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

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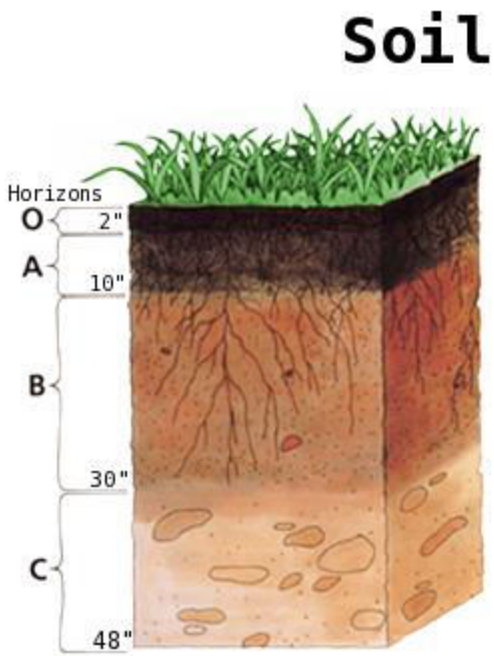
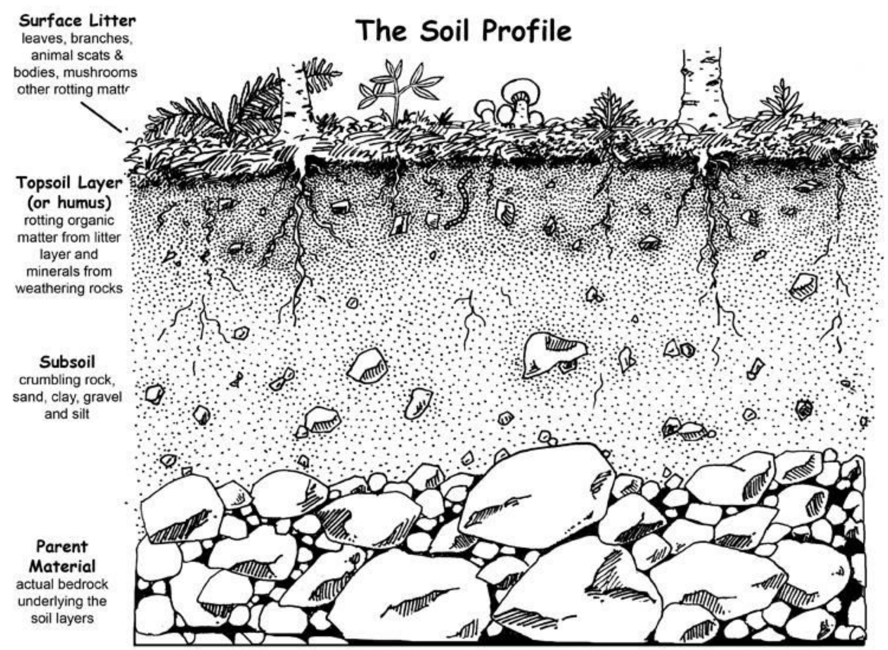
Definition 1

Soil

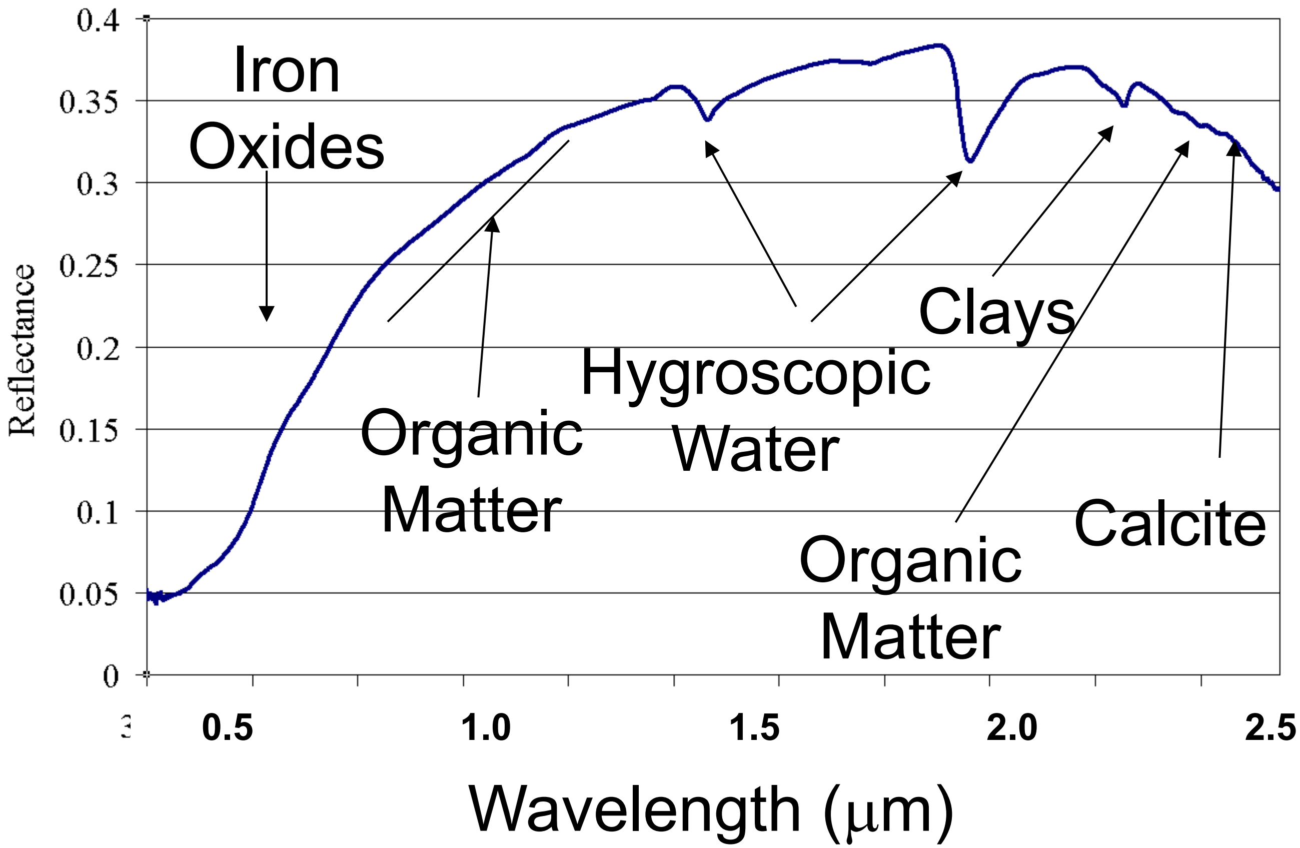
The upper l … material which is dug, … son 1957)

medium for plants to grow





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



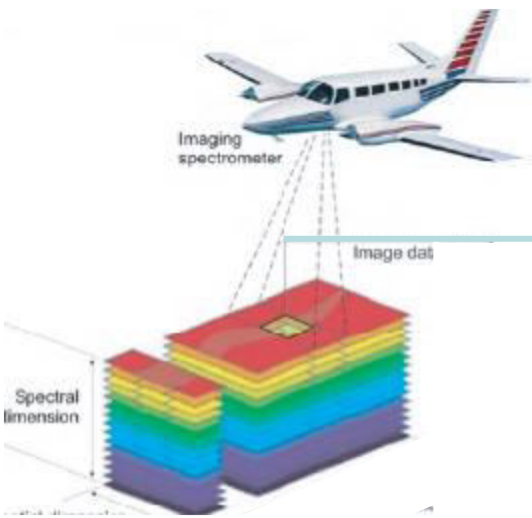
Strong Link between Point and Image Spectroscopy

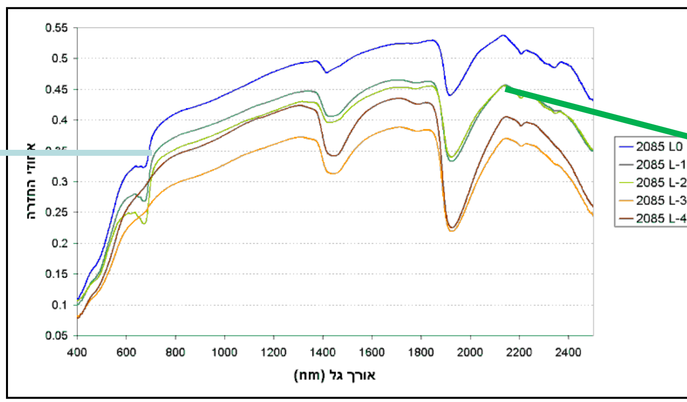
Image Spectroscopy

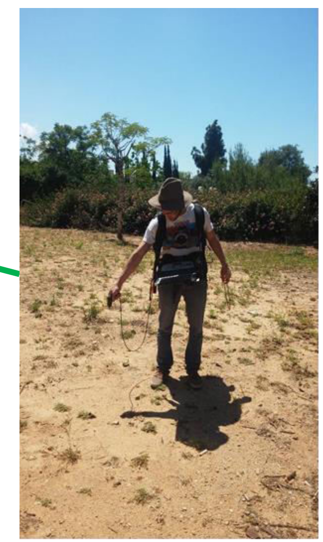
Geology
Vegetation
Water

Point Spectroscopy

Soil







Quantitative spectroscopy – Chemometrics

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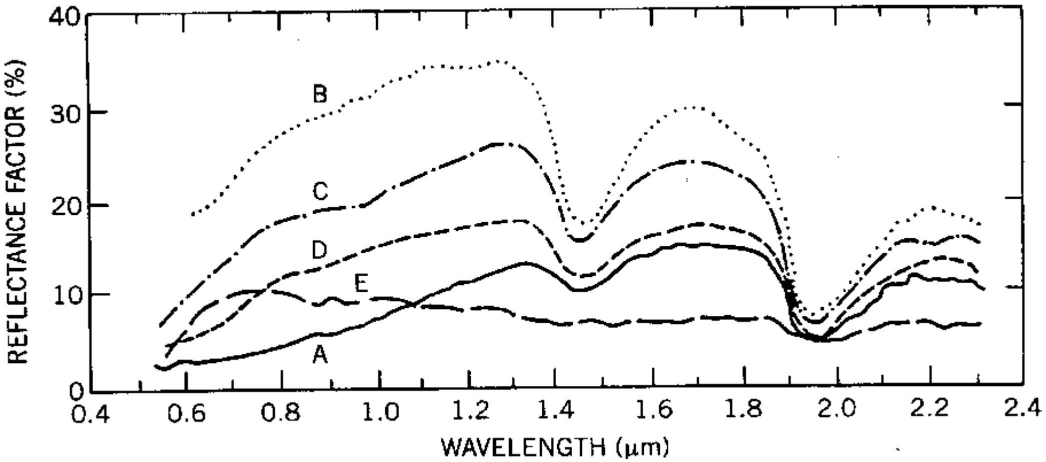
1980 –First Soil Spectral Library

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

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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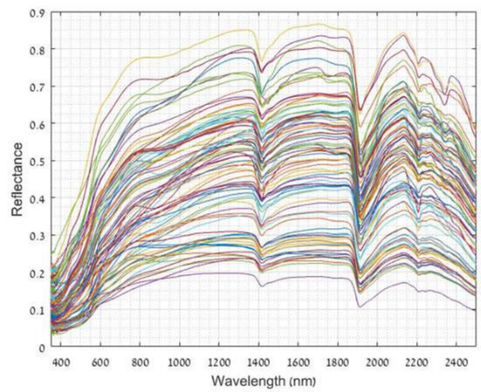
Today: Supervised Machine Learning for data mining

- 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

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Spectral Archive

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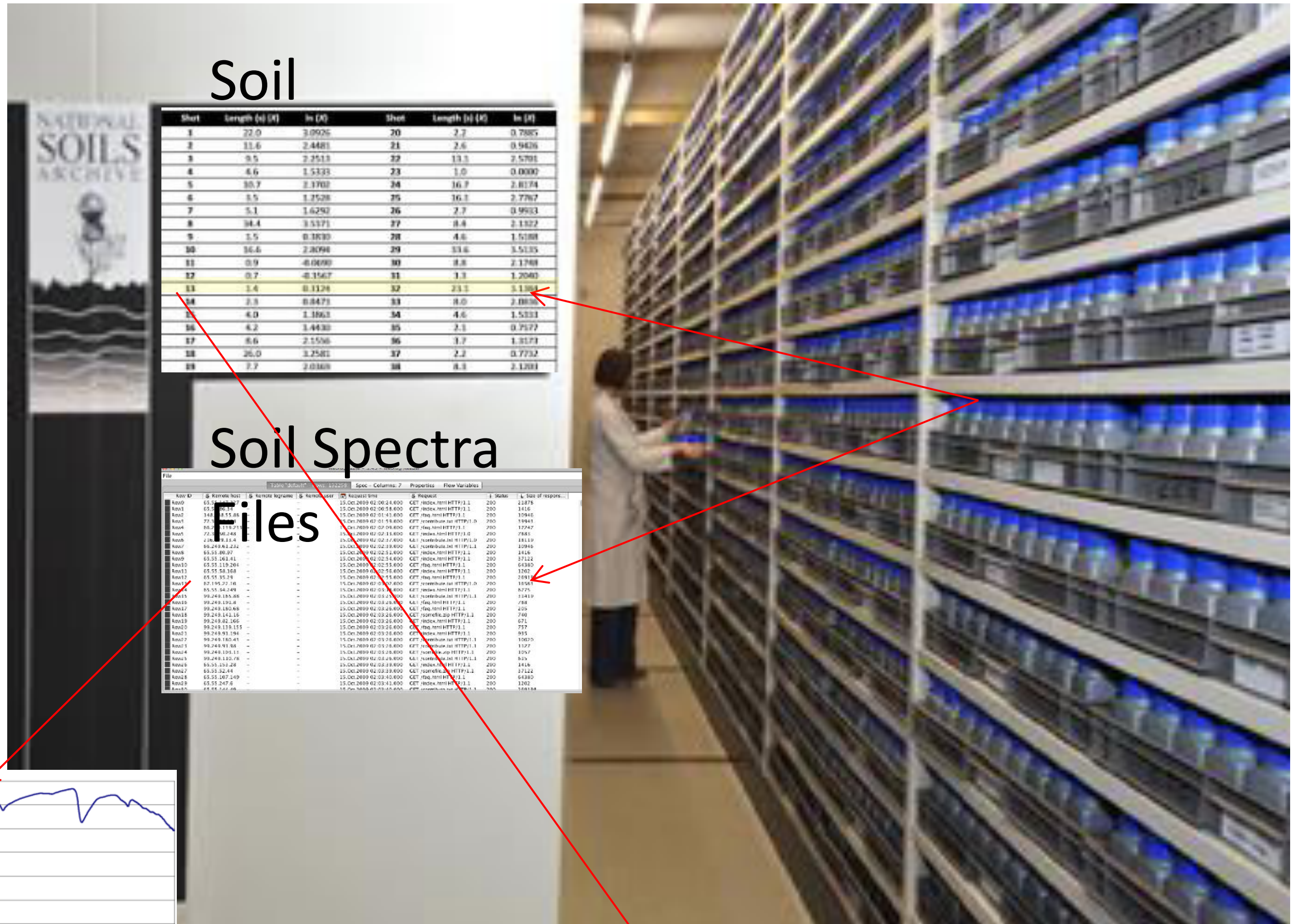
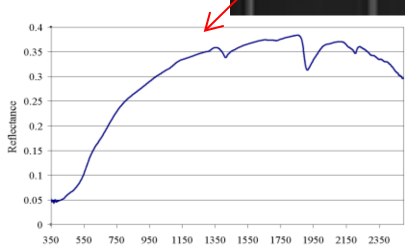
Soil Spectral Library : chemistry and spectroscopy



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	2.8098	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	0.8471	33	8.0	2.0806
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%

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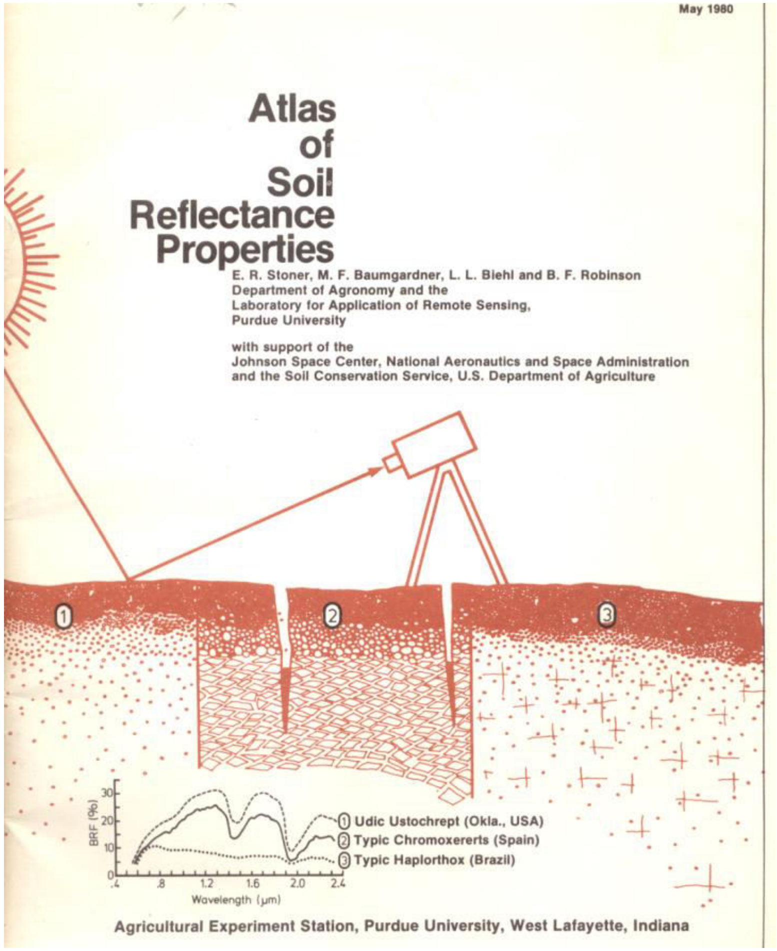
Past : 1980 –First Soil Spectral Library

Around 4000 spectra



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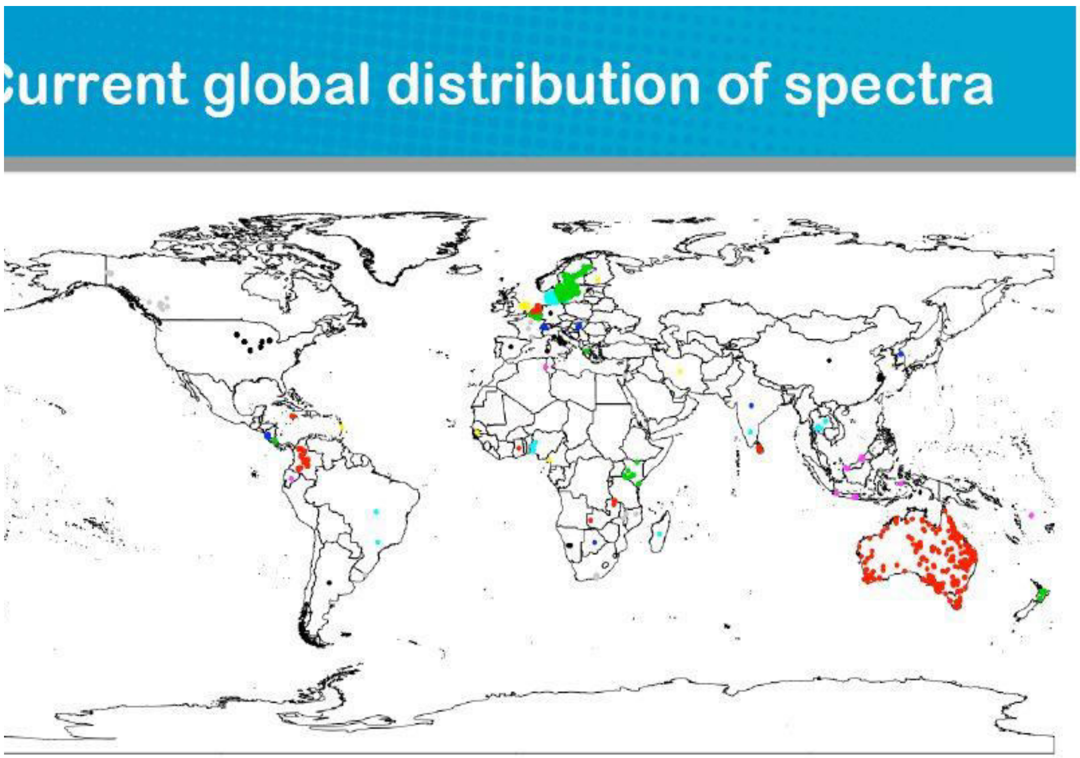
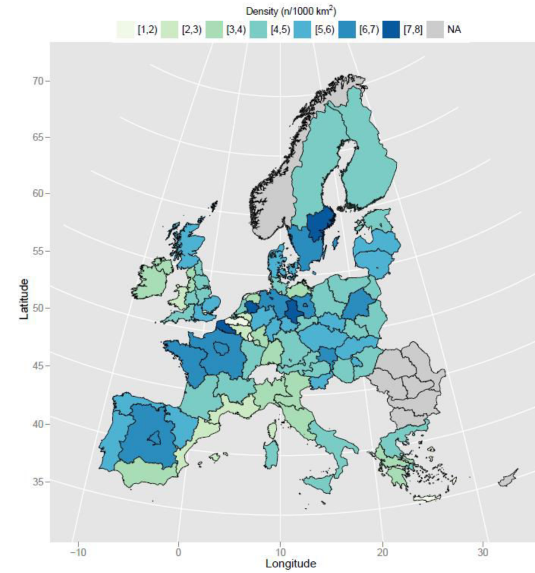
Today: World Soil Spectral Libraries (no measurement protocols) – many users





2016

2015

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

(1980 – **4,000)**

Today

There is a publication on the global library

Contents lists available at ScienceDirect

Earth-Science Reviews

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

A global spectral library to characterize the world's soil

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]

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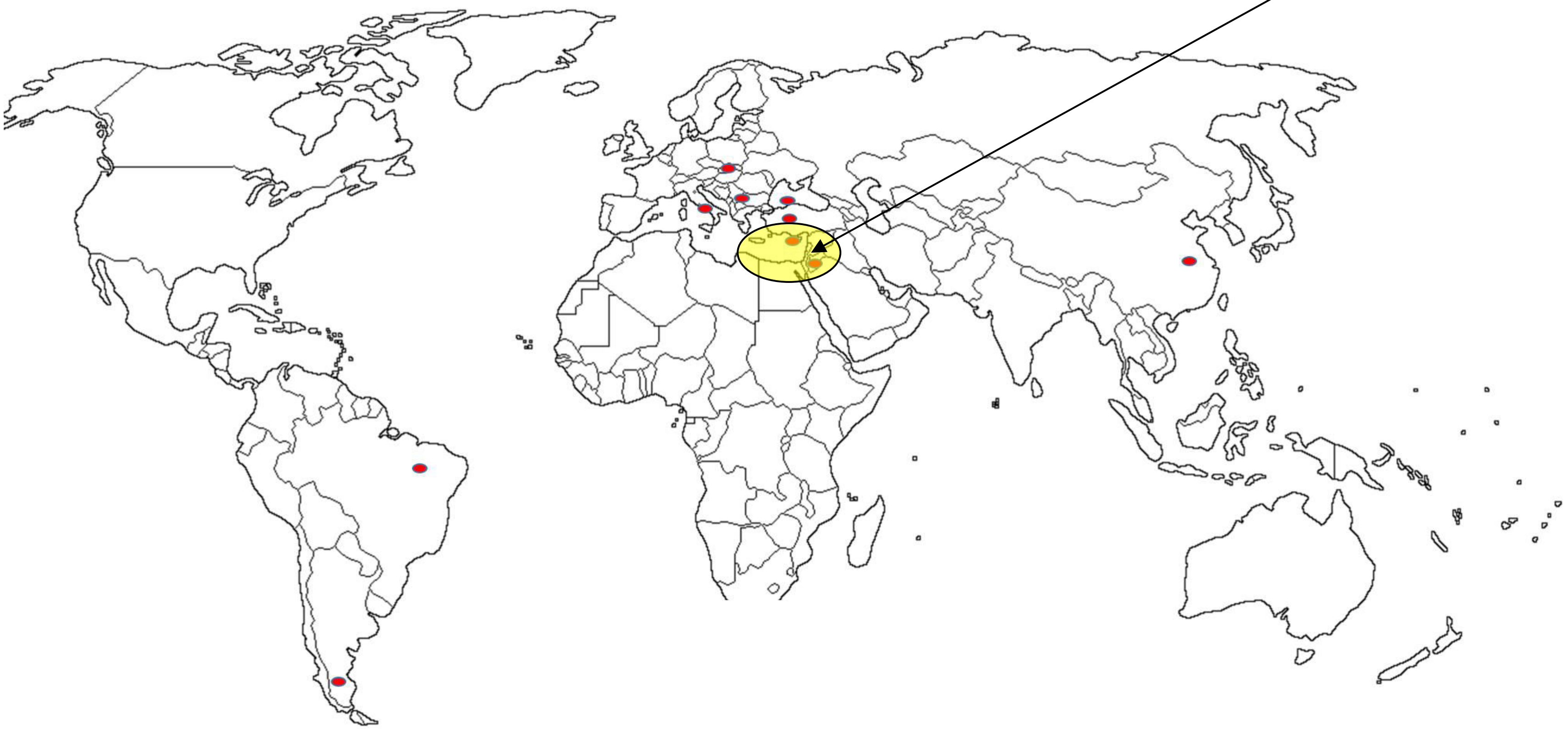
Tomorrow : *New Standard world wide Soil Spectral Library*

World Soil Spectral Library under ISS protocell



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Imaging Systems

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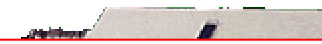
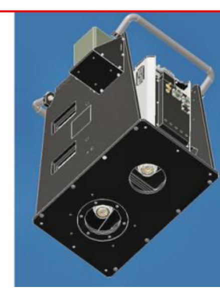
from heavy (past) to light sensors (present and future)



Petri SPECIM March 23, 2015

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



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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)

Interest

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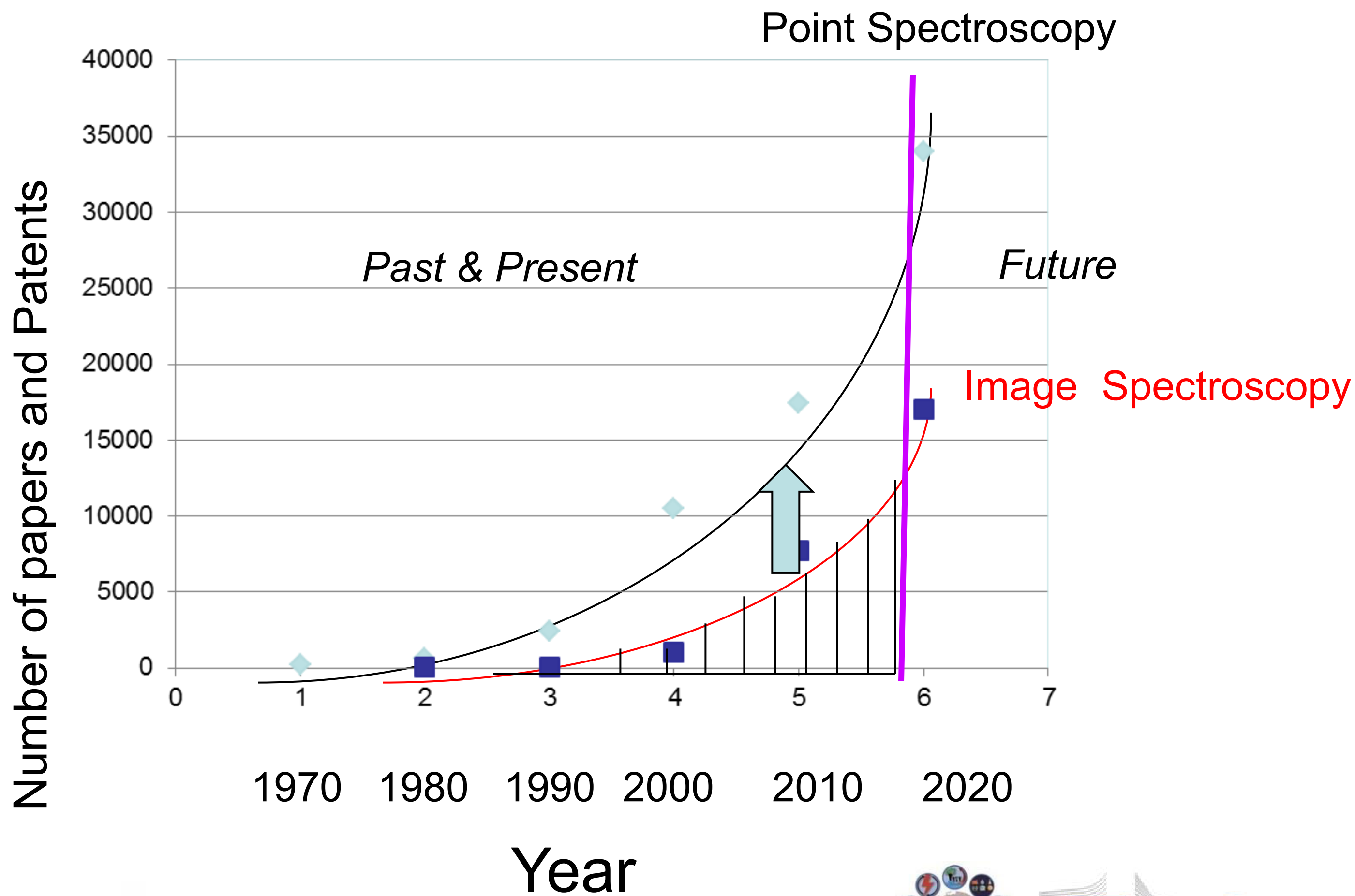
Interest

How point spectroscopy driven the image spectroscopy of soils



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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

25.1 Introduction 709
25.2 Soil 709
Soil System • Soil Composition
25.3 Remote Sensing 711
General
25.4 Remote Sensing of Soils 718
25.5 Soil Reflectance Spectroscopy 718
Definition • Historical Notes • Radiation Interactions with a Volume of Soil
Radiation Source and Atmospheric Windows 724
General • Factors Affecting Soil Reflectance in Remote Sensing
Quantitative Aspects of Soil Spectroscopy 728
Proximal Sensing • Application Notes • Constraints and Cautions in Using Proximal Remote Sensing for Soils
Soil Reflectance and Remote Sensing 730
General • Application of Soil Remote Sensing: Examples
Summary and Conclusions 750
...nces 751

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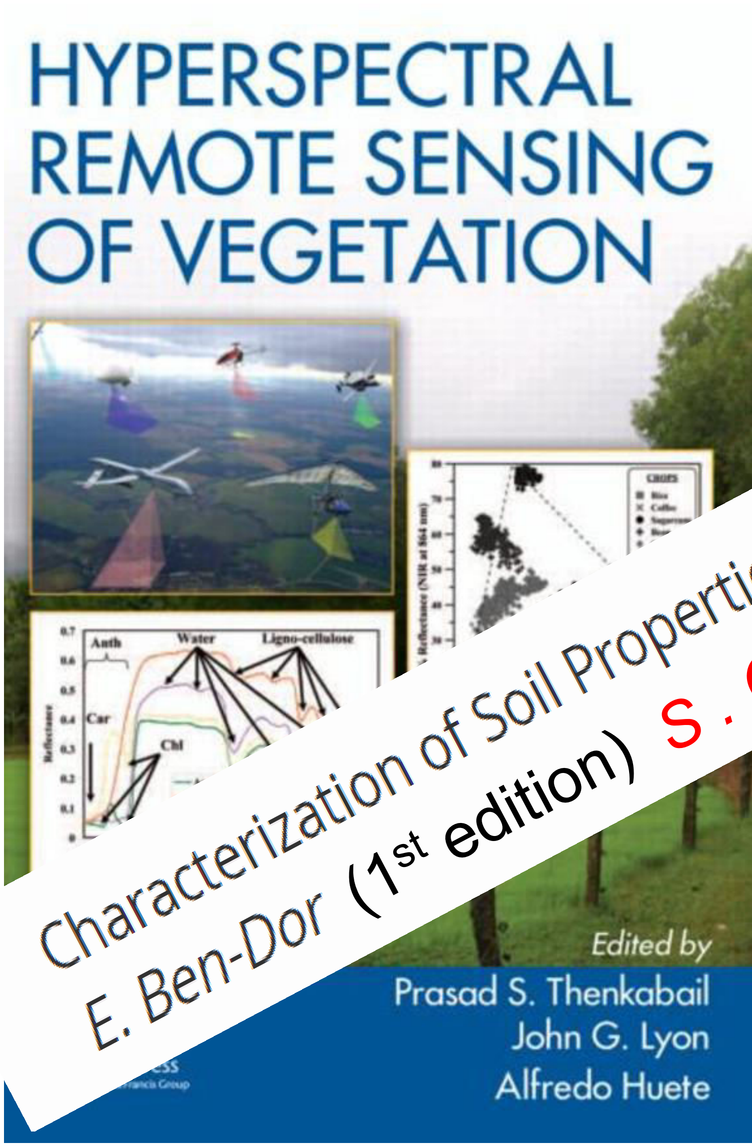

Characterization of Soil Properties Using Reflectance Spectroscopy

E. Ben-Dor (1st edition)

S. Chabrillat and J. Dematte (2nd edition)

Tomorrow

Table of Contents

Introduction and Overview

Advances in Hyperspectral Remote Sensing of Vegetatior
Prasad S. Thenkabail, John G. Lyon, and Alfredo Hu

Hyperspectral Sensor Systems

Hyperspectral Sensor Characterist
Mounted; Integration of Hyp
Fred Ortenberg

Species Iden

Crop ... Data
...piphanio, Fábio Marcelo Breunig, and

...ecies in Tropical Forests Using Hyperspectral Data

...d Mapping Invasive Plant Species by Using Hyperspectral Data
...g Pu

Land Cover Applications

Hyperspectral Remote Sensing for Forest Management
Valerie Thomas

Hyperspectral Remote Sensing of Wetland Vegetation
Elijah Ramsey III and Amina Rangoonwala

Characterization of Soil Properties Using Reflectance Spectroscopy
E. Ben-Dor

Detecting Crop Management, Plant Stress, and Disease

Analysis of the Effects of Heavy Metals on Vegetation Hyperspectral Reflectance Properties
E. Terrence Slonecker

Hyperspectral Narrowbands and Their Indices on Assessing Nitrogen Contents of Cotton Crop Applications
Jianlong Li, Cherry Li, Dehua Zhao, and Chengcheng Gang

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

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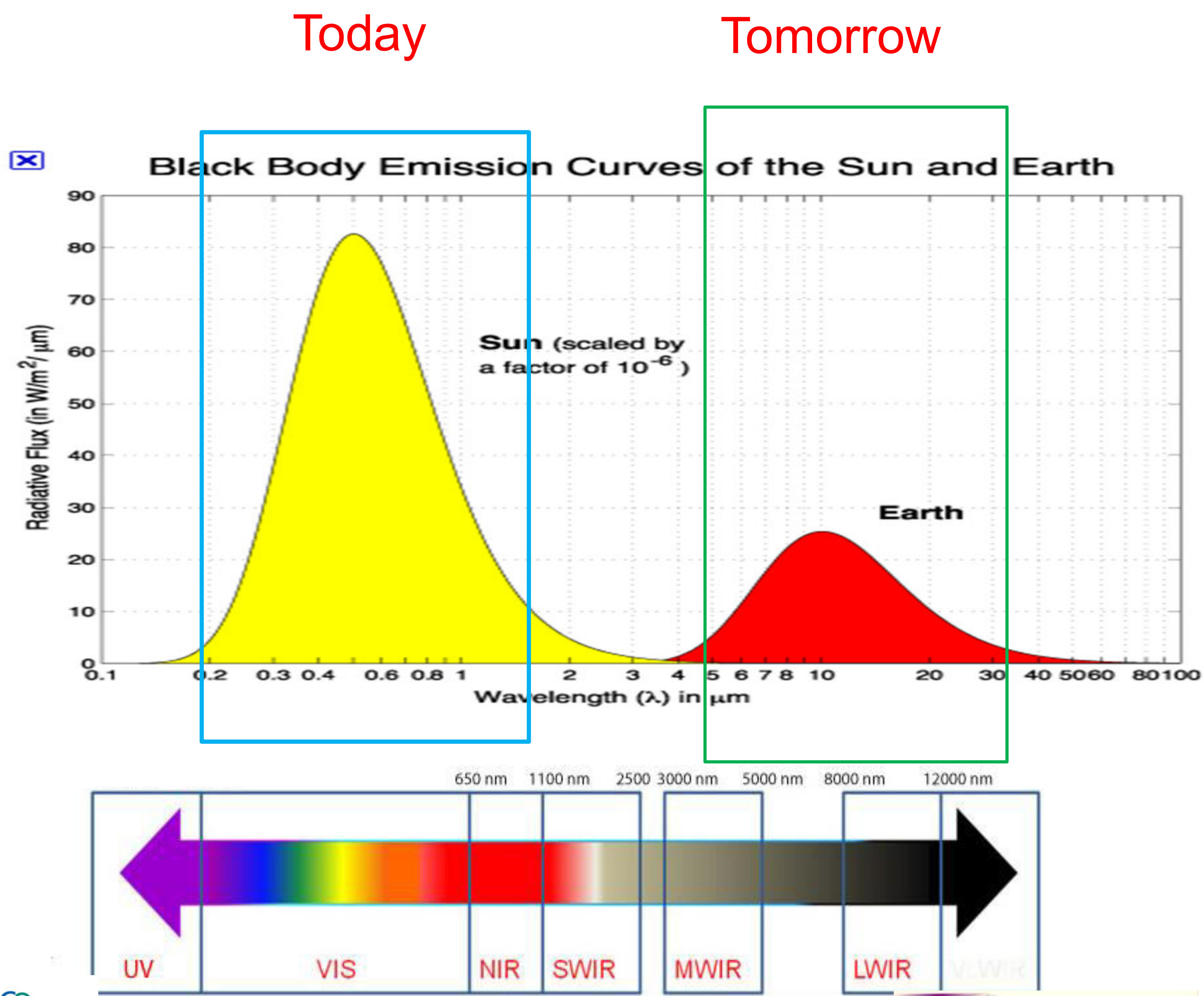
Spectral Region



Today
Tomorrow
Black Body Emission Curves of the Sun and Earth
Radiative Flux (in W/m2/ µm)
Sun (scaled by a factor of 10-6)
Earth
Wavelength (λ) in µm
650 nm
1100 nm
2500
3000 nm
5000 nm
8000 nm
12000 nm
UV
VIS
NIR
SWIR
MWIR
LWIR

Mid IR for soil P (soluble and solid)

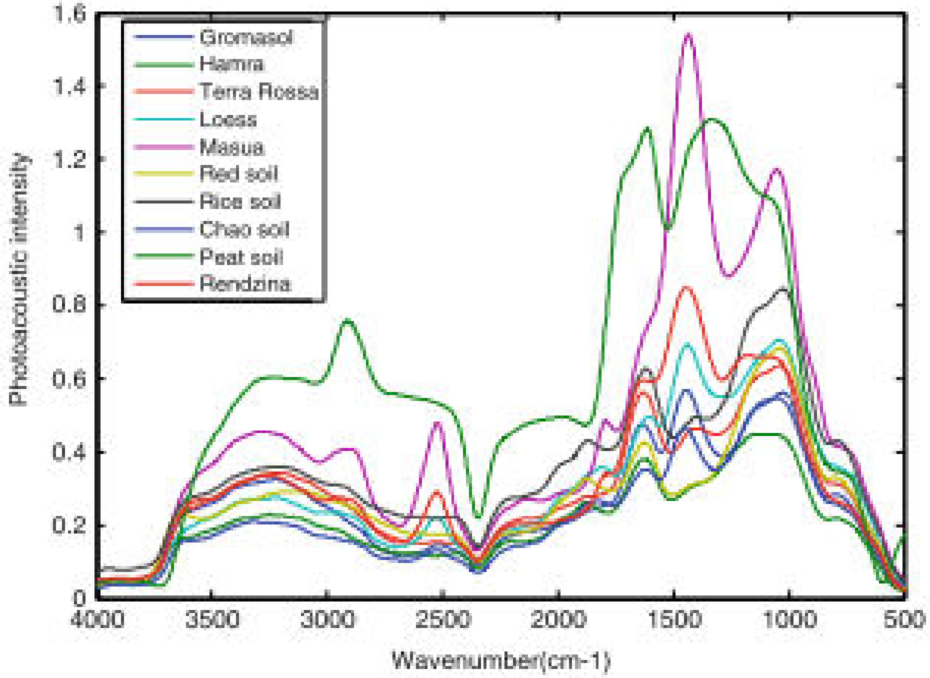
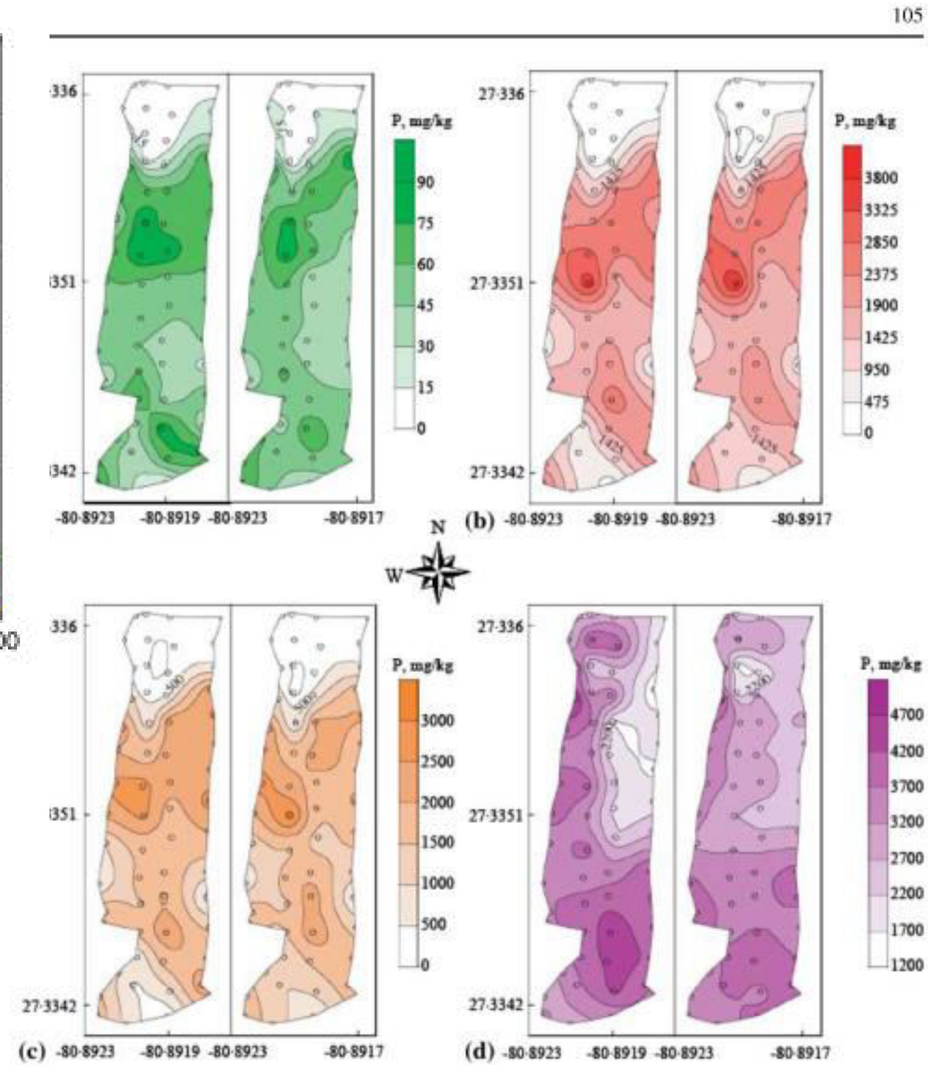


Fig. 8 Mid-infrared photoacoustic spectra of different soils



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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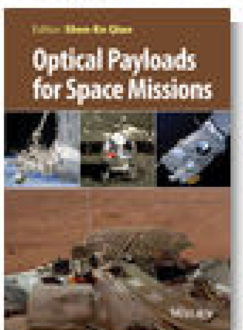
Space Programs

Space Programs

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

Optical Payloads for Space Missions



Editor(s): Shen-En Qian

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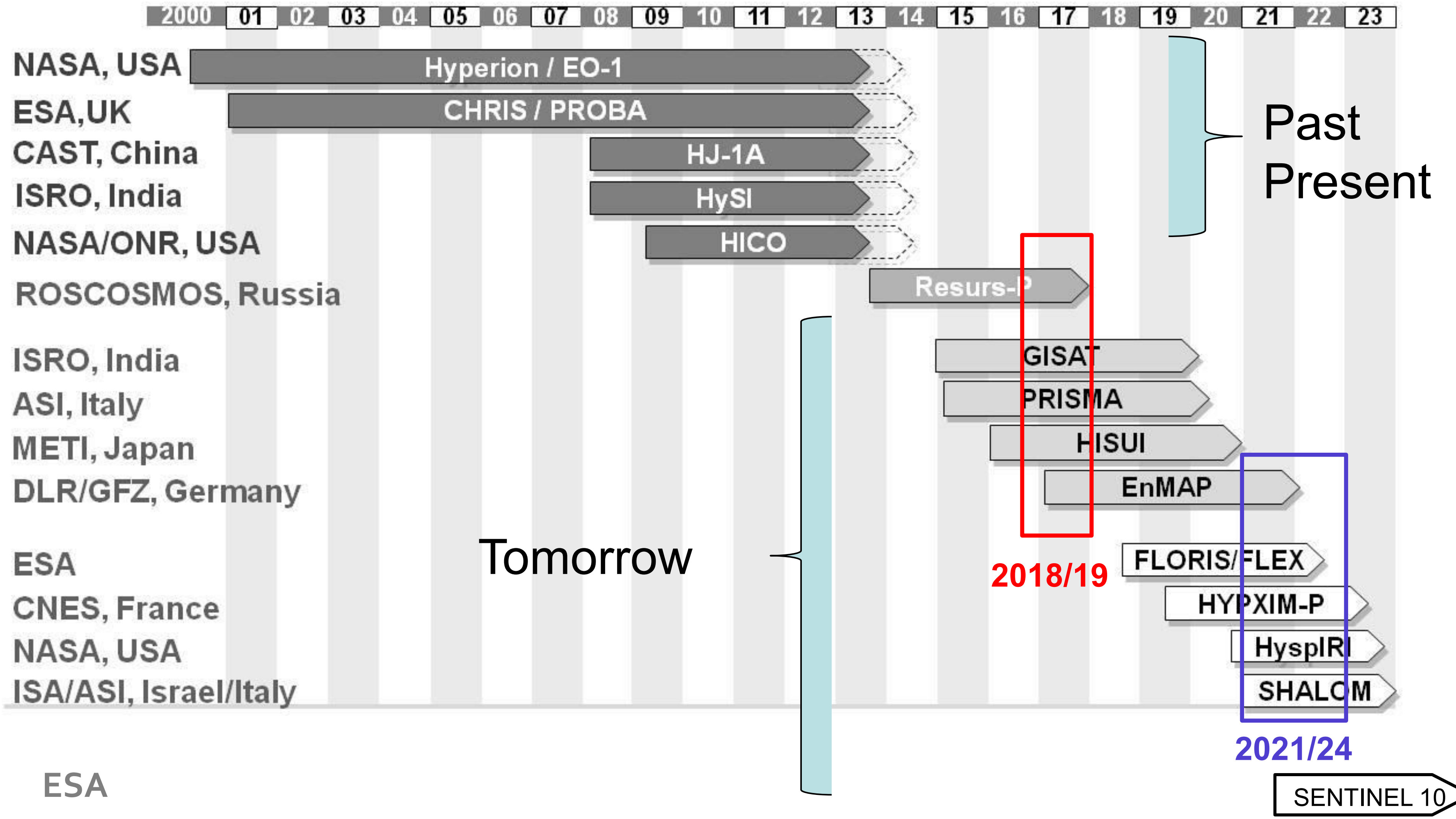
HSR Orbital Mission



ESA

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: (H_2O)

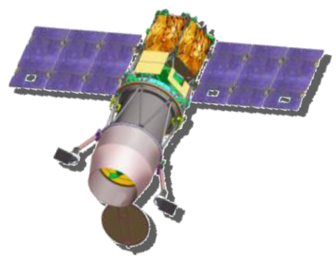
Soil Quality : (Bio Assay test)

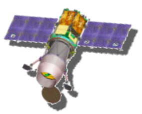
Soil Nutrition (N, P,K)

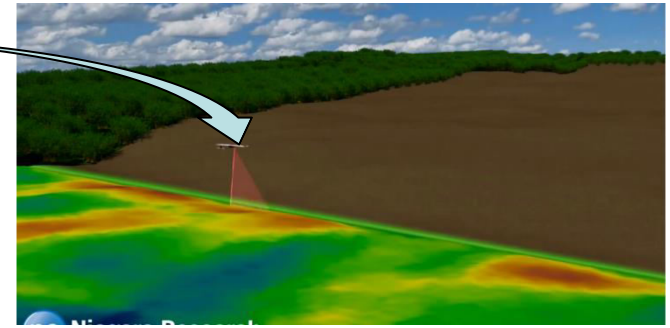
Soil Degradation: (all the above)

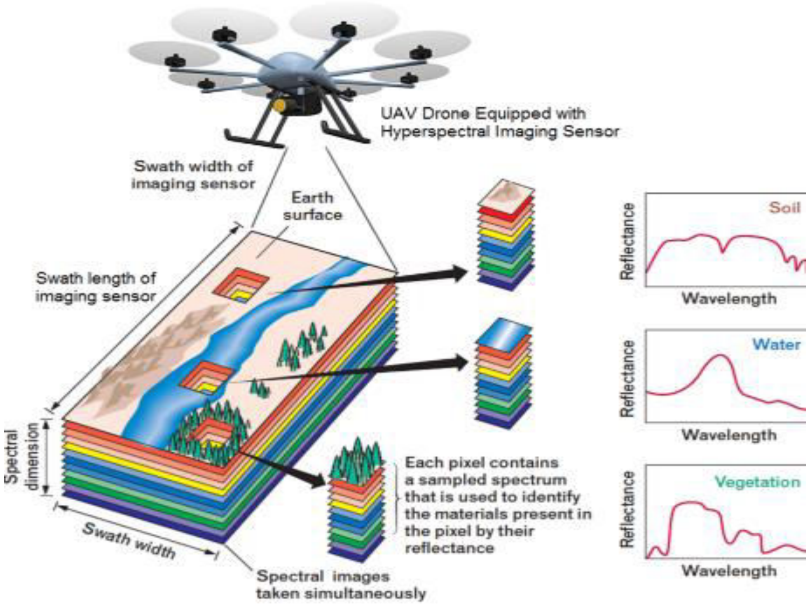
Spectral Change Detection (all the above)

Many others by Indirect Relationship

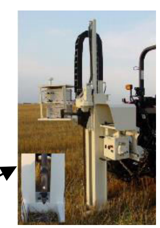


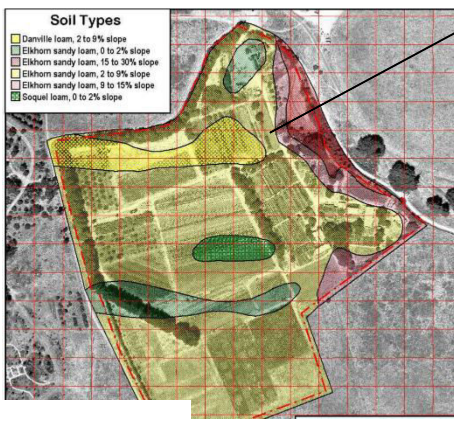






Model from SSL





Tomorrow's vision

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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)

SSL Israel

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Collecting Soil samples for local ISS

from:

RSL field survey

Ministry of Agriculture

Sherut Sade – Field Survey

Soil Conservation and Drainage monitoing unit

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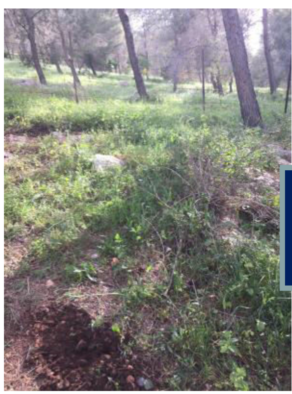
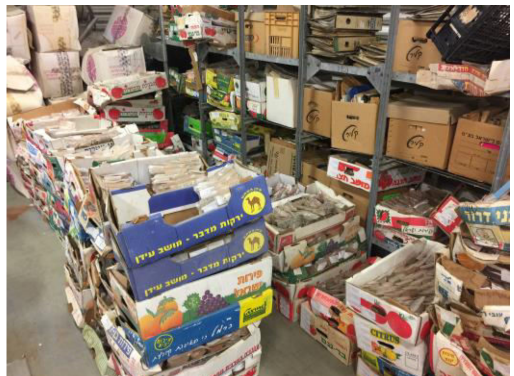
RSL Field survey



756

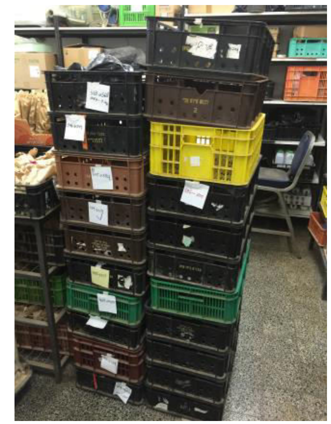
Ministry of agriculture



78
(potential for >2000)

1790

Sherut Sade (Zemach & Neve Yaar)



956

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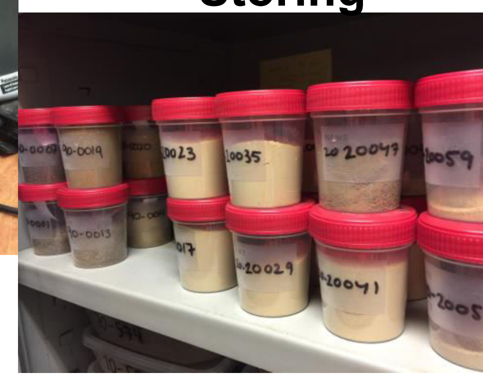
Locating (field/storage)

Cataloging

Measuring

Storing



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Important Points to established SSLs

- **Samples selection** – Need to represent the soil orders of the country (GEO-CRALE)
- **Meta Data** – Need to be organized at a standard way (GEO-CRADLE)
- **Soil Attributes** – Need to be obliged (5 attributes, GEO-CRADLE) and optional (OPEN)
- **Chemical Analyses** – At the same protocol and experimental errors must be provided (OPEN)
- **Spectral Measurement** – Under standard and protocol (GEO-CRADLE)
- **Data archiving** –Book's Library protocl (for finding samples on the shelves) (GEO-CRADLE)
- **Digital filing and saving format** – an agreed structure (GEO-CRADLE)

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Thank You for Your Attention

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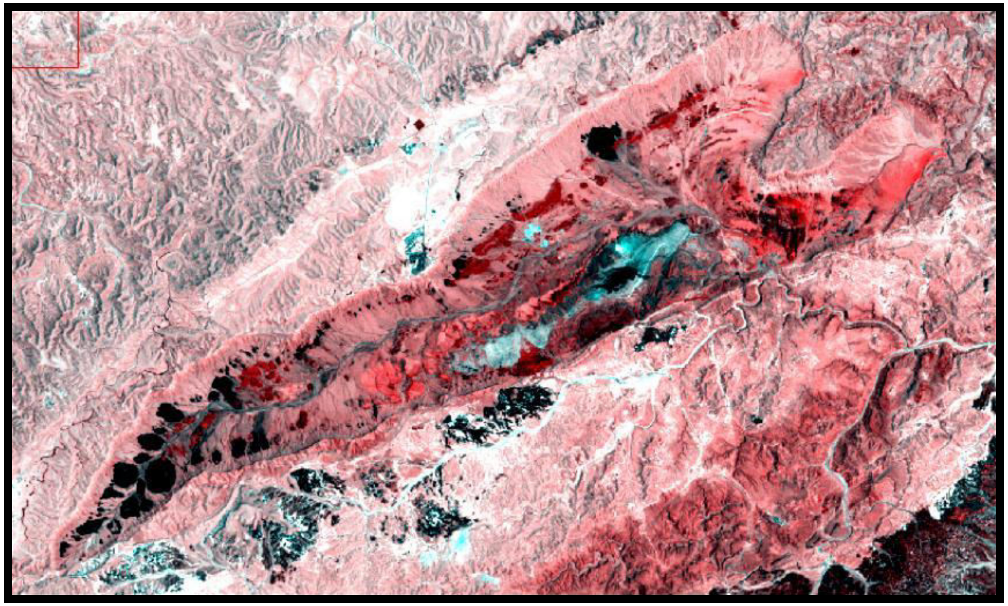

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