sensitivity, sampling, attributes stability and complex). The Spectroscopy is a very important tool to monitor both soil and our environment.

4.2. Specific

- There are many other spectral quantitative activities taking place in other discipline that can help our group. The technology is existing but more applications are still hidden.
- Organic matter is playing a major role (67% of the presentation dealt with SOM). The SOM is very complex and vary in space and time. It needs probably more information and better spectral coverage such as the MIR-TIR region.
- There are on the shelf infrastructures to be used. Merging all together may provide a powerful tool to study the soil from a spectral perspective.
- Soil Chemometrics is a well recognized commercially market.
- There is still a big gap between hyperspectral remote sensing (HSR) and laboratory spectral accuracy and resolution, but this will be soon closed.
- Soil moisture is still a problem to assess and to evaluate its interaction with other soil attributes.
- Physical rather than empirical models are highly recommended and effort to that end should be addressed.
- The NIRS approach is available since 20 years – literature is available, learn from other disciplines using this technology (e.g. food, pharmaceutical, textile, tobacco).
- It is important to provide uncertainties parameters to the final results.
- New spectral profile sensor is innovative tool to study spectrally the soil profile composition whereas few softwares to handle the data are available, especially free. Data can be modeled by programs such as Unscrambler and there are commercial systems that can measure the soil powder with less uncertainties than other laboratory methods can offer.
- Register to the EWG on soil applications on the EUFAR web page

5. Advice to aircraft and instrument operators

- Advertise more the potential of instruments for the non-expert users
- Use of the technology in the user community needs more availability of data and of delivery of soil-finished products
- High interest of the user community in automatic toolboxes to extract soil maps
- MIR (Thermal RS) is a powerful potential for soil applications

6. Advice to funding agency

- Advertise more the EUFAR activities in user communities such as soil and agriculture government agencies, national geological surveys, local/regional communities.
- Organic matter is playing a major role (67% of the presentation dealt with SOM)
- Soil is a 3D structure and soil mapping should include the profile information
- MIR (3-12 microns) is a powerful potential for soil applications

7. Summary

We decided to continue the activity of this working group not only electronically, but rather in student exchange activity, organizing a summer School in Soil Spectral Analysis and HSR mission planning for soil applications and have the workshop runs under annual basis.

6. Action list

No Action List available

7. Annexes (if applicable)

All annexes are available either in this report or at www.eufar.net

ANNEXES SUMMARY:

ANNEX I: Workshop agenda

ANNEX II: Workshop abstract book (available only on eufar web page)

ANNEX III: Workshop presentations (available only on eufar web page)

ANNEX I

Thursday 15/04/2010

<i>Time</i>	<i>Soil spectroscopy workshop</i>	<i>Speaker (abstract number)</i>
09:00 – 09:30	Registration & Coffee	
09:30 – 10:00	Welcome Address Organisation	Eyal Ben Dor Sabine Chabrillat
10:00 - 12:00	Session 1: Soil Mapping – Potential and constraints (invited session)	Eyal Ben Dor (Chair)
10:00 – 10:30	The development of a global soil spectral library - useful for digital soil mapping	Raphael Viscarra-Rossel (4)
10:30 – 11:00	Spectral Sensing and Soil Survey: Past, Present, Future; Applications, Problems and Perspectives. How to make SS function?	Jose Dematte (26)
11:00 – 11:30	Hyperspectral (and radiometric) mapping of soil properties in Australia	Tom Cudahy (25)
11:30 – 12:00	Soil properties inference based on Imaging Spectroscopy and multivariate regressions: problems and potential solutions	Antoine Stevens (29)
12:00 – 13:00	Lunch Break	
13:00 – 14:45	Session 2: NIRS-HSR Problems and Solutions	Tom Cudahy (Chair)
13:00 – 13:15	“Blind Signal Separation” approach for soil properties mapping in partially vegetated pixels.	Cecile Gomez (17)
13:15 – 13:30	Determination of soil properties in Thuringia (Germany) using laboratory spectra and imaging spectroscopy	Kristin Böttcher (33)
13:30 – 13:45	Assessing soil chemical properties using lab spectroscopy and hyperspectral imagery	Tom Jarmer (14)
13:45 – 14:00	Soil spectroscopy as a tool to assess organic carbon in the Subtropical Thicket Biome of Eastern Cape Province of South Africa	Marco Nocita (27)

14:00 – 14:15	Quantitative derivation of soil parameters on the basis of hyperspectral remote sensing data. A study in regard to restoration efforts in the Subtropical Thicket Biome, South Africa.	Anita Bayer (31)
14:15 – 14:30	Visible, near-infrared reflectance spectrometry for simultaneous assessment of geophysical sediment properties (water content, grain-size) using the Automated Modified Gaussian Model (AMGM)	Charles Verpoorter (30)
14:30 – 14:45	Acid mine drainage sink by tidal influence using HyMap data (River Odiel, Andalousia, Spain)	Asuncion Riaza (16)
14:45 – 15:15	Coffee Break	
15:15 – 17:15	Session 3: Soil Spectroscopy Models and Effective Soil attributes	Jose Dematte (Chair)
15:15 – 15:30	Application of combined neural network and genetic algorithm techniques for modeling soil characteristics	Mordehai Ben Haim (7)
15:30 – 15:45	Selecting the best VNIRS-model to estimate total N in soil samples – a Swiss case study	Andreas Gubler (23)
15:45 – 16:00	Using local soil parent material-based PLSR models to investigate strength of relationships between particle size distribution and VNIR-DRS at regional scale	Barry G. Rawlins (32)
16:00 – 16:15	Using pre-processing techniques to improve estimation of soil organic carbon content in post-glacial soils by diffuse reflectance spectroscopy	Krzysztof Kuśnierek (1)
16:15 – 16:30	Soil organic carbon monitoring using VNIR reflectance spectroscopic techniques	Bas van Wesemael (28)
16:30 – 16:45	Stratification methods for improved spectral estimation of soil properties	Harm Bartholomeus (24)
16:45 – 17:00	Spectrophotometric imaging: the next challenge of soil survey in Earth's spectral remote sensing?	Patrick Pinet (18)
19:30	Gala Diner – Alter Stadtwächter Restaurant – Potsdam	

Friday 16/04/2010

<i>Time</i>	<i>Soil spectroscopy workshop</i>	<i>Speaker (abstract number)</i>
09.00 – 10:30	Session 4: Tradition Soil Spectroscopy, pre-treatment	Antoine Stevens (Chair)
09:00 – 09:15	Soil spectroscopy to assess sensitive areas affected by soil degradation in Los Monegros (Spain).	Thomas Schmid (12)
09:15 – 09:30	Estimation of soil variables using laboratory, field and airborne hyperspectral measurements to assist soil erosion assessment on agricultural fields of the test site DEMMIN	Heike Gerighausen (38)
09:30 – 09:45	Spectroscopy of lignite-rich anthropogenic sediments and ways how to differentiate between these toxic materials and soils rich in organic matter	Veronika Kopačková (11)
09:45 – 10:00	Comparing near and mid-infrared reflectance spectroscopy for the determination of soil organic and biological properties in Madagascar	Bernard Barthes (9)
10:00 – 10:15	Characterization of soil carbon using visible and near-infrared spectroscopy	Ivana Vukovic (5)
10:15 – 10:30	Assessment of the interaction between spectral properties of soil organic matter and iron content. Implication for quantification.	Alicia Palacios-Orueta (19)
10:30 – 10:45	Czech Soil Spectral Library for Quantitative Digital Soil Mapping	Lukas Brodsky (20)
10:45 – 11:15	Coffee Break	
11:15 – 13:45	Session 5 : Demonstrations (sensors methods)	Sabine Chabrilat (Chair)
11:15 – 11:45	The Spectral Database SPECCHIO and its Application in Soil Spectroscopy	Andreas Hueni (3)
11:45– 12:15	Analysis of spectral data – the holistic approach	Frank Westad (35)
12:15 – 12:45	Soil spectroscopy with AgriQuant Influences from noise, spectral range and sampling (+ demonstration)	Anders Larsen (22)
12:45 – 13:15	TSG (The Spectral Geologist) Software Demonstration	Tom Cudahy (36)
13:15 – 13:45	Quantitative assessment of petroleum hydrocarbons <i>in situ</i> by diffused reflectance spectroscopy and a penetrating optical sensor. (outside demonstration)	Guy Schwartz (2)

13:45 – 14:45	Lunch Break	
14:45 – 16:15	Session 6: Soil Spectroscopy Stability and Models	Raphael Viscarra-Rossel (Chair)
14:45 – 15:00	An innovative approach to normalize soil reflectance spectra acquired by different spectrometers and operators	Eyal Ben Dor (8)
15:00 – 15:15	Development of automatic algorithms for soil properties extraction based on spectral reflectance : Are we ready for it?	Sabine Chabrillat (13)
15:15 – 15:30	The water influence on vis-NIR spectra a tool for normalizing the matrix heterogeneity between samples	Bo Stenberg (6)
15:30 – 15:45	Application of a global soil spectral library as tool for soil quality assessment in Sub-Saharan Africa	Thomas Terhoeven-Urselmans (15)
15:45 – 16:00	Extending NIR models by spiking with weighting: what samples are more useful to improve the accuracy?	César Guerrero (34)
16:00 – 16:15	Can you trust your terrestrial spectra?	Andras Jung (37)
16:15 – 16:30	Closing Remarks	Eyal Ben Dor
16:30 – 16:45	Coffee Break	
16:45 – 17:45	Technical Meeting	