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

GEO-CRADLE webinar (4.2)

Wednesday, 14th June, 2017

Soil, spectroscopy and SSL

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THE REMOTE SENSING LABORATORIES

The GEO-CRADLE project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No .690133

HORIZON 2020

Highlights

- The role of GEO-CRADLE

  The importance of building a global SSL

- Introduction to soil science

Composition and its role in agriculture

- Basic principles of spectroscopy

- Soil spectroscopy

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The importance of building a global SSL

Why Global Soil Spectral Library?

Data mining from spectral information to generate an attribute "model" requires hundreds of samples in order to provide reliable results

Global Soil Spectral Library (GSSL) will compose of hundreds samples that represents all the soils world wide

The need of Soil Spectral Library

- For quantitative applications: many soil samples are needed (**Soil data mining of a “model” requires hundreds of spectra samples in order to provide reliable results.**

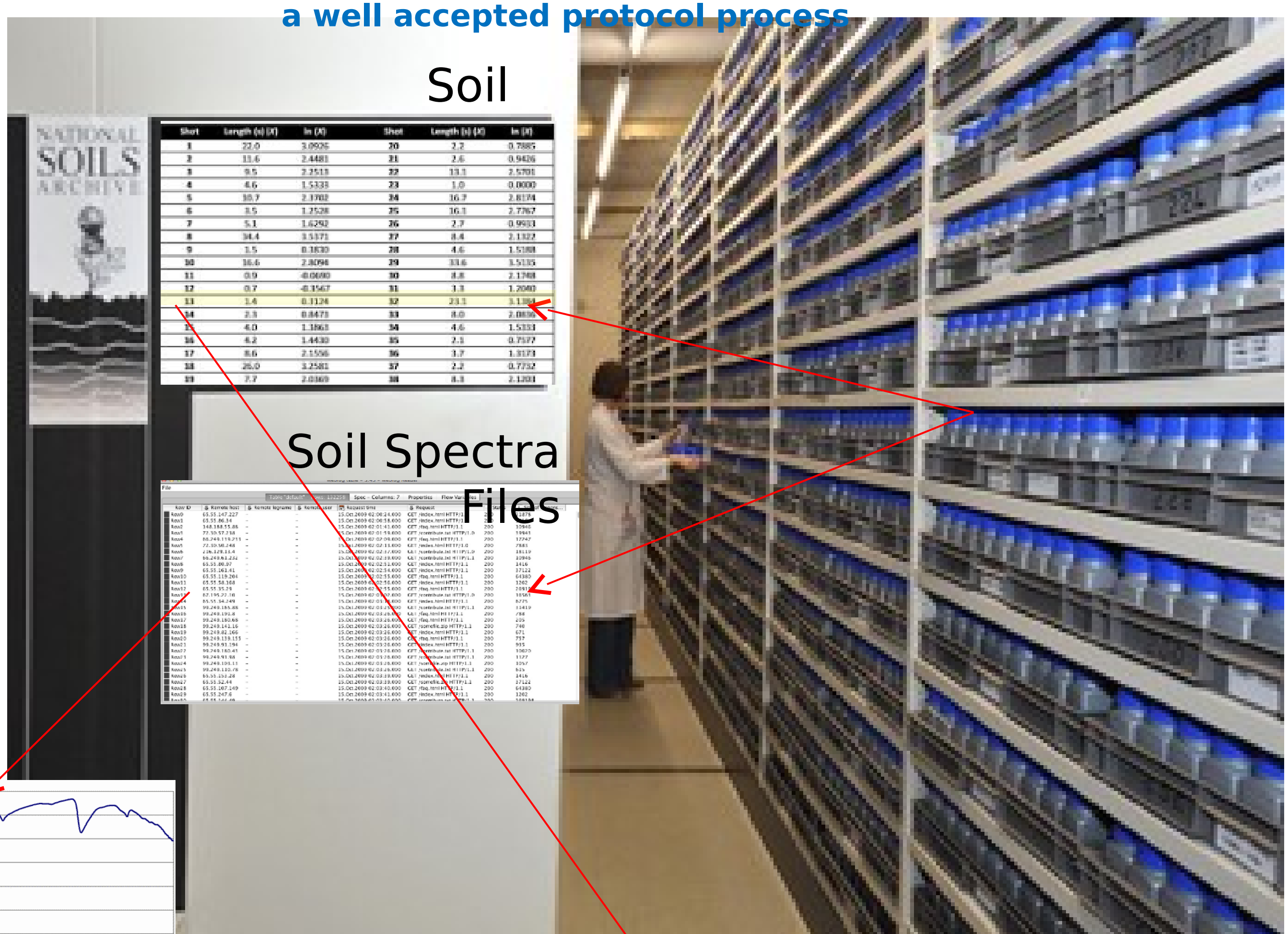
- Users are gathering many soil samples mostly under local scale.

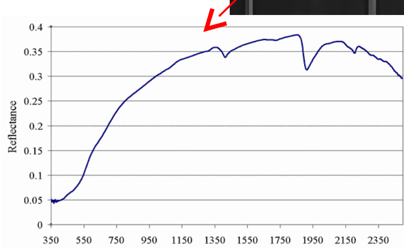
- A need for regional and global scales’ library is essential.

- Gathering local and regional spectral data (soil spectral library) needs agreed “standard and protocols”

Soil Spectral Library : The Practical Structure

Soil samples at storage, with wet chemistry data plus reflectance spectra measured under a well accepted protocol process





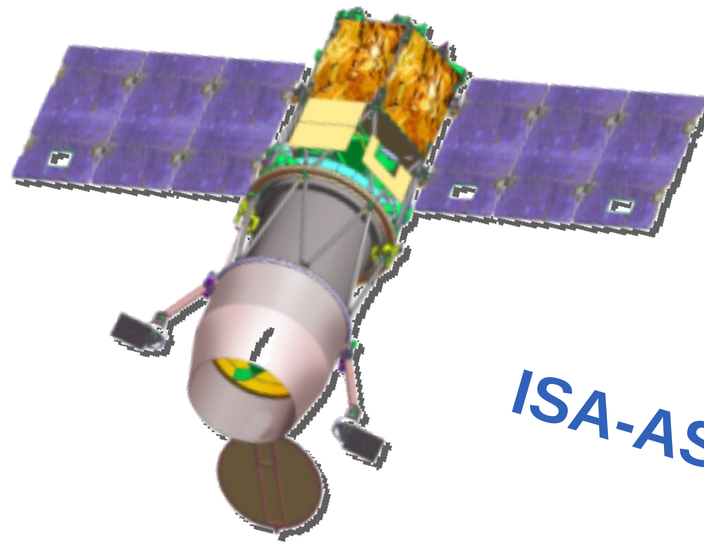
Sample	Location	OM	Clay ….Lime
A1	34,5467.67	2.4 %	34% 23.4%

e Concept of Soil Mapping using SSL and HSR from orbit

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

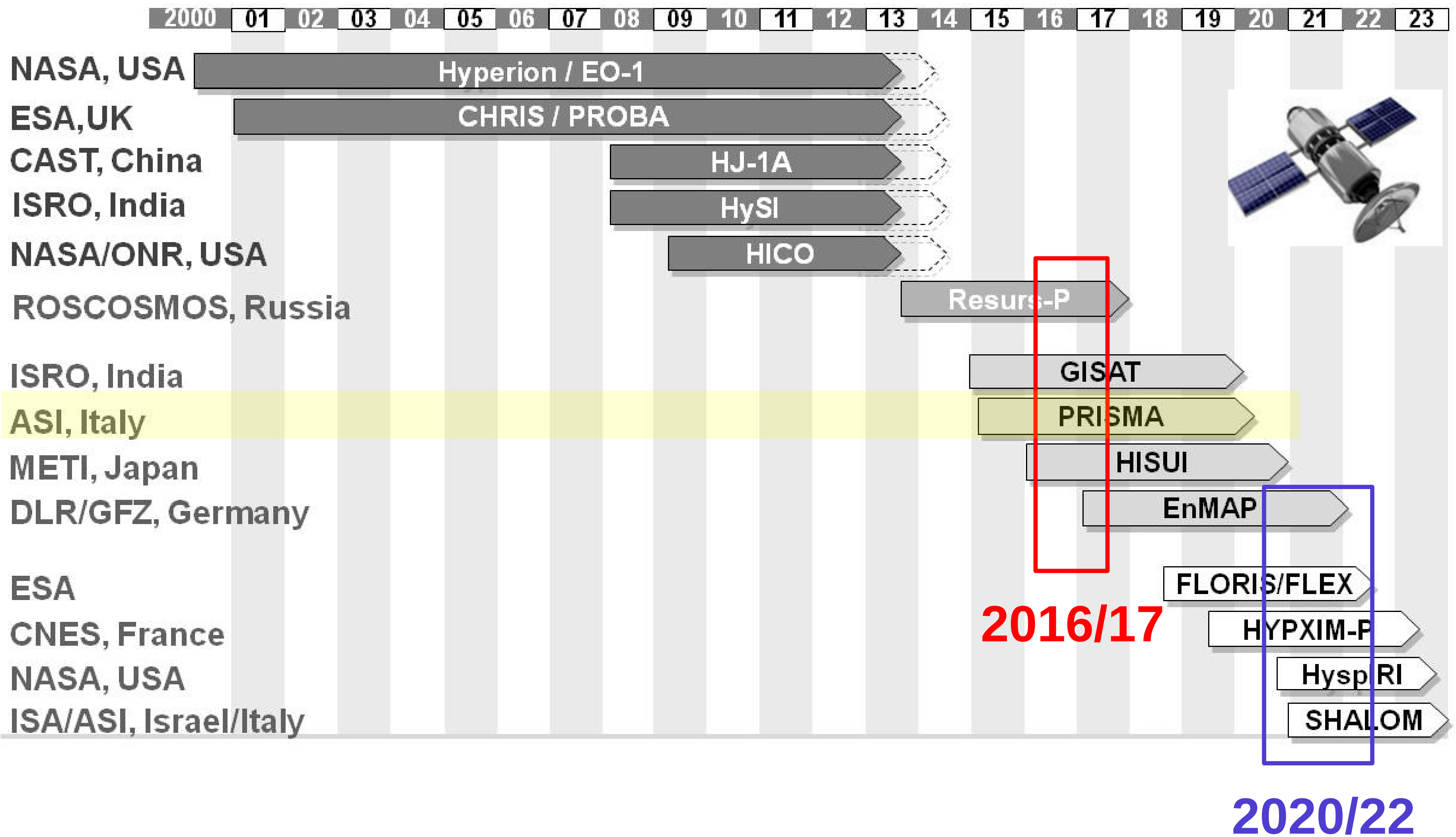
SHALOM (9m GDS)

SHALOM products that are based on GSSL



ISA-ASI

HSR Satellites

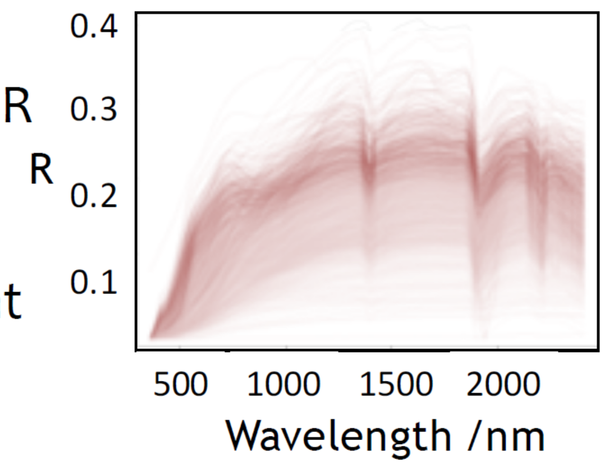


The Global Soil Spectral Library (GSSL)

In 2006 *Raphael Viscorra Rossel* understood the GSSL importance and initiated an activity toward establishing the first GSSL

Global spectral library project

- Started in 2008 as voluntary collaboration in response to growing interest in soil vis–NIR spectroscopy



- Scientists from each continent coordinated and developed guidelines and protocols
- Aim to bring together a community of scientists, encourage research, development of new applications and adoption of spectroscopy in the soil, earth and environmental sciences.

provided by Viscorra Rossel

First World Soil Spectral Library

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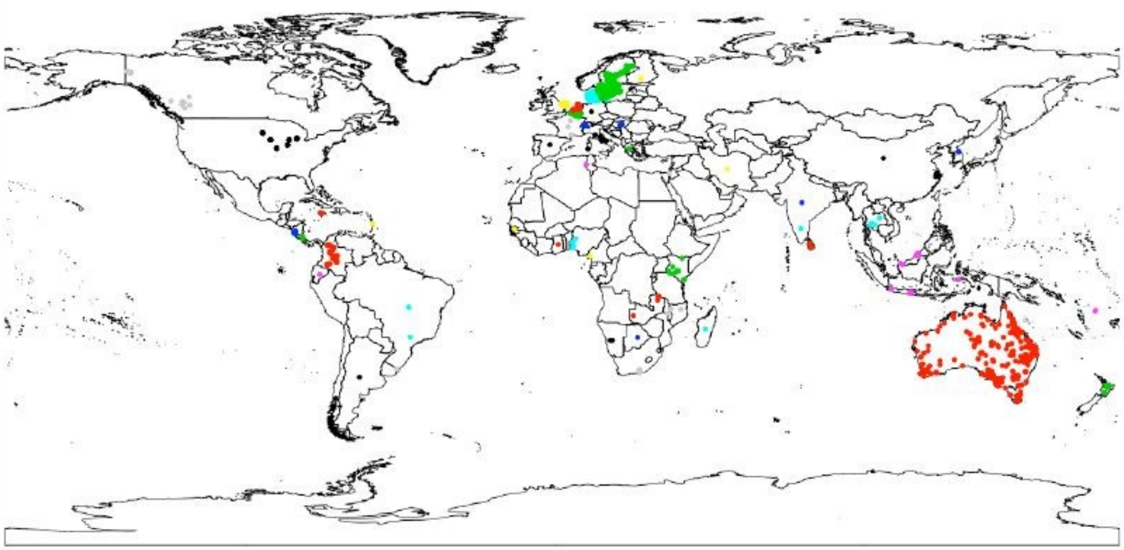
2008

Current global distribution of spectra

Argentina	64
Australia	355
Belgium	262
Botswana	4
Brazil	528
Brunei	147
Cameroon	1
Canada	130
China	147
Colombia	172
Costa Rica	49
Cuba	15
Denmark	210
Ecuador	8
Finland	1
France	233
Germany	183
Ghana	1
Greece	1
Hungary	17
India	2
Indonesia	7
Iran	142
Israel	220
Italy	100
Jamaica	3
Kenya	100
Korea	92
Madagascar	18
Malaysia	2
Martinique	67
Mozambique	6
Namibia	4
Netherlands	95
New Zealand	210
Nicaragua	23
Nigeria	7
Samoa	3
Senegal	72
South Africa	113
Spain	493
Sri Lanka	6
Sweden	396
Switzerland	160
Thailand	6
Tunisia	89
UK	392
Uruguay	2
USA	1361
Zambia	6



Total of 6721 spectra

Not all representative – e.g. China only field-scale data

Coords for Brazil, Argentina and Ecuador coming

Coords for large part of USA still to be added

No samples in Russia and eastern Europe

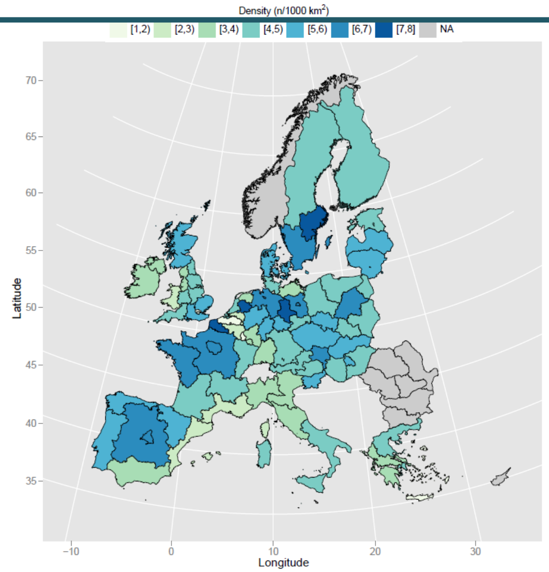
CSIRO

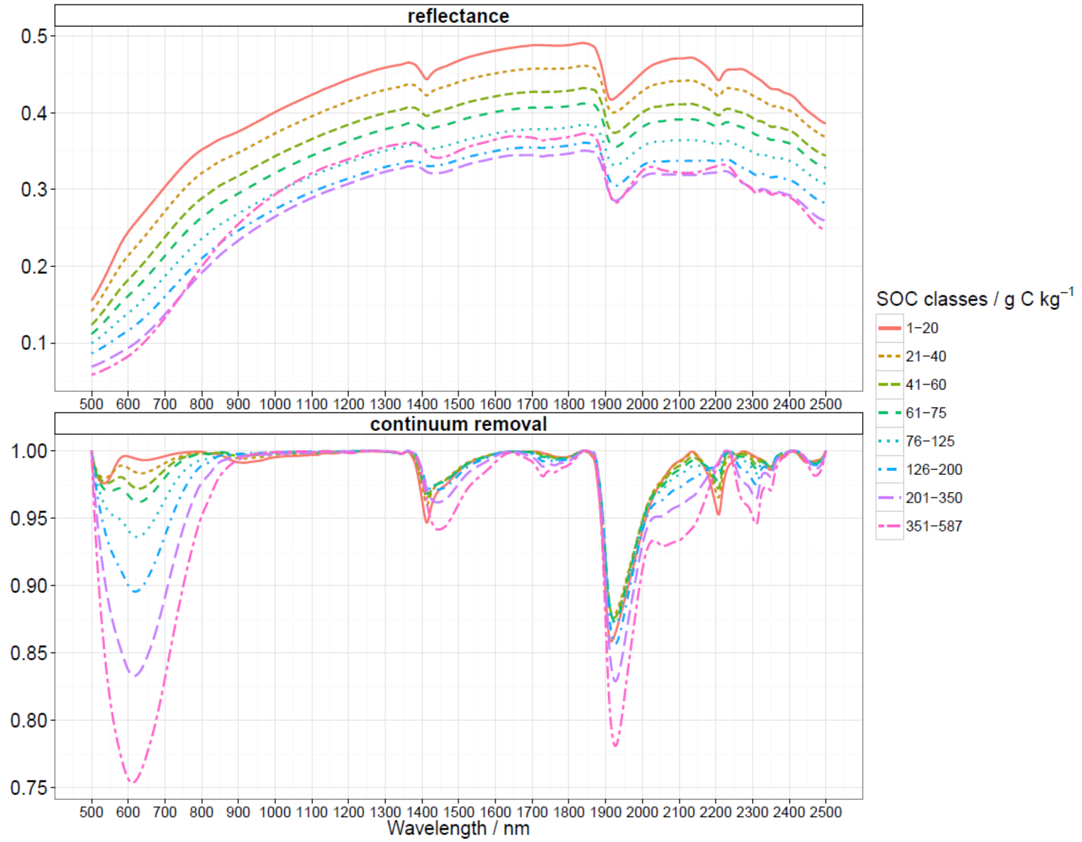
http://groups.google.com/group/soil-spectroscopy/files

The European Soil Spectral Library

The LUCAS spectral library

2011





- Current status:
- 23 European countries
- ~20,000 high quality spectral readings
- Metadata: Clay, silt, sand, OC, pH, CEC, $CaCO_3$, Geographical coordinates, land use, etc

,Creation of four subsets: Cropland Grassland, Woodland, and Organic soils

In 2015 Raphael effort yield the first GSSL

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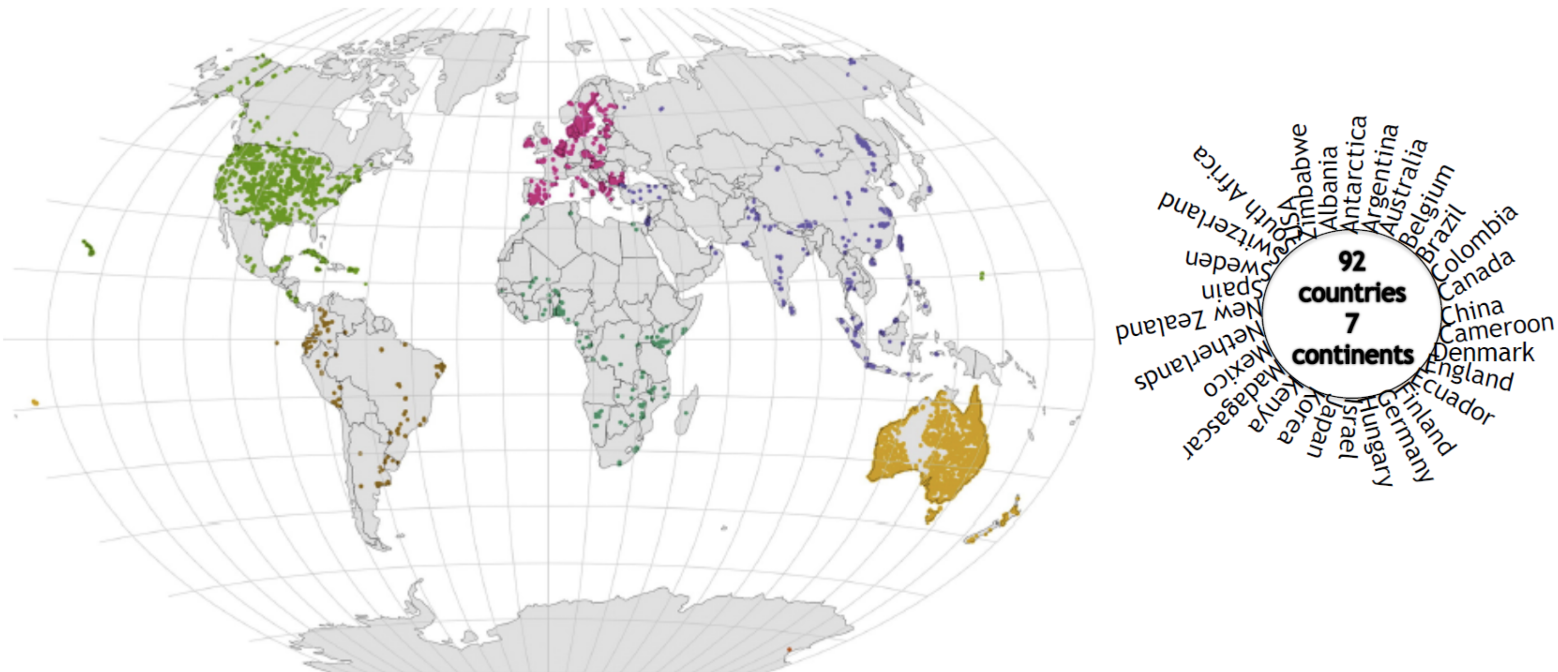
Global Soil VNIR-SWIR Spectra

Some 20,[illegible] VNIR-SWIR [illegible] spectra from 12,509 sites

45 collaborators from 35 institutions



provided by Viscorra Rossel

Global soil vis–NIR spectra in numbers

Continent

- 8646 **Oceania**
- 5198 **North, Central America**
- 3518 **Europe**
- 3097 **Asia**
- 1621 **Africa**
- 1407 **South America**
- 144 **Antarctica**

Position

- 84% with **coordinates**
- 60% from the **0–30 cm**
- 30% from the **30–100 cm**
- 10% from **> 1m**

Attributes

- **pH** 20,515 (20,515)
- **Organic C** 17,931 (9757)
- **Clay** 17,463 (10,064)
- **Sand** 12,058 (3395)
- **CEC** 9588 (5014)
- **Silt** 9542 (1280)
- **Fe** 4151 (3311)
- **$CaCO_3$** 2960 (1388)

Description

- 15% have **soil horizon**
- 95% with **FAO WRB**
- 80% with **land cover**

provided by Viscorra Rossel

There is a publication on the global library

Authors: Those who contribute to GSSL established by Viscorra Rossel

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A global spectral library to characterize the world's soil

CrossMark

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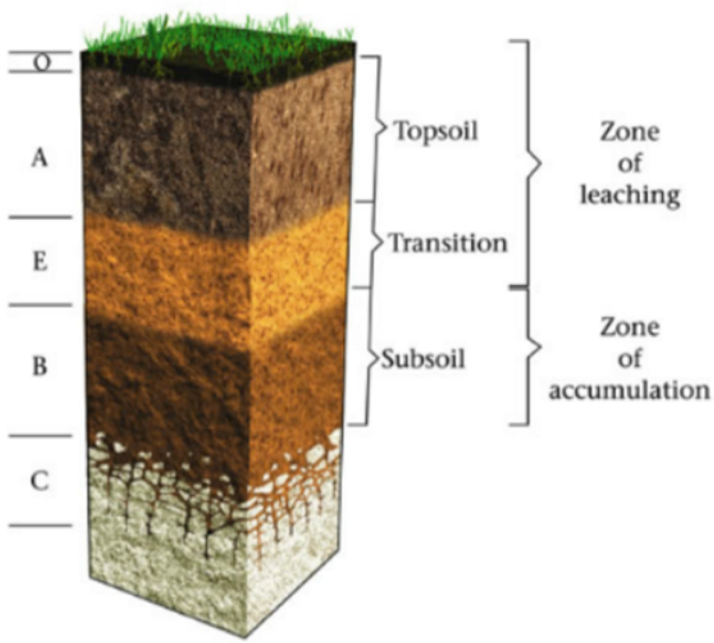
Introduction to soil science

Soil - The upper layer of the earth (≈ 0-2m) represent its loose surface material which is dug, plowed and being a **medium for plants to grow**.
(Thompson 1957)

$$Soil = f\,(P, C, T, O, t)$$



(b)

FIGURE 5.11

Essentials of Geology, 2nd Edition

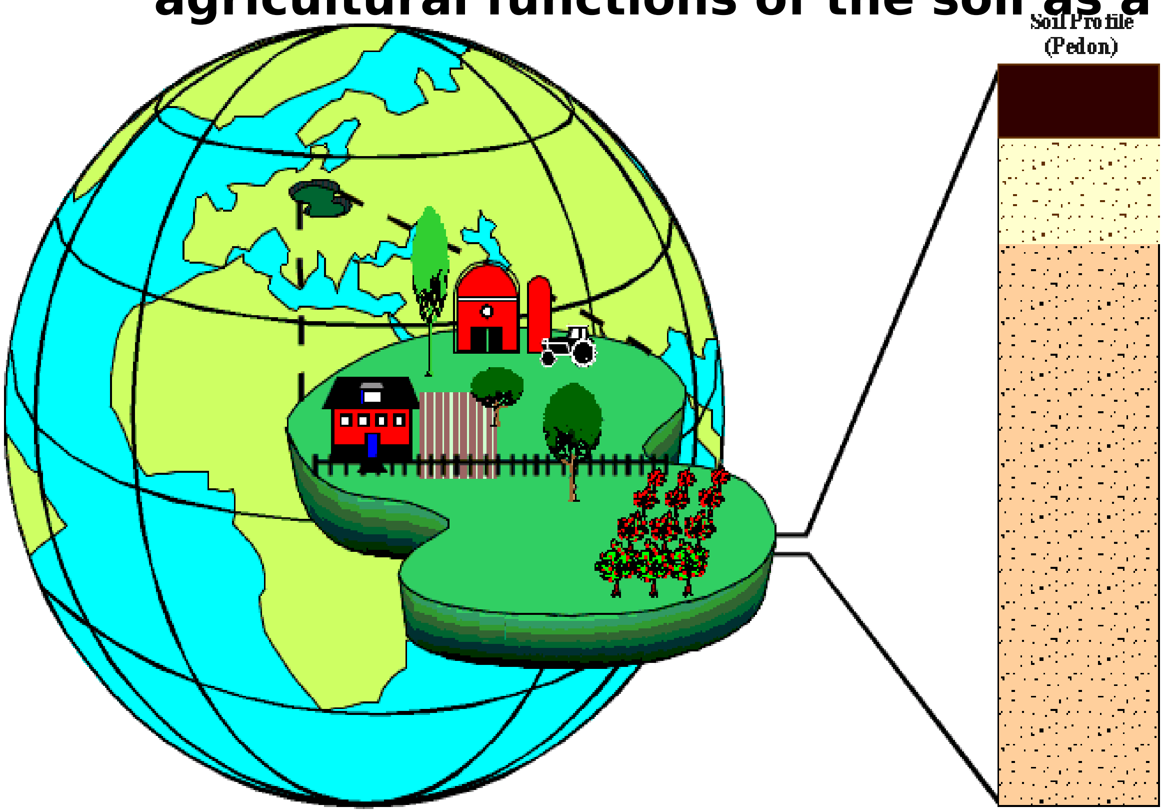
Introduction to soil science

$$Soil = f(P, C, T, O, t)$$

Physical composition	**Chemical composition**
Texture	Clay content
Specific surface area	Organic matter
color	Mineralogy

Soil as a Complex System

Soil is a complex system characterized by chemical and physical attributes that provides an overview on the agricultural functions of the soil as a food producer

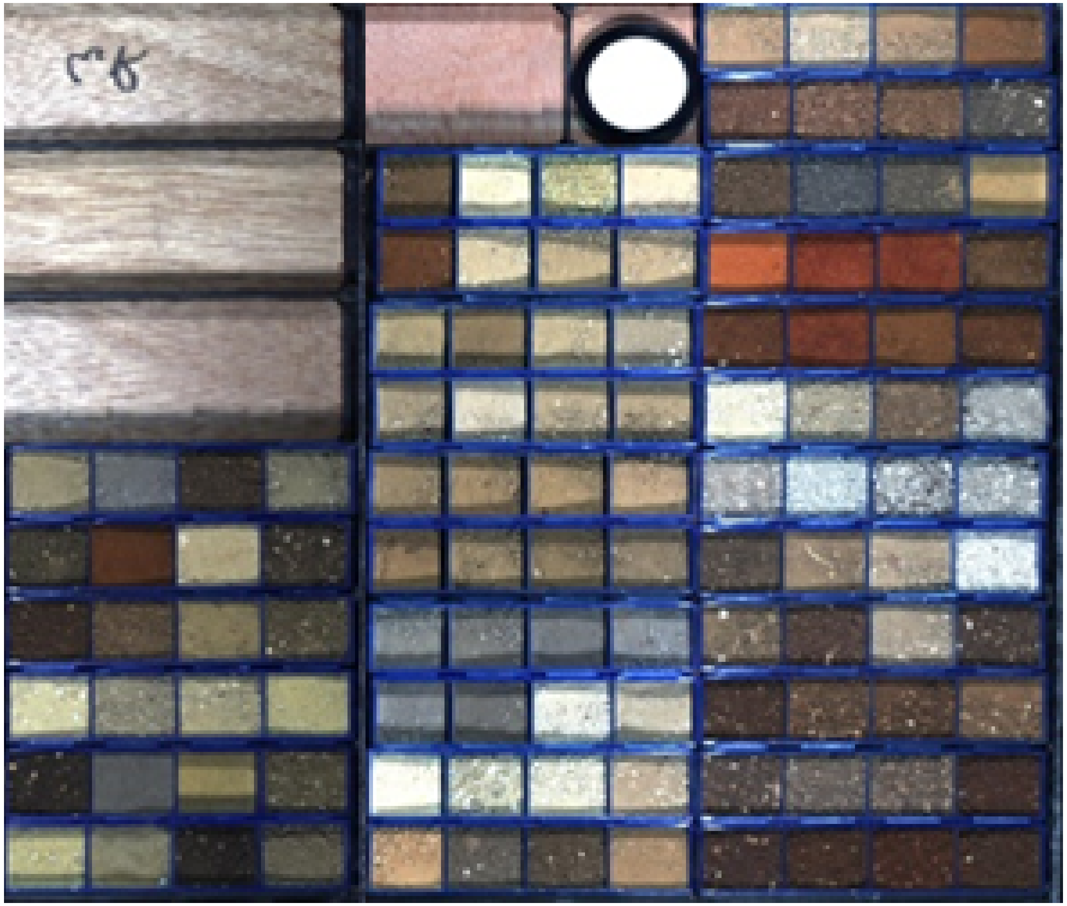


An area of land and the soil profile (pedon) that characterizes it.

Soil is composed of

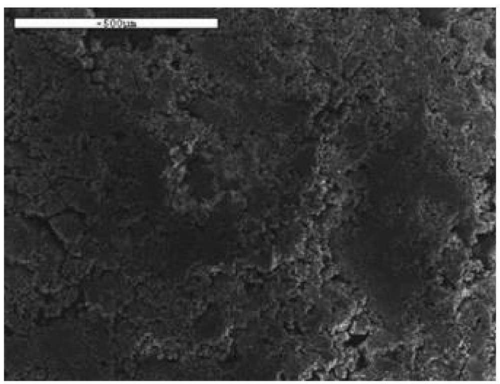
Clay
silt
sand
organic matter
carbonates
iron oxides
water
particle size
air
Cations
Anions
Flora
Fauna

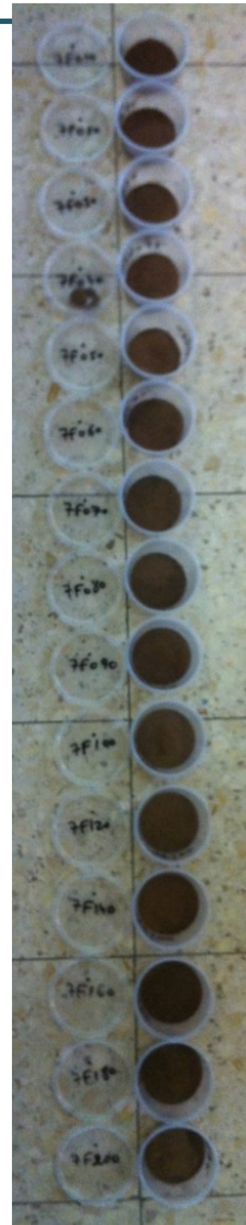
Soils differentiate from one another by their chemical and physical composition

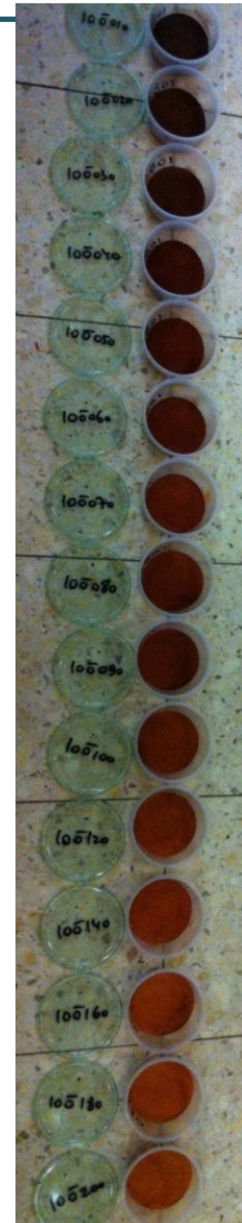


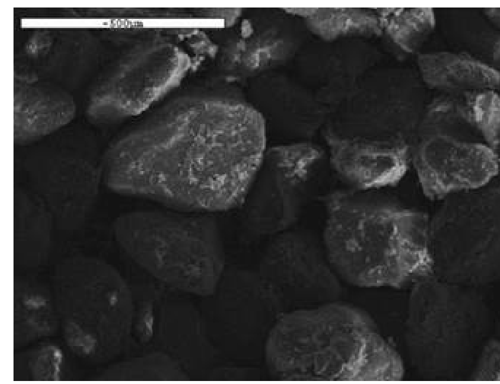
Introduction to soil science

Spatial and vertical changes









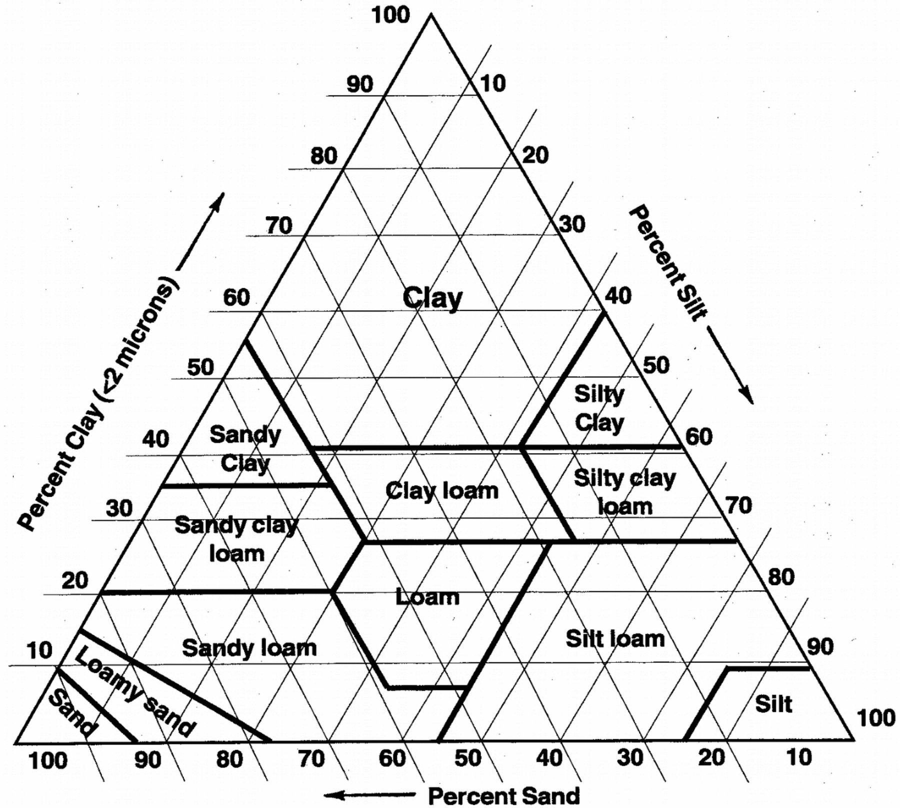
Soil texture

Hydrometer

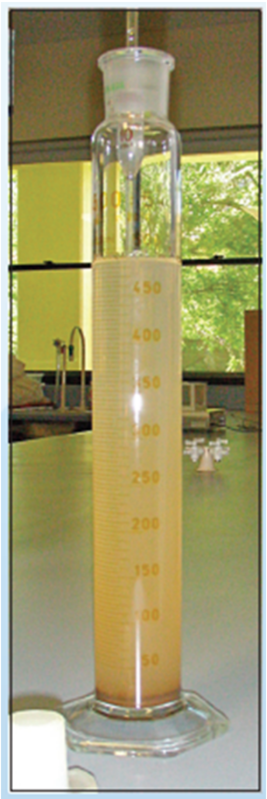
Sieve

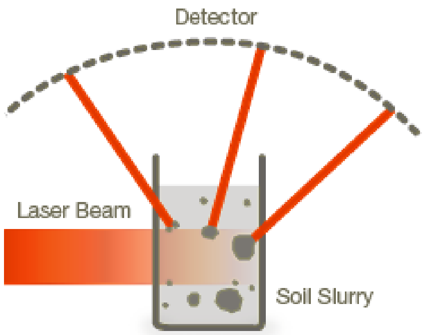
Laser

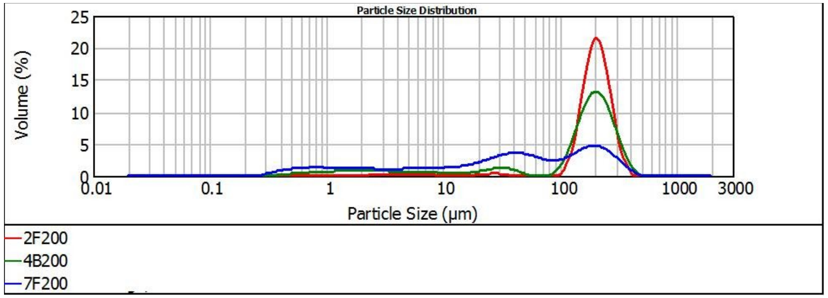
diffraction



Soil texture







The importance of soils

- Plants grow on soils.
- Plants support animal life.
- Plants and animals support human life.
- World population is rapidly increasing, with high food demand.
- A large part of the world's population has inadequate nutrition.
- Soil affects all the above

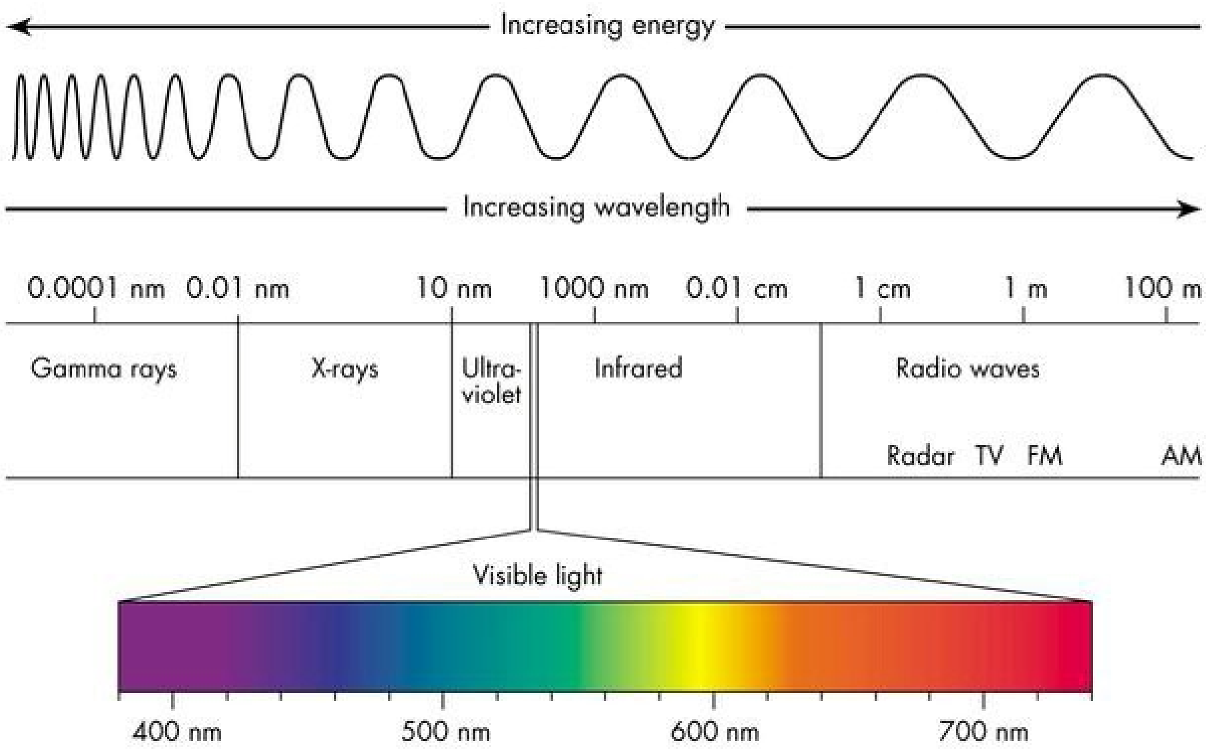
Basic principles of spectroscopy

Basic principles of spectroscopy

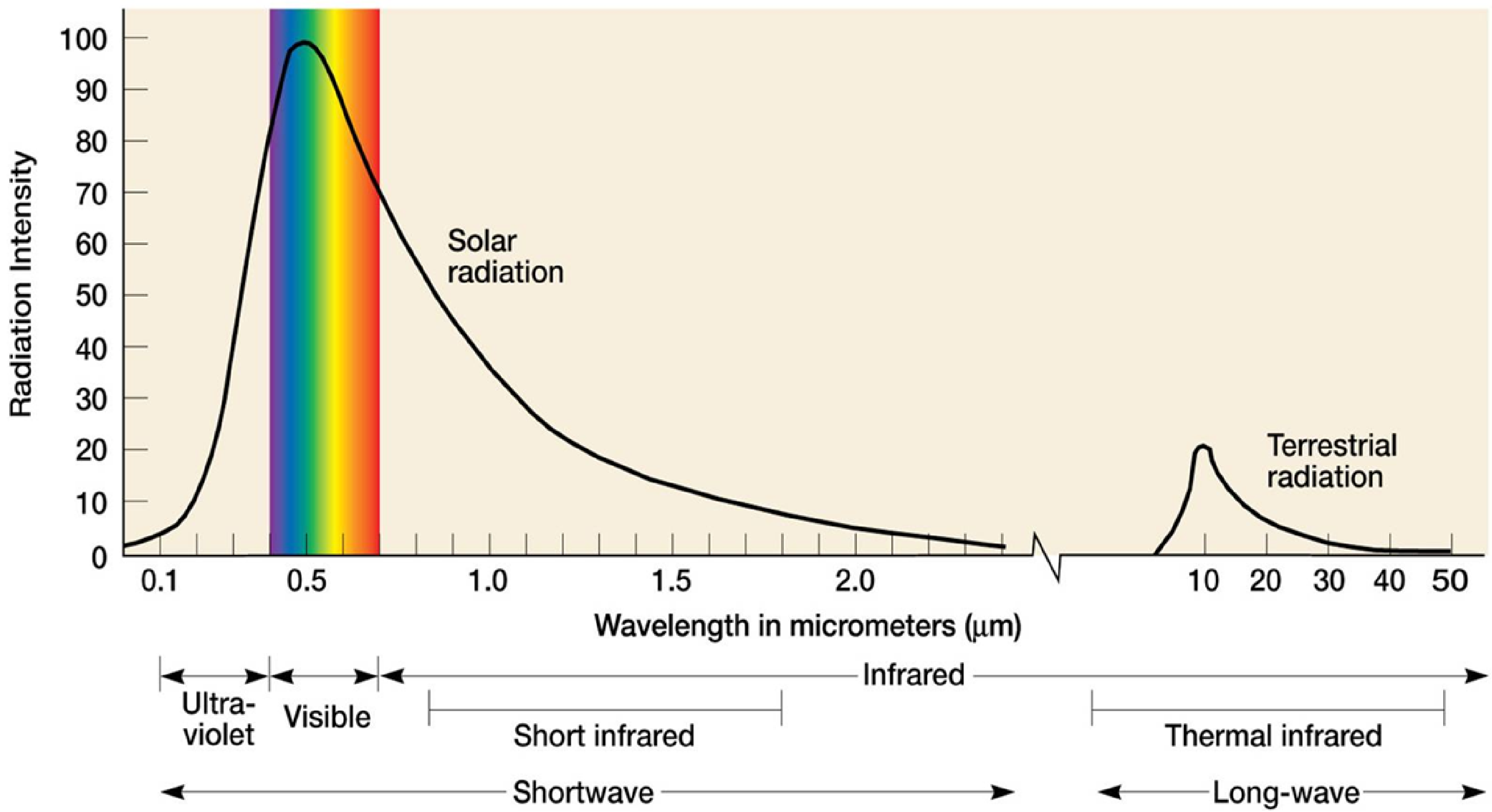
The study of interaction between matter and radiated energy.

Spectroscopy is used in physical and analytical chemistry to detect, identify and quantify information about the atoms and molecules and determine the chemical composition and physical properties of various targets.

Electromagnetic spectrum



Basic principles of spectroscopy



Basic principles of spectroscopy

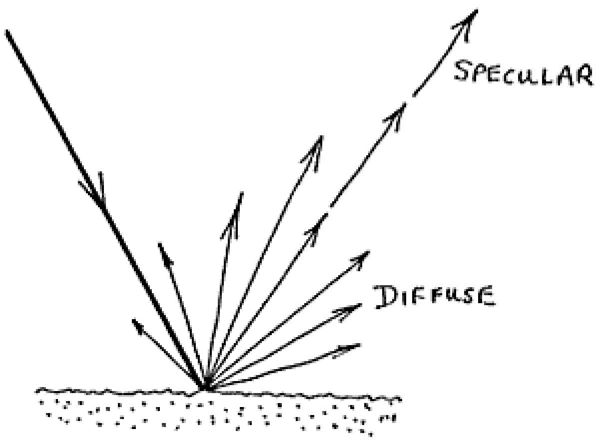
Radiation

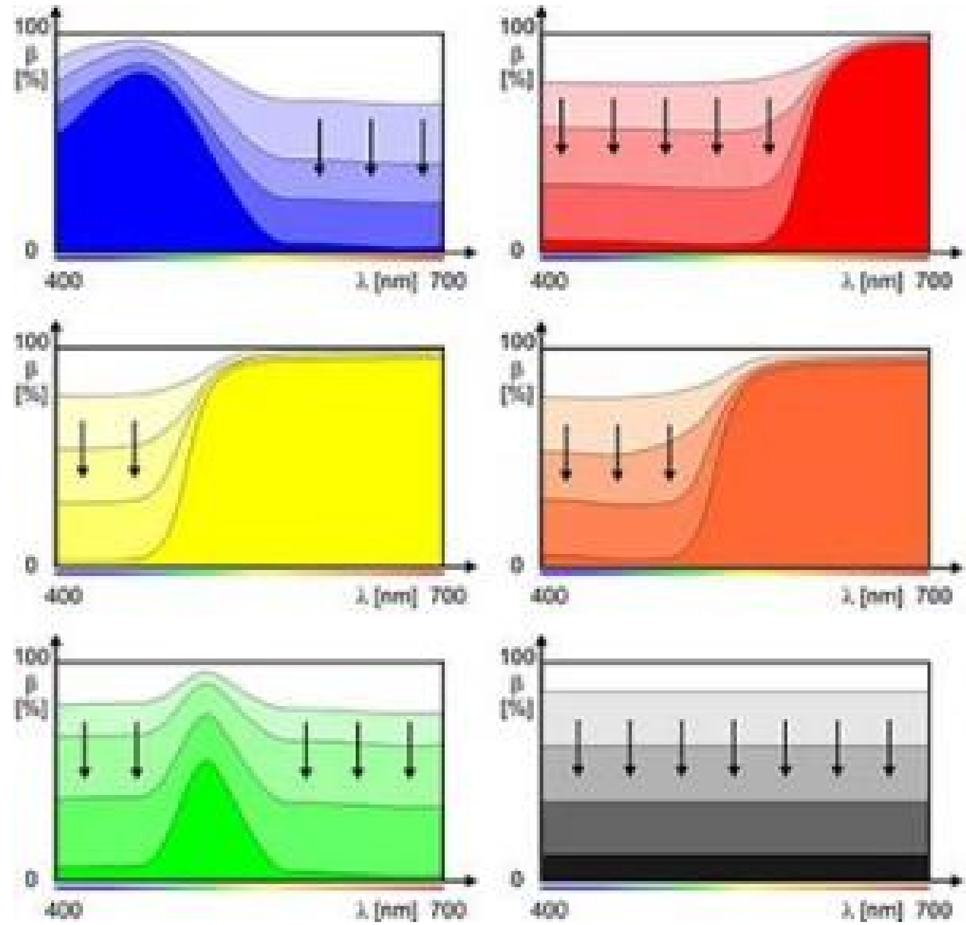
Interaction with surface

Reflected **Absorbed** **Emitted**

Basic principles of spectroscopy

Reflectance



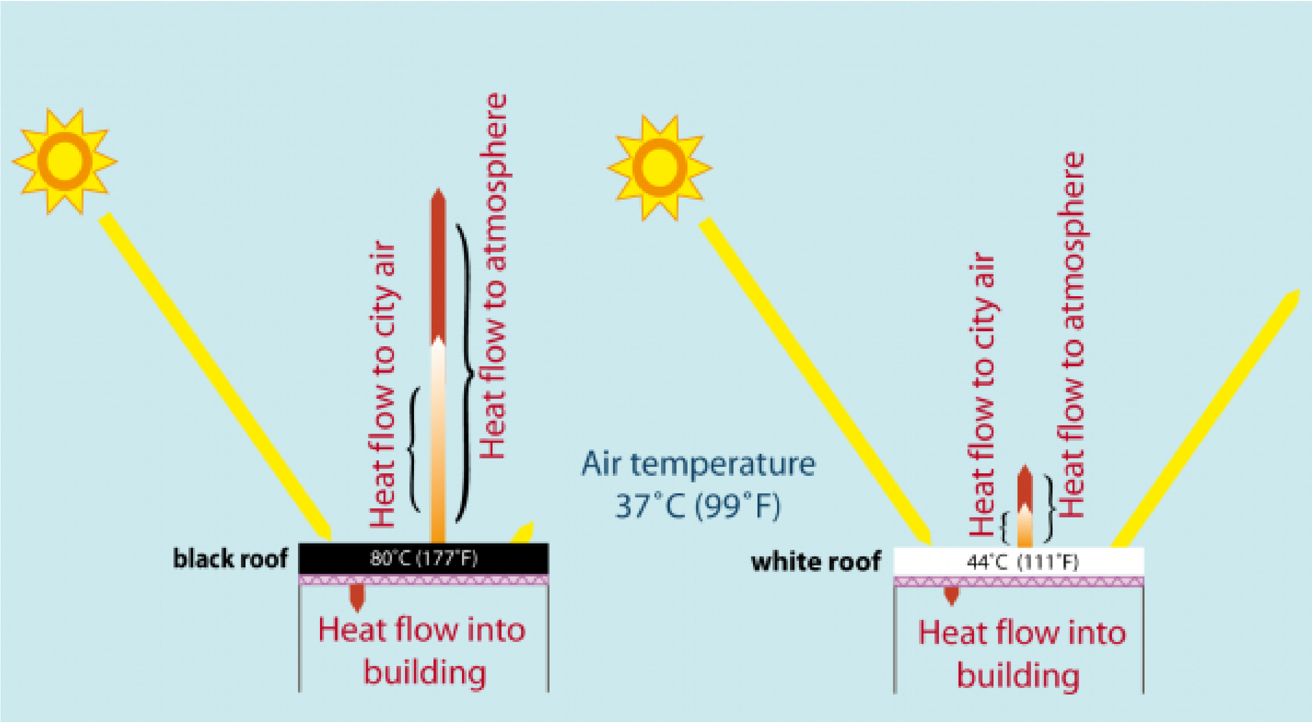


nm 400-2500
μm 0.4-2.5

Absorption

In the field of spectroscopy in the VNIR-SWIR ranges, two main processes exist which cause an absorption of energy: **excitation processes** between electronic states that cause electrons to shift from basic molecular orbital into exited orbital stage and **vibrational processes** which arise from molecular vibrations (Wallace and Hobbs, 2006).

Emittance

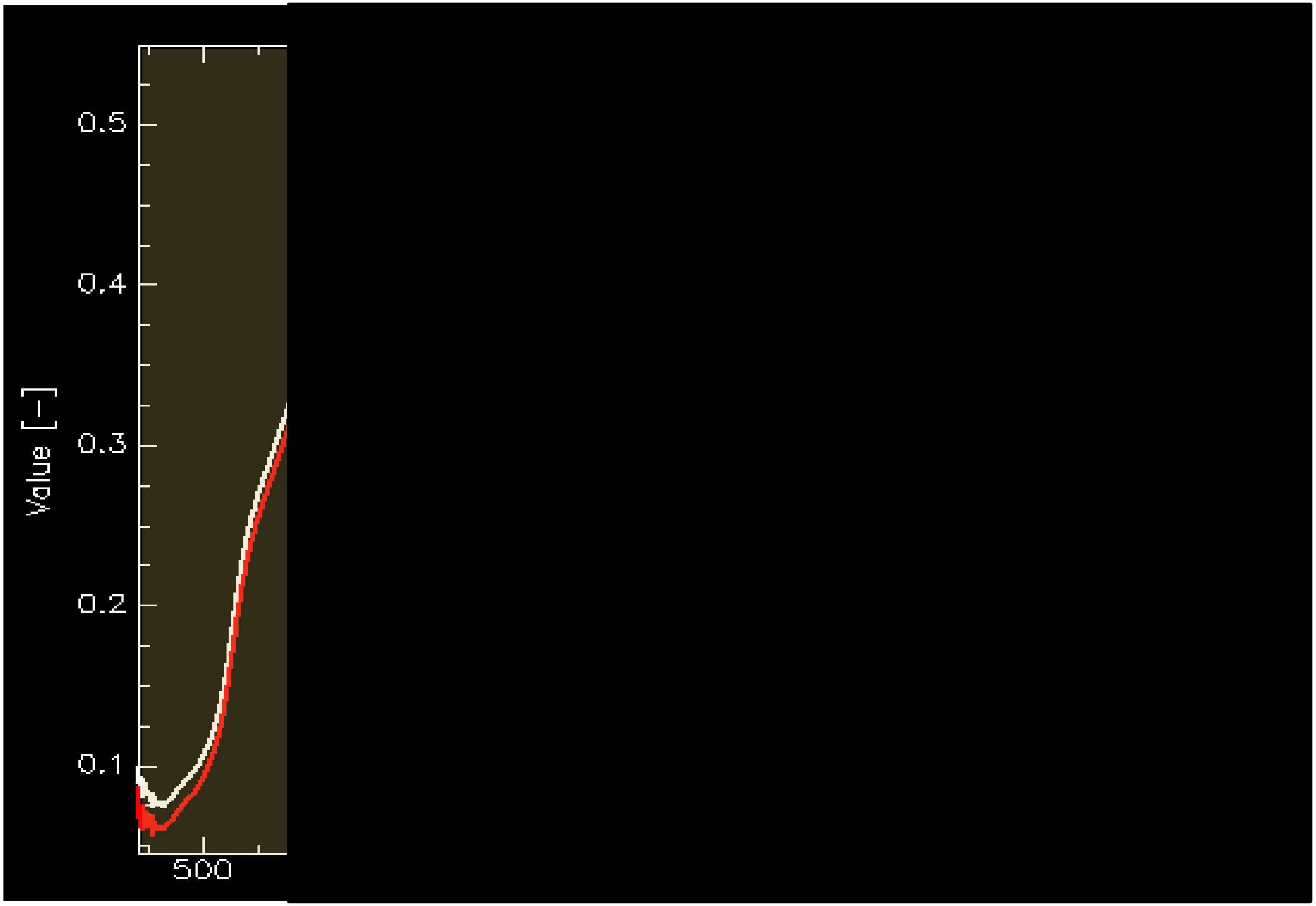


nm 8000-12000

µm 8-12

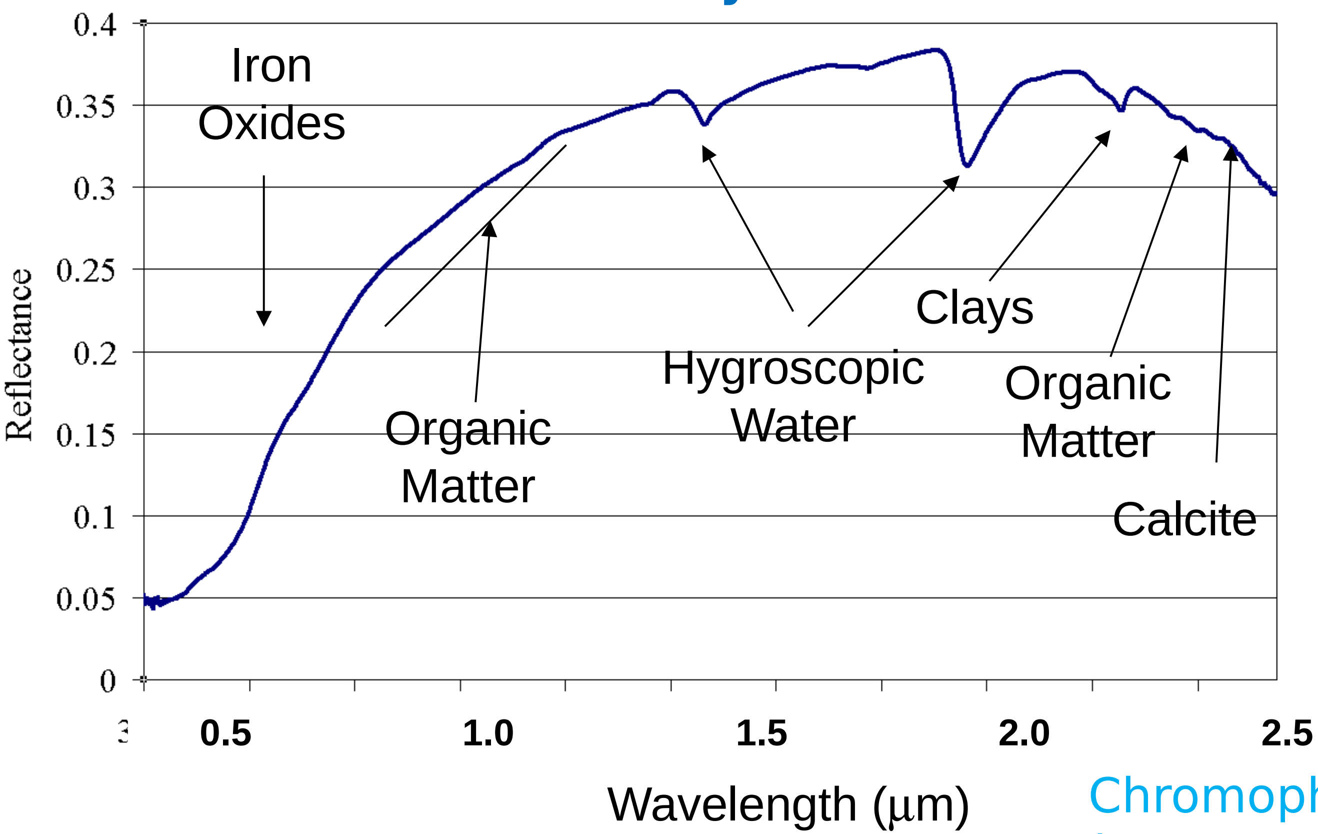
Soil spectroscopy

Soil spectroscopy



Soil spectroscopy

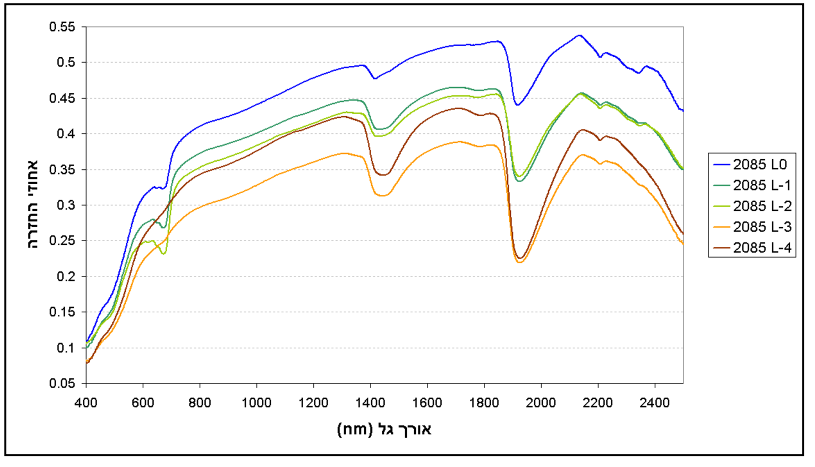
An effective way to simplest the complexity of the soil system



Chromophore = An attribute that interact with the electromagnetic radiation

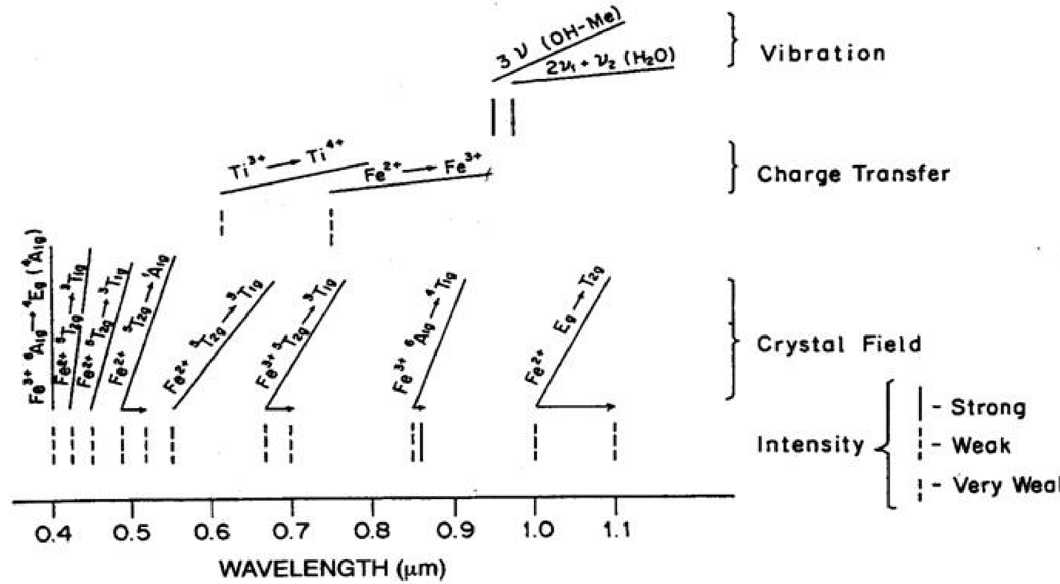
oil spectroscopy

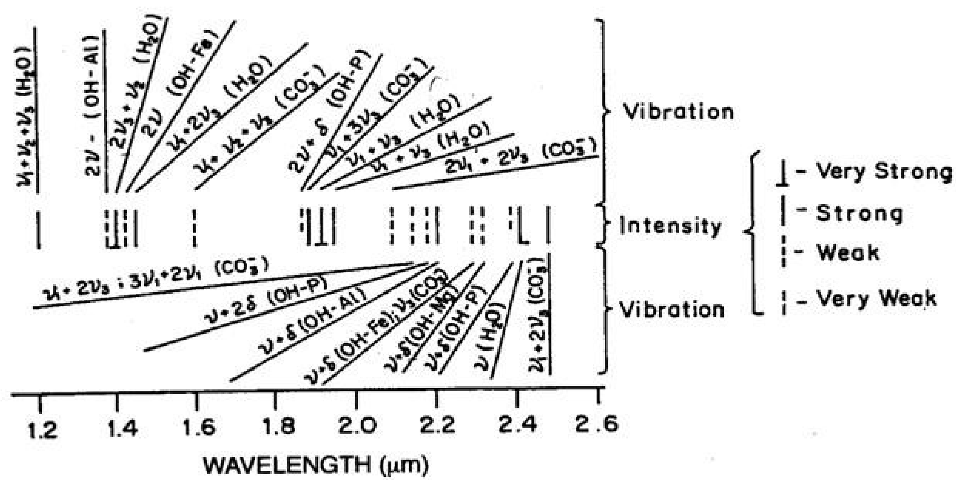
The reflectance/emittance part of the electromagnetic radiation that interacts with the soil across the VIS-NIR-SWIR-TIR spectral regions (0.35-14μm).



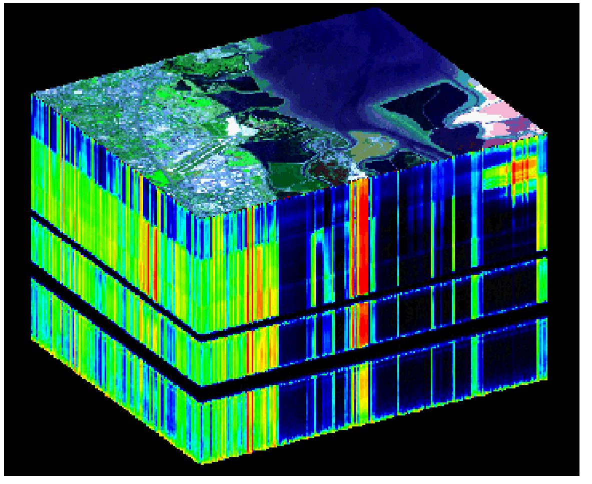
Point – one pixel

Absorption Mechanism





erspectral Remote Sensing



adjusted From A. Goetz 1994

Simultaneous acquisition of images in many registered spectrally- high resolution continuous bands at selected (or all) spectral domains across the UV-VIS-NIR-SWIR–MWIR-LWIR spectral region (0.3-12μm)

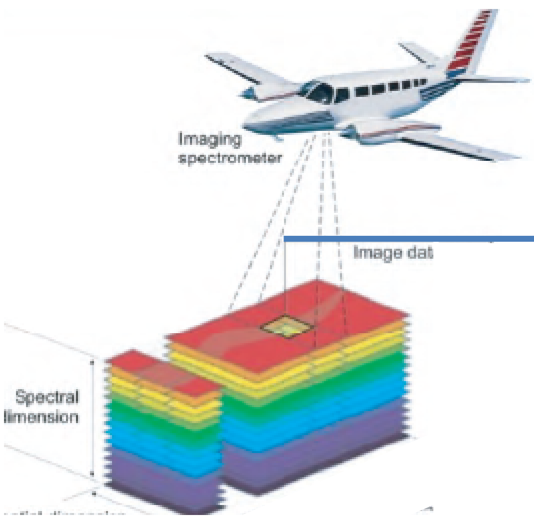
Strong Link between Point and Image Spectroscopy

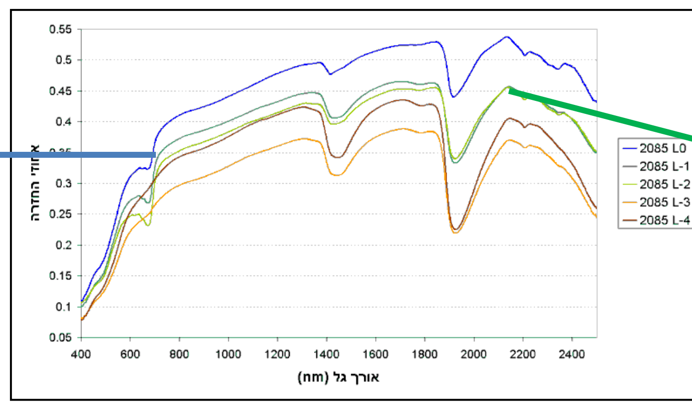
Image Spectroscopy

Geology
Vegetation
Water

Point Spectroscopy

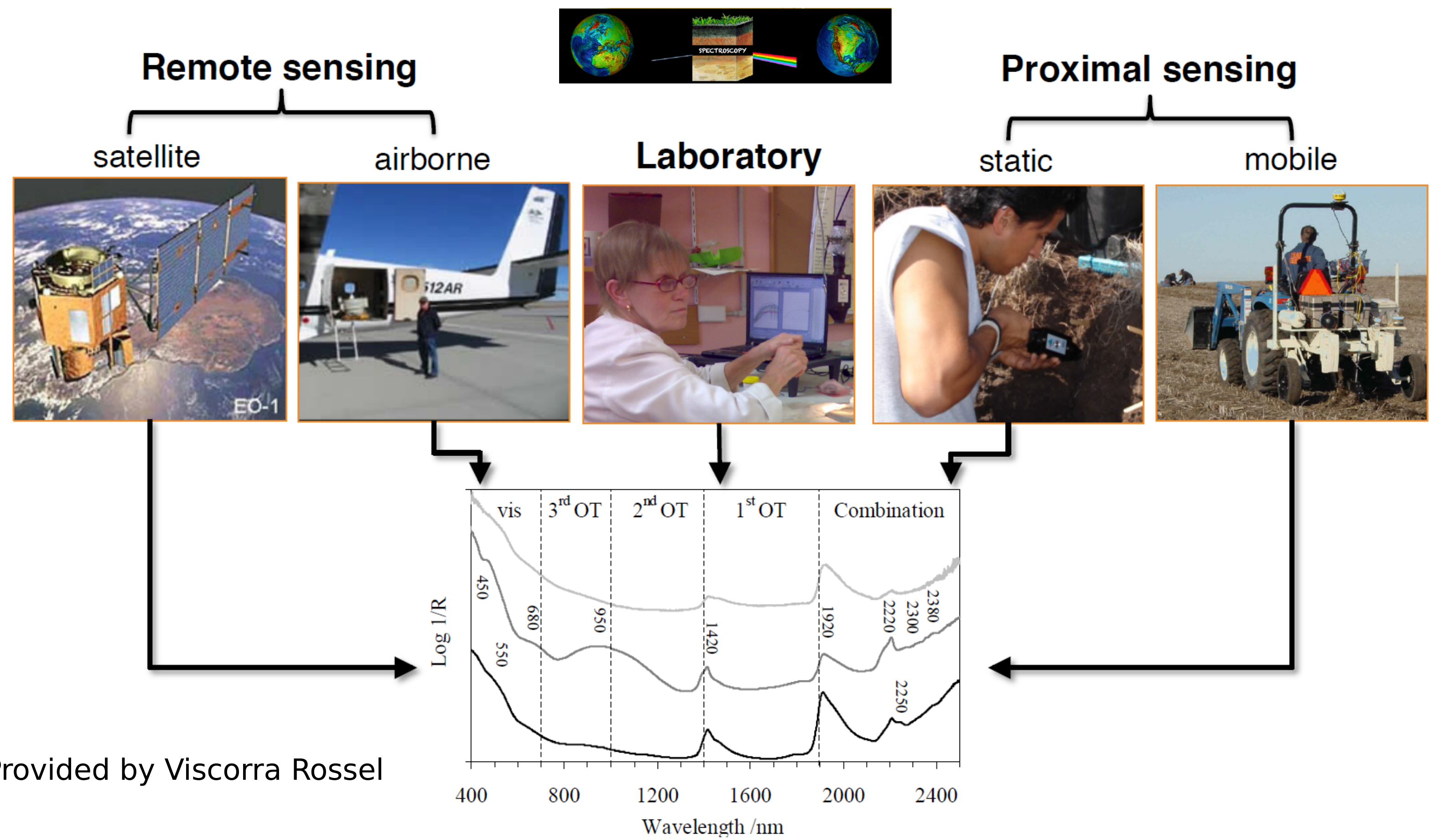
Soil





Soil Spectroscopy

Why so much interest in soil spectroscopy?

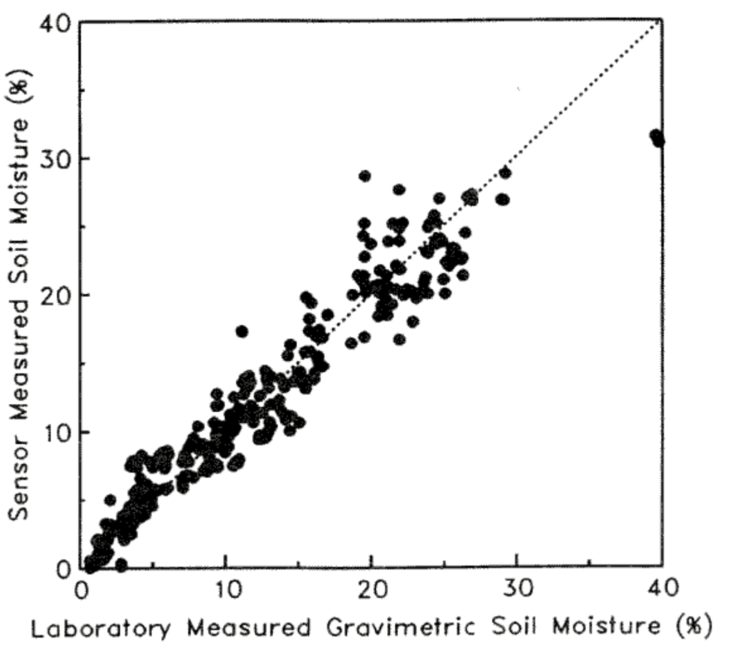


Provided by Viscorra Rossel

Soil Spectroscopy

Quantitative Information on soil attributes can be Extracted from soil spectral information

Dalal, R.C., and R.J. Henry. 1986. Simultaneous determination of moisture, organic carbon and total nitrogen by near infrared reflectance spectroscopy. Soil Science Society of America Journal 50:120-12



Simple, rapid, inexpensive and
can be applied from large domains (laboratory, field, air and space)

Soil Spectroscopy

Examples of some of the soil attributes that can be extracted from spectral library (1)

Soil attribute	Spectral region	Spectral range (nm)	Multivariate method[a]	n_{calib} | n_{valid}[b]	RMSE	R^2	Authors
Mg; g/kg	VIS–NIR	400–2500	modified PLSR	315		0.90	Cozzolino and Moron (2003)
Mg (exch.); cmol(+)/kg	VIS–NIR	350–2500	MARS	493|246	11	0.81	Shepherd and Walsh (2002)
Mg (exch.); mg/kg	VIS–NIR	400–2498	PCR (9)	30|119	12.8	0.68	Chang et al. (2001)
Mg; mmol(+)/kg	UV–VIS–NIR	250–2500	PCR	121|40		0.63	Islam et al. (2003)
Mn (DTPA); mg/kg	MIR	2500–25,000	PLSR	183		0.57	Janik et al. (1998)
Mn (exch.); cmol/kg	MIR	2500–25,000	PLSR	183		0.66	Janik et al. (1998)
Mn (Mehlich III); mg/kg	VIS–NIR	400–2498	PCR (12)	30|119	56.4	0.70	Chang et al. (2001)
OC; %	MIR	2500–20,000	PLSR			0.92	Janik and Skjemstad (1995)
OC; %	MIR	2500–25,000	PLSR	188		0.93	Janik et al. (1998)
OC; g/kg	MIR	2500–25,000	PLSR (17)	177|60		0.94	McCarty et al. (2002)
OC; (acidified soil) g/kg	MIR	2500–25,000	PLSR (19)	177|60		0.97	McCarty et al. (2002)
OC; %	NIR	1100–2500	MLR (1744, 1870, 2052)	72|48		0.93	Dalal and Henry (1986)
OC; %	NIR	1100–2500	RBFN	140|60	0.32	0.96	Fidêncio et al. (2002)
OC; %	NIR	700–2500	PCR	121|40		0.68	Islam et al. (2003)
OC; g/kg	NIR	1100–2498	PLSR (18)	177|60		0.82	McCarty et al. (2002)
OC; mg/kg	NIR	1100–2300	PLSR (8)	180 x-val		0.94	Reeves and McCarty (2001)
OC (acidified soil); g/kg	NIR	1100–2498	PLSR (17)	177|60		0.80	McCarty et al. (2002)
OC; g/kg	VIS–NIR	400–2498	PLSR (6)	76|32	0.62	0.89	Chang and Laird (2002)
OC; g/kg	VIS–NIR	350–2500	MARS	449|225	0.31	0.80	Shepherd and Walsh (2002)
OC; dag/kg	VIS–NIR	350–1050	PLSR (5)	43|25	0.36		Viscarra Rossel et al. (2003)
OC; %	UV–VIS–NIR	250–2500	PCR	121|40		0.76	Islam et al. (2003)
OM; %	MIR	2500–25,000	PLSR (4)	31 x-val	0.72	0.98	Masserschmidt et al. (1999)
OM; %	NIR	1000–2500	MRA (30 bands)	39|52		0.55	Ben-Dor and Banin (1995)
OM; %	VIS–NIR	400–1100	NN	41		0.86	Daniel et al. (2003)
OM; %	VIS–NIR	400–2400	SMLR (606, 1311, 1238)	15|10		0.65	Shibusawa et al. (2001)
P (avail.); mg/kg	MIR	2500–25,000	PLSR	186		0.07	Janik et al. (1998)
P (avail.); mg/kg	VIS–NIR	400–1100	NN	41		0.81	Daniel et al. (2003)
pH	MIR	2500–20,000	PLSR			0.72	Janik and Skjemstad (1995)
pH	NIR	1100–2300	PLSR (8)	180 x-val		0.74	Reeves and McCarty (2001)
pH	NIR	1100–2498	PLSR (11)	120|59		0.73	Reeves et al. (1999)
pH	VIS–NIR	350–2500	MARS	505|253	0.43	0.70	Shepherd and Walsh (2002)
pH_{Ca}	MIR	2500–25,000	PLSR	183		0.67	Janik et al. (1998)

R.A. Viscarra Rossel et al. / Geoderma 131 (2006) 59–75

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Soil Spectroscopy

Examples of some of the soil attributes that can be extracted from spectral library (2)

Soil attribute	Spectral region	Spectral range (nm)	Multivariate method[a]	n_{calib} | n_{valid} [b]	RMSE	R^2	Authors
OC; %	MIR	2500–20,000	PLSR			0.92	Janik and Skjemstad (1995)
OC; %	MIR	2500–25,000	PLSR	188		0.93	Janik et al. (1998)
OC; g/kg	MIR	2500–25,000	PLSR (17)	177|60		0.94	McCarty et al. (2002)
OC; (acidified soil) g/kg	MIR	2500–25,000	PLSR (19)	177|60		0.97	McCarty et al. (2002)
OC; %	NIR	1100–2500	MLR (1744, 1870, 2052)	72|48		0.93	Dalal and Henry (1986)
OC; %	NIR	1100–2500	RBFN	140|60	0.32	0.96	Fidêncio et al. (2002)
OC; %	NIR	700–2500	PCR	121|40		0.68	Islam et al. (2003)
OC; g/kg	NIR	1100–2498	PLSR (18)	177|60		0.82	McCarty et al. (2002)
OC; mg/kg	NIR	1100–2300	PLSR (8)	180 x-val		0.94	Reeves and McCarty (2001)
OC (acidified soil); g/kg	NIR	1100–2498	PLSR (17)	177|60		0.80	McCarty et al. (2002)
OC; g/kg	VIS–NIR	400–2498	PLSR (6)	76|32	0.62	0.89	Chang and Laird (2002)
OC; g/kg	VIS–NIR	350–2500	MARS	449|225	0.31	0.80	Shepherd and Walsh (2002)
OC; dag/kg	VIS–NIR	350–1050	PLSR (5)	43|25	0.36		Viscarra Rossel et al. (2003)
OC; %	UV–VIS–NIR	250–2500	PCR	121|40		0.76	Islam et al. (2003)
OM; %	MIR	2500–25,000	PLSR (4)	31 x-val	0.72	0.98	Masserschmidt et al. (1999)
OM; %	NIR	1000–2500	MRA (30 bands)	39|52		0.55	Ben–Dor and Banin (1995)
OM; %	VIS–NIR	400–1100	NN	41		0.86	Daniel et al. (2003)
OM; %	VIS–NIR	400–2400	SMLR (606, 1311, 1238)	15|10		0.65	Shibusawa et al. (2001)
P (avail.); mg/kg	MIR	2500–25,000	PLSR	186		0.07	Janik et al. (1998)
P (avail.); mg/kg	VIS–NIR	400–1100	NN	41		0.81	Daniel et al. (2003)
pH	MIR	2500–20,000	PLSR			0.72	Janik and Skjemstad (1995)
pH	NIR	1100–2300	PLSR (8)	180 x-val		0.74	Reeves and McCarty (2001)
pH	NIR	1100–2498	PLSR (11)	120|59		0.73	Reeves et al. (1999)
pH	VIS–NIR	350–2500	MARS	505|253	0.43	0.70	Shepherd and Walsh (2002)
pH_{Ca}	MIR	2500–25,000	PLSR	183		0.67	Janik et al. (1998)

R.A. Viscarra Rossel et al. / Geoderma 131 (2006) 59–75

THE REMOTE SENSING LABORATORIES

ging Soil Spectral Library : The problems

Most of the SSLs today are generated in the laboratory domains

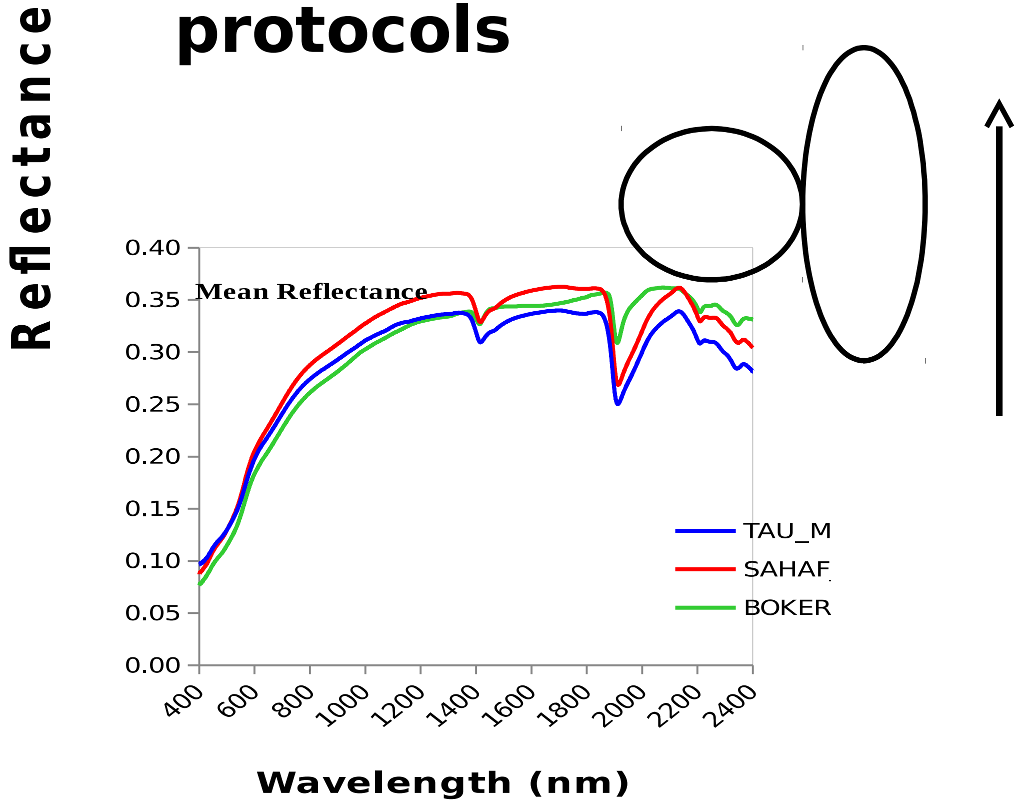
- Users are focused on their own protocols (*measurement methods and instrumentation*)

- Protocol may affects the final spectrum……

- Quantitative models are sensitive to these effects (small spectral changes) …..

The Problems - Example 1:
Spectral Domain

One soil: Three different protocols



The problem - 2: *Analytical Domain*

100 samples (60 cal, 40 val) – three protocols : Quantitative analysis

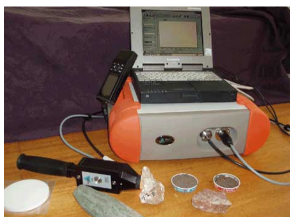
Instrument / Operator	Internal standard	$CaCO_3$		Clay Content		Organic Matter		Fe2O3	
		RMSEP		RMSEP		RMSEP		RMSEP	
TAU	**Original**	**13.24**		**5.4**		**1.54**		**4316**	
SAHAF	Original	13.33		8.2		1.50		5169	
BOKER	Original	17.44		8.9		1.79		4687	

Soil Laboratory Spectroscopy: Problems

) Systemic = Non Systematic(

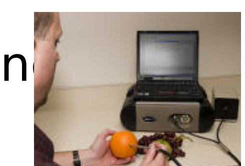
:two sources are responsible for that

Systematic
Non systematic ef



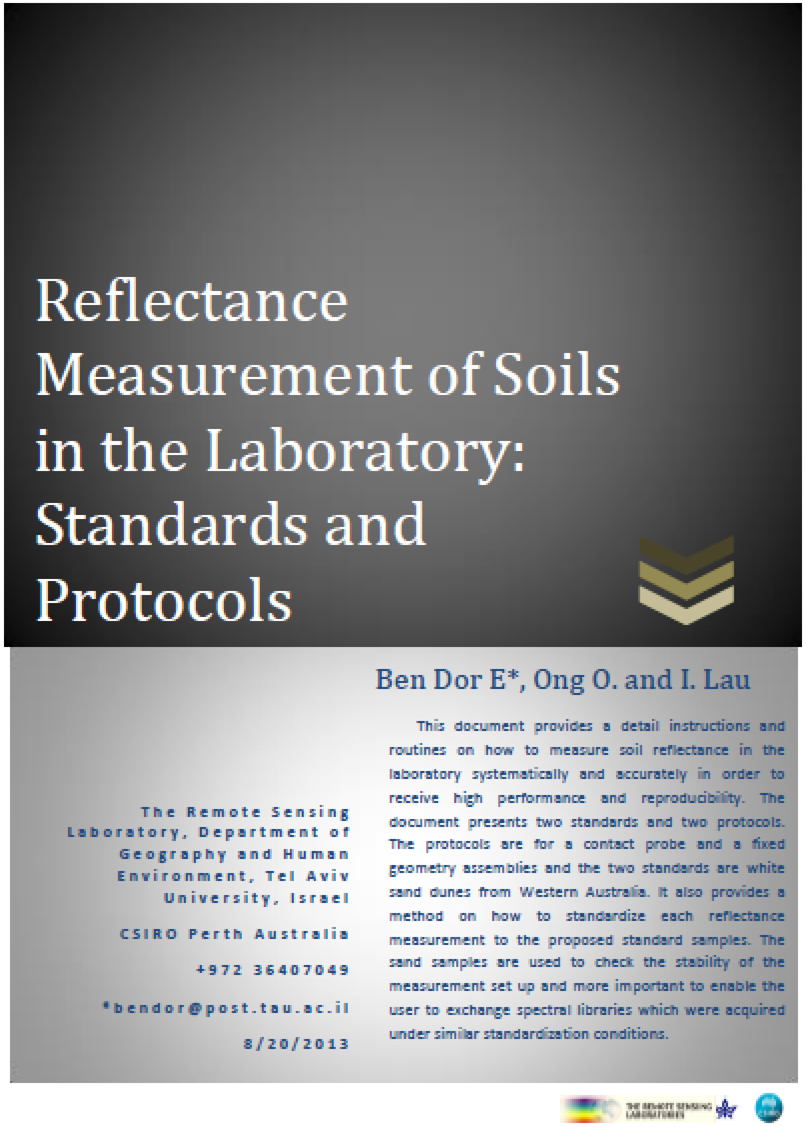
Systematic Effects: e.g. Spectrometer Calibration, Geometry between measurement sets, Bulb Response

Non Systematic Effects: e.g. Spectrometer instability, Geometry within measurement set
Bulb instability, atmosphere attenuations, user experien



Correcting for Non Systematic Effect - Using an agreed protocol
Correcting for the Systematic Effects – Using an Internal Soil Standard Method

Protocol (Non systematic effects)



Reflectance Measurement of Soils in the Laboratory: Standards and Protocols

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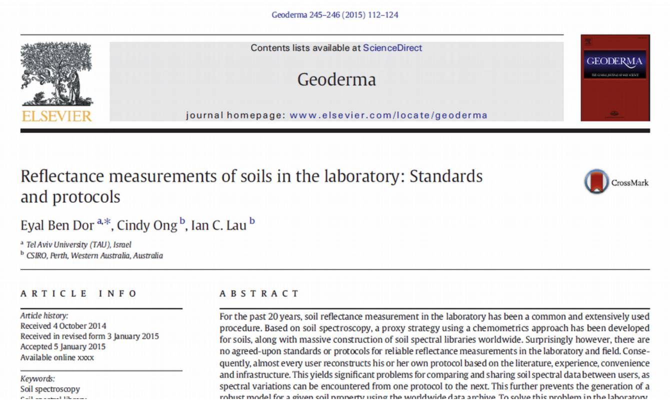
8/20/2013

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.

A simple protocol has established for new users Since 2014



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Reflectance measurements of soils in the laboratory: Standards and protocols

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ABSTRACT

For the past 20 years, soil reflectance measurement in the laboratory has been a common and extensively used procedure. Based on soil spectroscopy, a proxy strategy using a chemometrics approach has been developed for soils, along with massive construction of soil spectral libraries worldwide. Surprisingly however, there are no agreed-upon standards or protocols for reliable reflectance measurements in the laboratory and field. Consequently, almost every user reconstructs his or her own protocol based on the literature, experience, convenience and infrastructure. This yields significant problems for comparing and sharing soil spectral data between users, as spectral variations can be encountered from one protocol to the next. This further prevents the generation of a

Internal Soil Standard (ISS) purse: to align with systematic effects of protocols

Adopted from the wet chemistry analytical practices

Internal standard

From Wikipedia, the free encyclopedia

An **internal standard** in analytical chemistry is a chemical substance that is added in a constant amount to samples, the blank and calibration standards in a chemical analysis. This substance can then be used for calibration by plotting the ratio of the analyte signal to the internal standard signal as a function of the analyte concentration of the standards. This is done to correct for the loss of analyte during sample preparation or sample inlet. ***The internal standard is a compound that matches as closely, but not completely***, the chemical species of interest in the samples, as the effects of sample preparation should, relative to the amount of each species, be the same for the signal from the internal standard as for the signal(s) from the species of interest in the ideal case. Adding known quantities of analyte(s) of interest is a distinct technique called standard addition, which is performed to correct for matrix effects.

$$F_R(i) = (\text{counts/gram})_{\text{standard}} / (\text{counts/gram})_{\text{component } i} \quad (1)$$

Internal Soil Standards (ISS) characteristics

General:

A simple and low cost material that can be shipped easily worldwide (no valuable cost, light in weight

Spectral:

A material that will hold stable absorption features, across the VIS-NIR-SWIR region and will be an inertial material

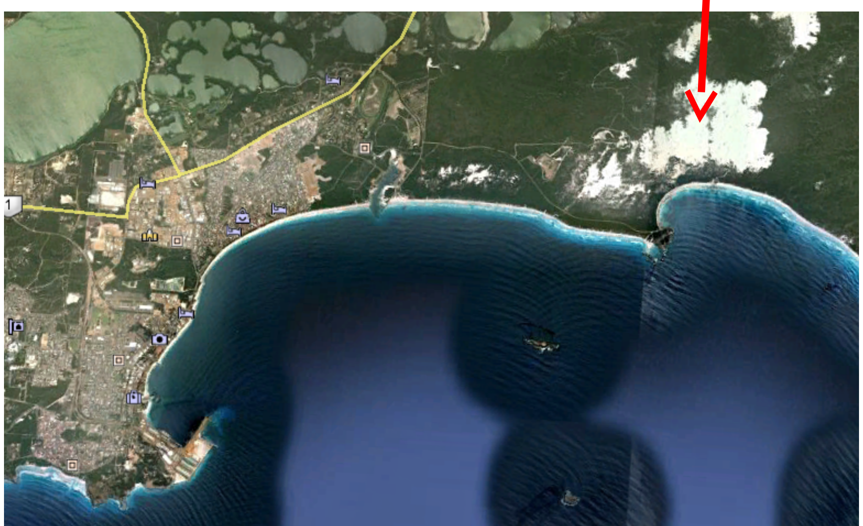
Radiometrical:

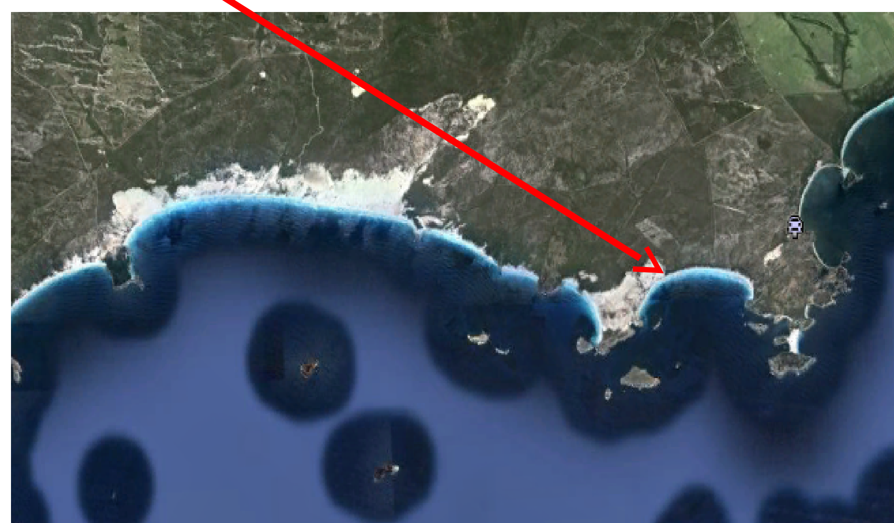
A material that will hold the soil particle size (<2mm) and characterizes with no absorption features

Searching for an ideal standard took almost 4 years

Wiely Bay

Lucky Bay

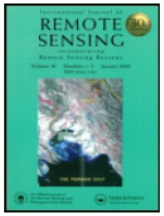




The soil standards

Lucky Bay

Wiley Bay



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Normalizing reflectance from different spectrometers and protocols with an internal soil standard

Veronika Kopačková & Eyal Ben-Dor

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Soil Mineralogy

Performance of Three Identical Spectrometers in Retrieving Soil Reflectance under Laboratory Conditions

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Gila Notesco
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A wide range of electronic and mechanical noise factors can affect soil spectra when using different instruments or even when repeating a specific sample's measurements with the same spectrometer. In soil samples where very weak spectral features are monitored for chemometric purposes, alterations in wavelength location, peak absorption shape, or albedo intensity can limit the use of previously developed spectral models. To quantify this alteration and propose a standardization method, 12 soil samples and three different materials for internal standards (sand, glass and polyethylene) were analyzed. This population was concurrently measured with three identical spectrometers using a strict measurement protocol, and then by different operators with different protocols. Significant changes in the soil spectra were found when different operators performed the measurements, being reduced >50% when the strict protocol was applied. Sand was found to be the ideal internal standard for correcting the spectra to a reference spectrometer, even when different measuring protocols were used. This standardization also showed an improvement in the prediction of soil properties when applying chemometric spectral models even with different instruments, concluding that the use of an internal standard and a strict protocol must be applied for soil spectral measurements. As the measuring factors described in this research also affect any infrared diffuse reflectance spectroscopy measurements, the proposed method should be applicable to any instrumentation and configuration being used. This is crucial to enabling spectral comparisons between different spectrometers or, more importantly, to establishing robust chemometric models and to exchange soil spectral information.

Abbreviations: ASD, Analytical Spectral Devices, Inc.; CR, continuum removal; NIRS, near infrared analysis; PLS, partial least squares; RGB, red-green-blue color model; RMSEP, root mean square error of prediction; SAM, spectral angle mapper; TAU, Tel Aviv University.

Many reflectance spectroscopy applications have been developed for soils in the last 20 yr (Malley et al., 2004). Today, reflectance in the VIS-NIR-SWIR region is considered to be a solid and mature technique for qualitative and quantitative analyses of soil material (Ben-Dor et al., 2008b). Soil spectroscopy has advanced the discipline of soil science by providing a rapid and accurate methodology for quantitative analyses that bypasses the traditional "wet" laboratory analyses. Whereas most of the work in evaluating soil information from reflectance spectroscopy has been performed under controlled laboratory conditions, field applications are now rapidly gaining an important place in soil spectroscopy (Ben-Dor et al., 2009; Cecillon et al., 2009). Accordingly, portable spectrometers are being developed and utilized worldwide for many natural resource applications, such as soil, rock, vegetation, and water studies. In addition, a wide range of soil spectral measurements are being gathered around the globe with the intention of building a universal soil spectral library (Viscarra Rossel, 2009). However, this kind of initiative, or even the routine analyses of spectral data collected in one specific laboratory, are limited by the differences that are usually obtained when different spectrometers and protocols are used (Milton et al., 2009; Price, 1994). Spectral performance may vary among different types of spectrometers, or even among models from the same manufacturer, being therefore important to characterize

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Received 20 Apr. 2010.
*Corresponding author (pimstein@uc.cl).

Spectral Normalization Process

Spectral standardization

$$CF_{\lambda} = 1 – ((S\rho_{\lambda} – M\rho_{\lambda}) / S\rho_{\lambda})$$

$$Rc_{\lambda} = Ro_{\lambda} x CF_{\lambda}$$

$S\rho_{\lambda}$ is the reflectance of the *Slave* reference (*your measurement of the ISS)*

$M\rho_{\lambda}$ is the reflectance of the *Master* reference (*standard ISS measured by a certified agreed- lab*)

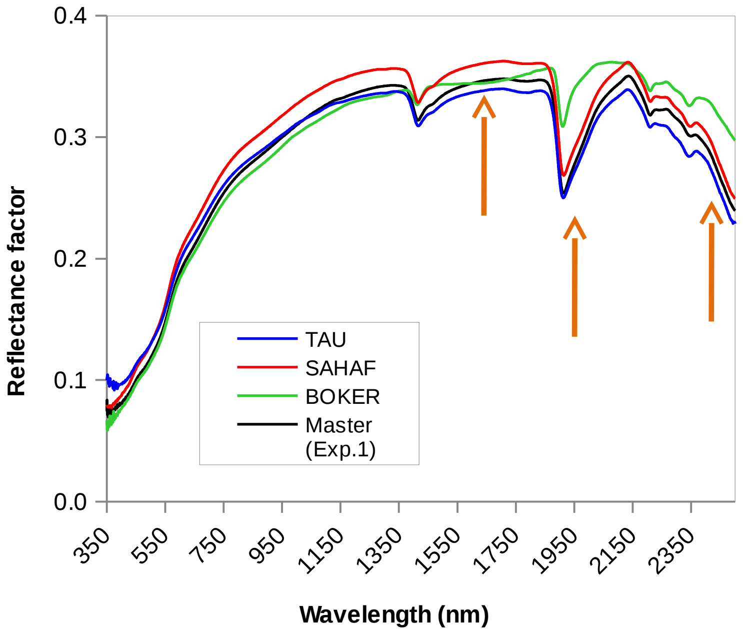
Rc_{λ} is the corrected sample reflectance (to the internal standard conditions, *standard*)

Ro_{λ} is the original sample reflectance (*sample*)

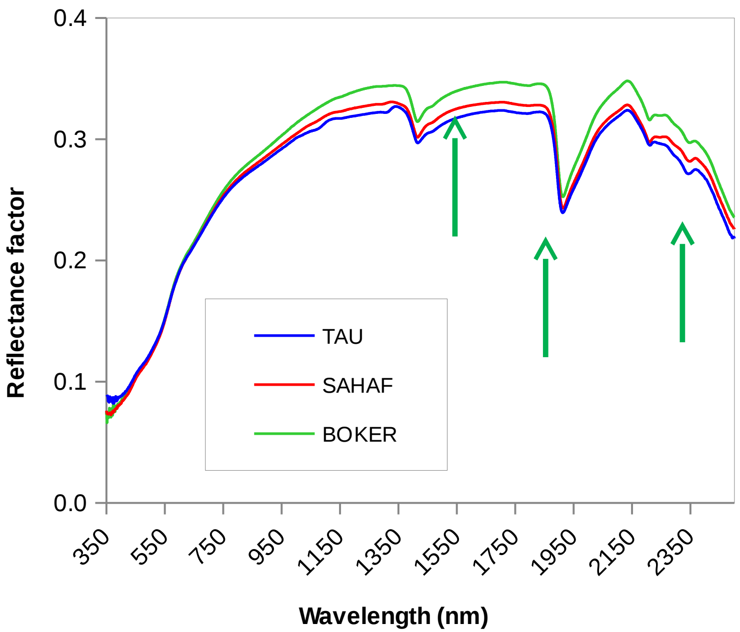
Results - Standardization

Soil B spectrum comparison before and after *Sand* standardization

Original



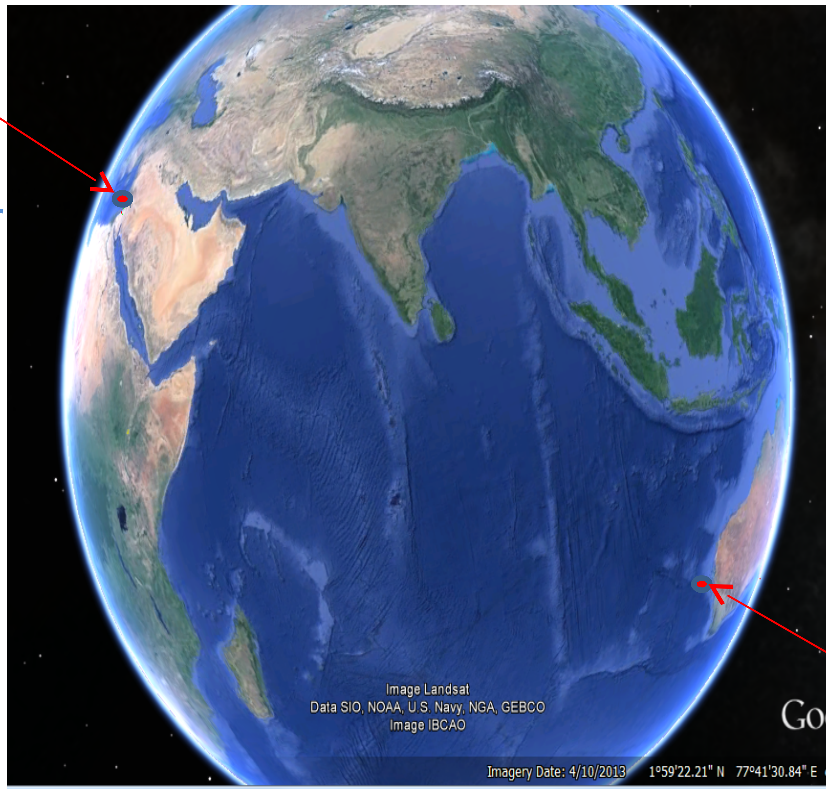
***Sand* corrected**



Sets Up (development)

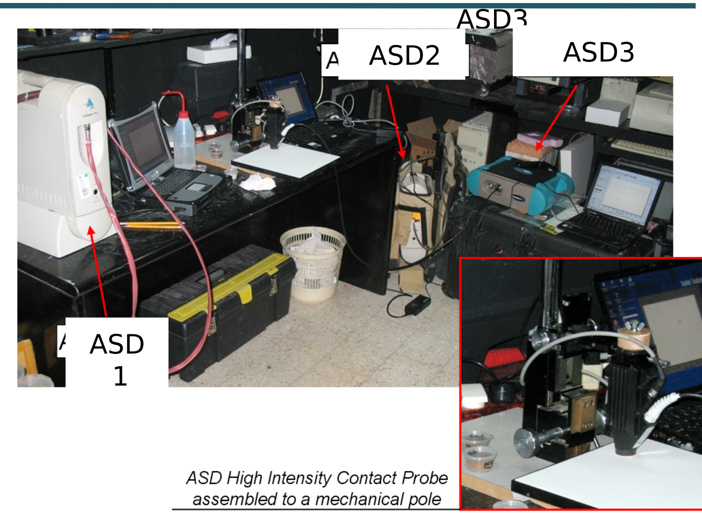
Tel Aviv

September



Perth

August



ASD High Intensity Contact Probe assembled to a mechanical pole

- 4 different protocols
- 5 different spectrometers
- 4 users
- 4 different White Reference
- 2 different geographical location

Same Soil Samples,
Same ISS

CSIRO 0 - Brand New HALON Plate as a WR with, ASD-2, contact probe (CP), User-1, Perth, Protocol A(0) **MASTER**

Standard for Systemic Effects

Lucky Bay

Wiely Bay

Soil Mineralogy

Performance of Three Identical Spectrometers in Retrieving Soil Reflectance under Laboratory Conditions

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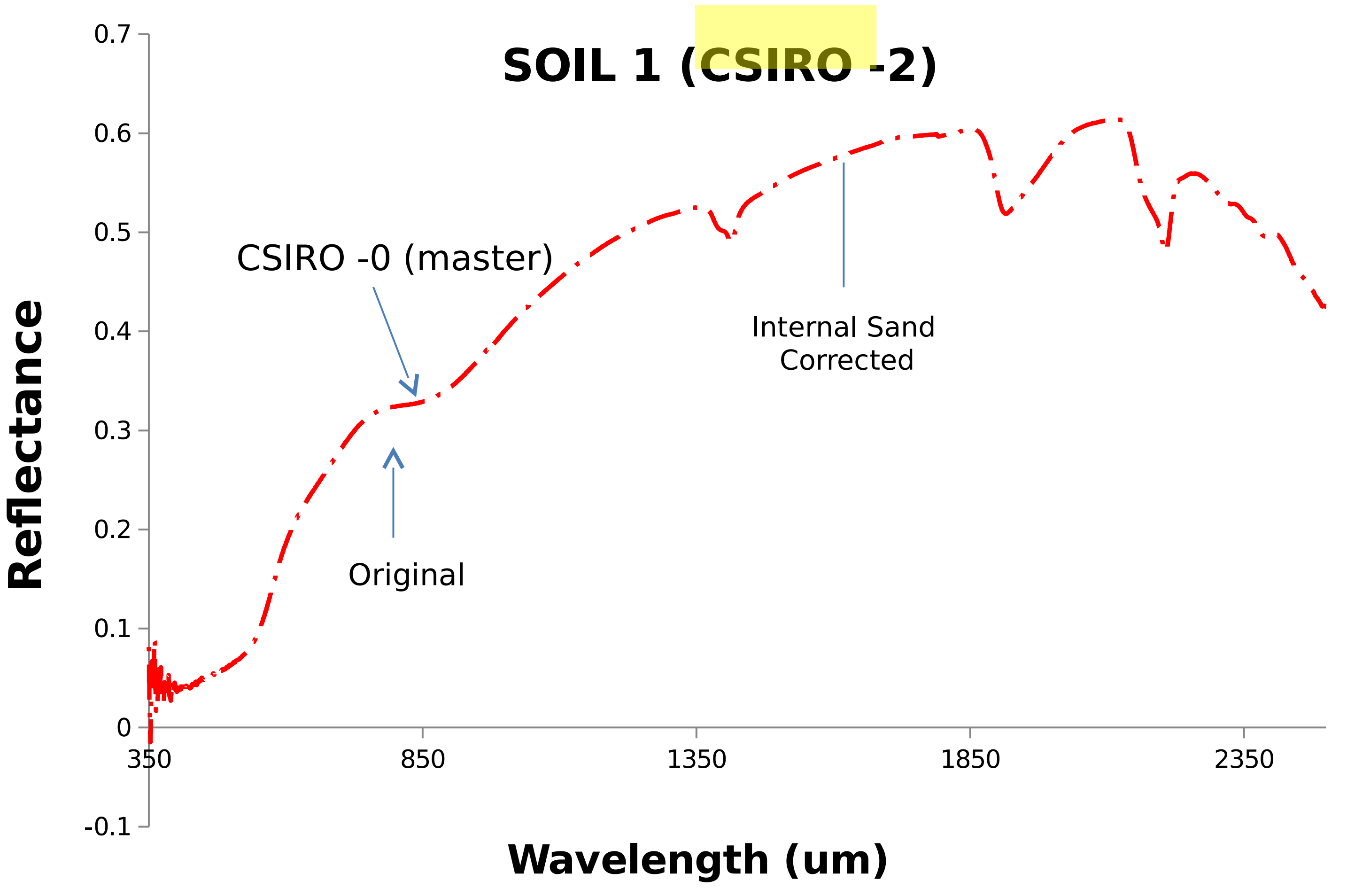

SOIL 1 (CSIRO -2)
CSIRO -0 (master)
Internal Sand
Corrected
Original
Reflectance
Wavelength (um)
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
350
850
1350
1850
2350

ASDS = Average Sum of Deviation Square (Ben-Dor et al., 2004)

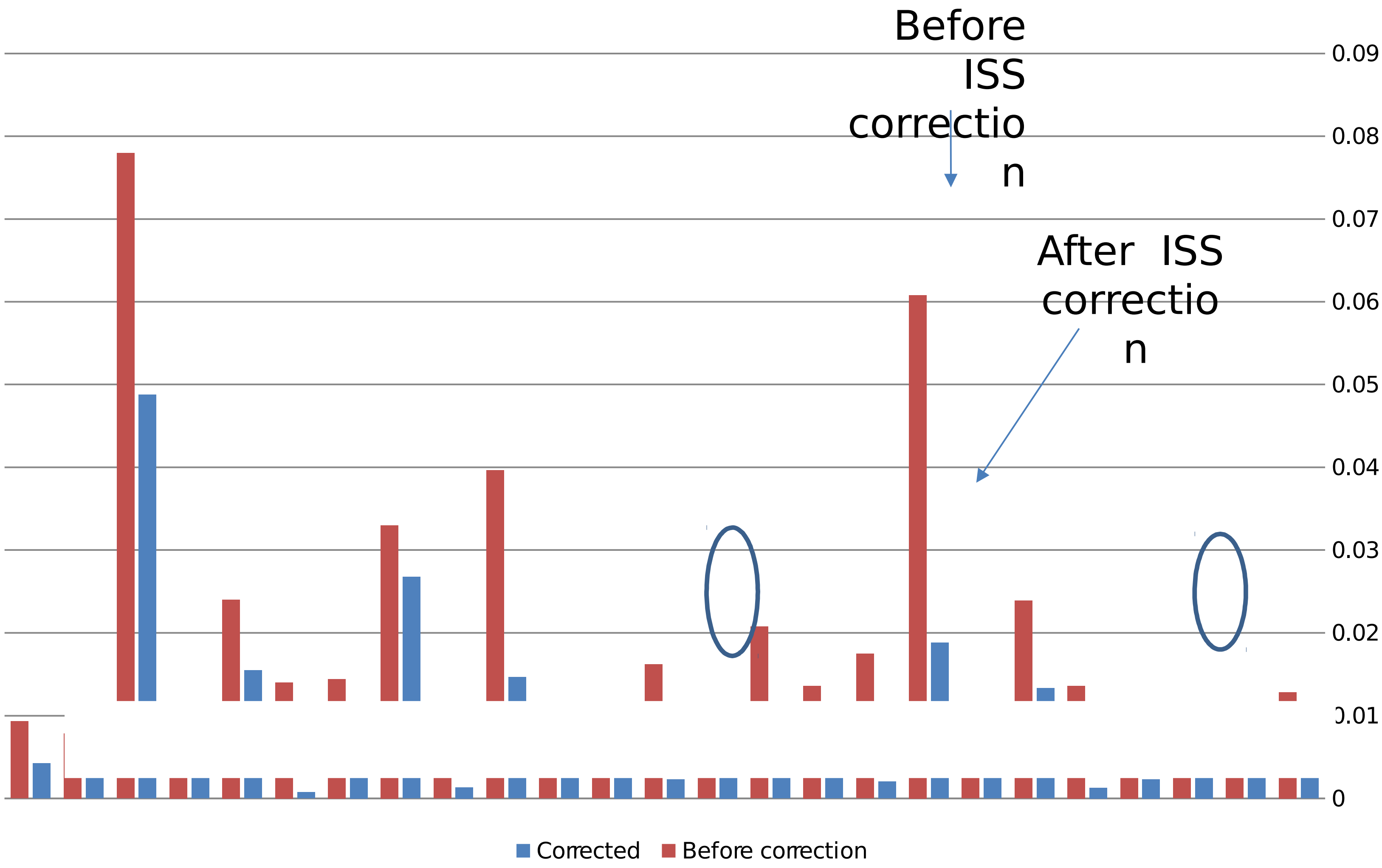
$$ASDS = \frac{\sum_{\lambda=350}^{2500} \sigma \left(1 - \rho_{\lambda} / \rho*_{\lambda}\right)^{2}}{2151}$$

ρ : sample reflectance
ρ * : reference reflectance

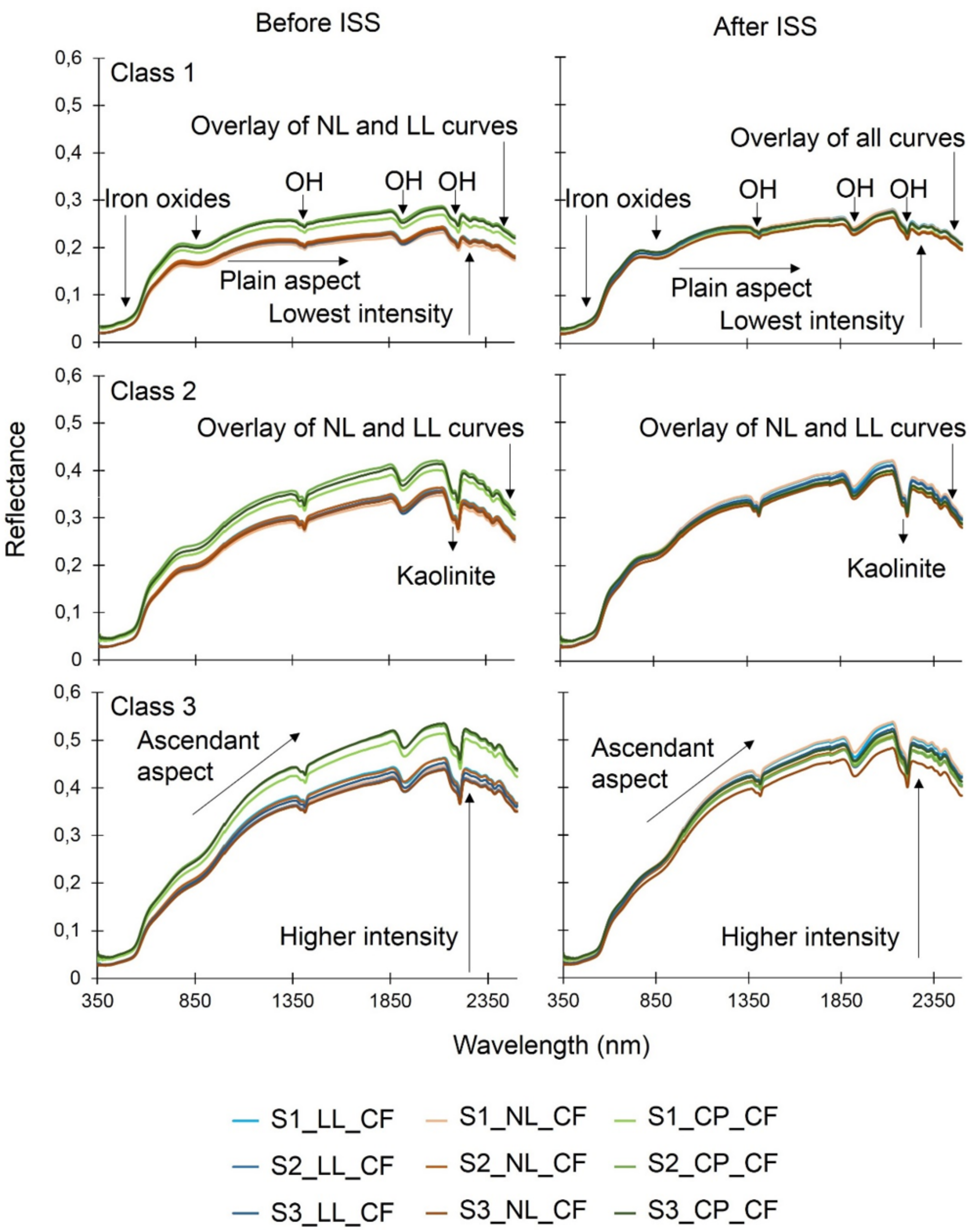
ASDS □ 0 = good match

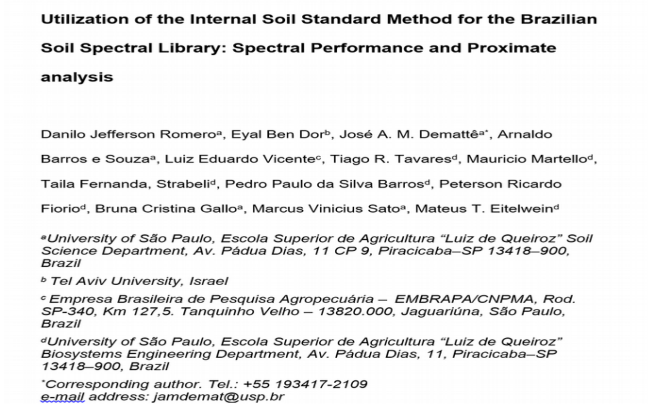
ASDS

success 92%



Sets Up (validation II)





Utilization of the Internal Soil Standard Method for the Brazilian Soil Spectral Library: Spectral Performance and Proximate analysis

Danilo Jefferson Romero[a], Eyal Ben Dor[b], José A. M. Demattê[a*], Arnaldo Barros e Souza[a], Luiz Eduardo Vicente[c], Tiago R. Tavares[d], Mauricio Martello[d], Taila Fernanda, Strabeli[d], Pedro Paulo da Silva Barros[d], Peterson Ricardo Fiorio[d], Bruna Cristina Gallo[a], Marcus Vinicius Sato[a], Mateus T. Eitelwein[d]

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[c] Empresa Brasileira de Pesquisa Agropecuária – EMBRAPA/CNPMA, Rod. SP-340, Km 127,5. Tanquinho Velho – 13820.000, Jaguariúna, São Paulo, Brazil

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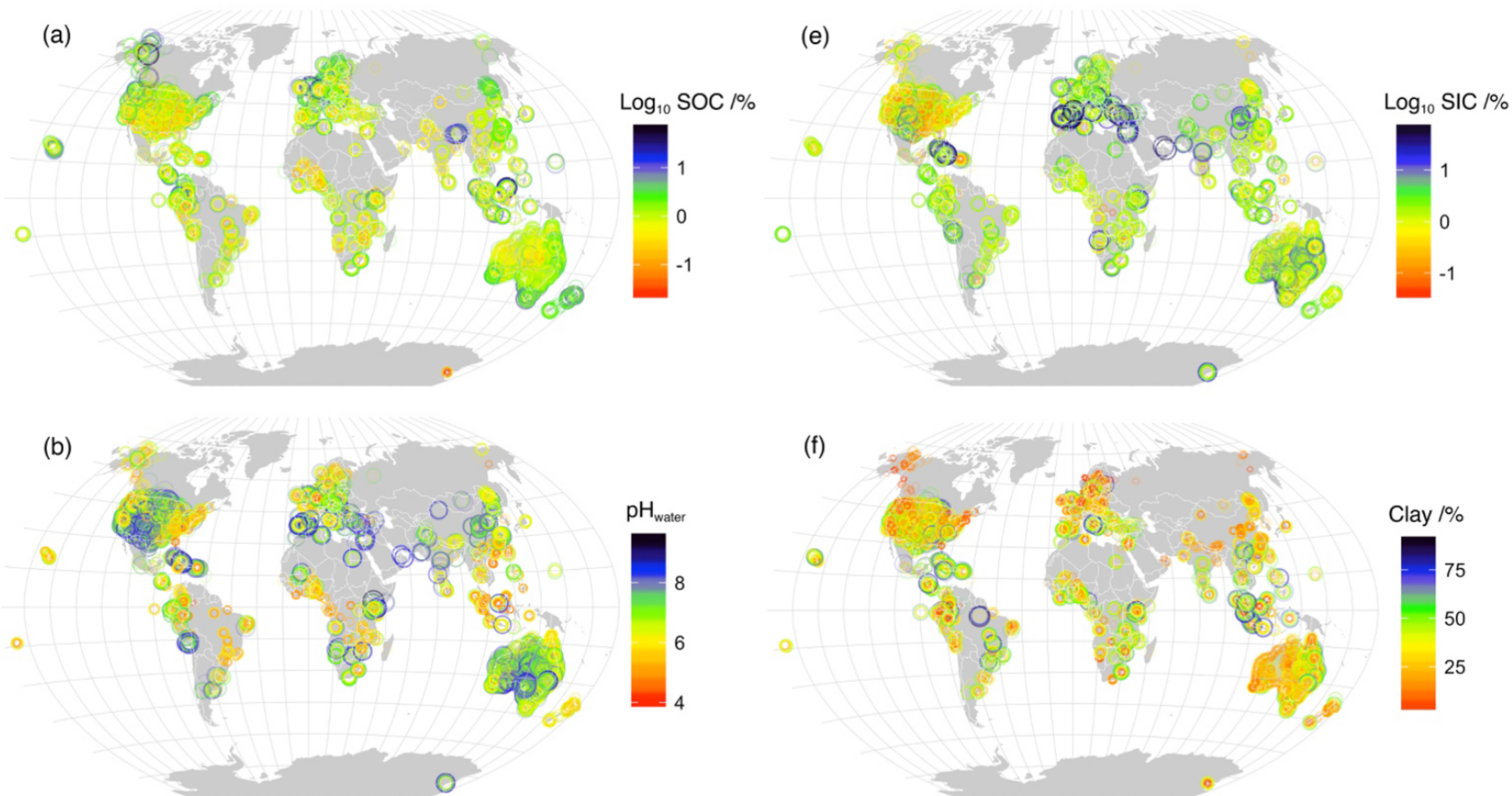
The ISS method has been successfully adopted by Brazil for the national project entitle: Establishing the Brazilian National Soil - Spectral Library " 2015

GSSL – Example

Chemomtric (non linear spectral data mining) from the GSSL

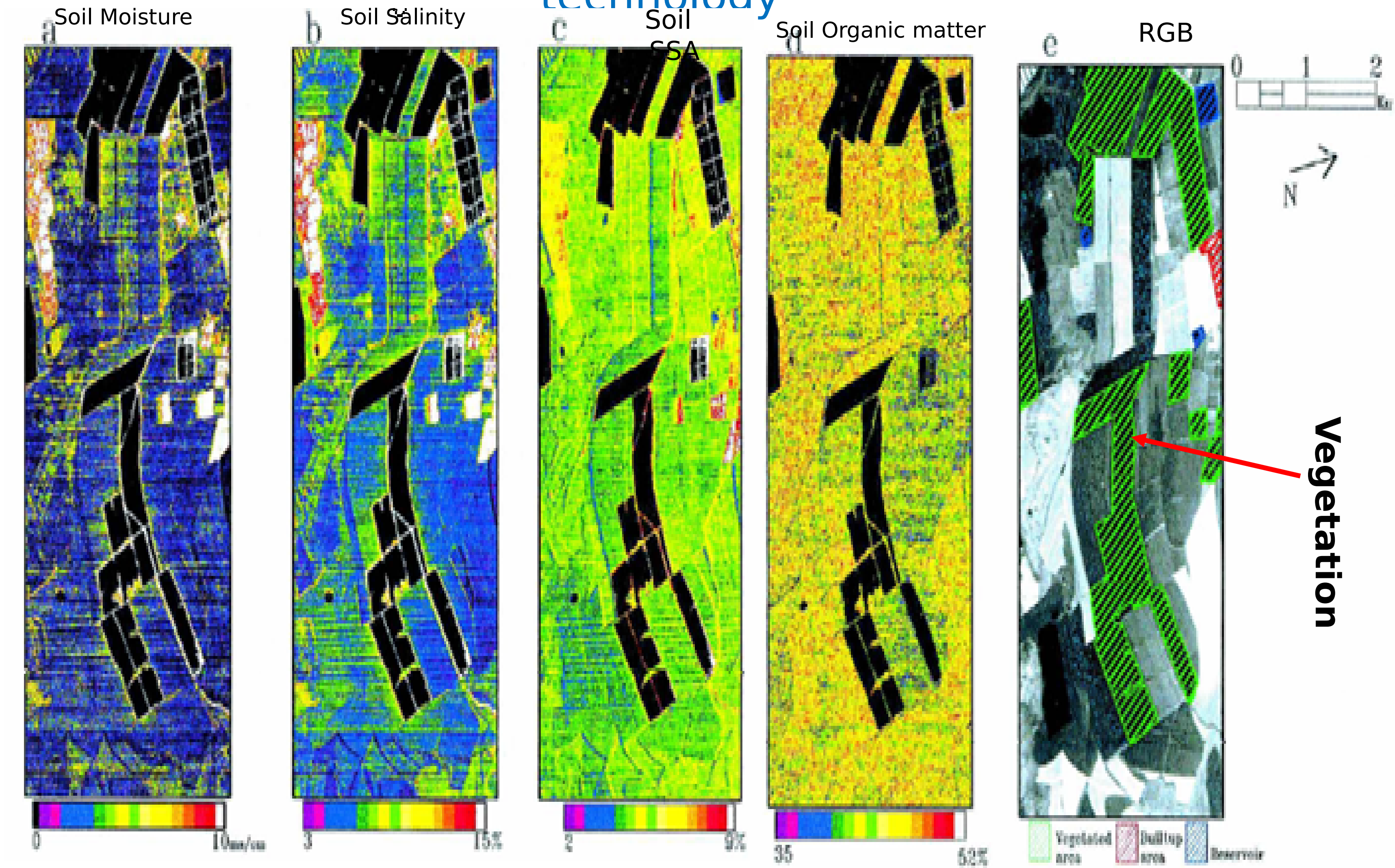
Spatial distribution of predictions



Viscorra Rossel 2015

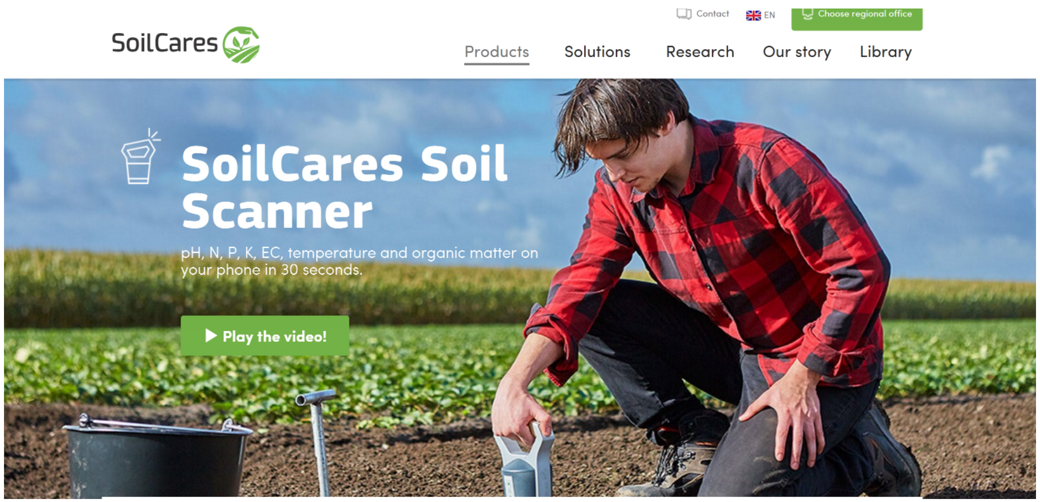
Regional Soil Spectral Library

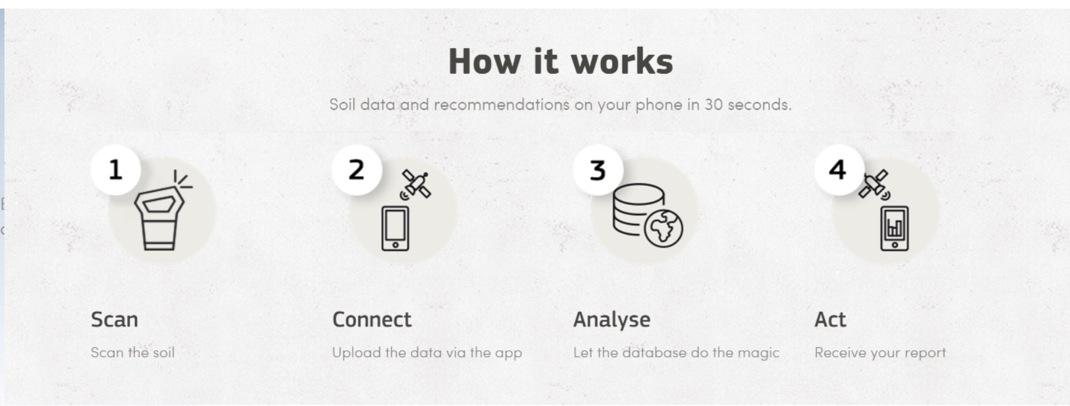
Agricultural Soil Mapping based on Local SSL and HSR technology



Ben-Dor et al., 2004

Soil Spectral Library : The Commercial Value (1)





/http://www.soilcares.com/en/products/scanner

Soil Spectral Library : The Commercial Value (1)

News

10.18.16 | Research, Development and Innovation

Innovative technology analyzes soil in just 30 seconds

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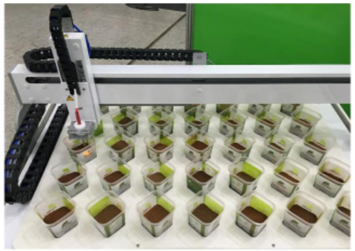
Photo: André Marcelo de Souza



Embrapa Solos (RJ), in partnership with the private sector, has developed a technology package for the soil analysis that will revolutionize the market in Brazil. Called SpecSolo, it has the advantage of analyzing soil samples non-destructively, quickly and economically. Tens of fertility parameters (soil organic carbon, pH, calcium, magnesium, phosphorus, potassium, among others) and physical soil (clay, silt, sand) can be analyzed simultaneously in 30 seconds. Conventional analysis takes days to present the same parameters.

"The SpecSolo is based on the use of techniques of vibrational spectroscopy and artificial intelligence," explains André Marcelo de Souza, from Embrapa Solos researcher and responsible for technology. Souza explains that the technology makes use of accurate and efficient algorithms. "These algorithms", explains the scientist, "will use a robust database with over one million representative soil samples from Brazil." Souza says that the samples and related analytical data were obtained from one of the largest laboratories in the world soil analysis, the Brazilian Institute of Analysis (IBRA), development of project partner and co-responsible for technology.

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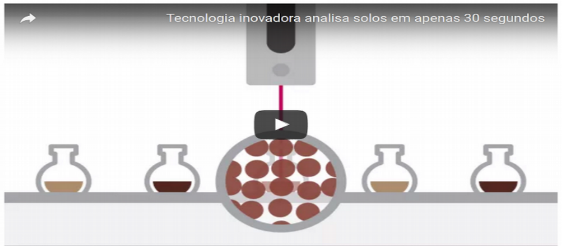
soil analysis goes to the producer

Rapid (and massive) analyses of soil samples with out the need for “wet” laboratories

2016

"The SpecSolo analytical solution is one of the greatest innovations in the analysis of the last five decades soils in Brazil, resuming the mission of Embrapa to propose and implement new methodologies for soil analysis in the Brazilian agricultural scenario," reiterates the general head of Embrapa Solos Daniel Vidal Pérez. Both the instrument and technology have the seal of Embrapa. Therefore, the SpecSolo will be an official method recommended by the Company for soil analysis in Brazil.

How it works



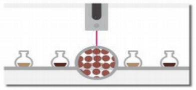
For the duo of directors of IBRA Armando Saretta Parducci Parducci and Thiago Camargo, the partnership between Embrapa Soils and IBRA enabled the development of technology. "We are the pioneers in Brazil to build a robust database with such a significant number of samples of Brazilian soil, essential for the development and success of technology," says Armando Parducci.

In addition to the large database, the technology package SpecSolo has a unique hosted software in the cloud for processing information and innovative equipment dedicated to soil analysis, called SpecSolo-Scan.

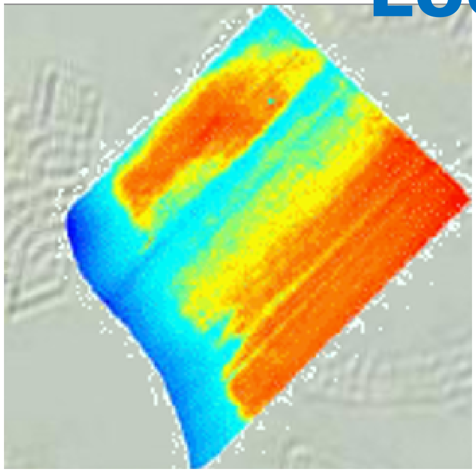
The equipment has an automatic sampler that allows simultaneous analysis of 40 soil samples and autonomy to work alone for 20 minutes. After that time, the analytical results are generated automatically, remotely accessing the database. The results can be released according to the service purchased by the customer and may be in the form of analytical results of each soil parameter or interpretation of bands of soil fertility.

The project also includes an expert system to generate fertilizer recommendations and liming, according to the main manual available in the country. SpecSolo-Scan is the first commercial instrument near infrared spectroscopy and visible (VisNIR) the world to present an autosampler and an integrated system with database fully dedicated to soil analysis.

Videos See more



Soil Mapping in the Field using Local SSL



The concept of using GSSL using Airborne Sensors

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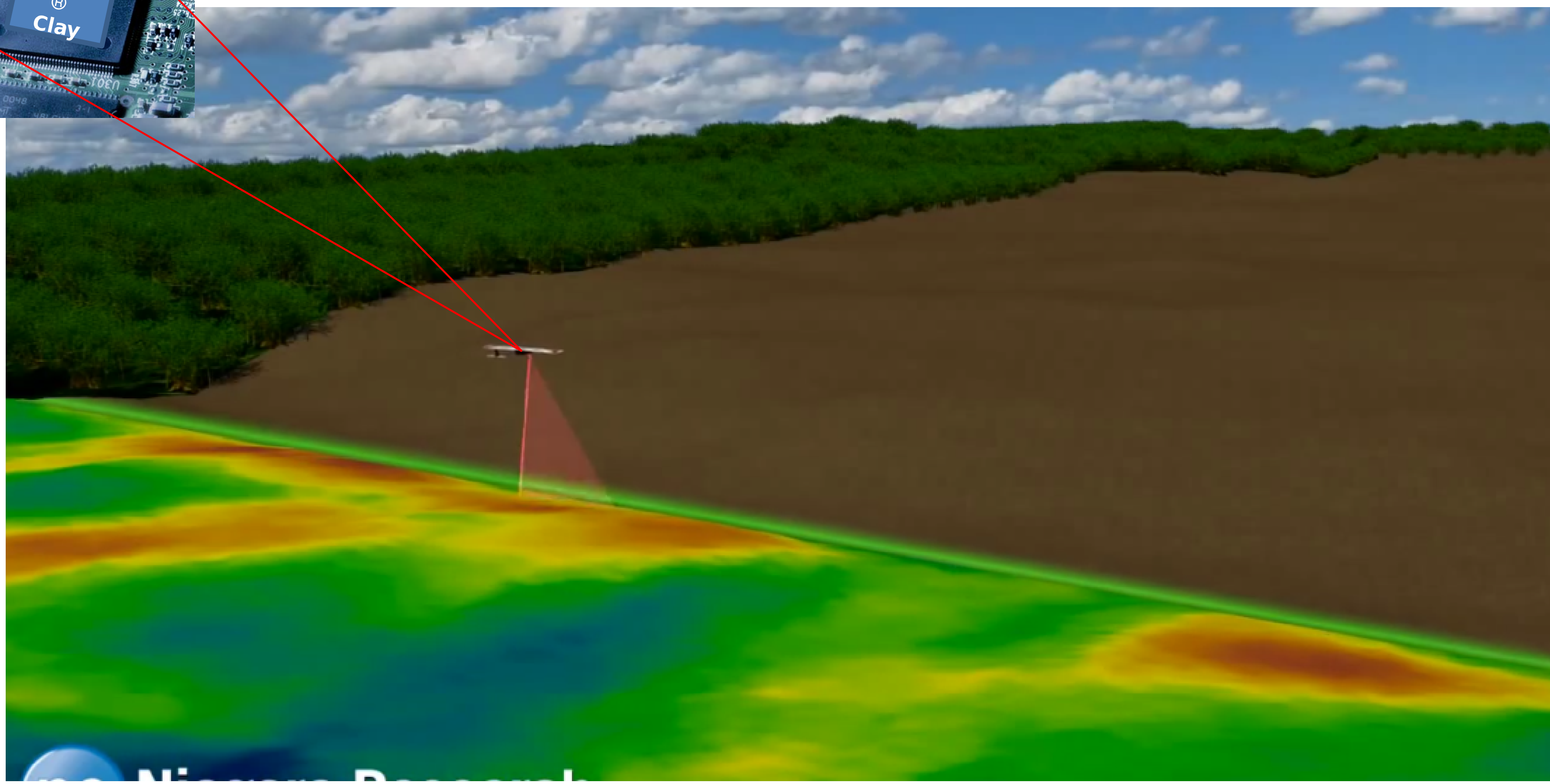
Drones



o oil Mapping using LSSL and Drones in real time mode

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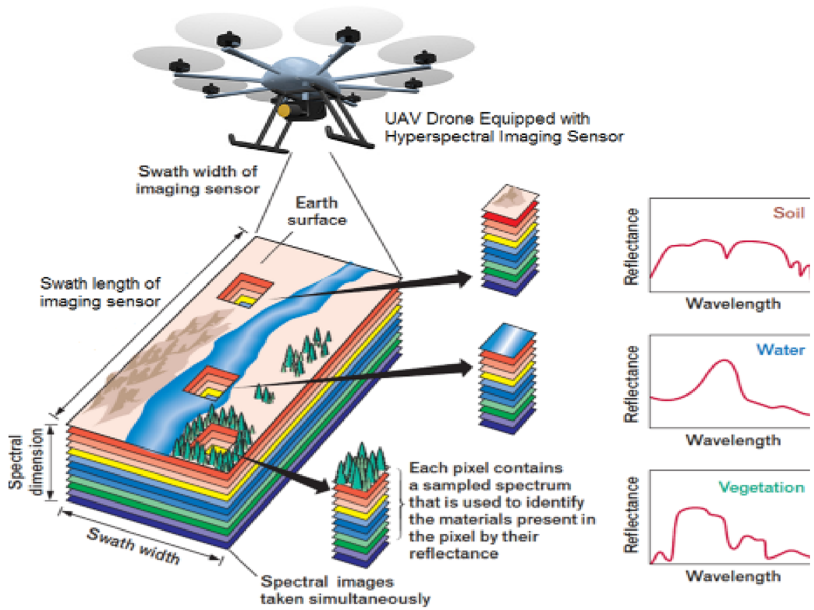
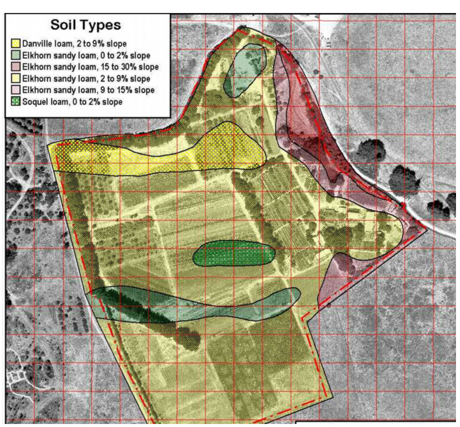


Model
from
SSL



e Soil Spectroscopy Library Summary

- Reflectance spectroscopy (RS) of soils is an important property for Food Security issues world wide.
- Spectral libraries are generated under regional, national, continental and global scales.
- The GSSL initiative paves the road to accumulate libraries from all scales and resources global wide.
- SSLs from North Africa, Mediterranean and Balkan countries should be extend in order to be a data base for modern precision agriculture activities.
- Standard and protocols are existing and should used for the GEO-CRADLE's Reginal SSL PILOT.

!! Thank You

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