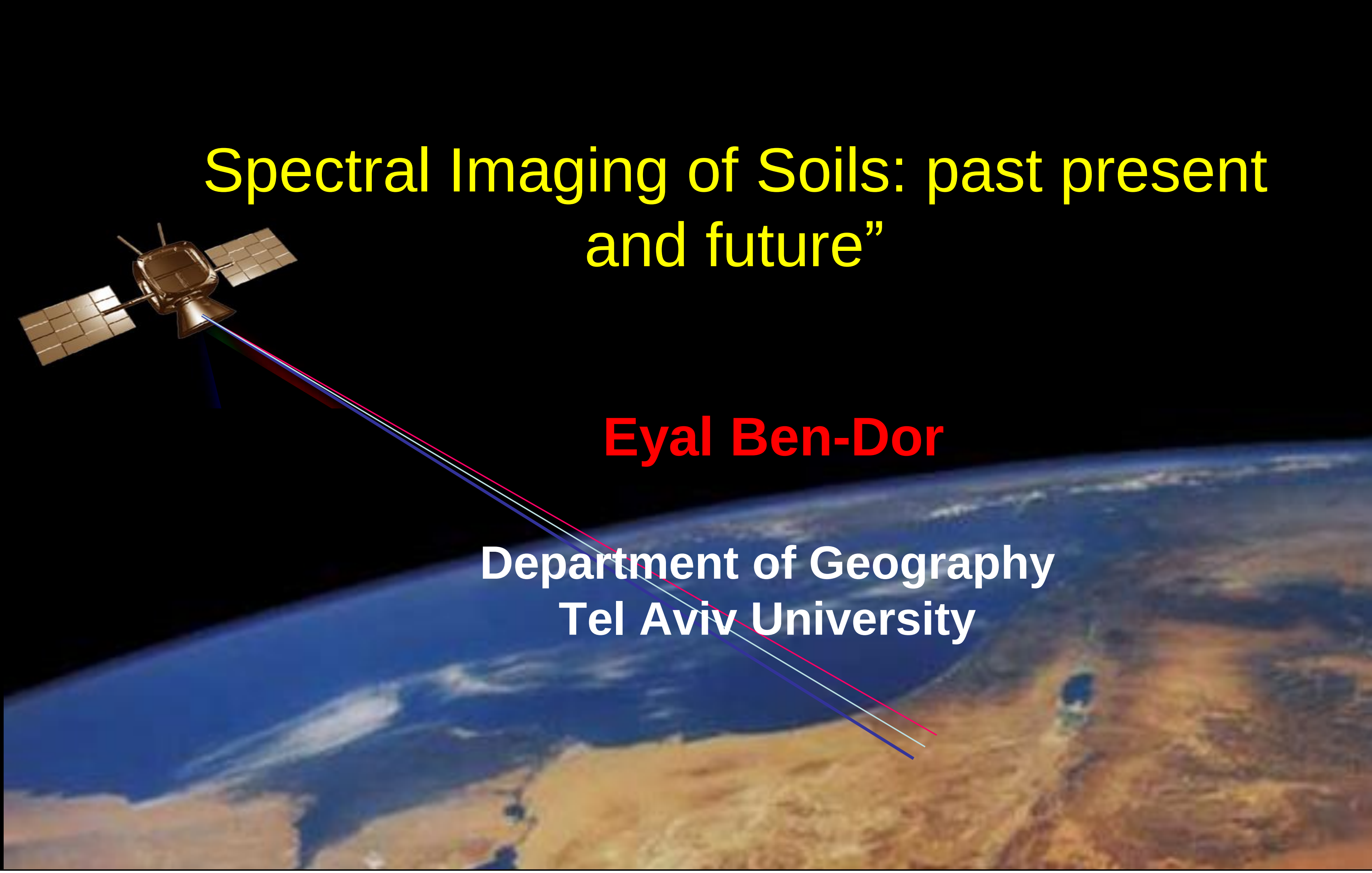


Spectral Imaging of Soils: past present and future”

Eyal Ben-Dor

Department of Geography
Tel Aviv University

2nd International Conference on Airborne Research for the Environment, DLR - the German Aerospace Research Center, in Oberpfaffenhofen, 10 - 13 July 2017

OUTLINE

- Definitions

Each item- Past and Future

- Soil Spectroscopy and its information
- Deep Learning to extract soil attributes
- Soil Imaging and field spectroscopy, big data issues
- Soil Spectral libraries and importance
- Soil standardization
- Image visualization
- Interests
- New Spectral dimensions
- Sensors and Platforms (airborne): big to light maned aircraft to drones (VNIR only)
- Satellites program

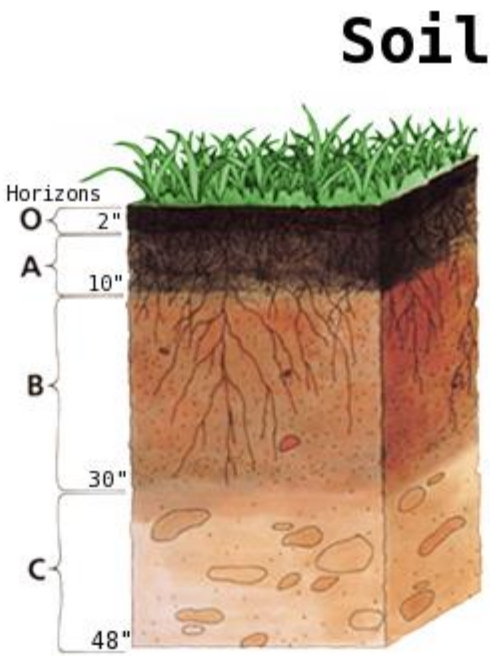
n

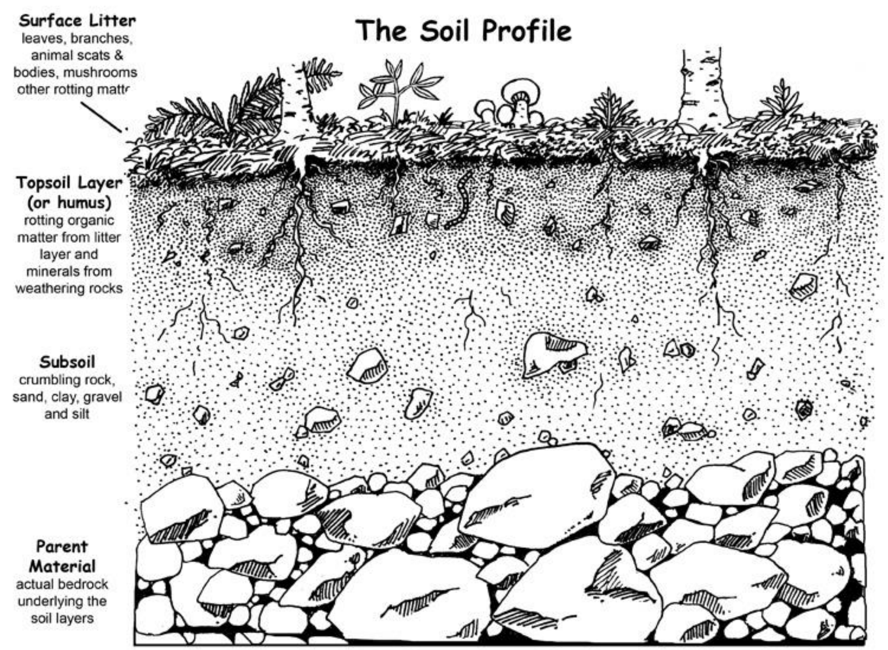
Definition 1

Soil

The upper l ***aterial which is dug, p*** ***son 1957)***

medium for plants to grow





THE REMOTE SENSING LABORATORIES

GROUP ON EARTH OBSERVATIONS

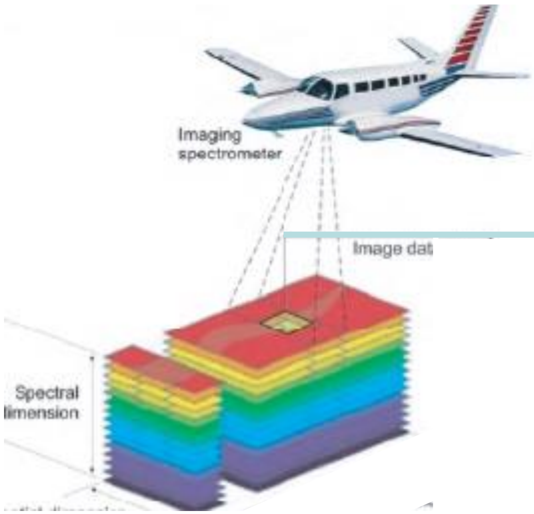
Strong Link between Point and Image Spectroscopy

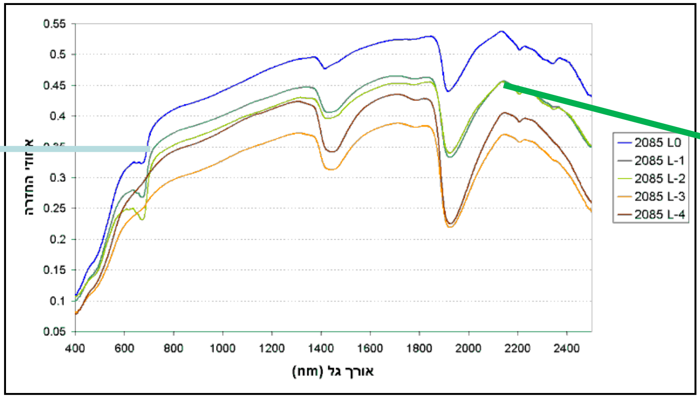
Image Spectroscopy

Geology
Vegetation
Water

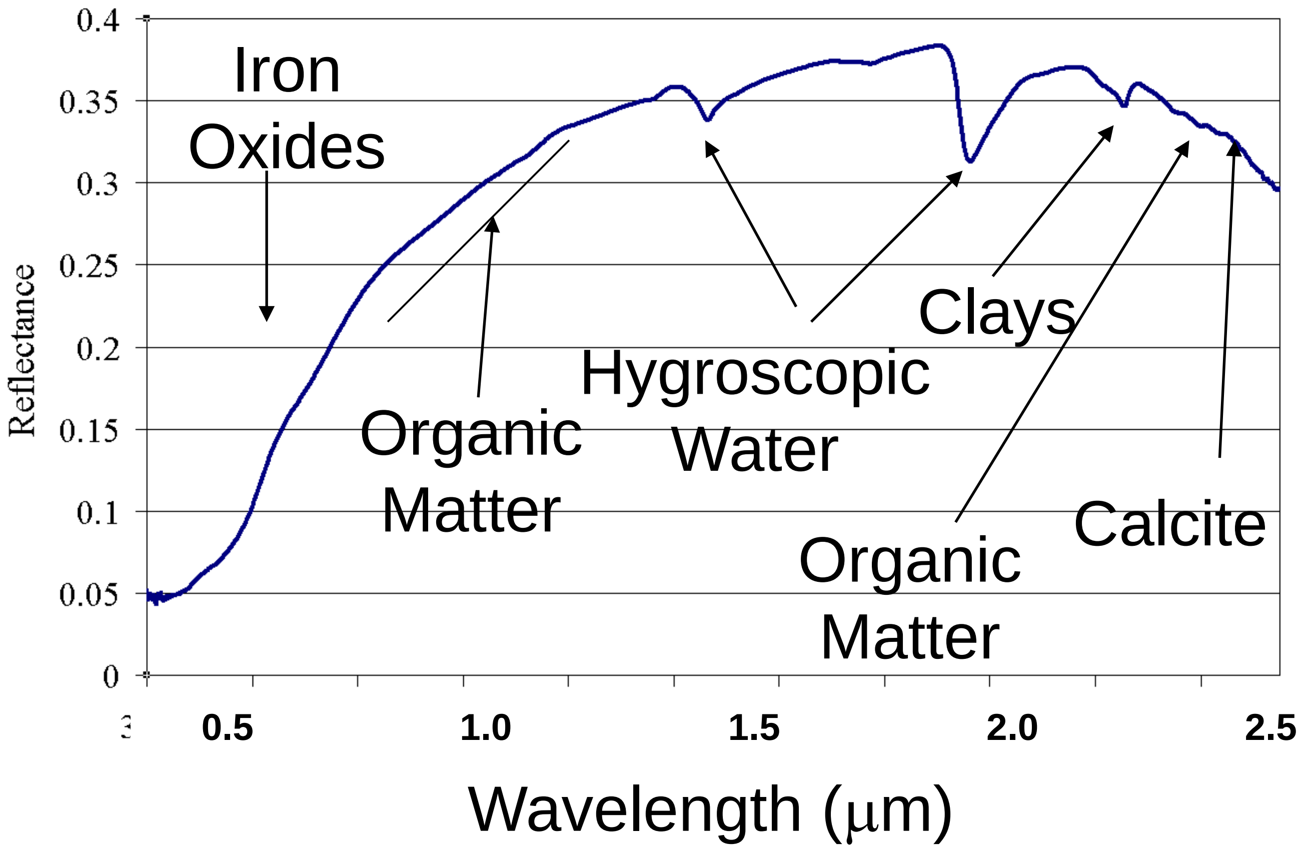
Point Spectroscopy

Soil





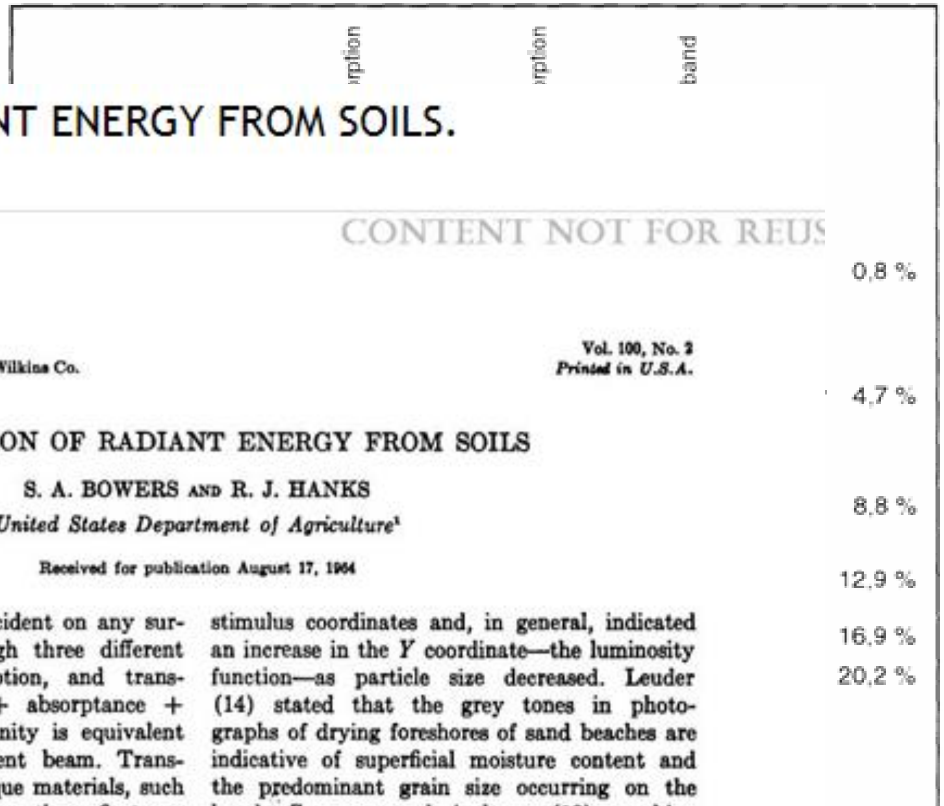
Soil Spectrum – An elegant wat to simplest the complexity of the soil system



Quantitative spectroscopy – Chemometrics

First article on soil spectra quantification 1965 demonstrated the power of soil spectroscopy

Clayey Soil and Soil Moisture



REFLECTION OF RADIANT ENERGY FROM SOILS.

BOWERS, S. A.; HANKS, R. J.

Soil Science
Copyright © 1965 by The Williams & Wilkins Co.

Vol. 100, No. 2
Printed in U.S.A.

REFLECTION OF RADIANT ENERGY FROM SOILS

S. A. BOWERS AND R. J. HANKS
United States Department of Agriculture[1]

Received for publication August 17, 1964

When radiant energy is incident on any surface it is distributed through three different processes: reflection, absorption, and transmission. Thus, reflectance + absorptance + transmittance = 1, where unity is equivalent to the energy in the incident beam. Transmittance, however, with opaque materials, such as soils, is zero, and increasing the reflectance therefore decreases the absorptance an equivalent amount. The possibility of influencing the various thermally dependent soil processes, such as evaporation, by changing the reflectance is worthy of consideration. Such a consideration first requires a determination and evaluation of the factors that influence reflectance, and this

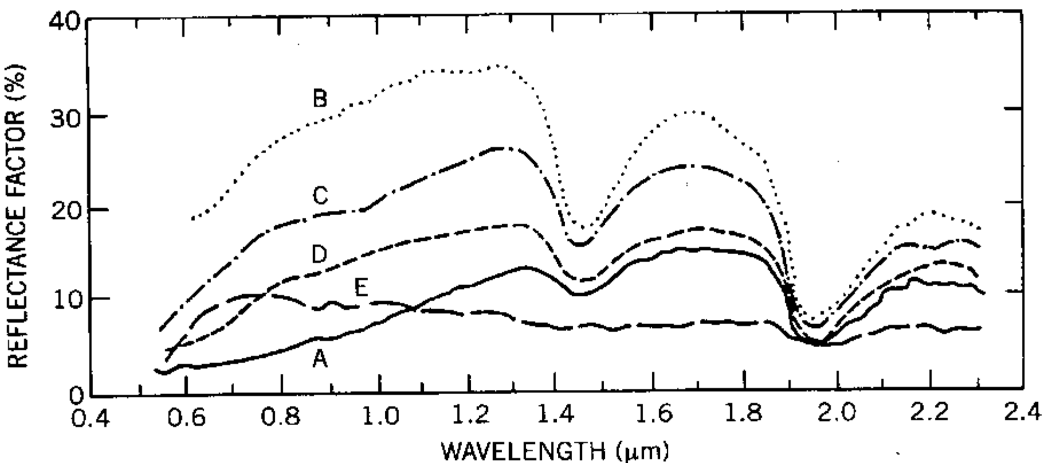
stimulus coordinates and, in general, indicated an increase in the Y coordinate—the luminosity function—as particle size decreased. Leuder (14) stated that the grey tones in photographs of drying foreshores of sand beaches are indicative of superficial moisture content and the predominant grain size occurring on the beach. Zwerman and Andrews (18), working with enameled surfaces, stated that at a given wavelength a material of given refractive index reflects light with an intensity that varies inversely as the particle diameter. The increase in reflectance with fine milling is attributed to the increased interface between opacifier and frit.

Bowers and Hanks, 1965

1980 –First Soil Spectral Library

5 spectral types
in USA

Around 4000 spectra



Stoner, E.R. and M.F., Baumgardner, 1981. Characteristic variations in reflectance of surface soils. Soil Science Society of American Journal 45: 1161-1165

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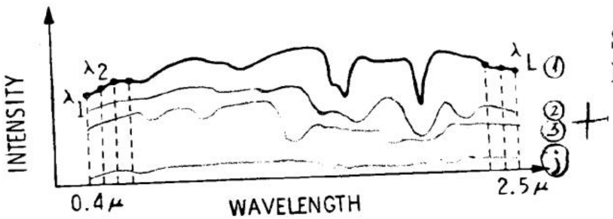
Common method 1990-2002

Multiple Linear Regression Analyses

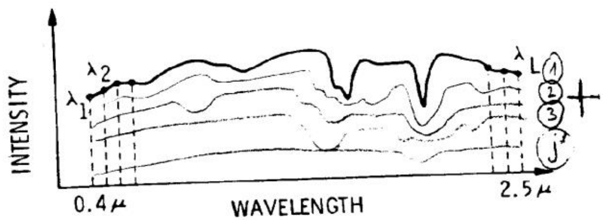
calibration



Sample Number	Concentration C1	C2 …	Ci
1	*Cm1,1*	*Cm1,2*	*Cm1,i*
2	*Cm2,1*	*Cm2,2*	*Cm2,i*
.	.	.	.
j	*Cmj,1*	*Cmj,2*	*Cmj,i*

$$C_p = b_0 + b_1L_1 + b_2L_2 + b_3L_3 + \ldots + b_nL_n$$

Validation



$$C_p = b_0 + b_1L_1 + b_2L_2 + b_3L_3 + \ldots + b_nL_n$$

Sample Number	Concentration C1	C2 …	Ci
1	*Cp1,1*	*Cp1,2*	*Cp1,i*
2	*Cp2,1*	*Cp2,2*	*Cp2,i*
.	.	.	.
j	*Cpj,1*	*Cpj,2*	*Cpj,i*

ARTICLE IN PRESS

Advanced in Agronomy

2015

Soil Spectroscopy: An Alternative to Wet Chemistry for Soil Monitoring

M. Nocita[*,§,1], A. Stevens[§], B. van Wesemael[§], M. Aitkenhead[¶], M. Bachmann[||], B. Barthès[#], E. Ben Dor[**], D.J. Brown[§§], M. Clairotte[#], A. Csorba[¶¶], P. Dardenne[||||], J.A.M. Demattê[##], V. Genot[†], C. Guerrero[***], M. Knadel[§§§], L. Montanarella[*], C. Noon[§], L. Ramirez-Lopez[¶¶¶], J. Robertson[¶], H. Sakai[||||||], J.M. Soriano-Disla[###], K.D. Shepherd[****], B. Stenberg[§§§§], E.K. Towett[****], R. Vargas[¶¶¶¶] and J. Wetterlind[§§§§]

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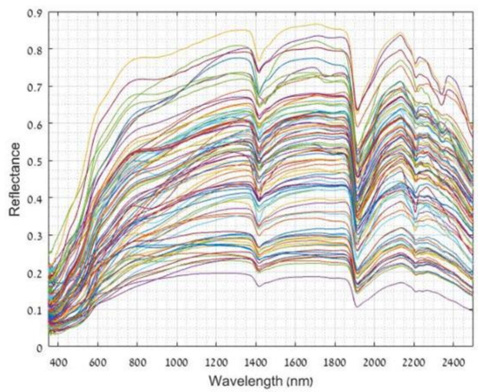
Today: Supervised Machine Learning for data mining

- The Unscrumbler©
- SPSS©
- Matlab©

Drawbacks

- Limited output
- Limited configuration
- Requires Programming knowledge
- No Automation for Pre-processing



Tomorrow : Automated Deep Leering Aproach

PARACUDA©

- One click button
- No need to be expert in machine learning approach
- Extracting the best model
- Image application

Software for data mining and image illustration

ELSEVIER

Chemometrics and Intelligent Laboratory Systems

Volume 90, Issue 1, 15 January 2008, Pages 72–83

Technical note

ParLeS: Software for chemometric analysis of spectrosc

Raphael A. Viscarra Rossel

Show more

doi:10.1016/j.chemolab.2007.06.006

Get rights and content

2008

HYSOMA: AN EASY-TO-USE SOFTWARE INTERFACE FOR SOIL MAPPING APPLICATIONS OF HYPERSPECTRAL IMAGERY

2010

S. Chabrillat [a], *, A. Eisele [a], S. Guillaso [b], C. Rogaß [a], E. Ben-Dor [c], H. Kaufmann [a]

The spectrum-based learner: A new local approach for modeling soil vis–NIR spectra of complex datasets

2013

Leonardo Ramirez-Lopez [a, b], Thorsten Behrens [a], Karsten Schmidt [a], Antoine Stevens [b], Jose Alexandre M. Demattê [c], Thomas Scholten [a]

Paracuda-II ®

An automated data mining machine for soil chemometric analysis (point and imaging)

E. Ben Dor

2015

FAST & AUTOMATICS

2017 and tomorrow

CODE OCEAN

Discover & Run Scientific Code

Code Ocean is a cloud-based **executable** research platform

What is Code Ocean?

Code Ocean is a cloud-based executable research platform that allows authors to share their algorithms in an effort to make the world's scientific code more open and reproducible. Uploading your algorithms and associated data files to the Code Ocean site is easy. Anyone can run an algorithm posted to Code Ocean, modify it, and test the modifications. The published algorithm that an author posts will remain unchanged.

1. ~~Find the code~~
2. ~~Acquire the right hardware~~
3. ~~Set up the environment~~
4. ~~Import the right files~~
5. ~~Installing all dependencies...packages, versions, OS etc...~~
6. ~~Errors.. Debugging.. Errors.. Debugging~~
7. Run
8. Results

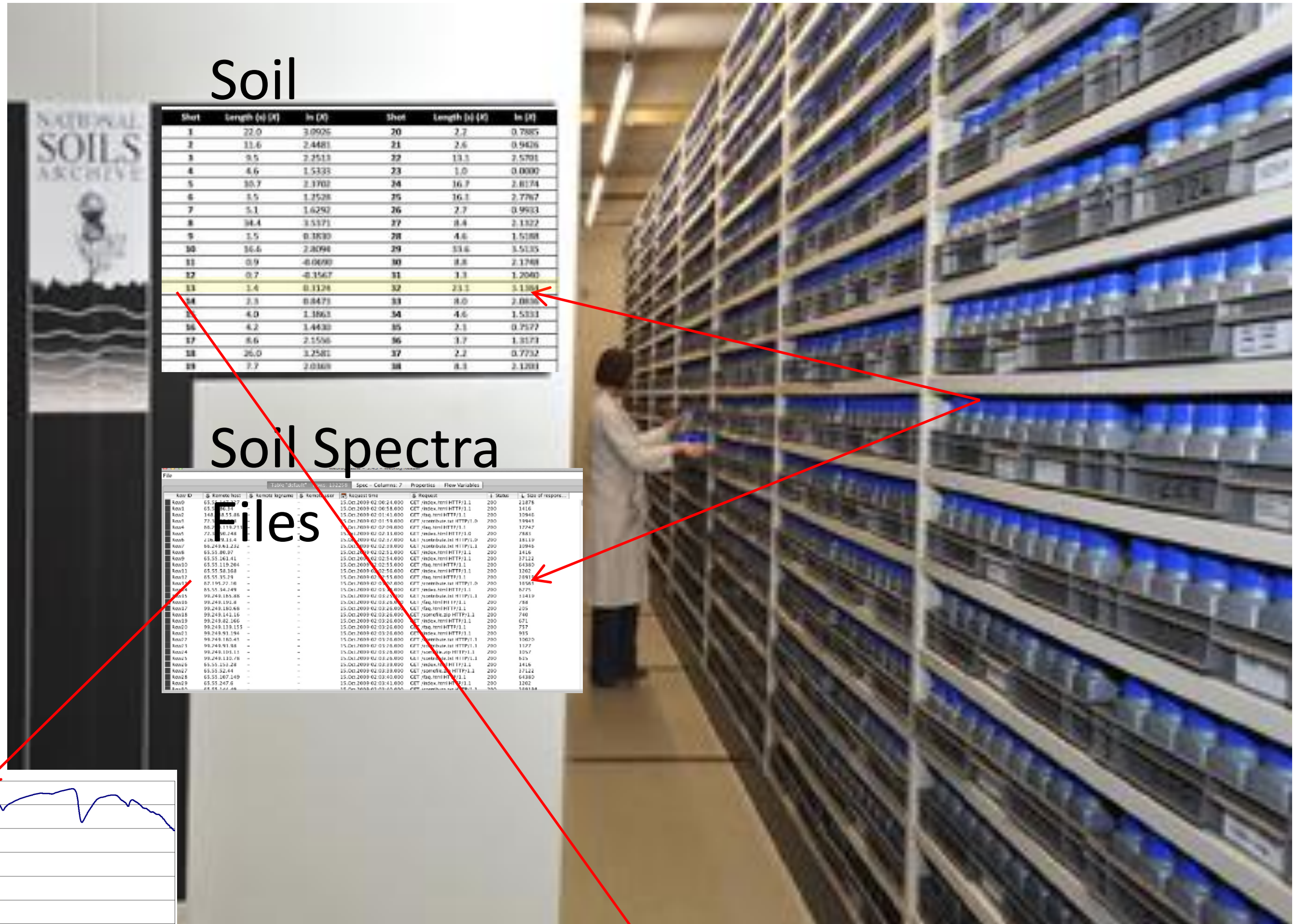
Steps 1 to 6 are already configured,

Just Run

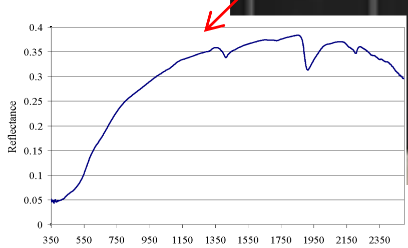
And see the results!

Spectral Archive

Soil Spectral Library : chemistry and spectroscopy



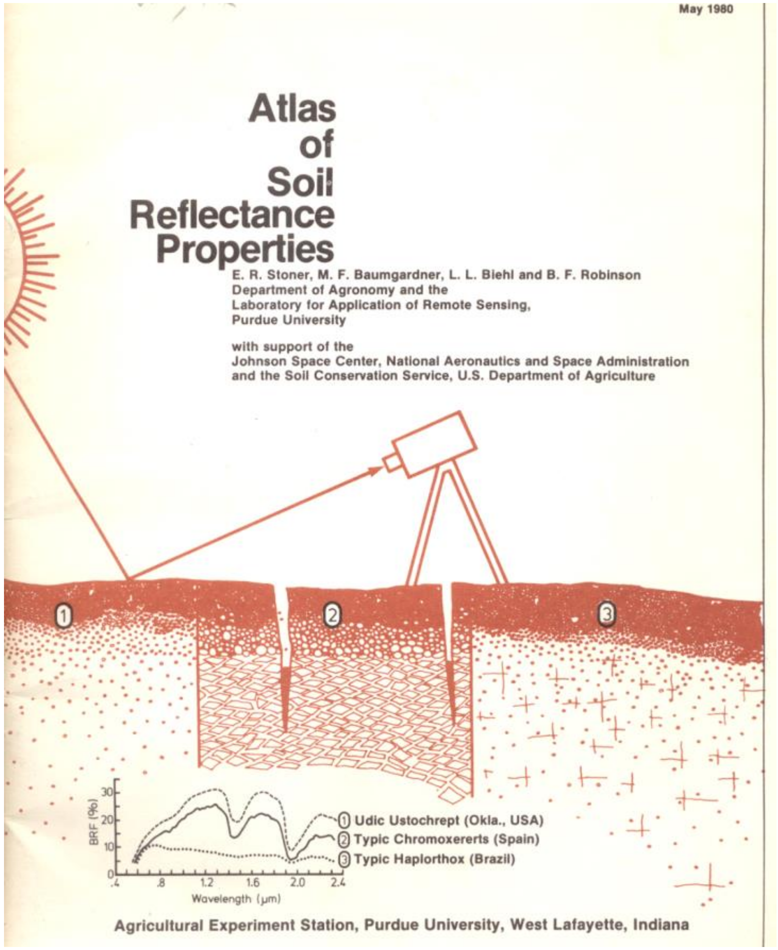
Shot	Length (s) (X)	ln (X)	Shot	Length (s) (X)	ln (X)
1	22.0	3.0926	20	2.2	0.7885
2	11.6	2.4481	21	2.6	0.9426
3	9.5	2.2513	22	13.1	2.5701
4	4.6	1.5333	23	1.0	0.0000
5	10.7	2.3702	24	16.7	2.8174
6	3.5	1.2528	25	16.1	2.7767
7	5.1	1.6292	26	2.7	0.9933
8	34.4	3.5371	27	8.4	2.1322
9	1.5	0.3830	28	4.6	1.5188
10	16.6	2.8094	29	33.6	3.5135
11	0.9	-0.0690	30	8.8	2.1748
12	0.7	-0.3567	31	3.3	1.2040
13	1.4	0.3124	32	23.1	3.1384
14	2.3	0.8473	33	8.0	2.0836
15	4.0	1.3863	34	4.6	1.5333
16	4.2	1.4430	35	2.1	0.7577
17	8.6	2.1556	36	3.7	1.3173
18	26.0	3.2581	37	2.2	0.7732
19	7.7	2.0369	38	8.3	2.1203



Sample	Location	OM	Clay	Lime….
A1	34,5467.67 36,654,32	2.4 %	34%	23.4%

Past : 1980 –First Soil Spectral Library

Around 4000 spectra



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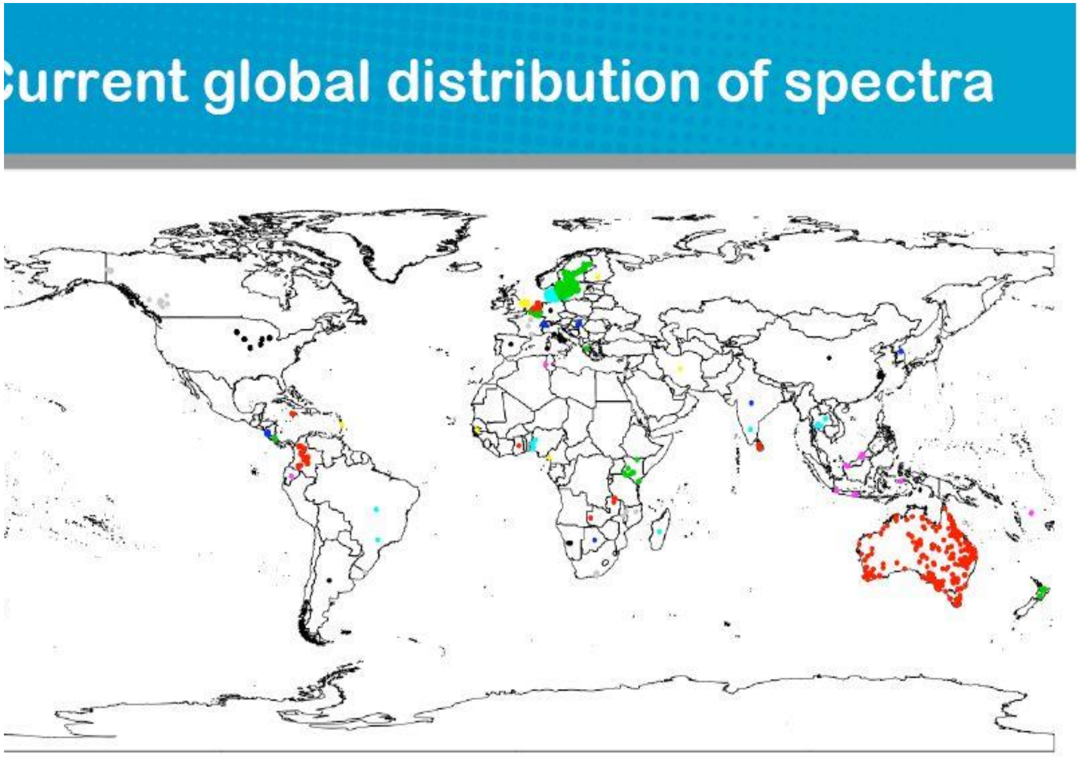
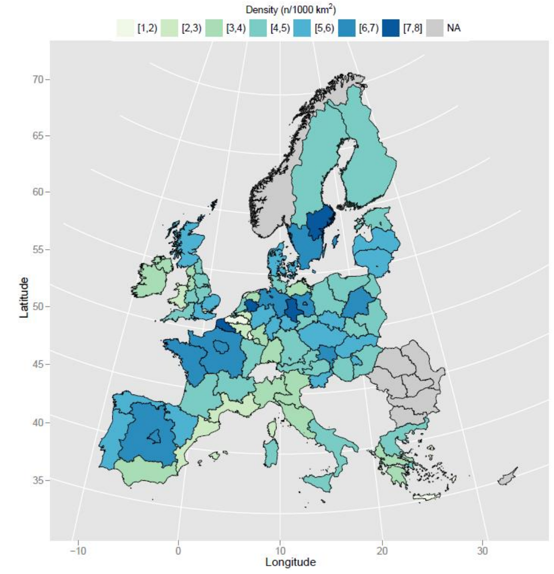
GEO GROUP ON EARTH OBSERVATIONS

European Commission

Today: World Soil Spectral Libraries (no measurement protocols) – many users





2016

2015

Estimation of total number of soil spectra : **400,000**

(1980 – **4,000**)

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Today

There is a publication on the global library

Contents lists available at ScienceDirect

Earth-Science Reviews

journal homepage: www.elsevier.com/locate/earscirev

ELSEVIER

EARTH-SCIENCE REVIEWS

A global spectral library to characterize the world's soil

CrossMark

R.A. Viscarra Rossel [a,*], T. Behrens [b], E. Ben-Dor [c], D.J. Brown [d], J.A.M. Demattê [e], K.D. Shepherd [f], Z. Shi [g], B. Stenberg [h], A. Stevens [i], V. Adamchuk [j], H. Aïchi [k], B.G. Barthès [l], H.M. Bartholomeus [m], A.D. Bayer [n], M. Bernoux [l], K. Böttcher [o,p], L. Brodský [q], C.W. Du [r], A. Chappell [a], Y. Fouad [s], V. Genot [t], C. Gomez [u], S. Grunwald [v], A. Gubler [w], C. Guerrero [x], C.B. Hedley [y], M. Knadel [z], H.J.M. Morrás [aa], M. Nocita [ab], L. Ramirez-Lopez [ac], P. Roudier [y], E.M. Rufasto Campos [ad], P. Sanborn [ae], V.M. Sellitto [af], K.A. Sudduth [ag], B.G. Rawlins [ah], C. Walter [s], L.A. Winowiecki [f], S.Y. Hong [ai], W. Ji [a,g,j]

Past – no protocol for spectral measurements

Present and future : a new standard and protocol for global soil spectral library

Geoderma 245–246 (2015) 112–124

Contents lists available at ScienceDirect

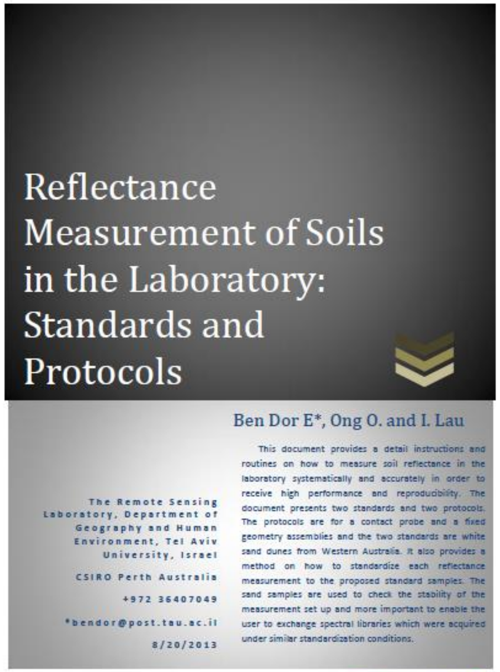
Geoderma

journal homepage: www.elsevier.com/locate/geoderma

Reflectance measurements of soils in the laboratory: Standards and protocols

Eyal Ben Dor [a,*], Cindy Ong [b], Ian C. Lau [b]

[a] Tel Aviv University (TAU), Israel
[b] CSIRO, Perth, Western Australia, Australia


Reflectance Measurement of Soils in the Laboratory: Standards and Protocols

Ben Dor E*, Ong O. and I. Lau

The Remote Sensing Laboratory, Department of Geography and Human Environment, Tel Aviv University, Israel

CSIRO Perth Australia

+972 36407049

*bendor@post.tau.ac.il

8/20/2013

This document provides a detail instructions and routines on how to measure soil reflectance in the laboratory systematically and accurately in order to receive high performance and reproducibility. The document presents two standards and two protocols. The protocols are for a contact probe and a fixed geometry assemblies and the two standards are white sand dunes from Western Australia. It also provides a method on how to standardize each reflectance measurement to the proposed standard samples. The sand samples are used to check the stability of the measurement set up and more important to enable the user to exchange spectral libraries which were acquired under similar standardization conditions.

Standardization – Reducing Non Systematic
Soil Internal Standard – Reducing Systematic Effects

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European Commission

GEO GROUP ON EARTH OBSERVATIONS

Tomorrow : *New Standard world wide Soil Spectral Library*

Coordinating and integRating state-of-the-art Earth Observation Activities in the regions of North Africa, Middle East and Balkans and Developing Links with GEO related intiatives toward GEOSS

Thematic Areas

Adaptation to Climate Change

(ACC)

Improved Food Security – Water Extremes Management

(IFS)

Access to Raw Materials

(ARM)

Access to Energy

(SENSE)

Protocol , SSL

GROUP ON EARTH OBSERVATIONS

WP 4 – TAU-i-BEC mission

- To establish a soil spectral library SSL for the **North Africa, Middle East and Balkans**
- To establish a basic foundation to use the SSL for EO means (from field, air and domains)
- To built a data base with a GEOSS sharing regulation

European Commission

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Spectral Sensors – laboratory and field

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LABORATORIES

Field Spectrometer and Accessories

Past

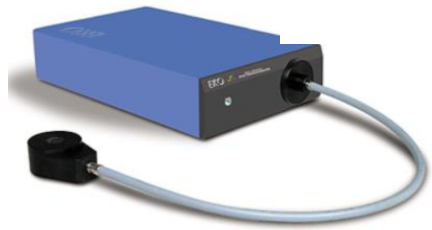
ASD

PERS

1994

1974

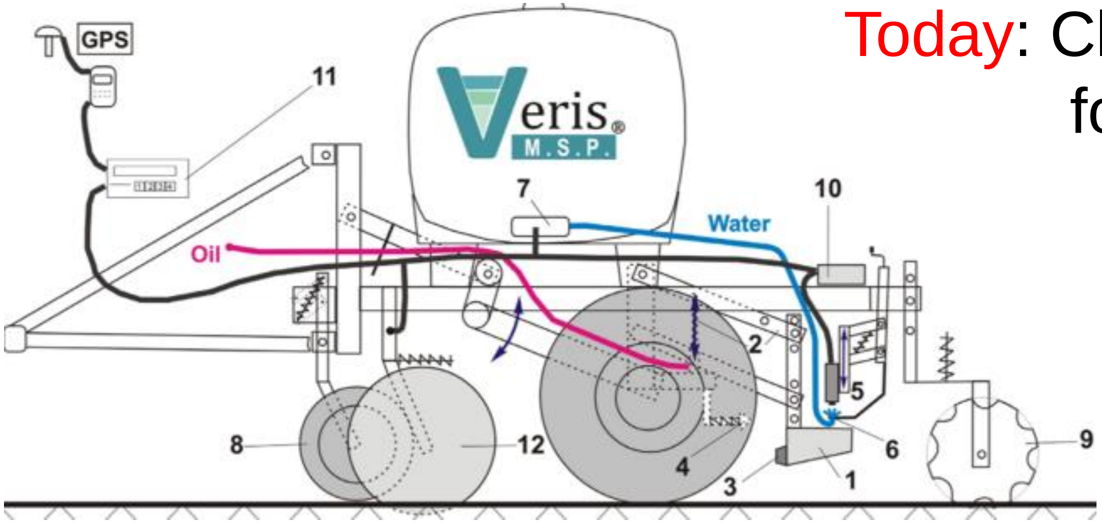
Today and tomorrow : Many instruments



Today: Field soil measurement is leaning on the sun radiation

E.J. Milton et al. / Remote Sensing of Environment 113 (2009) S92–S109

Today: Close moving chamber for 27/7 option



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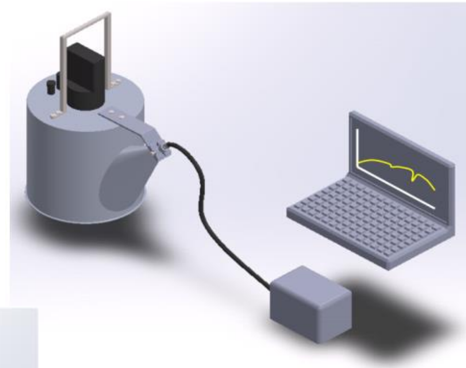
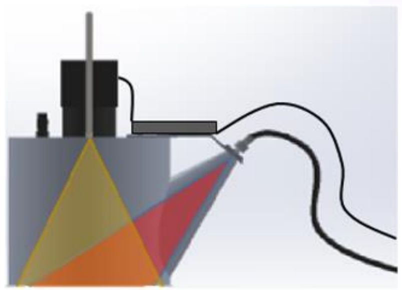
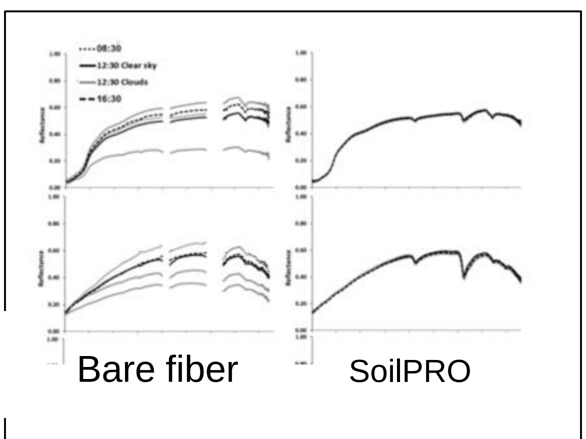
Tomorrow : Close chamber compatible with all spectrometers and easy to use

Soil field Probe (SoilPRO®)





Laboratory quality in field measurements



Past: Soil spectral Profiling

Veris technologies

SSSAJ: Volume 72: Number 4 • July–August 2008 1113

A Novel Method of Classifying Soil Profiles in the Field using Optical Means

Eyal Ben-Dor*
Daniela Heller
Alexandra Chudnovsky
Remote Sensing and GIS Lab.
Geography and Human Environment Dep.
Tel-Aviv Univ.
P.O. Box 39040
Ramat Aviv
Tel-Aviv 69978
Israel

The rationale of this study was to develop a new, objective method for characterizing soil profiles in the field by using the optical means commonly available to most users. For that purpose, we used a field spectrometer (analytical spectral device, ASD) and a specific accessory used to read sub-soil reflectance data, together with a multivariate spectral analysis approach. To that end, we developed and constructed a housing assembly that can be adapted to any portable field spectrometer, thus making subsoil spectral readings possible. This accessory, the sub-surface spectral head device (termed 3S-HeD), penetrates into the subsoil profile after a small hole, the size of the accessory, is drilled in the soil. To examine and demonstrate this idea, we selected and studied four different soil profiles from semiarid environments during the summer. Soil samples were taken from the drilled holes (40), near trenches (30), and a local soil bank (90). All of these samples were mixed together to create a working group against which multivariate spectral models were run, using the spectral

POS – Penetrating Optical Sensor ®

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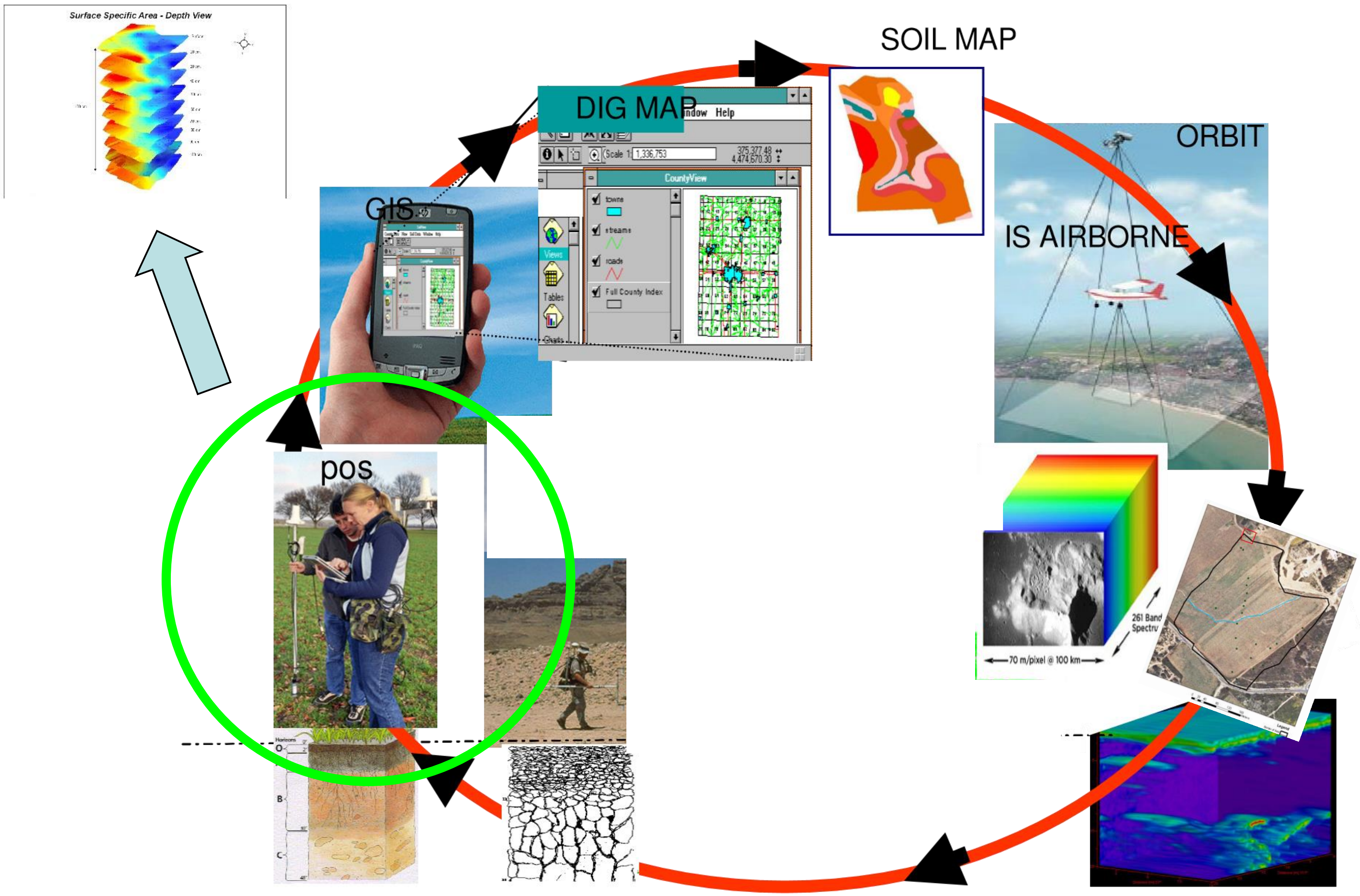
Tomorrow: Merging profiling spectroscopy with surface data



European Commission

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Imaging Systems

from heavy (past) to light sensors (present and future)



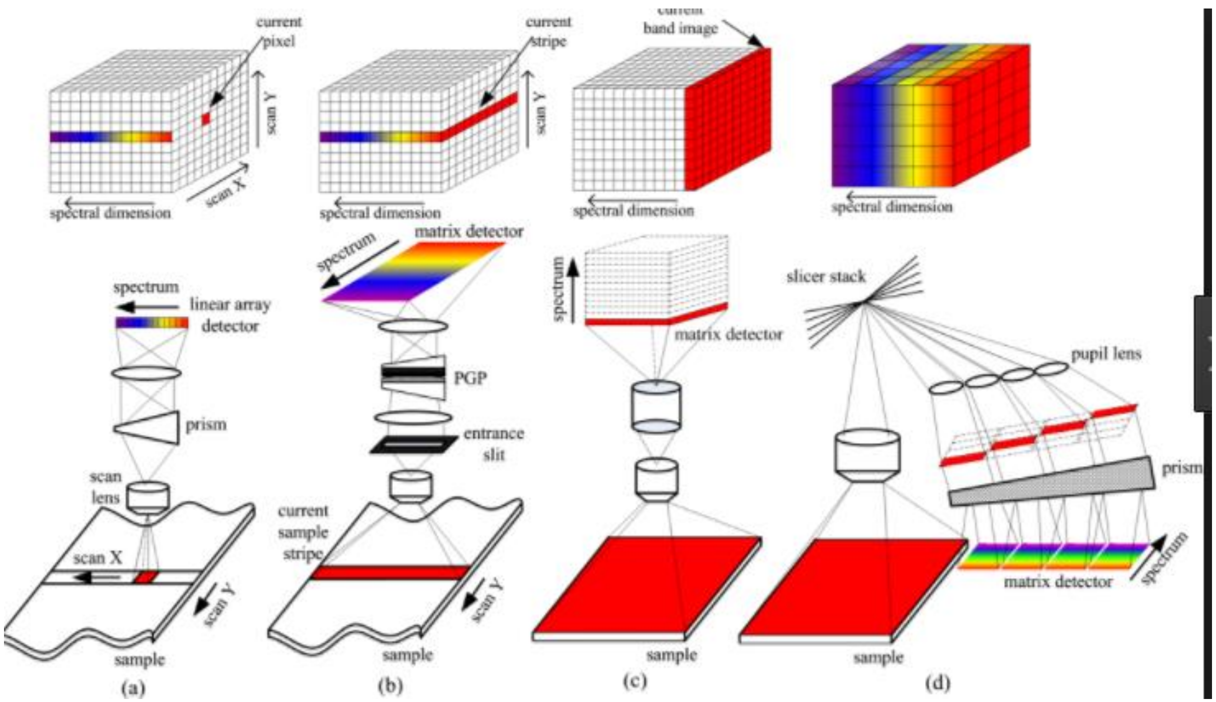
Petri SPECIM March 23, 2015

“ we have sold now way over 4000 spectrographs, of which ~110 have gone into airborne AISA systems!”





From point and scanning (past) to snap shot systems (present and future)



Imaging Platforms (air borne)

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Past: Heavy aircrafts and complicated constructions (airborne)

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Present: light aircraft and UAVs (airborne)

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Tomorrow: Combination between airborne and satellite

High Altitude Pseudo-Satellites (HAPS)

- Unmanned flying platform
- Running exclusively on solar power
  - batteries charged during daytime for operation at night
  - airborne for weeks→months(→years)
- Operating in the stratosphere (altitude ~20 km) to be
  - above weather (clouds, jet streams)
  - above regular air traffic
  - Covering local→regional footprints

Long endurance
Global coverage
High cost

HAPS:

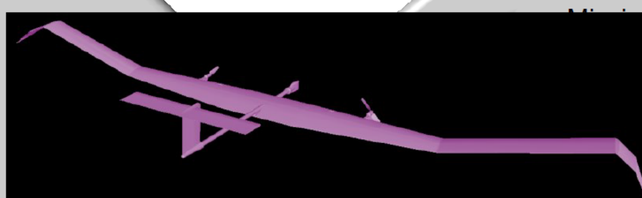
ver
me for operation at night
→years)
titude ~20 km) to be
- above weather (clouds, jet streams)
- above regular air traffic
- Covering local→regional footprints

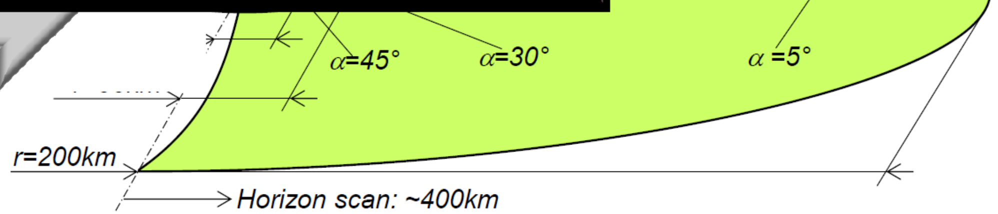
n types similar to satellites
kable and repairable

HAPS fill the gap between satellites and fuel-powered aircraft providing

affordable, persistent, local satellite-like services

HAPS are:
- enduring like a satellite
- focused like an aircraft
- cheaper than both of them





Short endurance
Local footprint
High cost

20 Km

4 Weeks

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European Commission

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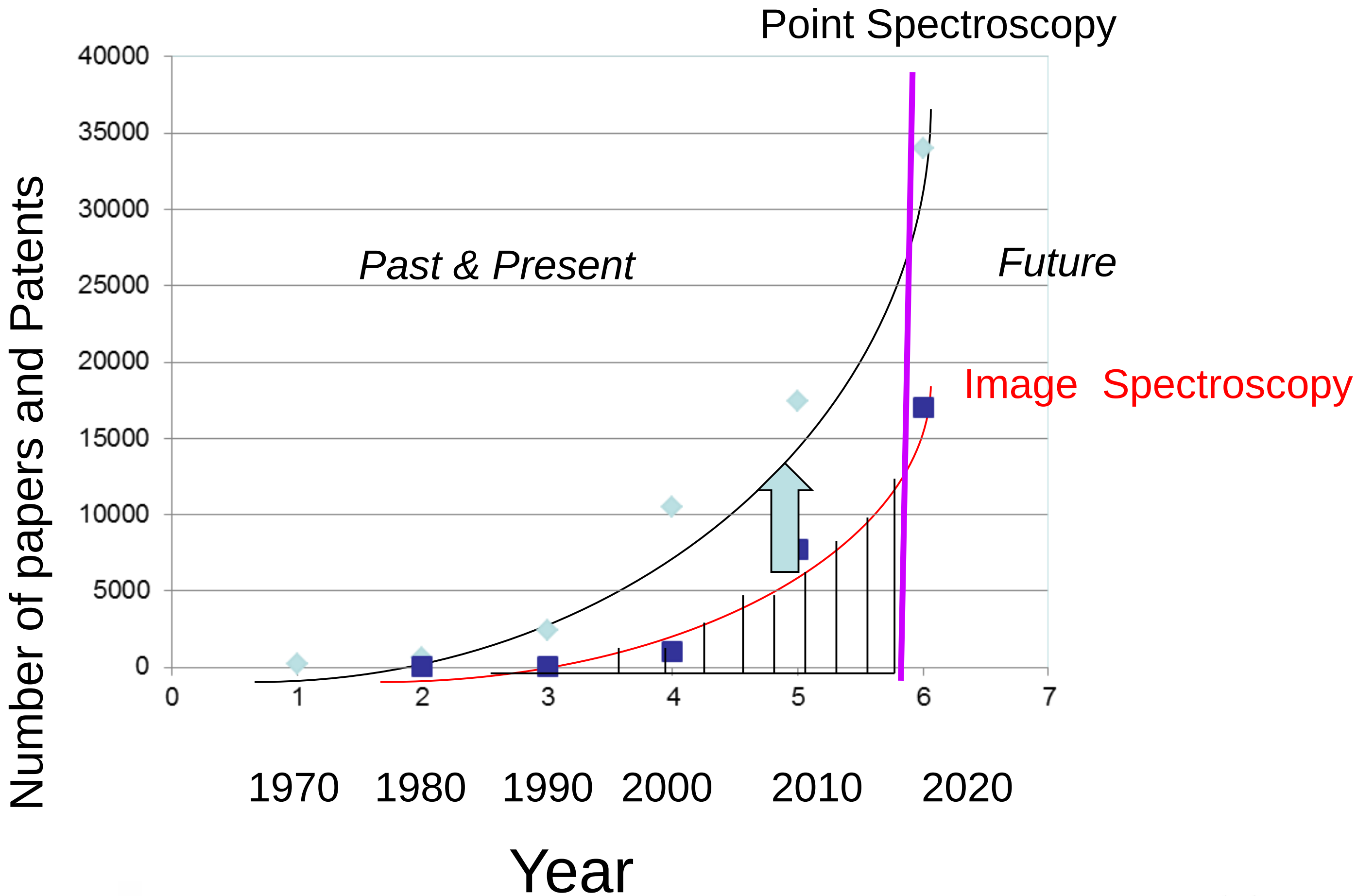
AIRBUS DEFENCE & SPACE

Interest

Interest

How point spectroscopy driven the image spectroscopy of soils



Past: Special Issues on Soil (Field) Spectroscopy

2013

plied and Environmental Soil Science
lume 2013 (2013), Article ID 616578, 3 pages
p://dx.doi.org/10.1155/2013/616578

itorial

ıantitative Soil Spectroscopy

ɔine Chabrillat,[1] Eyal Ben-Dor,[2] Raphael A. Viscarra Rossel,[3] and José A. M.
mattê[4]

72

2015

Special Issue of
JNIRS—Journal of Near Infrared Spectroscopy on

NIR Spectroscopy of Soil

Special Issue on NIR Spectroscopy of Soil is 15 May 2015.

2015 is the International Year of Soils and *JNIRS—Journal of Near Infrared Spectroscopy* will publish a **Special Issue on NIR Spectroscopy of Soil** to celebrate the contribution of NIR spectrosc
understanding of this fundamentally important part of our environment.

Rejectec

Special Issues on Soil (Field) Spectroscopy

remote sensing

A special issue of *Remote Sensing* (ISSN 2072-4292).

Deadline for manuscript submissions: **31 July 2015**

Impact Factor= 2.72

Special Issue Editor

Guest Editor
Prof. Dr. Eyal Ben-Dor
Remote Sensing Laboratory, Department of Geography, Tel Aviv University, Israel
Website: http://www.tau.ac.il/~rslweb/bendor.html
E-Mail: bendor@post.tau.ac.il

Special Issue Information

Dear Colleagues,

Field spectroscopy has emerged in tandem with space agencies' progress in developing more bands and higher spectral resolutions across the passive remote-sensing domains. Field spectroscopy was first used to understand the interaction of objects with solar electromagnetic radiation, and then to design the best spectral channels for remote sensing the Earth from space. Later, this technology was adopted by other disciplines, which opened new frontiers in the environmental monitoring field, and enabled rapid measurements of targets on the ground. Applications involve precision agriculture, geological prospecting, and monitoring of soil and water contamination. The need for field spectroscopy by many users encouraged electro-optic companies to design and manufacture portable spectrometers for easy operation, resulting in a significant increase in the number and activities of these devices. Today, it would be hard to find any remote-sensing group without one or more portable spectrometers at hand, with other, non-remote-sensing communities also possessing these means. Thus field spectroscopy is no longer simply an accessory tool for remote-sensing activities but rather, stands as an important tool for many applications in all spheres (*i.e.*, the atmosphere, hydrosphere, geosphere, pedosphere, cryosphere, and biosphere). The field spectrometer can be a point or imaging spectrometer covering solar (VIS–NIR–SWIR) or earth (MWIR–LWIR) radiation. In general, field spectroscopy is aimed at understanding the interaction of the targets in question with electromagnetic radiation under better conditions than those available when operating air and orbit sensors. Uses of field spectroscopy include the calibration and validation of remote-sensing sensors and their products, the development of semi- and fully quantitative models for terrestrial applications, the study of interactions between higher spectral resolution radiation and solids, liquids, and gases, and the development of as yet undiscovered applications.
The aim of this Special Issue is to cover research dedicated exclusively to field spectroscopy (point or imaging) across the 400–14,000 nm spectral region and to promote further work in this direction. Sensor calibration, spectral modeling, the development of quantitative models for outdoor applications, and of standards and protocols for field measurements, are just a few examples. Relevant fields will include environmental monitoring, civil engineering assessments, precision-agriculture applications, the monitoring of soil and water contamination, the detection of atmospheric pollution and forest management, among others.

Authors are required to check and follow specific *Instructions to Authors*, see https://dl.dropboxusercontent.com/u/165068305/Remote_Sensing-Additional_Instructions.pdf.

Prof. Dr. Eyal Ben-Dor
Guest Editor

As for March 27, 2015
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the ***Remote Sensing Handbook*** **(Volume I, II, III)**

Will be published by *Taylor and Francis Inc. CRC Press*, September 2015

Prasad T, Editor

Past

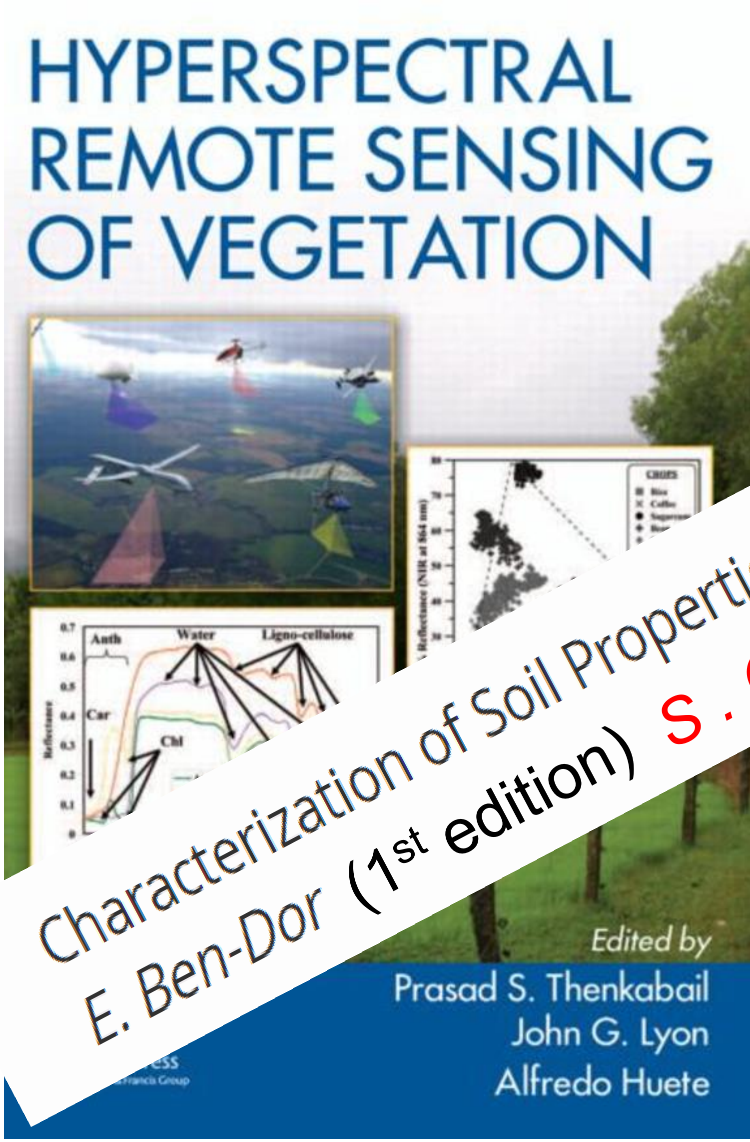
25

pp: 709-764

Remote Sensing of Soil in the Optical Domains

Eyal Ben-Dor
Tel Aviv University

Jose A.M. Dematte
University of Sao Paulo



Tomorrow

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Characterization of Soil Properties Using Reflectance Spectroscopy

E. Ben-Dor (1st edition) S . Chabrillat and J. Dematte (2nd edition)

GROUP ON EARTH OBSERVATIONS

THE REMOTE SENSING LABORATORIES

4th Global Workshop on Proximal Soil Sensing (GWPSS2015)

The 4th Global Workshop on Proximal Soil Sensing (GWPSS2015) will take place from May 12-15, 2015 in Hangzhou, China. The workshop's theme is "Sensing soil condition and functions".

Deadline for Abstracts: Dec. 31, 2014
Deadline for Early Registration: Feb. 28, 2015
Deadline for Full Paper: Mar. 31, 2015

About 150 members

"visNIR" community

Professional Groups

Dear Eyal BEN DOR,

"VNIR-SWIR-TIR " community

This is an overview of the last update of your "Hyperspectral Applications for Soil" mailing list:

* 320 continuing members;

* 1 new member: LAGOUARDE Jean-pierre(lagouarde@bordeaux.inra.fr);

* 0 removed member;

* 0 refused member;

* 0 applicant;

> 300 members

You can manage all your EUFAR mailing lists in the back office mailing list page

THE REMOTE SENSING LABORATORIES

GROUP ON EARTH OBSERVATIONS

Tomorrow

RIO18 21st World Congress of Soil Science Rio de Janeiro August | 12 - 17

ORGANIZATION OF SYMPOSIUM

GUIDELINES FOR DIVISIONS, COMISSIONS, WORKING GROUPS, COORDINATORS AND OTHER PARTICIPANTS

Remote Sensing Applied to Soil Science

Eyal Ben Dor, Tel Aviv University, Department of Geography and Human Environment., School of Earth Science, Faculty if Exact Science, Tel. 03-6407049
Email: bendor@post.tau.ac.il

José Alexandre M. Demattê, University of São Paulo, College of Agriculture "Luiz de Queiroz'
Tel. +55 019-3417-2109, Email: jamdemat@usp.br

5. Rationale

Remote sensing is a very important topic and a growing scientific field. With many satellites, airborne (manned and un-manned) platforms and new advance sensors, this research area attracts many scientists, stakeholders, governmental entities, environmental policies and decision makers. Accordingly, this field holds a significant interest at many countries worldwide while the scientific papers on this topic grows exponentially. For soils, this theme has a great potential to attract many researchers from all over the world that could not find yet nor appreciate them in the past WCSS Symposiums. Establishing of the soil remote sensing theme in the current WCSS Symposium will, beside of exchanging information and experiences between current and future users, to foster future activity in this promising technology with other soil themes within the WCSS. Indeed, we can say that this technology works in two fields, where one is the use of available data sources (ie, free images, google earth and others) and the other is the use of specific data acquisition processes.
Researchers from other soil themes may have an access to the remote sensing technology and accordingly open new horizons for better science. In the proposed theme, a worldwide reputation of scientists will take part and contribute a fresh attitude to this old new technology that will no dough contribute much to the soil science arena.

6. Objectives

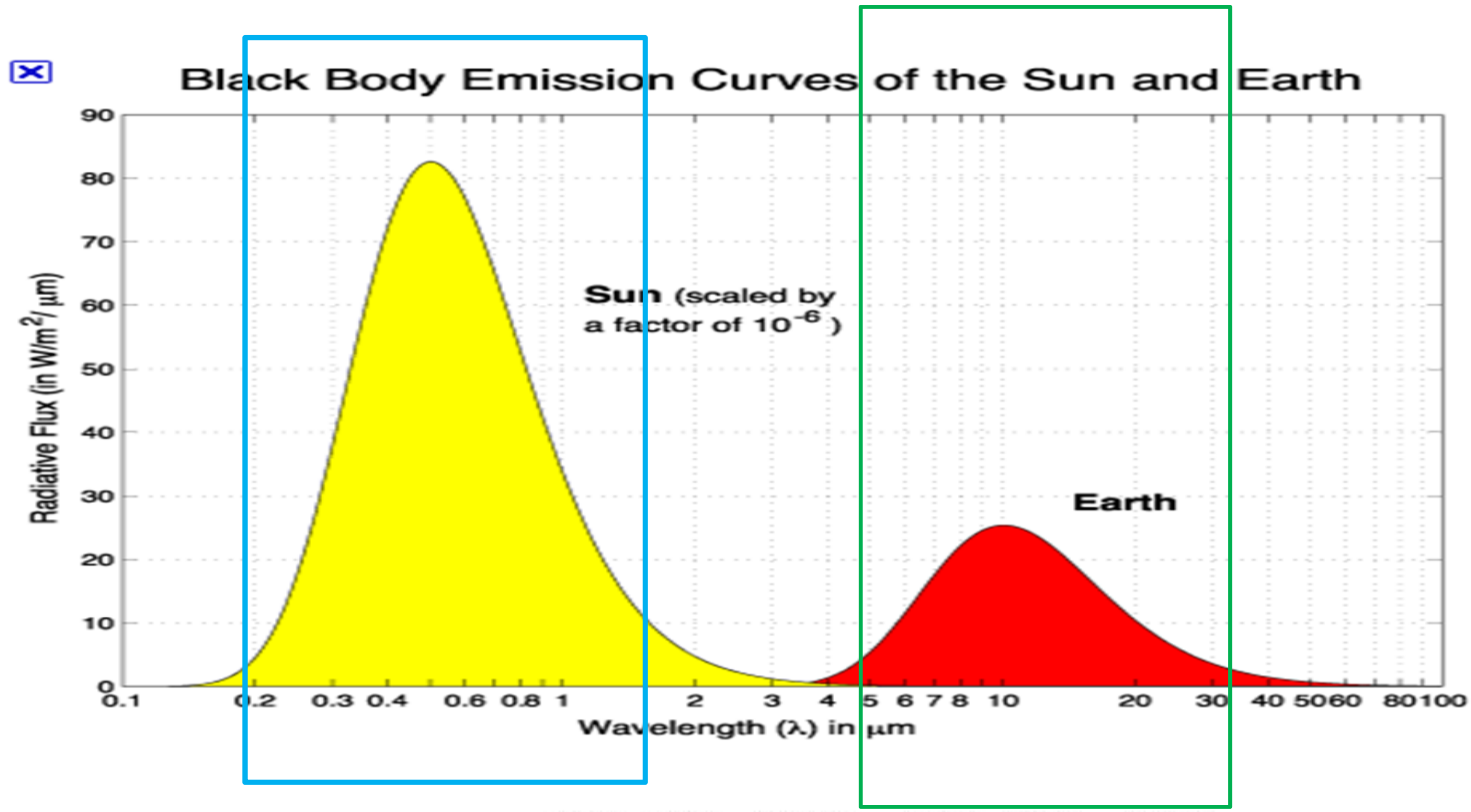
The objectives of the symposium are to report on the development of:

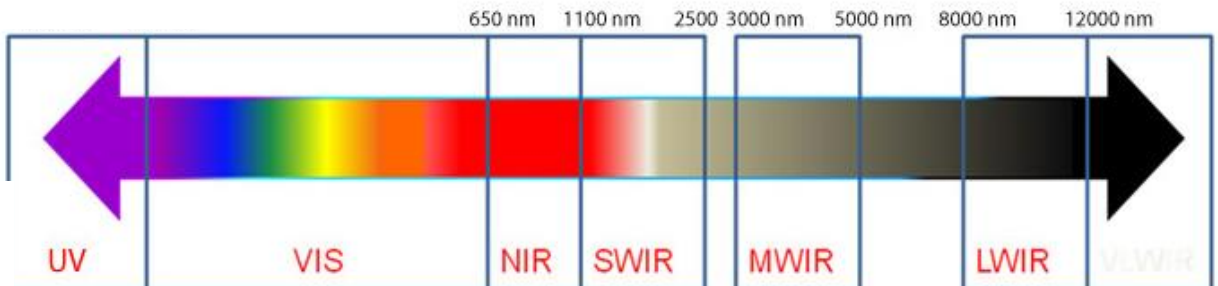
a. Updating of research on applications of remote sensing in Soil Science
b. Soil remote sensing data analyses by chemometric methods
c. Integration of the multi and hyperspectral sensors data for soil science
d. Use of the remote sensing data in digital soil mapping, precision agriculture, soil attributes prediction, land use, soil monitoring and environment soil impact.
e. Available platforms and data bases for soil remote sensing study
f. Research integration
g. Remote sensing and others soil science integration

Spectral Region

Today

Tomorrow





Mid IR for soil P (soluble and solid)

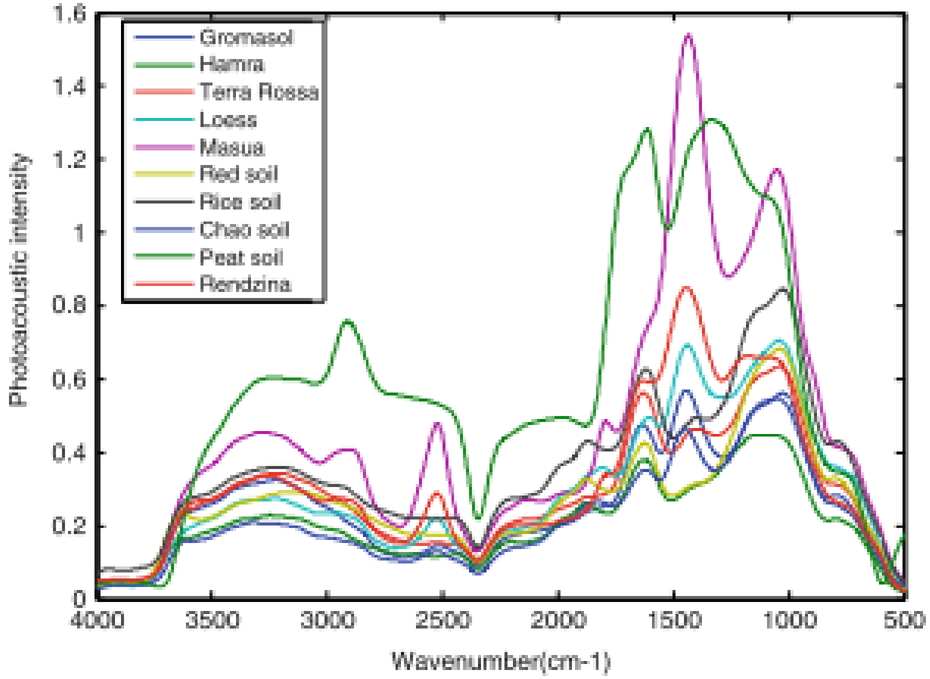
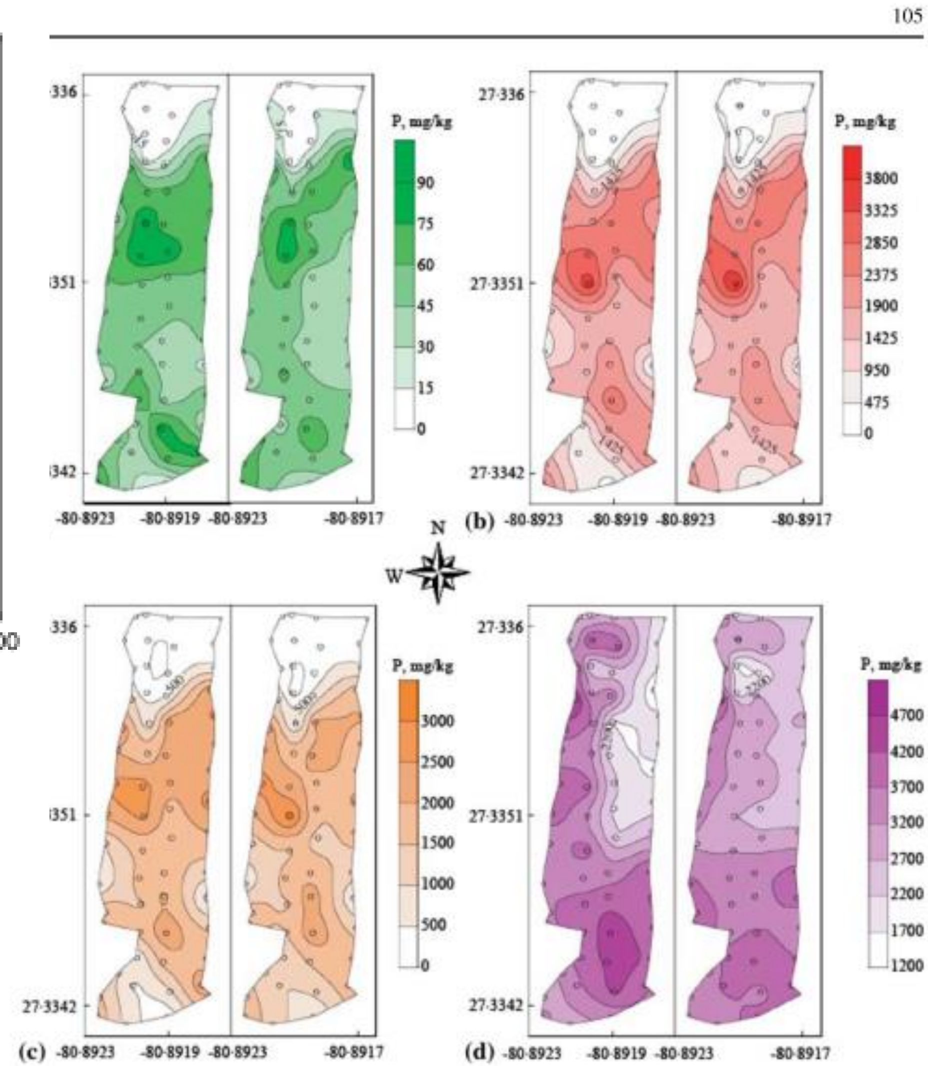


Fig. 8 Mid-infrared photoacoustic spectra of different soils



Du, C., & Zhou, J. (2009). Evaluation of soil fertility using infrared spectroscopy: a review. *Environmental Chemistry Letters*, *7*(2), 97-113.

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Space Programs

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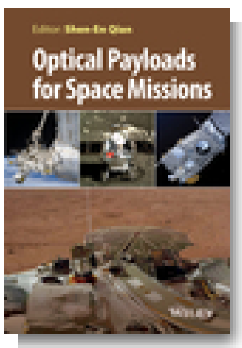
Space Programs

Optical Payloads for Space Missions, First Edition. Edited by Shen-En Qian.

Optical Payloads for Space Missions



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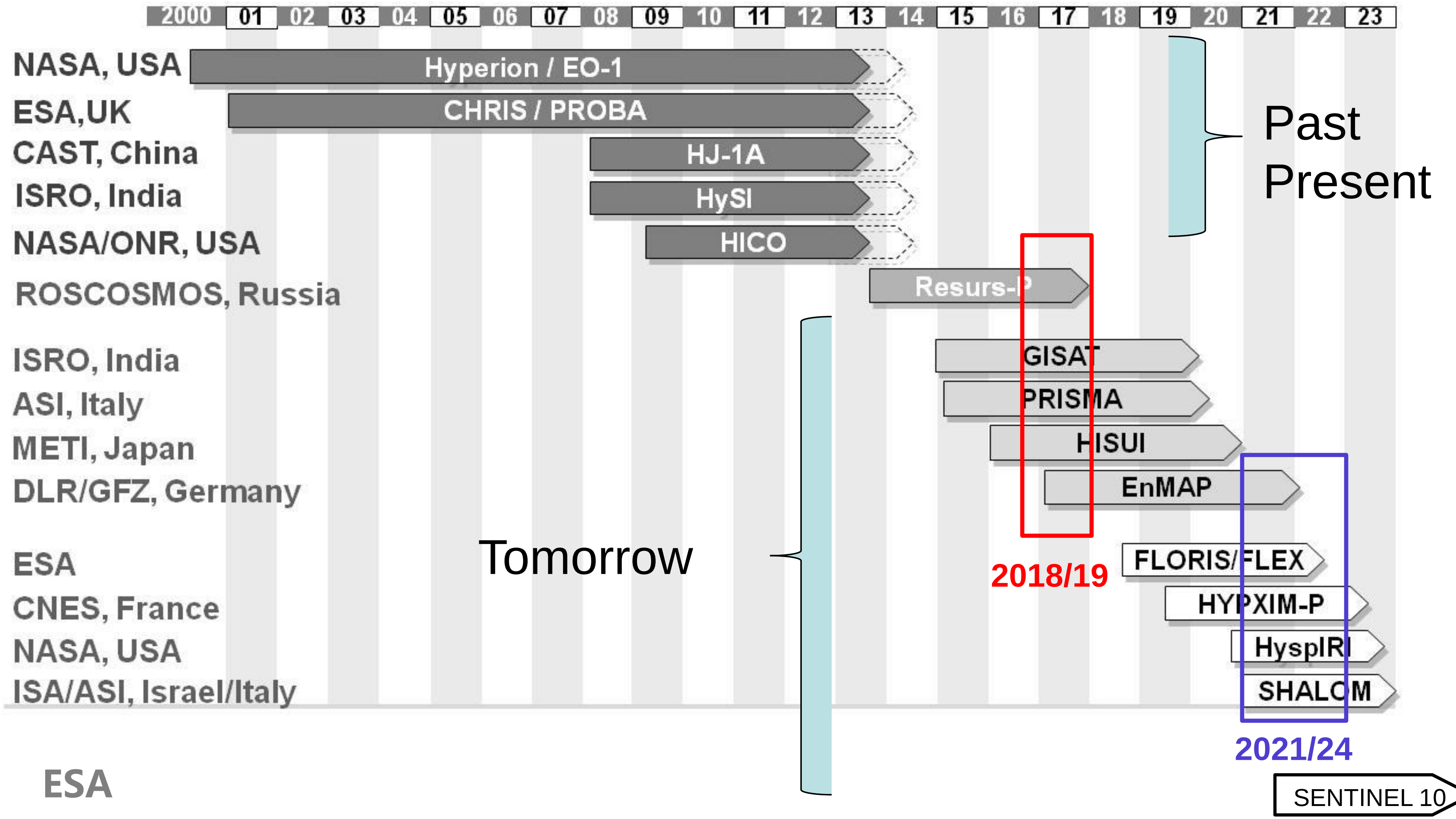
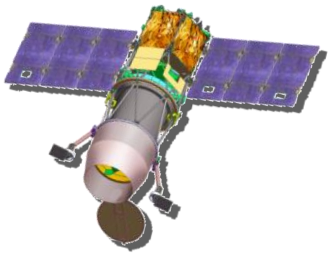
HSR Orbital Mission



Soil monitoring from space are playing a major role in SHALOM and SENTINEL 10 missions

Product Name
Crop, Rangeland and Invasive Species Map
Burnt Area Map
Vegetation Status Indicators
Vegetation Damage and Stress Indicators
Fire Fuel Map
Mineral Map
Coastal Bathymetry Map
Urban And industrial Functional Area Map
Lithological Map
Lava Flow Parameters
Soil Surface Pollutants Map
Volcanic Gas And Aerosol Emission Map
Forest Species Map
Forest Biomass Map
Ice Cover Map
Soil Characterization Map
Land Cover Map
Land Cover Change Detection Map
Snow Cover Map
Forest Nitrogen and Chlorophyll Map
Wetlands Classification Map
Marine And Aquatic Quality And Productivity Indicators
Lava and ash distribution map
Snow And Ice Cover Characterization

Soil Salinity: (gypsum, sodium)
Soil Minerals: (iron oxides, organic matter, clay, carbonates, CEC, SSA, Quartz)
Soil infiltration: (crust, classes)
Soil Formation: (clay, iron oxides)
Soil Erosion (Iron Oxised, Clay Minerals)
Soil Contamination: (heavy metals, TPH)
Soil Hydrophobicity (Organic Matter)
Soil Moisture: (H2O)
Soil Quality : (Bio Assay test)
Soil Nutrition (N, P,K)
Soil Degradation: (all the above)
Spectral Change Detection (all the above)
Many others by Indirect Relationship



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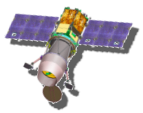
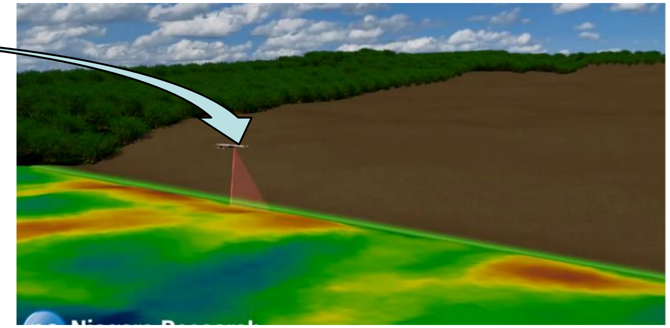
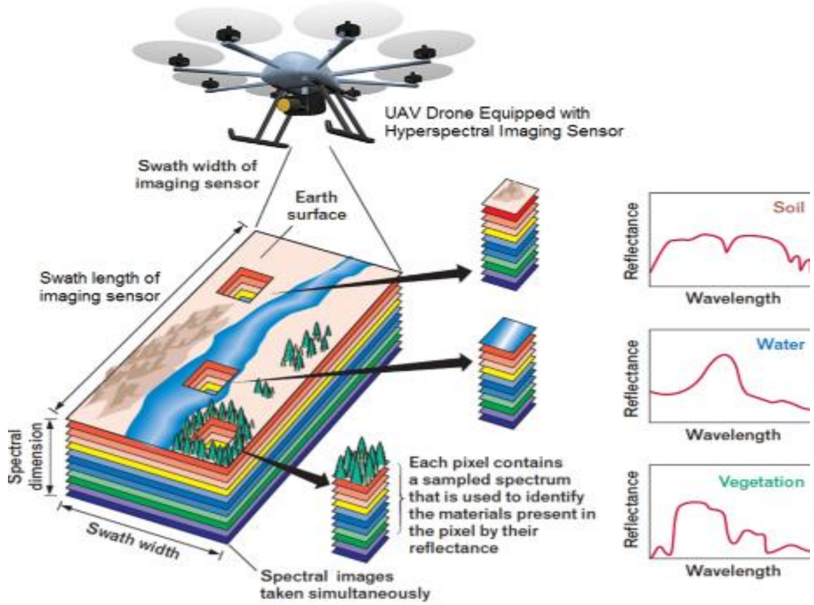
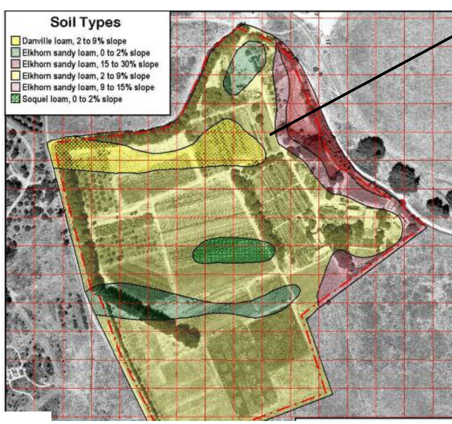






Model from SSL



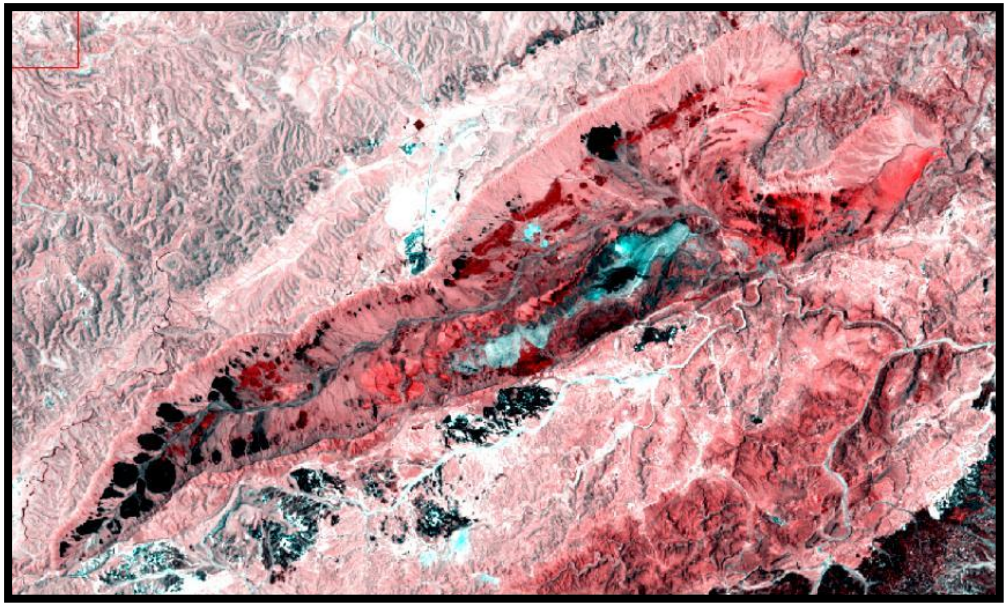
Tomorrow's vision

Conclusions

- Soil Hyperspectal Remote Sensing is a growing field with a growing recognition
- Soil Hyperspectral Remote Sensing has a great potential in many directions.
- The future is bright in soil spectral imaging base on the knowhow already accumulated and on the forthcoming advance technology (sensors, accessories, platforms)

Thank You for Your Attention

Makhtesh Ramon Israel



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