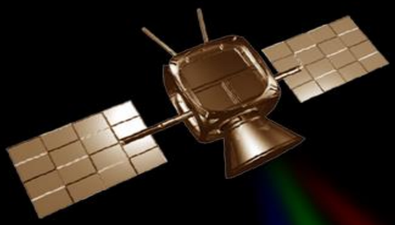
Combating Soil Degradation from Space
(using Hyperspectral Technology)



Eyal Ben Dor
Department of Geography
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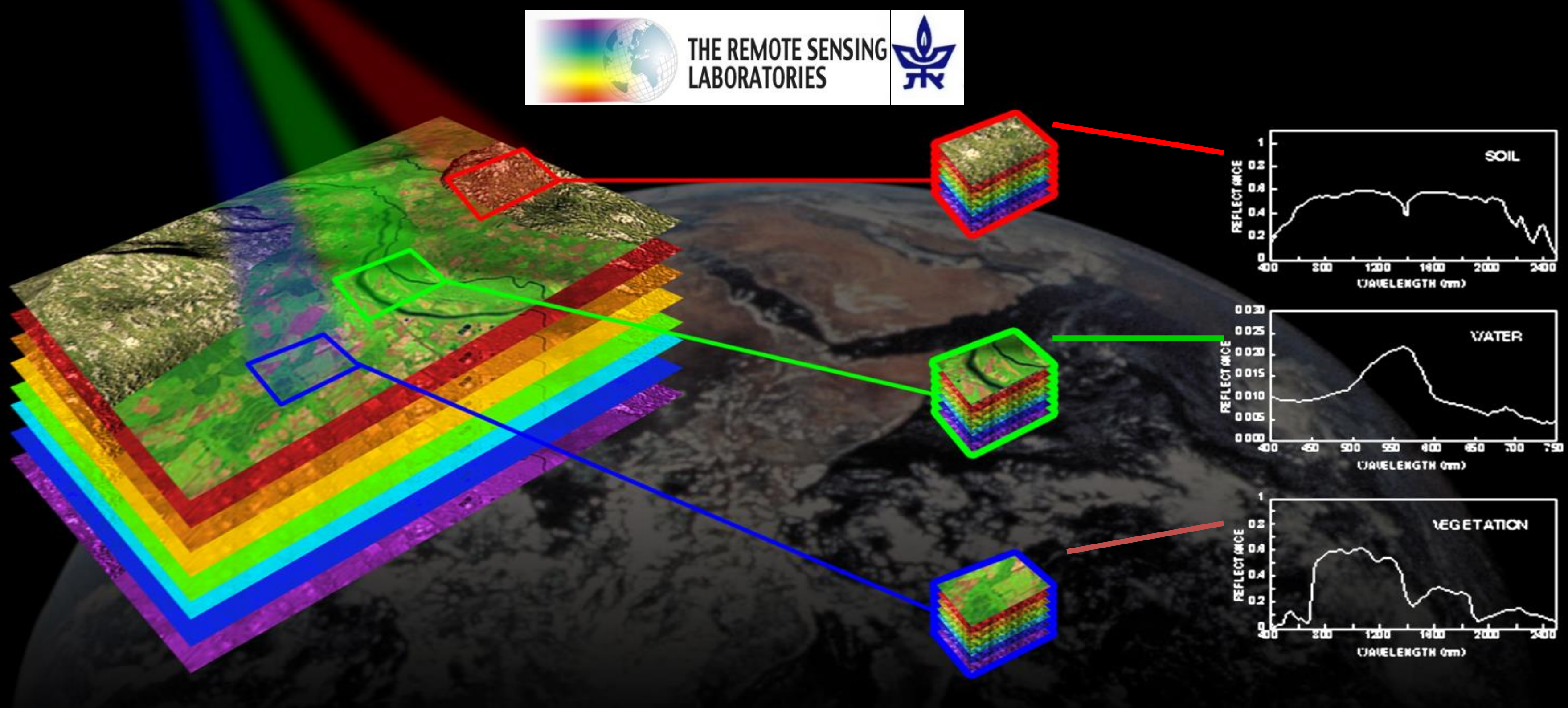
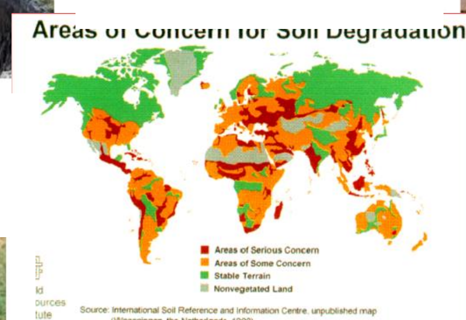


Definition 1

Soil Degradation

http://www.worldometers.info/

Soil degradation is defined as the lost of soil production either by chemical or physical processes (Singer and Munas, 2002).



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Problems

- How to monitor soil degradation in real time domain covering large areas ?
- How to use this information to better mange soil preservation and production ?

Solutions

To use innovative remote sensing technique.

More specifically:

- **Imaging Spectroscopy / Hyperspectral Remote Sensing**

- **Soil Spectroscopy**

Definition 2

Hyperspectral Remote Sensing (HSR)

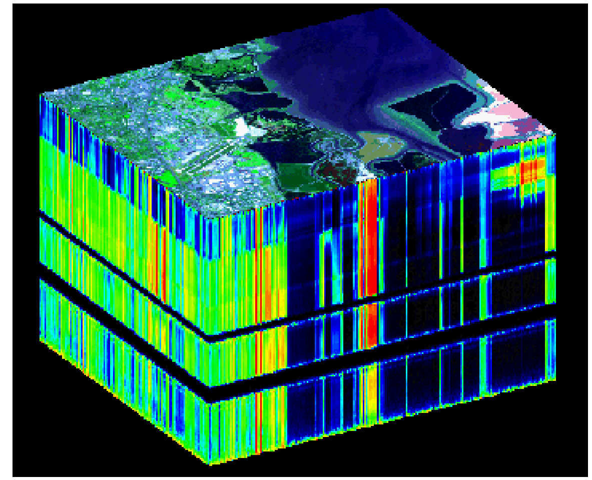
Imaging spectroscopy

From Wikipedia, the free encyclopedia

Imaging spectroscopy is the simultaneous acquisition of spatially coregistered images in many spectrally contiguous bands. To be scientifically useful, such measurement should be done using an internationally recognized system of units. The image produced by imaging spectroscopy is similar to an image produced by a digital camera, except each pixel has many bands of light intensity data instead of just three bands: red, green and blue.

Imaging spectrometer data acquisition allows the quantitative and qualitative characterization of both, the surface and the atmosphere, using geometrically coherent spectrodirectional radiometric measurements. These measurements can then be used for the unambiguous direct and indirect identification of surface materials and atmospheric trace gases, the measurement of their relative concentrations, subsequently the assignment of the proportional contribution of mixed pixel signals (e.g., the spectral unmixing problem), the derivation of their spatial distribution (mapping problem), and finally their study over time (multi-
ter

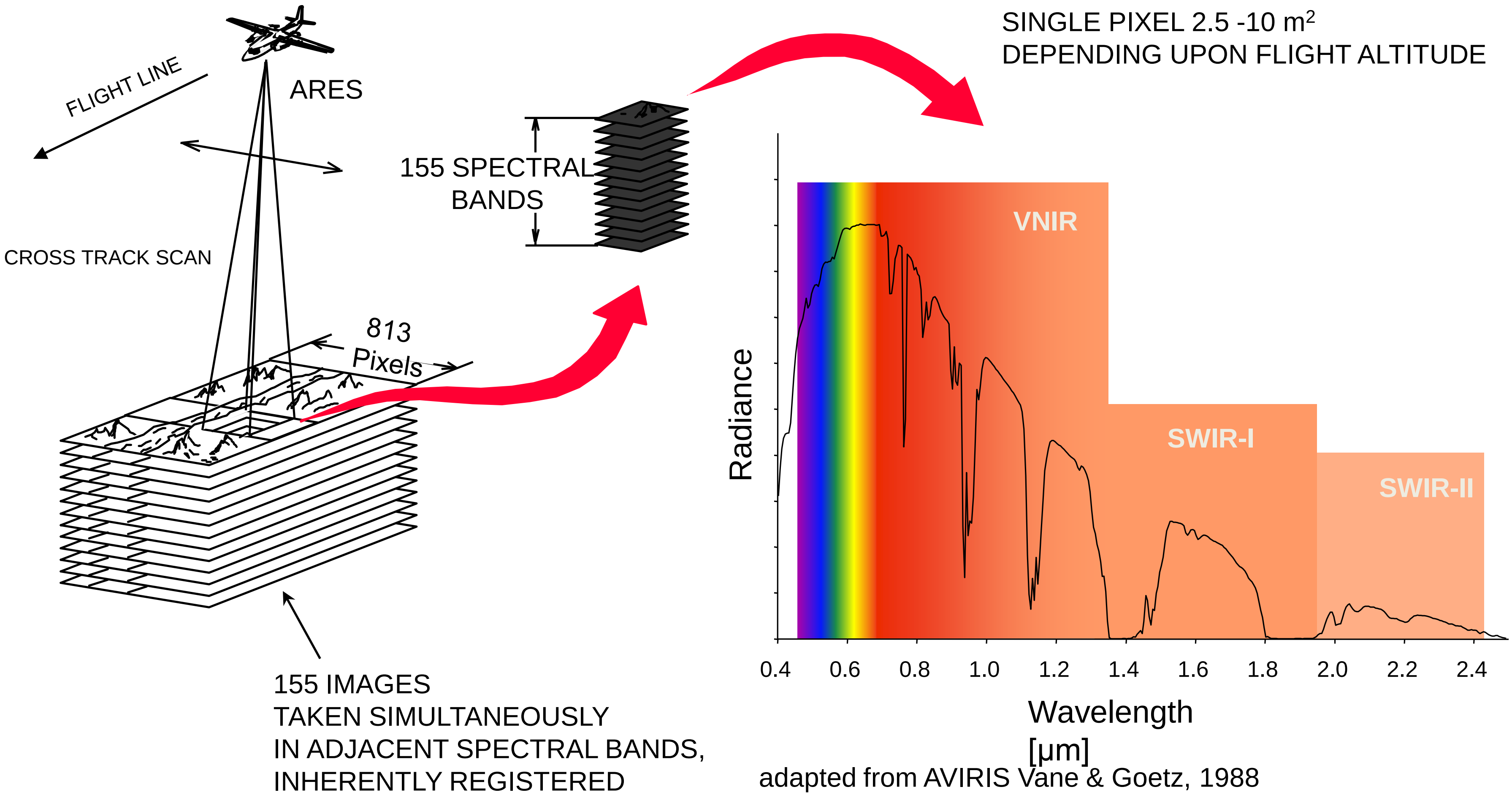
Ash plumes on Kamchatka Peninsula, eastern Russia. A MODIS image.



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)

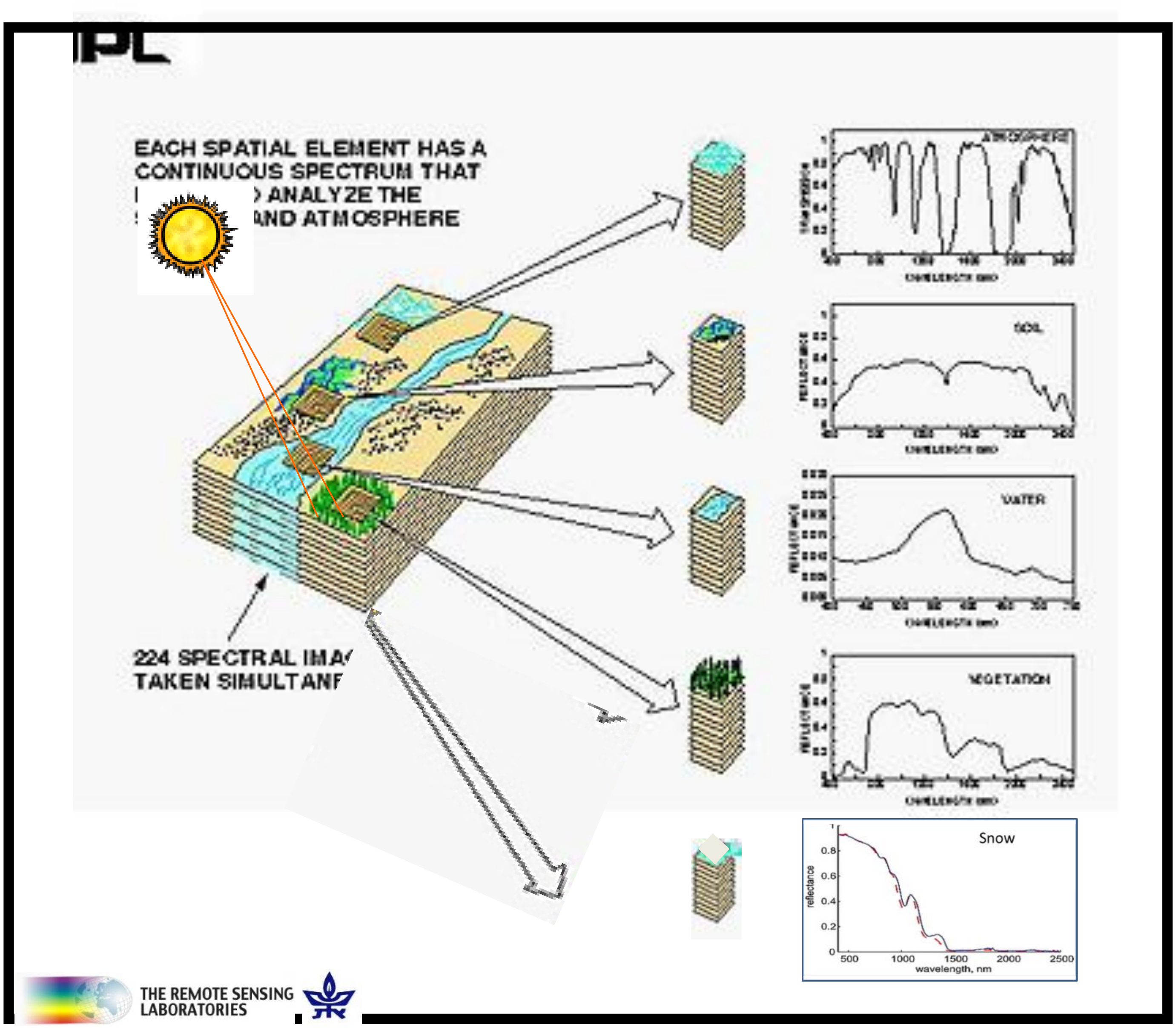
HSR – illustration



adapted from AVIRIS Vane & Goetz, 1988

Each pixel has a spectrum view

All Spheres



Atmosphere

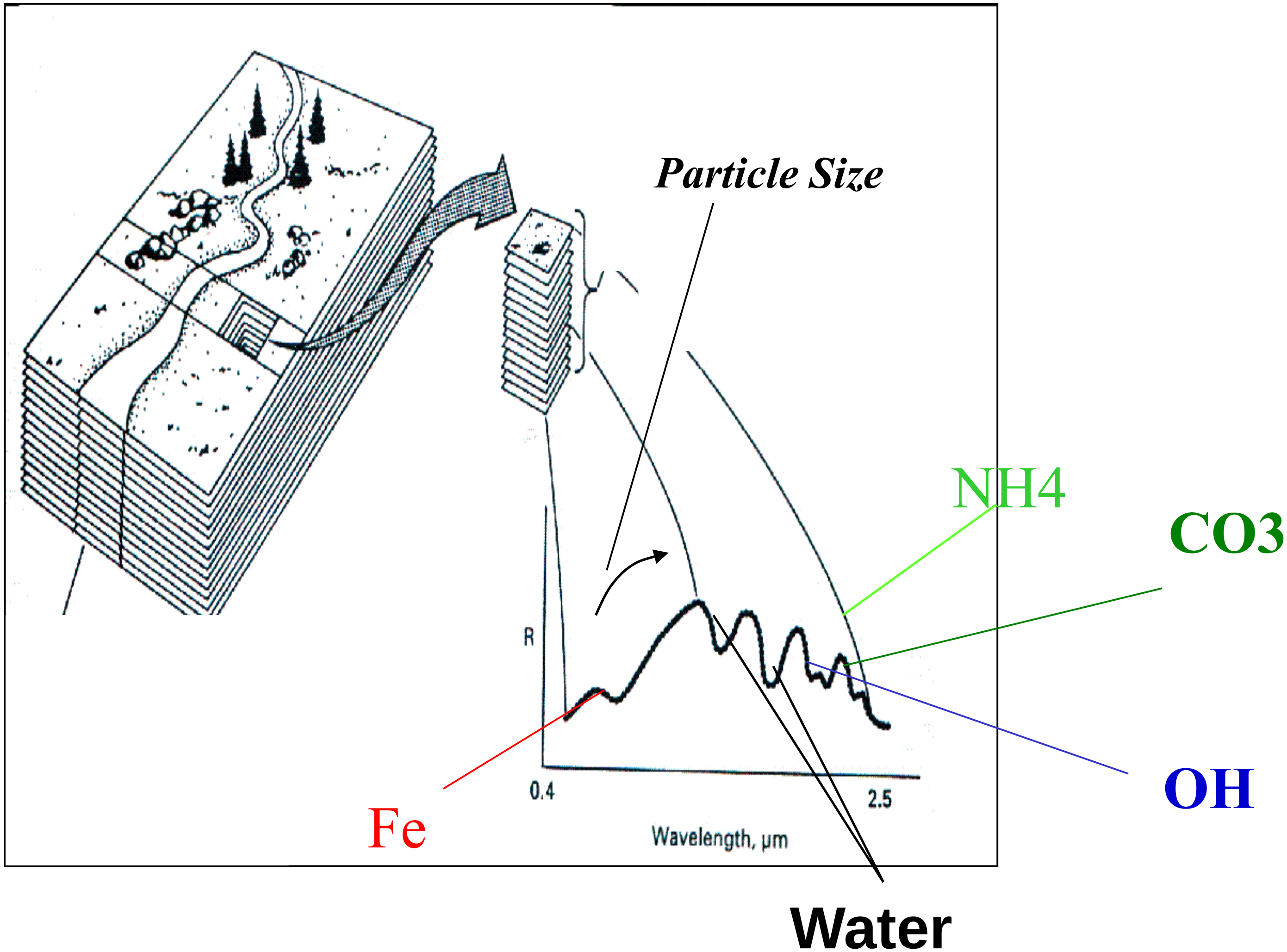
lithosphere

Hydrosphere

Biosphere

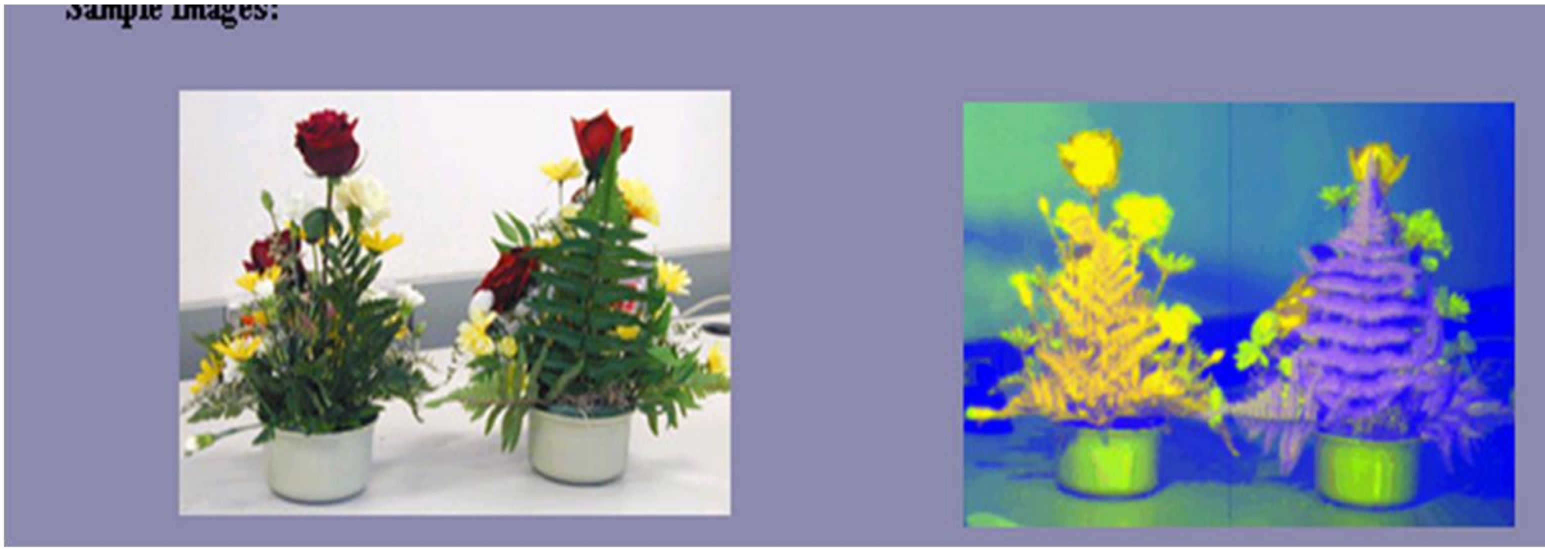
Criosphere

Each Pixel's spectrum provides chemical information
Than enables quantitative assessment and precise identification of materials



Example 1– at laboratory domain

Precise identification of “fake” vegetation



VIS -RGB

SWIR -RGB

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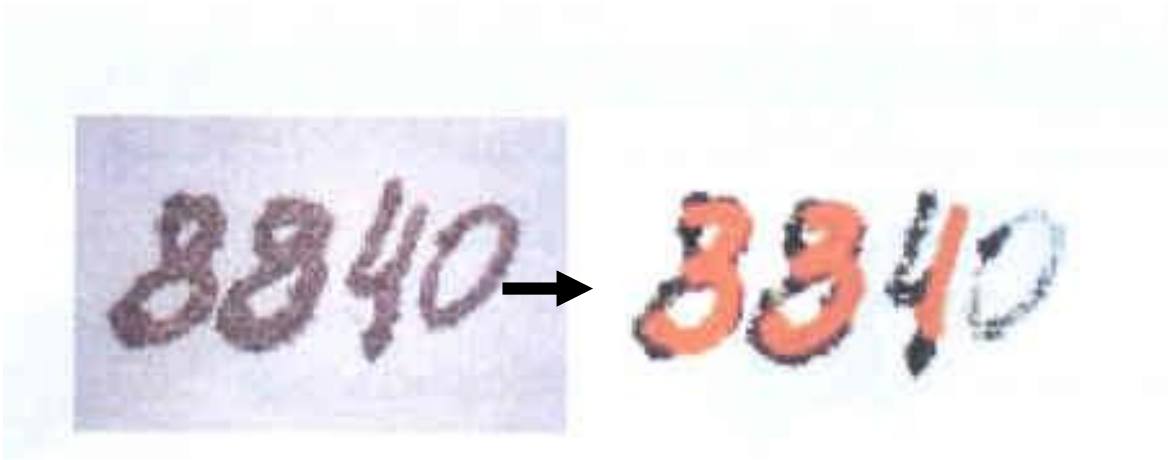
Example 2– at laboratory domain

Identification od Handwriting forgery

How 331 became 8840….



RGB domain IS domain

IS can do this job

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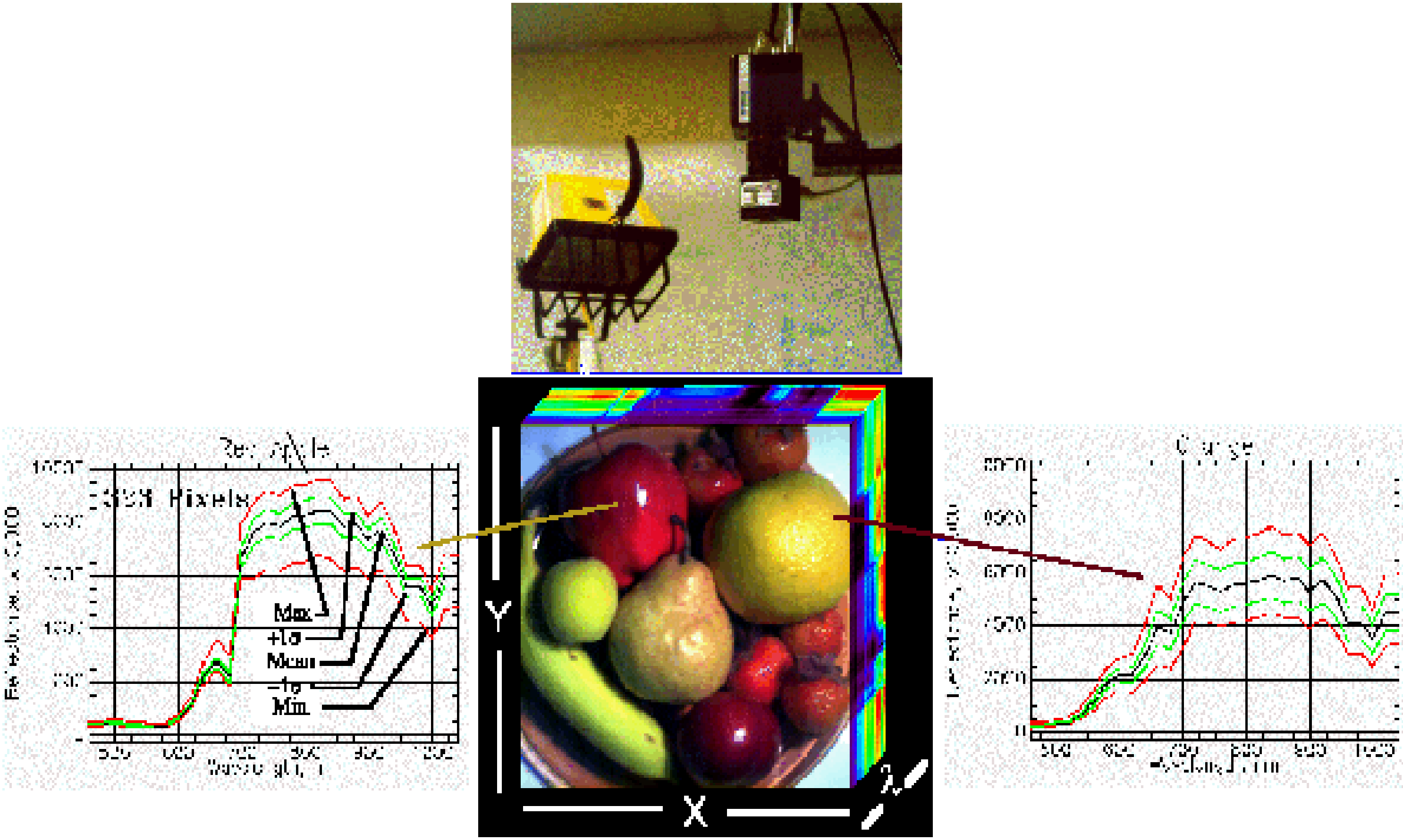
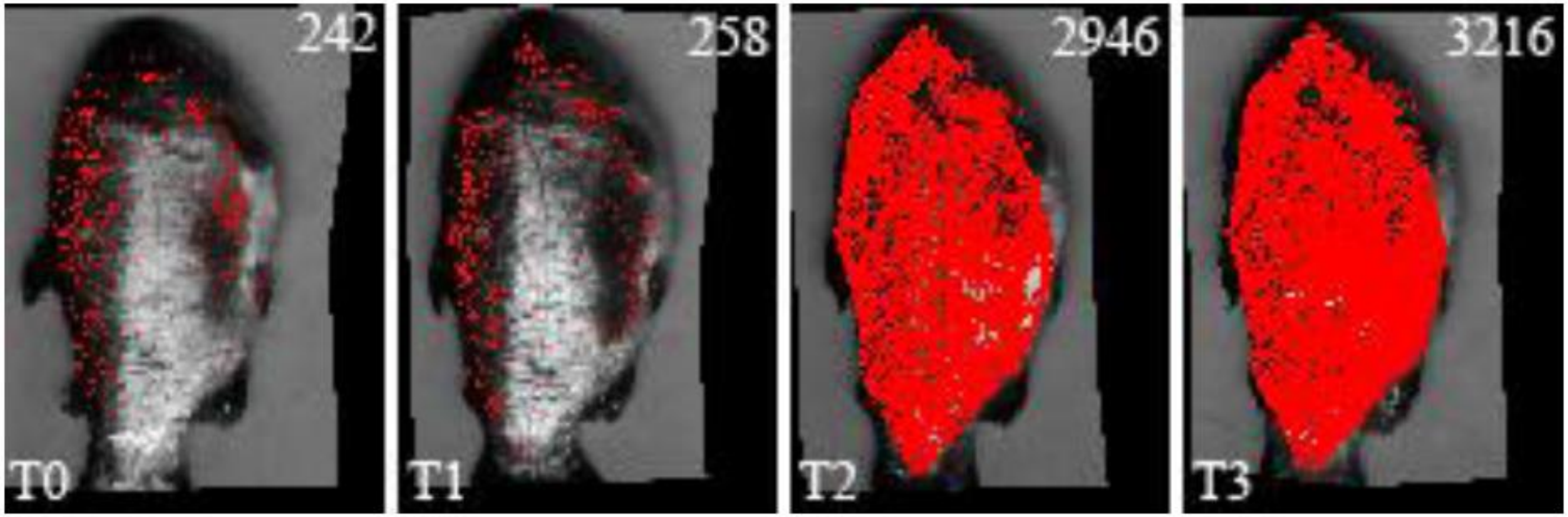
Example 3– at laboratory domain

sugar and moisture contents in fruits



Example 4 – at laboratory domain

Identification of Fish Freshness



Example of fish freshness classification (pixels in red are those classified as 'non-fresh').

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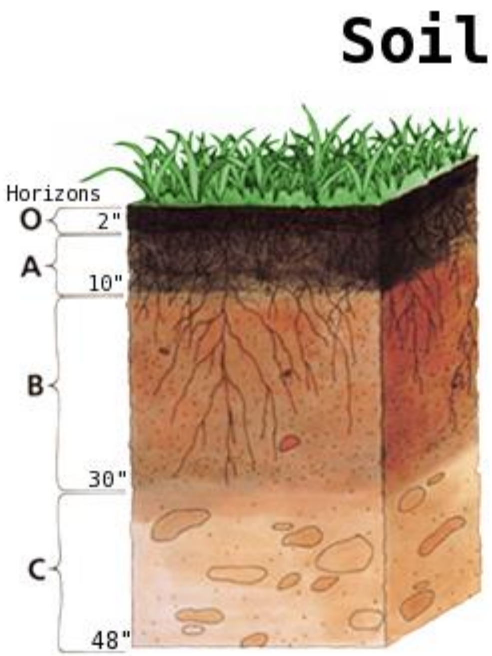
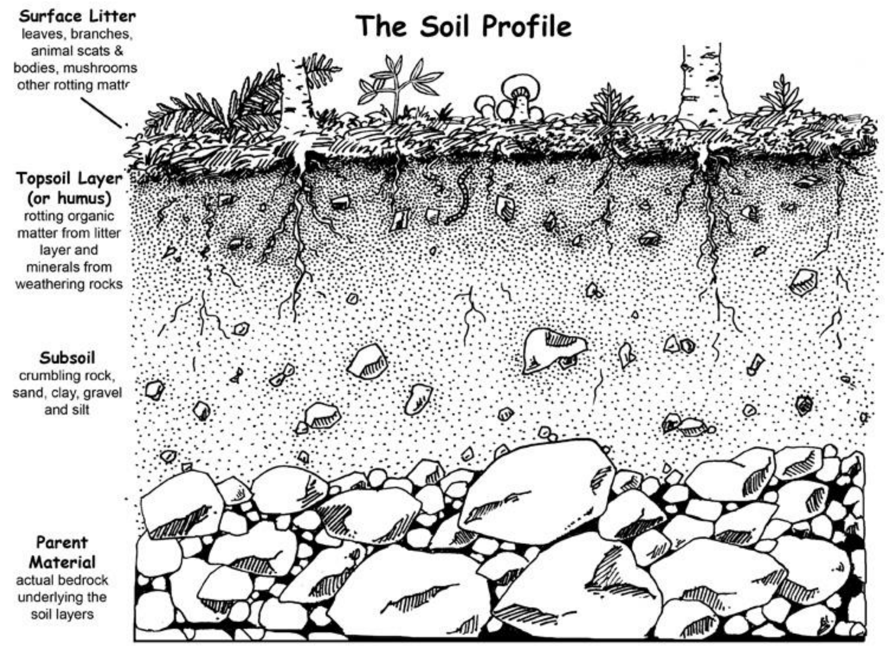
Definition 3

Soil

The upper laye **medium for plants to grow** *rial which is dug, plo* *1957)*





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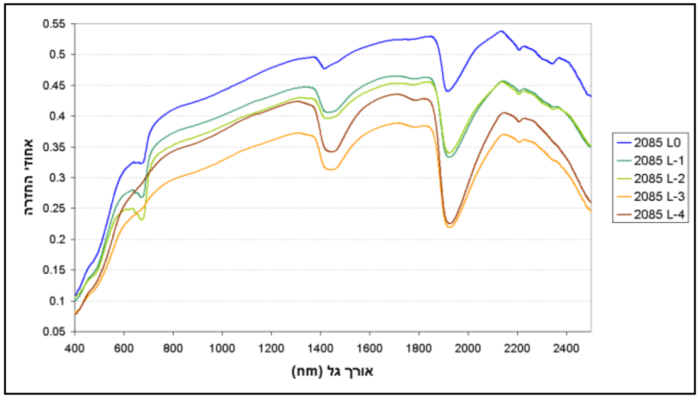
Definition 4

- Soil Spectroscopy refers to the reflectance/emittance part of the electromagnetic radiation that interacts with the soil matter across the VIS-NIR-SWIR-TIR spectral region range (0.35-14μm).



Point – one pixel

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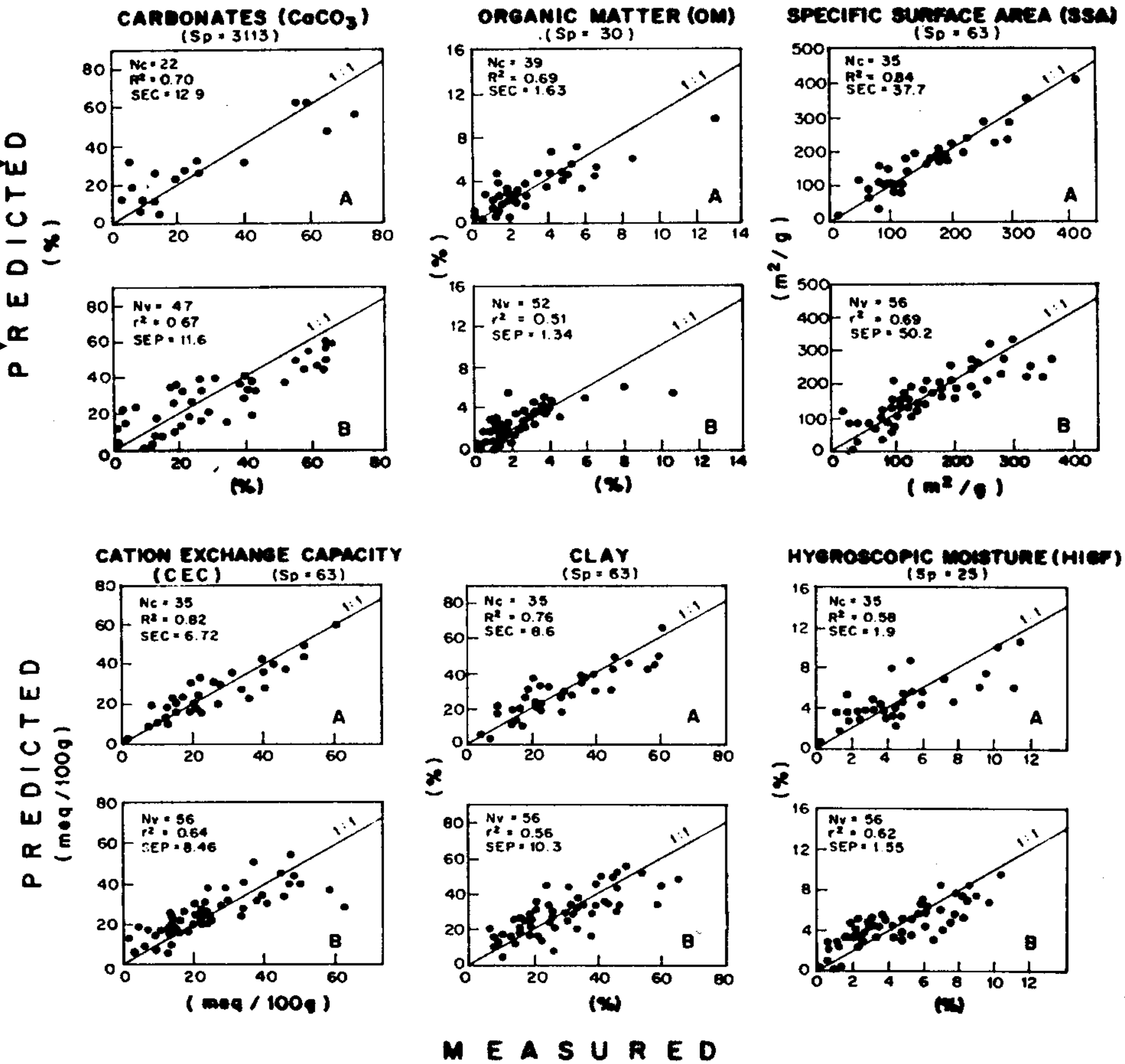
Predication →

Validation →



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Soil spectroscopy – an alternative way for wet laboratory measurements

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Table 1 (*continued*)

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)
N; %	MIR	2500–20,000	PLSR			0.88	Janik and Skjemstad (1995)
N; %	UV–VIS–NIR	250–2450	PLSR (11)	59 x-val	0.007		Walvoort and McBratney (2001)
N (NO_3); mg/100g	VIS–NIR	400–2400	SMLR (589, 1014)	15 | 10		0.54	Shibusawa et al. (2001)
N (miner.); mg/kg	NIR	1100–2498	PLSR (1)	179 x-val		0.08	Reeves et al. (1999)
N (pot. min); mg N/kg	VIS–NIR	400–2498	PCR (8)	30 | 119	26.05	0.72	Chang et al. (2001)
N (active); mg/kg	NIR	1100–2300	PLSR (8)	180 x-val		0.84	Reeves and McCarty (2001)
N (active); mg/kg	NIR	1100–2498	PLSR (9)	120 | 59		0.92	Reeves et al. (1999)
N organic (total); %	MIR	2500–25,000	PLSR	188		0.86	Janik et al. (1998)
N (total); %	NIR	1100–2500	MLR (1702, 1870, 2052)	72 | 48		0.92	Dalal and Henry (1986)
N (total); mg/kg	NIR	1100–2300	PLSR (10)	180 x-val		0.94	Reeves and McCarty (2001)
N (total); mg/kg	NIR	1100–2498	PLSR (8)	120 | 59		0.95	Reeves et al. (1999)
N (total); g/kg	VIS–NIR	400–2498	PLSR (7)	76 | 32	0.04	0.86	Chang and Laird (2002)
N (total); g/kg	VIS–NIR	400–2498	PCR (7)	30 | 119	0.06	0.85	Chang et al. (2001)
Na (exch.); cmol/kg	MIR	2500–25,000	PLSR	183		0.33	Janik et al. (1998)
Na (exch.); cmol/kg	VIS–NIR	400–2498	PCR (7)	30 | 119	1.3	0.09	Chang et al. (2001)
Na; mmol(+)/kg	UV–VIS–NIR	250–2500	PCR	121 | 40		0.34	Islam et al. (2003)
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)

(continued on next page)

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Table 1 (*continued*)

Soil attribute	Spectral region	Spectral range (nm)	Multivariate method[a]	n_{calib} | n_{valid}[b]	RMSE	R^2	Authors
pH_{Ca}	VIS–NIR	400–2498	PCR (13)	30 | 119	0.56	0.56	Chang et al. (2001)
pH_w	MIR	2500–25,000	PLSR	183		0.56	Janik et al. (1998)
pH_w	NIR	700–2500	PCR	121 | 40		0.70	Islam et al. (2003)
pH_w	VIS–NIR	400–2400	SMLR (959, 1214)	15 | 10		0.54	Shibusawa et al. (2001)
pH_w	VIS–NIR	400–2498	PCR (13)	30 | 119	0.55	0.57	Chang et al. (2001)
pH_w	UV–VIS–NIR	250–2500	PCR	121 | 40		0.71	Islam et al. (2003)
Clay; %	MIR	2500–20,000	PLSR			0.87	Janik and Skjemstad (1995)
Clay; %	MIR	2500–25,000	PLSR	88		0.79	Janik et al. (1998)
Clay; %	NIR	1000–2500	MRA (63 bands)	35 | 56		0.56	Ben-Dor and Banin (1995)
Clay; %	NIR	700–2500	PCR	121 | 40		0.75	Islam et al. (2003)
Clay; %	VIS–NIR	400–2498	PCR (12)	30 | 119	4.06	0.67	Chang et al. (2001)
Clay; g/kg	VIS–NIR	350–2500	MARS	305 | 152	7.5	0.78	Shepherd and Walsh (2002)
Clay; %	VIS–NIR	400–2500	modified PLSR	321		0.86	Cozzolino and Moron (2003)
Clay; %	UV–VIS–NIR	250–2450	PLSR (5)	59 x-val	2.9		Walvoort and McBratney (2001)
Clay; %	UV–VIS–NIR	250–2500	PCR	121 | 40		0.72	Islam et al. (2003)
Sand; %	MIR	2500–25,000	PLSR	88		0.94	Janik et al. (1998)
Sand; %	VIS–NIR	400–2498	PCR (8)	30 | 119	11.93	0.82	Chang et al. (2001)
Sand; %	VIS–NIR	400–2500	modified PLSR	319		0.70	Cozzolino and Moron (2003)
Sand; g/kg	VIS–NIR	350–2500	MARS	305 | 152	10.8	0.76	Shepherd and Walsh (2002)
Sand; %	UV–VIS–NIR	250–2500	PCR	121 | 40		0.53	Islam et al. (2003)
Silt; %	MIR	2500–25,000	PLSR	88		0.84	Janik et al. (1998)
Silt; %	VIS–NIR	400–2498	PCR (8)	30 | 119	9.51	0.84	Chang et al. (2001)
Silt; %	VIS–NIR	400–2500	modified PLSR	317		0.80	Cozzolino and Moron (2003)
Silt; g/kg	VIS–NIR	350–2500	MARS	305 | 152	4.9	0.67	Shepherd and Walsh (2002)
Silt; %	UV–VIS–NIR	250–2500	PCR	121 | 40		0.05	Islam et al. (2003)
Resp. rate; CO_2–C/kg/day	VIS–NIR	400–2498	PCR (9)	30 | 119	205.37	0.66	Chang et al. (2001)
Specific surface area; m^2/g	NIR	1000–2500	MRA (63 bands)	35 | 56		0.70	Ben-Dor and Banin (1995)
w 10 kPa; %	MIR	2500–25,000	PLSR	23		0.83	Janik et al. (1998)
w 30 kPa; %	MIR	2500–25,000	PLSR	23		0.90	Janik et al. (1998)
w (air dry); %	MIR	2500–25,000	PLSR	303		0.70	Janik et al. (1998)
w (air dry); g/g	NIR	700–2500	PCR	121 | 40		0.80	Islam et al. (2003)
w (air dry); %	NIR	1000–2500	MRA (25 bands)	35 | 56		0.62	Ben-Dor and Banin (1995)
w (air dry); %	NIR	1100–2500	MLR (1926, 1954, 2150)	72 | 48		0.97	Dalal and Henry (1986)
w (oven dry); %	VIS–NIR	400–2400	SMLR (606, 1329, 1499)	15 | 10		0.66	Shibusawa et al. (2001)
w; kg/kg	VIS–NIR	400–2498	PCR (8)	30 | 119	0.005	0.84	Chang et al. (2001)
w (air dry); g/g	UV–VIS–NIR	250–2500	PCR	121 | 40		0.85	Islam et al. (2003)
Zn (Mehlich III); mg/kg	VIS–NIR	400–2498	PCR (13)	30 | 119	15.28	0.44	Chang et al. (2001)

[a] Multivariate techniques include multiple regression analysis (MRA), stepwise multiple linear regression (SMLR), multivariate adaptive regression splines (MARS), radial basis function networks (RBFN), principle components regression (PCR), partial least-squares regression (PLSR). Shown in brackets are the spectral bands used or the number of bands or number of PCR components or number of PLSR factors used in the predictions.

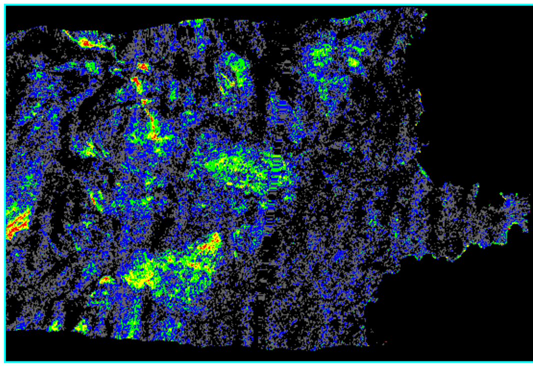
[b] n_{calib} | n_{valid} show the number of samples used in the spectral calibration and the number of factors use in the validation. X-val suggests that the validation was conducted independently using a statistical cross-validation technique.

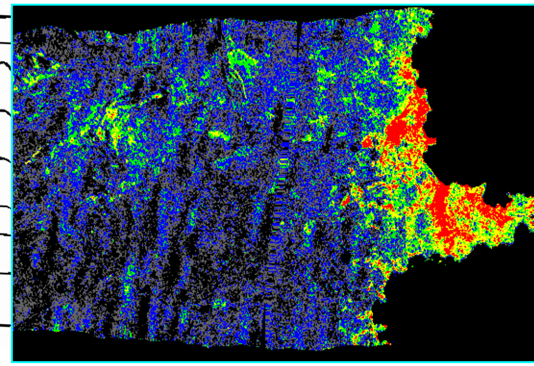
Scaling up the HSR for soil going from laboratory/filed domains to airborne domains

30 Spectral Bands 423-891nm (FHMW 6.21-6.84nm)

Altitude of 3000m, Pixel size 2m

Quantitative Capability under Spatial Domains


calcite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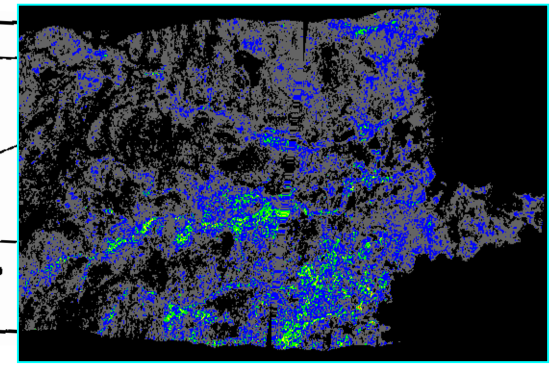
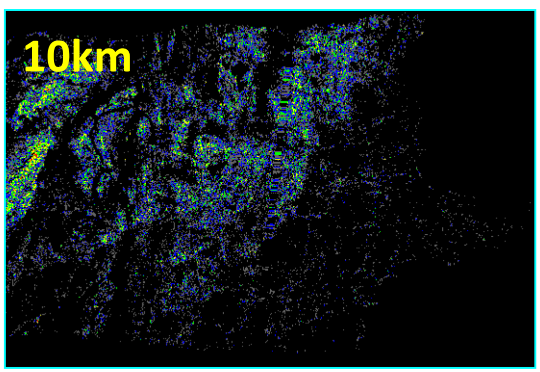
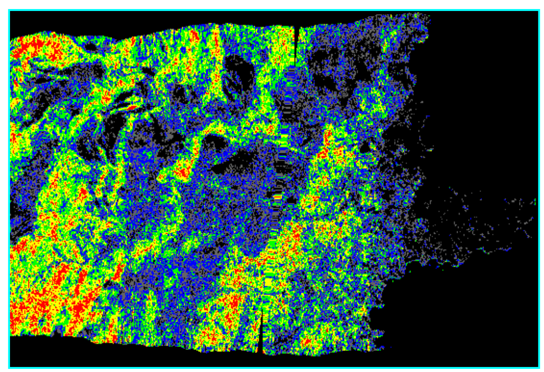

vegetation



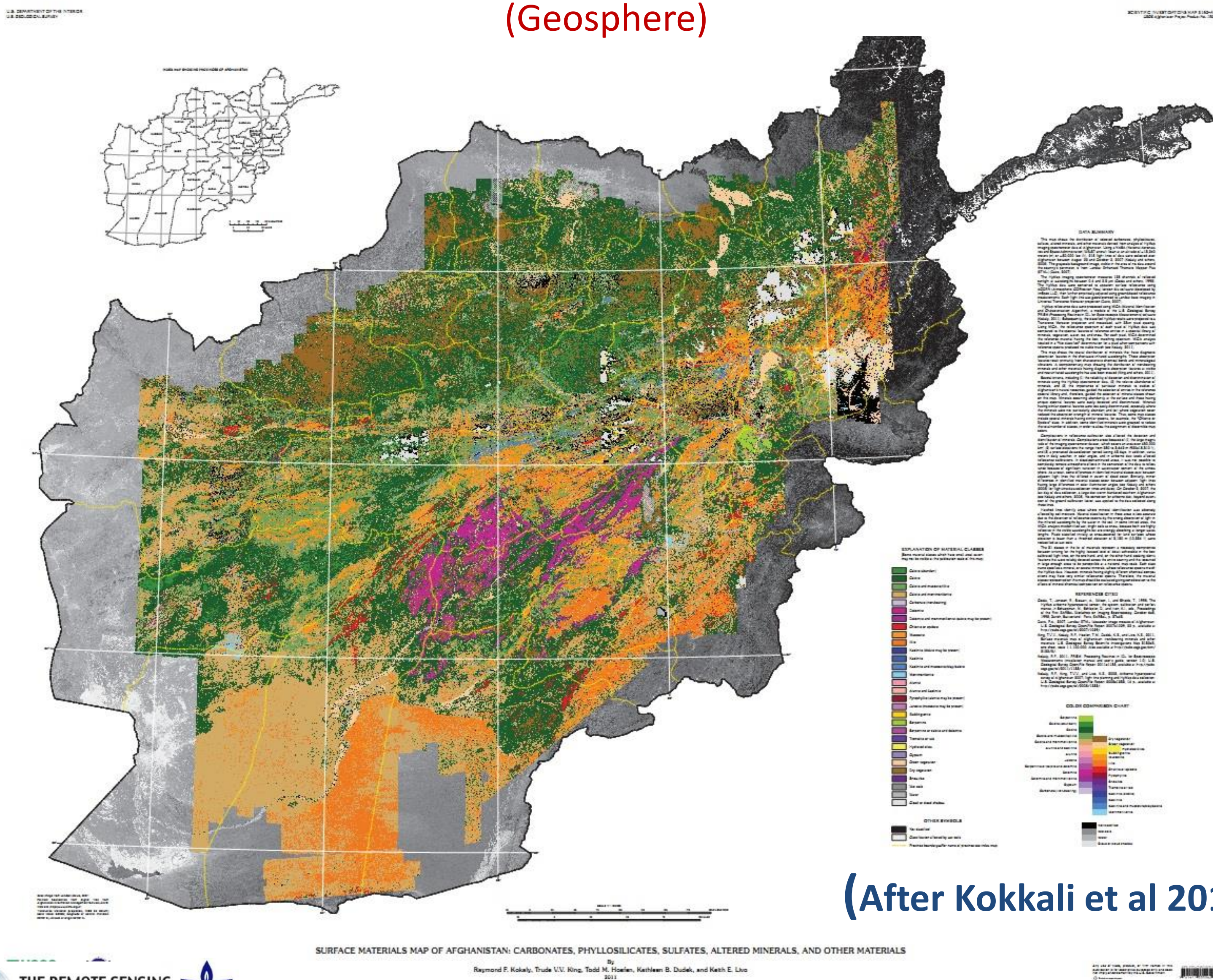
dolomite


muscovite

- 0 %
- 1 – 20 %
- 21 – 40 %
- 41 – 60 %
- 61 – 80 %
- 81 – 100 %

Afghanistan Mineral Mapping

(Geosphere)



(After Kokkali et al 2012, USGA)

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HSR and NIRA can work together:

Soil Salinity, Water and Organic matter

Table 2.

Property	SEC, SEP, SEL
Soil Field Moisture (SFM)	0.045, 0.14, 0.016 0.027@
Organic Matter (OM)	0.003, 0.015, 0.00 0.0012@
Soil-Saturated Moisture SPM	0.019, 0.021, 0.00 0.0006@
Electrical Conductivity (EC)	4.36, 4.58, 0.1 2.57@
PH	0.146, 0.26, 0.1 0.073@

wl stands for the wavelength (μm) predicted ($x=p$) domains. @ stands f multiple regression coefficient. SEP = [samples were not involved in the cali laboratory of sample i and AVE_i is the

Organic Matter Image

more details).

Assignments
1.65 μm-reflectance slope
0.688 μm-reflectance slope
~~0.739 μm-reflectance slope/chlorophyll~~
0.722 μm-chlorophyll remaining
1.678 μm-C-H in cellulose
2.328 μm-Humic acid, Pectin, Lignin
2.085 μm–adsorbed water OH
2.183 μm-OH combination of $\upsilon' + \delta$ in clay mineral lattice
1.538, 1.563 μm-OH combination of 2□□ in clay mineral lattice
0.739 μm-organic-matter assignments
1.65 μm-adsorbed water OH
2.166 μm-adsorbed water OH
Not determined

ıstituent values in the measured ($x=m$) and ıtory data (spectral and chemistry). R^2_m is a ıred ($x=m$) and predicted ($x=p$) domains in s to a single analytical measurement in the

Vegetation mask

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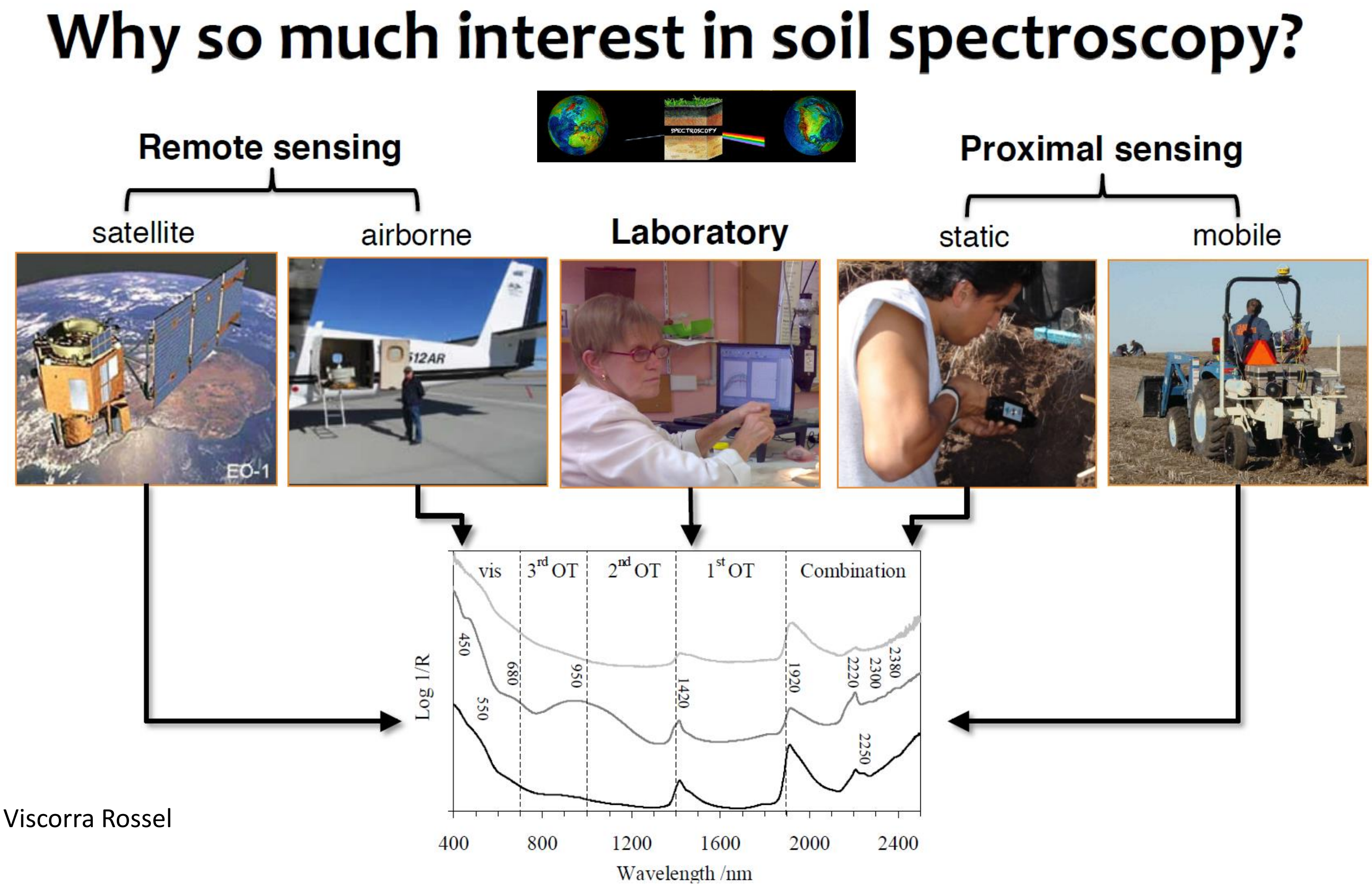
Soil Spectroscopy : importance

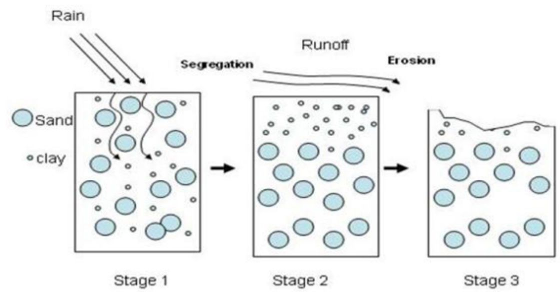


Provided by Viscorra Rossel

Soil degradation processes that can be measure by the HSR technology (1)

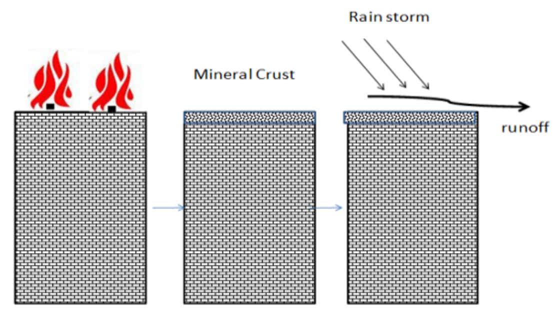
Soil Crusting Phenomenon

Caused by: *climate change*
Process: *heavy rain energy that segregates soil particles, thus blocking water infiltration*
Effect: *water loss, runoff, soil erosion*
Agro technical precaution: *gently plow the soil before before the next rain storm (based on its forecast energy)*
Spectral assessment in the lab: *Ben Dor et al., 2006*
Mapping from airborne HSR: *Ben Dor et al., 2008*
Mapping from space borne HSR: ***None***



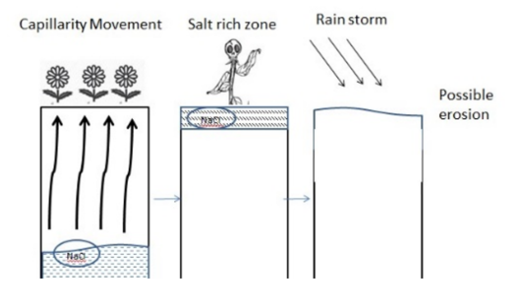
Soil after a Fire

Caused by: *climate change, human behavior*
Process: *heavy fires that alter minerals on the soil surface*
Effect: *water loss, runoff, soil erosion, declining biota*
Agro technical precautions: *mulching the burned areas*
Spectral assessment in the lab: *Lugassi et al., 2009*
Mapping from airborne HSR: ***None***
Mapping from spaceborne HSR: ***None***



Soil Salinity

Caused by: *climate change, human behavior*
Process: *deteriorating irrigation water, high water table*
Effect: *root malfunction, runoff, soil erosion, irreversible cultivation*
Agrotechnical precaution: *establishing a drainage system, irrigation control*
Spectral assessment in the lab: *Ben Dor et al., 2009*
Mapping from airborne HSR: *Ben Dor et al., 2002*
Mapping from spaceborne HSR: ***None***



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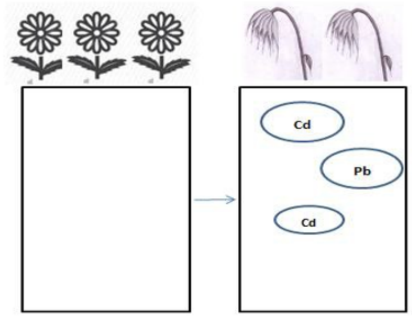
Soil degradation processes that can be measure by the HSR technology (2)

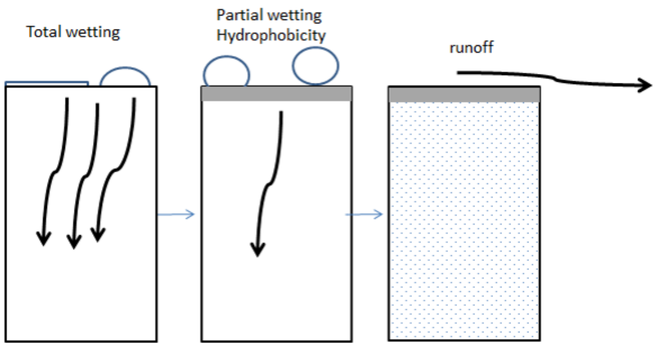
Soil Contamination with Heavy Metals

Caused by: *human behavior*
Process: *adsorption to soil particles, migration to ground water*
Effect: *Soil toxicity*
Agrotechnical precaution: *monitoring*
Spectral assessment in the lab: *Wh et al., 2005*
Mapping from airborne HSR: *Choe et al., 2008*
Mapping from spaceborne HSR: ***None***



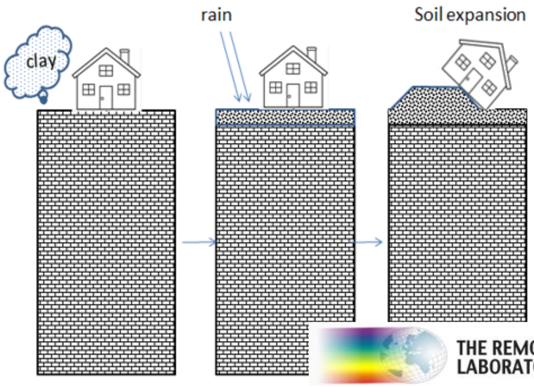
Soil Hydrophobicity

Caused by: *climate change*
Process: *interaction of organic substances on the soil surface*
Effect: *water loss to runoff*
Agrotechnical precaution: *controlling the surface structure*
Spectral assessment in the lab: *Ben Dor (preliminary results)*
Mapping from airborne HSR: ***None***
Mapping from spaceborne HSR: ***None***



Soil Swelling

Caused by: *soil formations, dust accumulation, climate change*
Process: *migration of smectite mineral to the soil surface*
Effect: *water loss, loss of stability, instability of buildings and roads, root breakdown*
Agrotechnical precaution: *mapping and consideration of soil cracks*
Spectral assessment in the lab: *Yitagesu, 2009*
Mapping from airborne HSR: *Chabrillat et al., 2002*
Mapping from spaceborne HSR: ***None***



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Soil degradation processes that can be measure by the HSR technology (3)

Soil Contamination with Total Petrol Hydrocarbon (TPH)

Caused by: *human behavior*
Process: *infiltration to ground water*
Effect: *soil toxicity*
Agrotechnical precaution: *monitoring, remediation*
Spectral assessment in the lab: *Schwartz et al., 2012*
Mapping from airborne HSR: ***None***
Mapping from spaceborne HSR: ***None***

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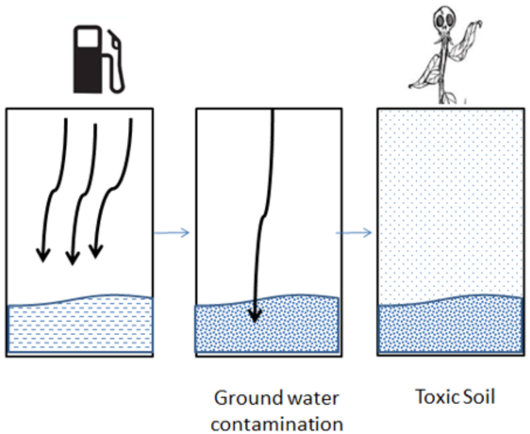
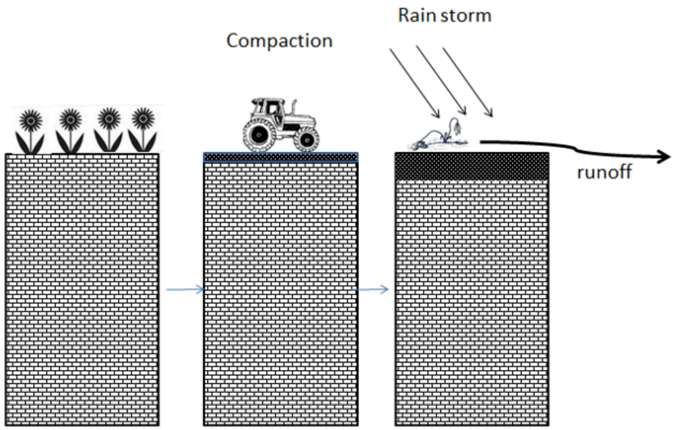


Soil Compaction

Caused by: *human behavior*
Process: *packing soils by driving over them with heavy vehicles*
Effect: *water loss, air loss, yield reduction*
Agrotechnical precaution: *direct heavy load activity in sensitive areas*
Spectral assessment in the lab: *Ahmad et al., 2000*
Mapping from airborne HSR: ***None***
Mapping from spaceborne HSR: ***None***



Soil degradation: Some examples from airborne HSR domain

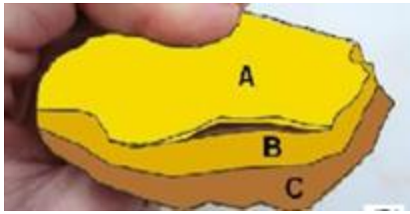
Airborne domains: Examples

- Physical Crust
- Salinity
- Erosion
- Dust
- Man made contamination: fuel

Physical Crust (Structural crust)

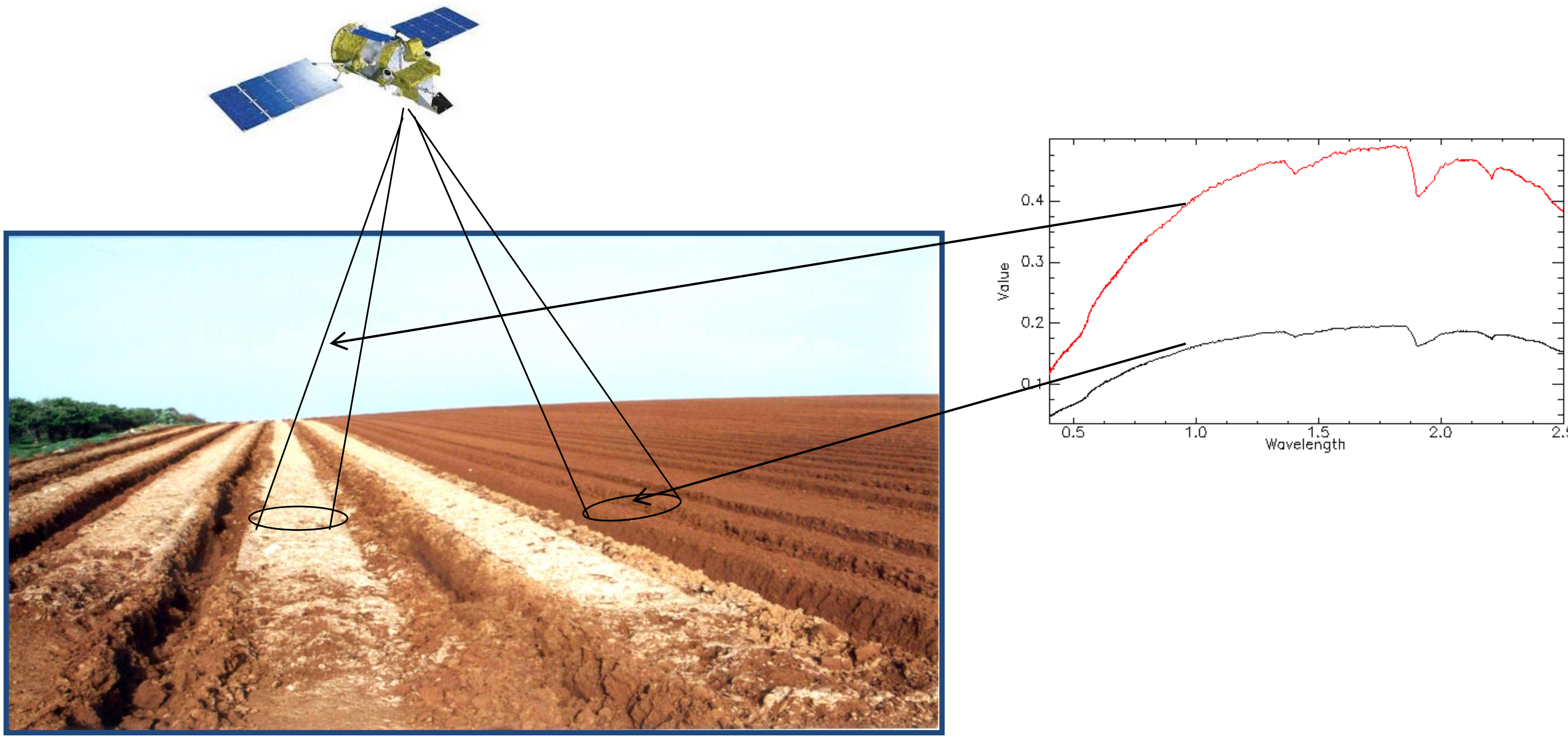
Definition: A thin layer formed on the soil surface during rain storm events. The crust is the result of a physical segregation and rearrangement of soil particles

Origin: A result between the impact of the rain drops' kinetic energy and the stability of the soil aggregates.



De Jong S.M., E.A. Addink, D. Duijsing & L.P.H. van Beek, 2011, Physical Characterization and Spectral Response of Mediterranean Soil Surface Crusts. CATENA 86(1), 24-35

Same soil – Physical Crust



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Problems and Solution

:Problems

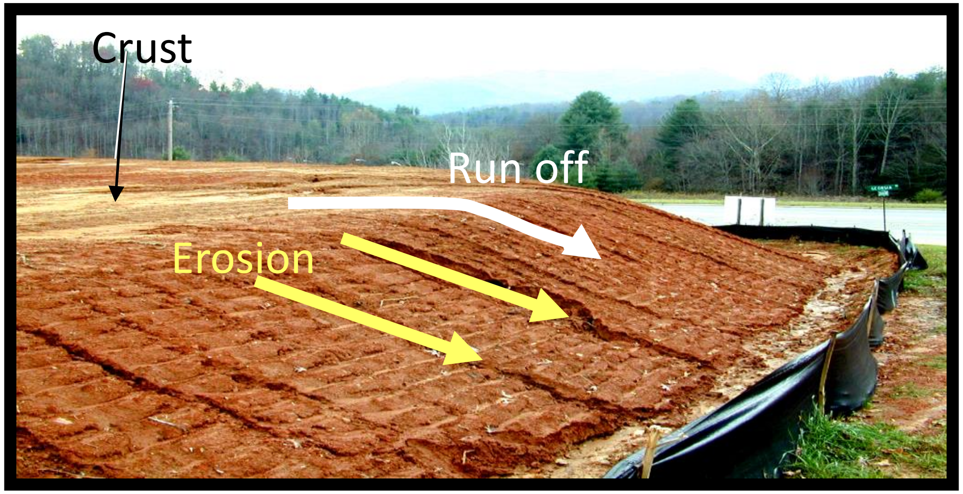
- Soil Degradation effects : The crust significantly affects many dynamic soil properties such as : infiltration rate, surface roughness, soil water storage and capacity, runoff and soil erosion

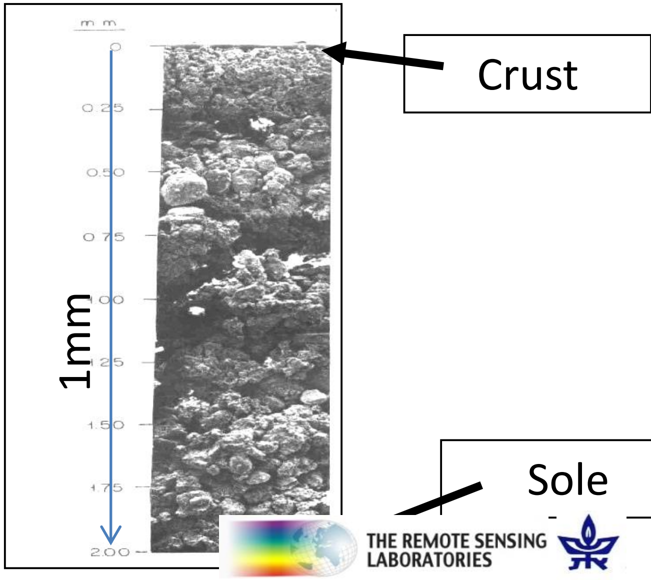
- Lack of information: As a dynamic property , no information on its spatial distribution nor magnitude is available prior to the next rain event

Solution:

To use reflectance spectroscopy

Microscopic Cross Section





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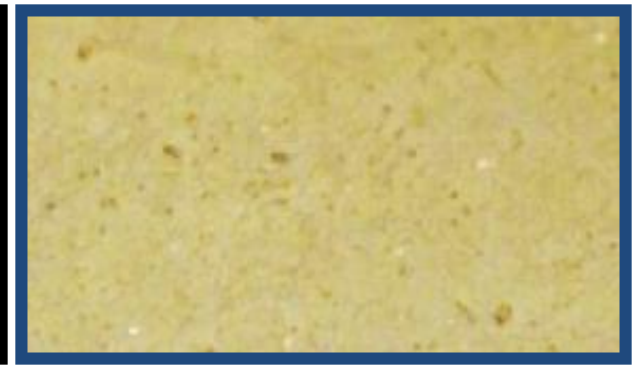
Laboratory Experiment

0 joule

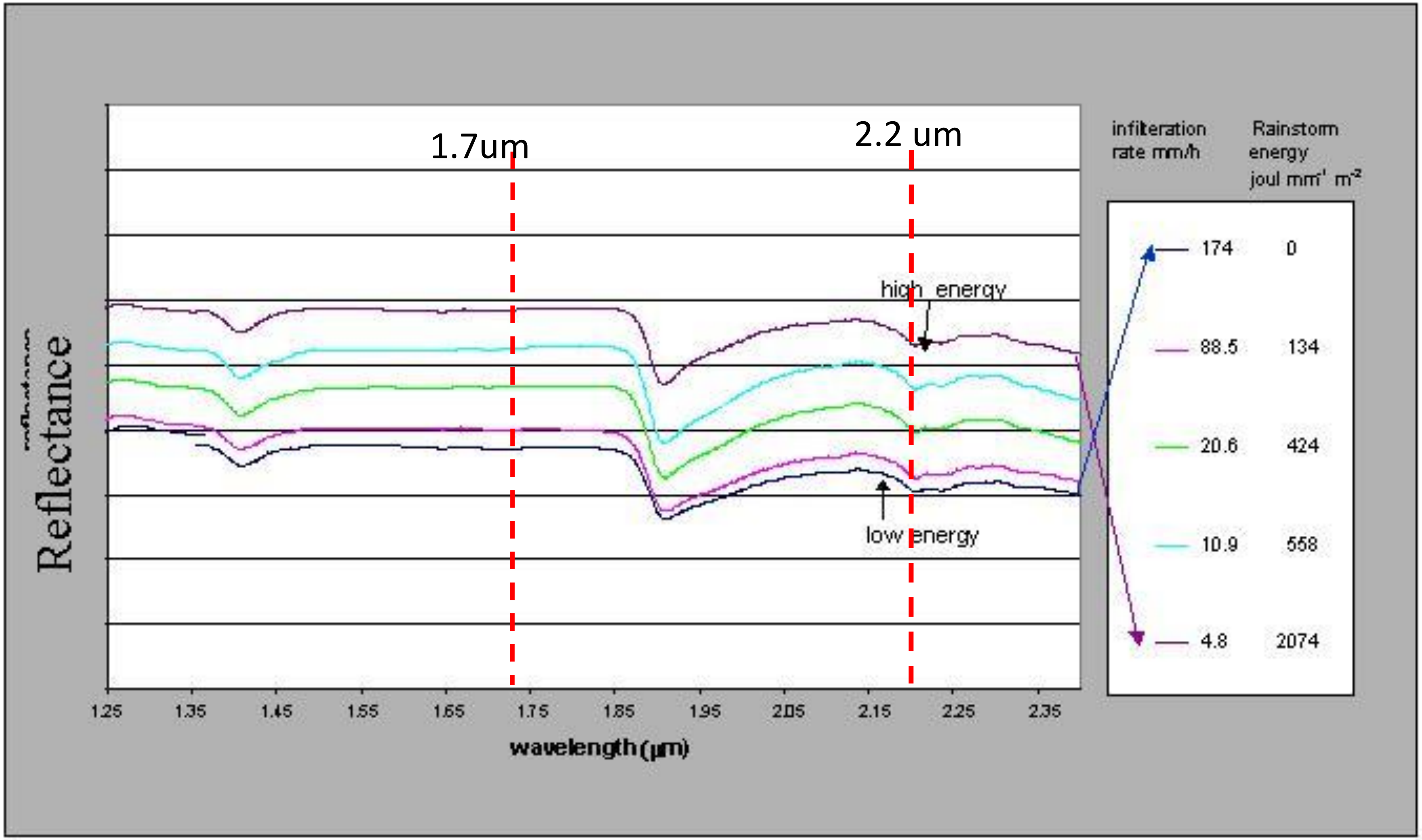
650 joule



1842 joule

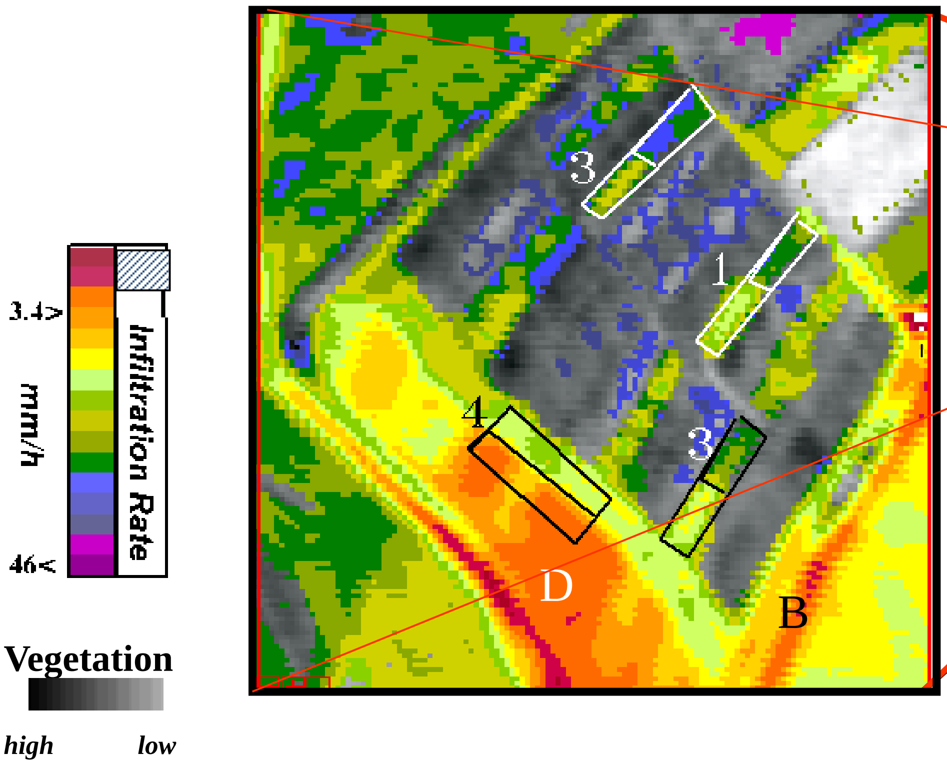
Loess Soil

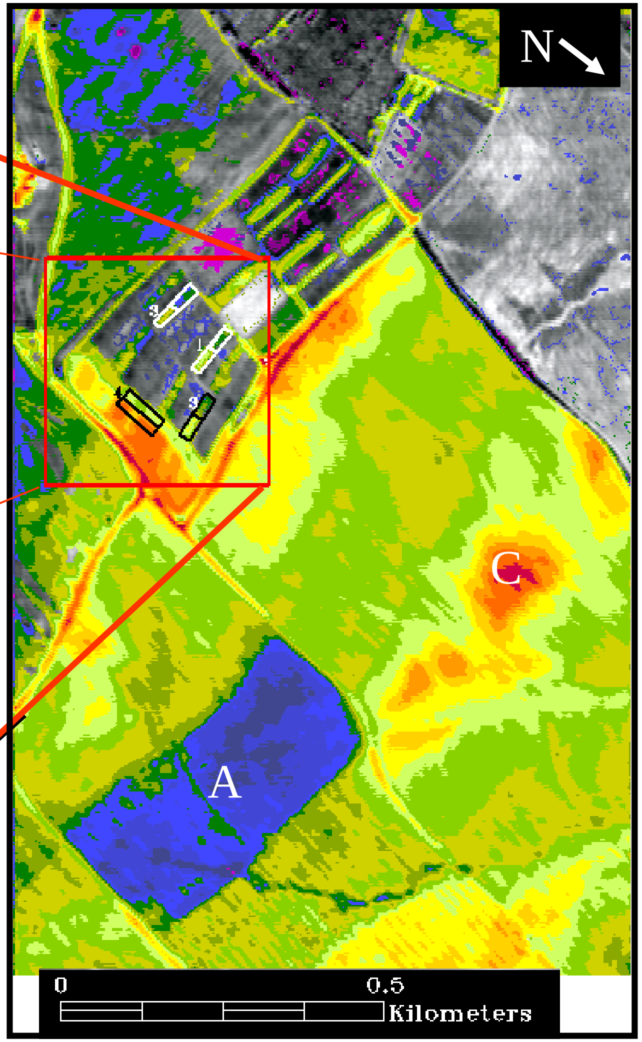
Spectral Results



Soil Infiltration and Erosion : Physical Crust (2)

Ben-Dor et al., 2004





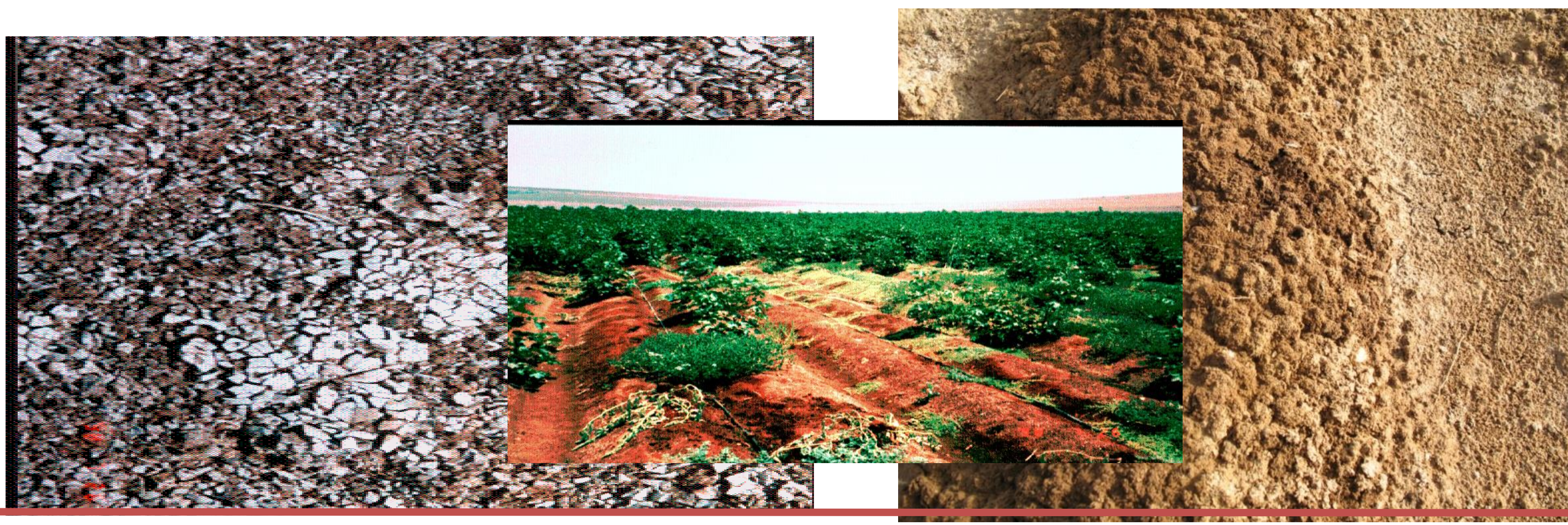
Soil Salinity

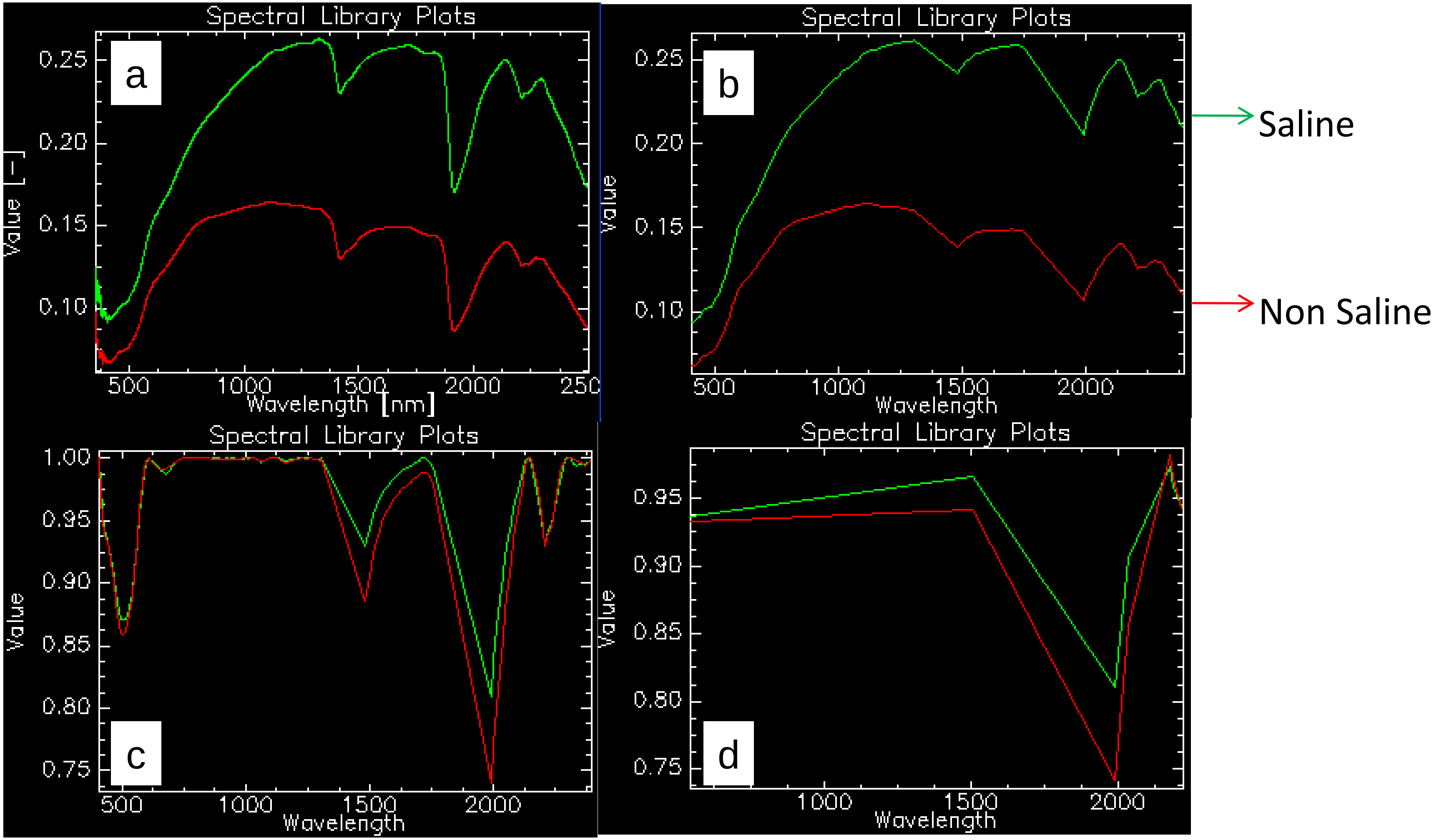
Definition: Significant increasing of salt content (mostly NaCl) within the soil profile

Origin: Poor drainage soils (mostly clays), utilization of low water quality and intensive use of fertilizers .

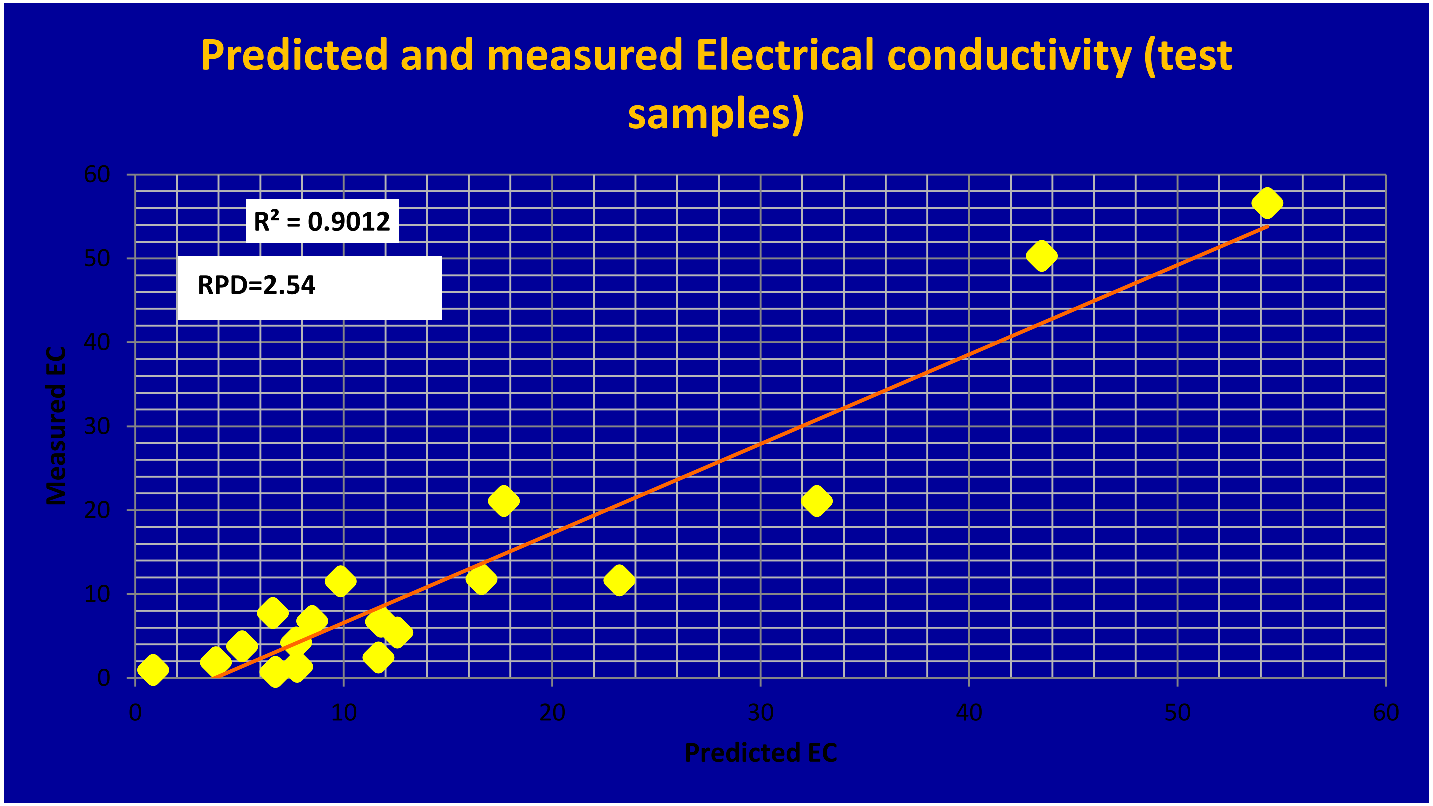
Problems and Solution

- **Soil degradation by salinity**: Decrease of soil productivity, low water infiltration to the soil profile, runoff and high soil erosion rate, infertility.
- **Lack of Information:** As a dynamic property no information on its spatial distribution nor magnitude is available . If available in advance – precaution can be taken
- **Solution**: To use reflectance properties for remote sensing by spectral means (HSR)



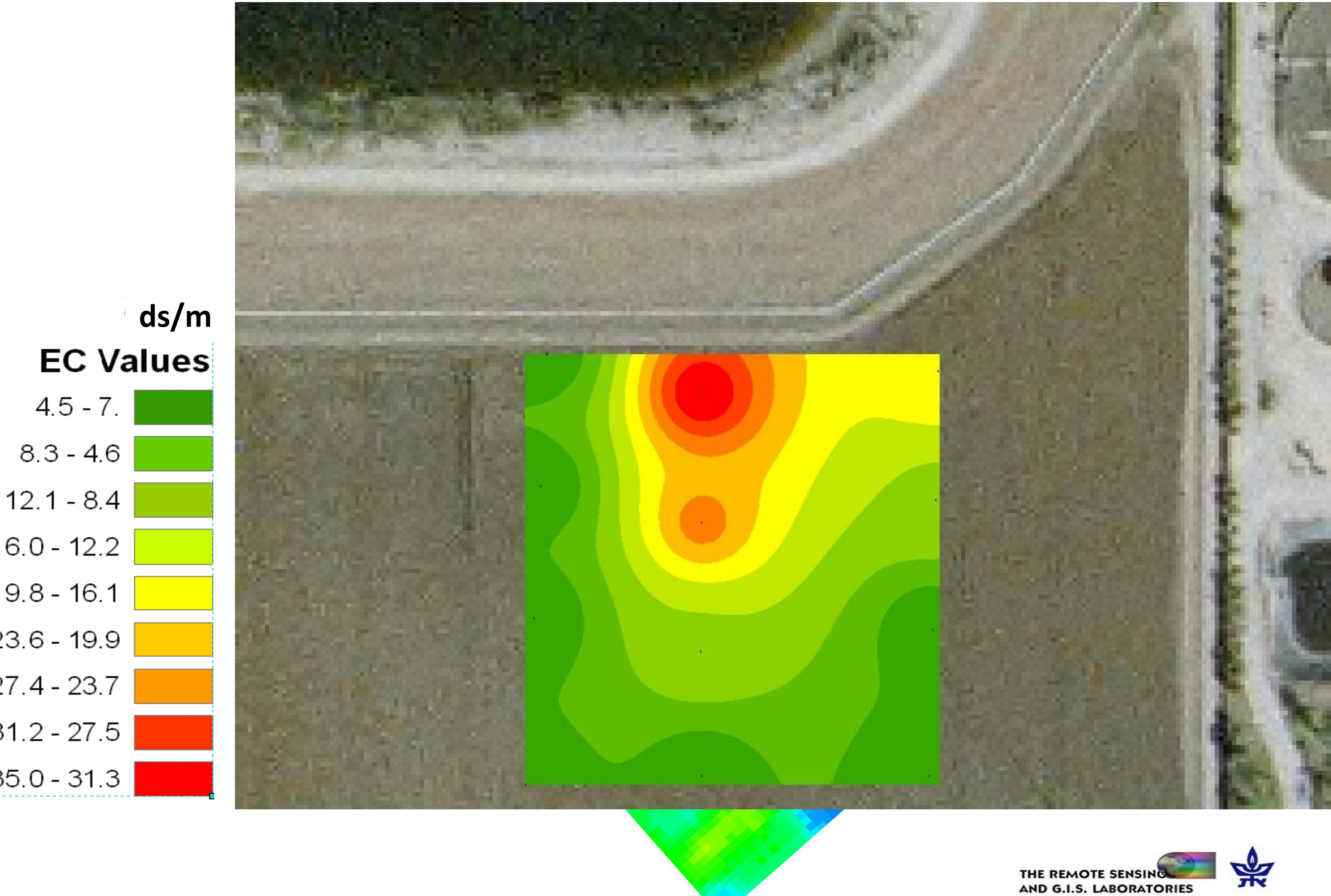


Spectra Example

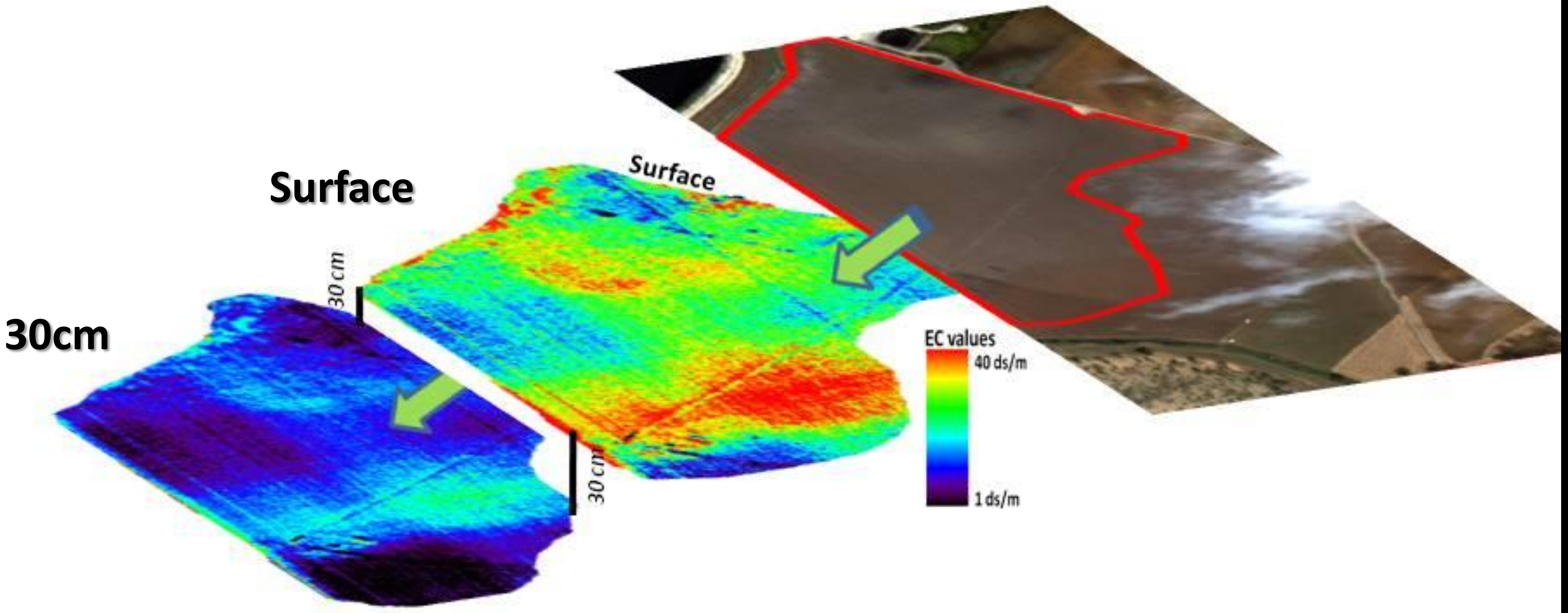


Wavelength (nm)	Factor (for continuum removed spectrum)
b0	*634.109192*
540.74	166.6197357
1503.06	-918.8959961
1989.99	-1519.586548
2036.36	2564.280273
2175.48	-919.4611206
2187.08	-951.8460693
2221.86	874.7788696

AISA-ES Versus *Kriging* of the Laboratory Measurements



Soil Salinity Mapping of the surface and at 30cm depth



Problems and Solution

- **Soil degradation by erosion** : Lose of soil material minerals and organic matter
- **Lack of Information:** Soil stability is varying
- **Solution**: To use reflectance properties for remote sensing by spectral means (HSR)

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Characterization of soil erosion indicators using hyperspectral data from a Mediterranean rainfed cultivated region

Thomas Schmid[1], Manuel Rodriguez-Rastrero[1], Paula Escribano[2], Alicia Palacios-Orueta[3], Eyal Ben Ddor[4], Antonio Plaza[5], Robert Milewski[6], Margarita Huesca[3], Ashley Bracken[7], Victor Cicuendez[3], Marta Pelayo[1], Sabine Chabrillat[6]

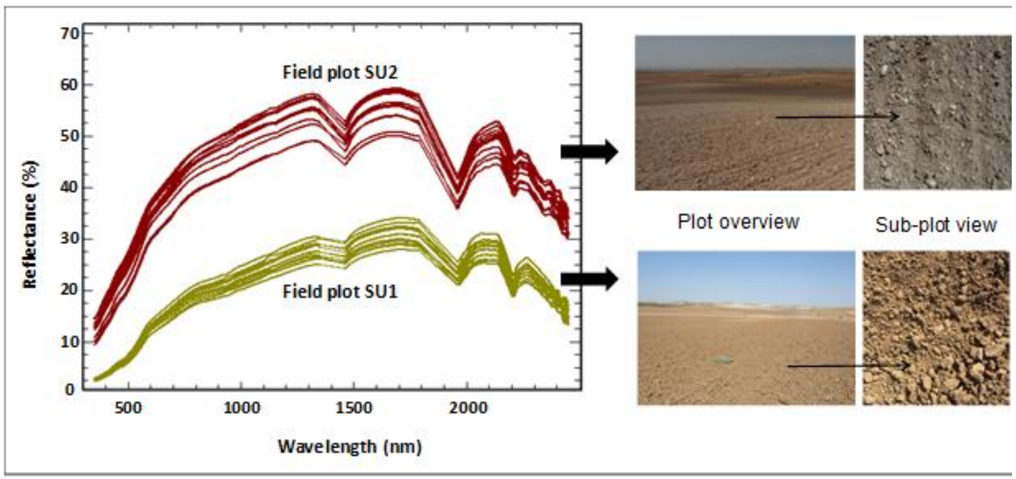

Fig. 5. Spectra of the field plots SU1 and SU2 representing soil erosion stages es2c a

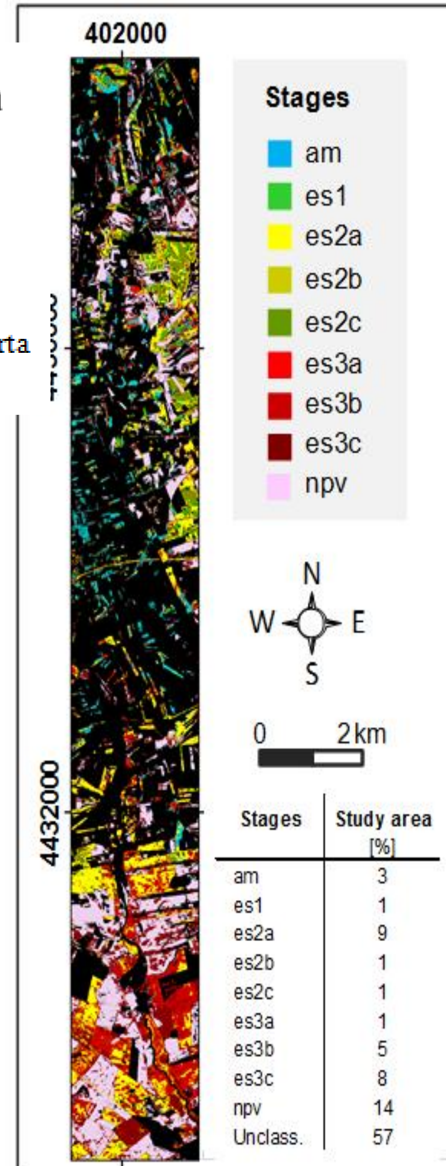

Fig. 9. Distribution of soil accumulati

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POTENTIAL OF HYPERSPECTRAL IMAGERY FOR THE SPATIAL ASSESSMENT OF SOIL EROSION STAGES IN AGRICULTURAL SEMI-ARID SPAIN AT DIFFERENT SCALES

Sabine Chabrillat[1], Robert Milewski[1], Thomas Schmid[2], Manuel Rodriguez[2], Paula Escribano[3], Marta Pelayo[2], Alicia Palacios-Orueta[4]

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cla

Soil Erosion by Fed “exposed” content

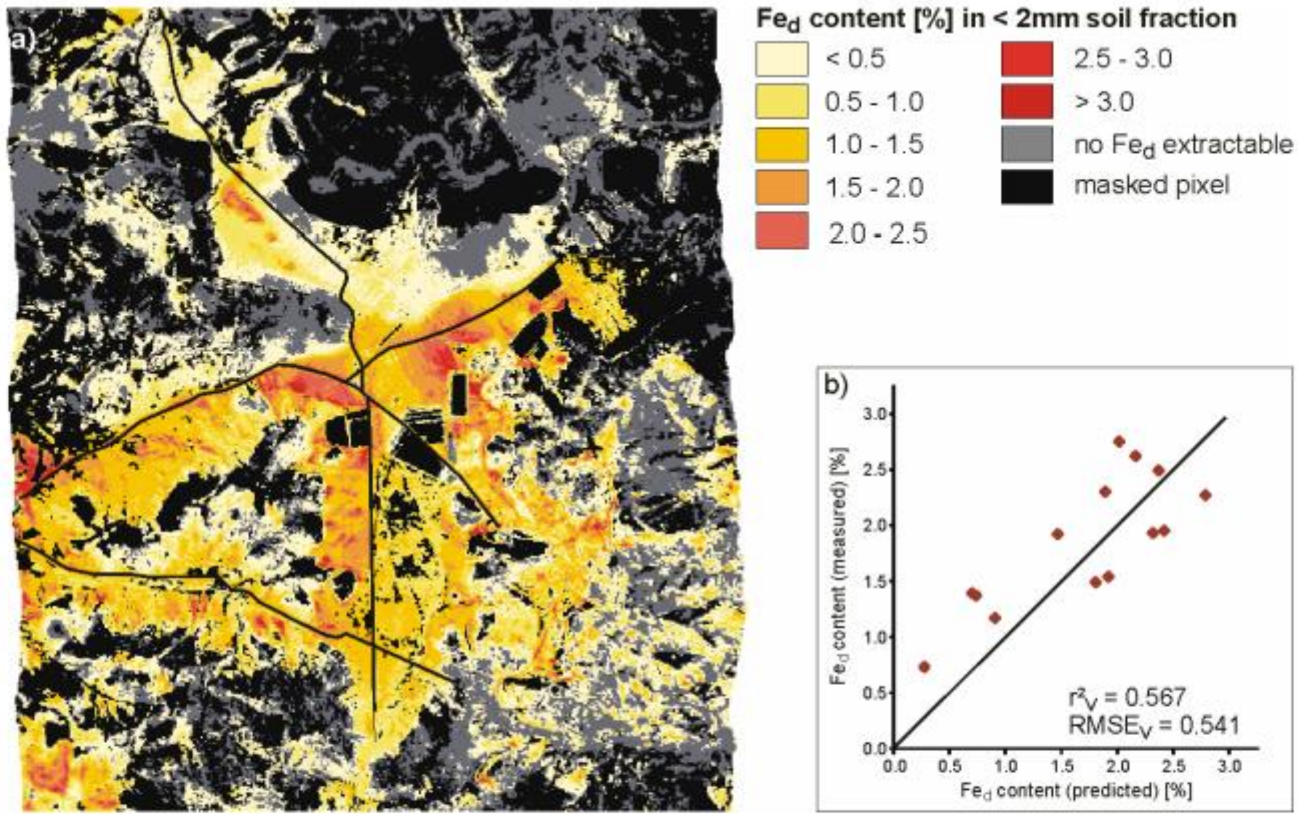

Figure 4: a) Soil iron (Fe_d) content, Cortijo del Fraile; b) measured vs. predicted Fe_d content.

Richter, Chabrialat

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Problems and Solution

- **Soil degradation by contamination of dust (coal)** : Poising the soil and reduction of fertility
- **Lack of Information:** Slow process and ignoring
- **Solution**: To use reflectance properties for remote sensing by spectral means (HSR)

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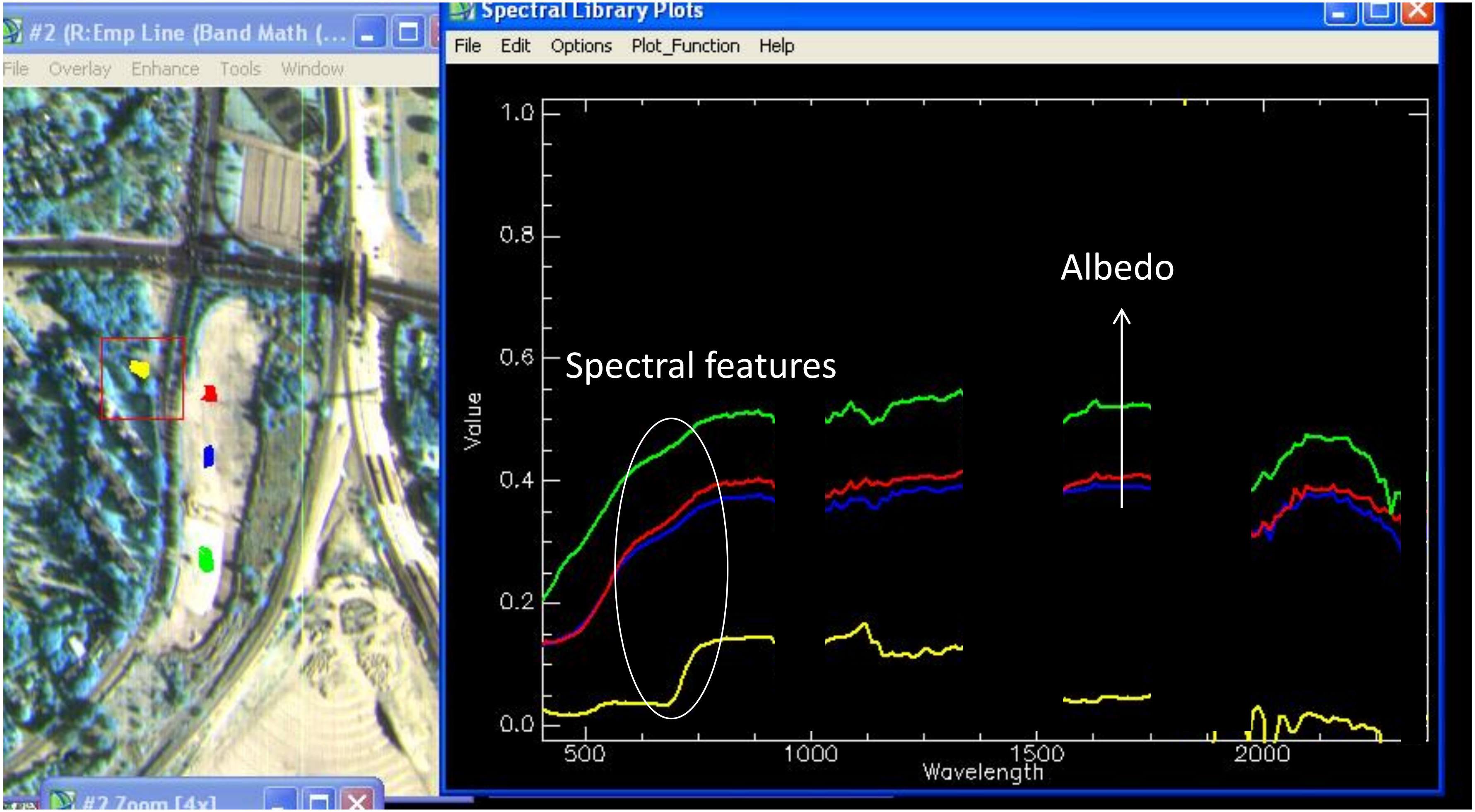
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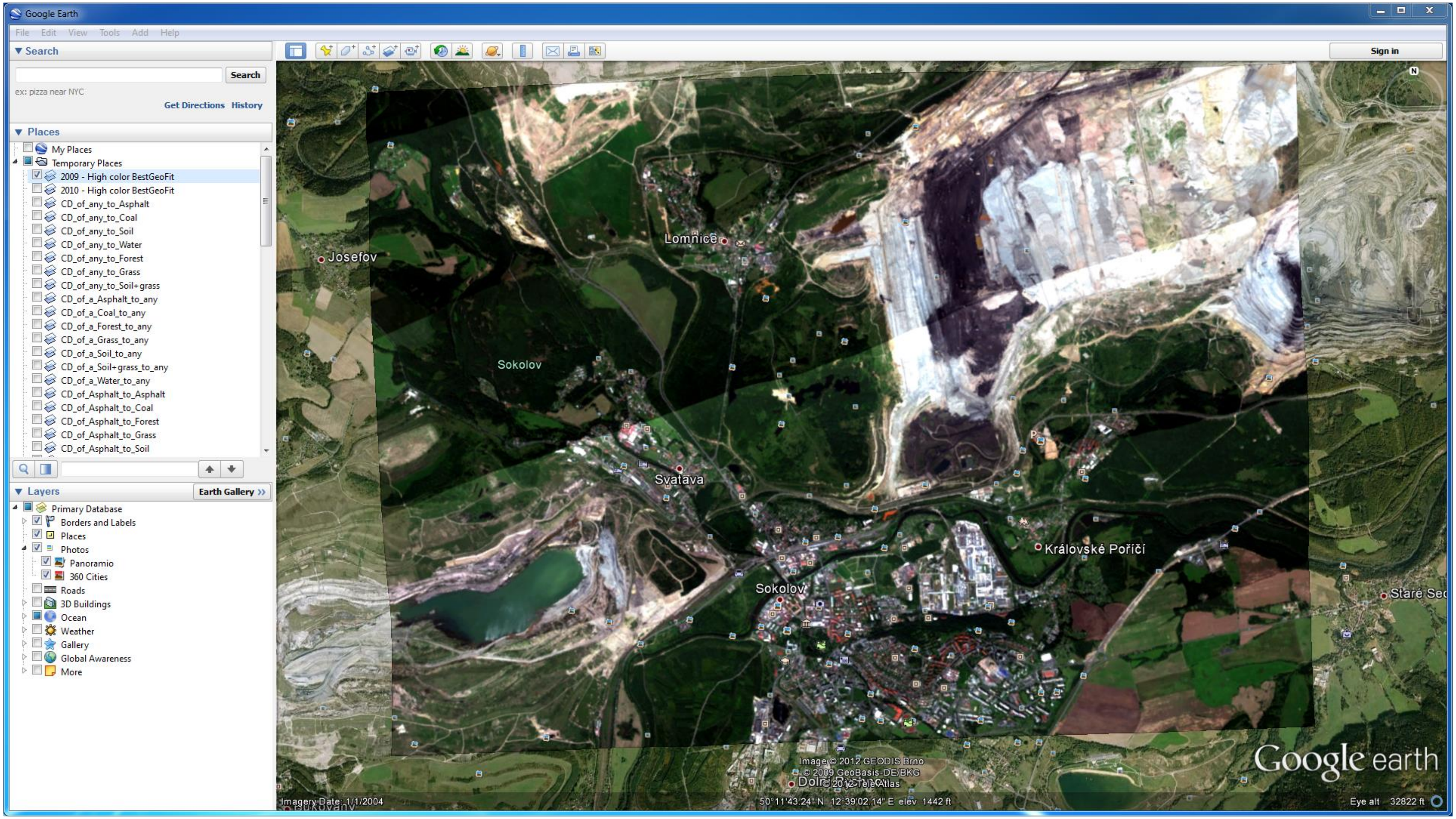
File Overlay Enhance Tools Window
#2 Zoom [4x]
Spectral Library Plots
File Edit Options Plot_Function Help
Albedo
Spectral features
Value
Wavelength
1.0
0.8
0.6
0.4
0.2
0.0
500
1000
1500
2000

2009



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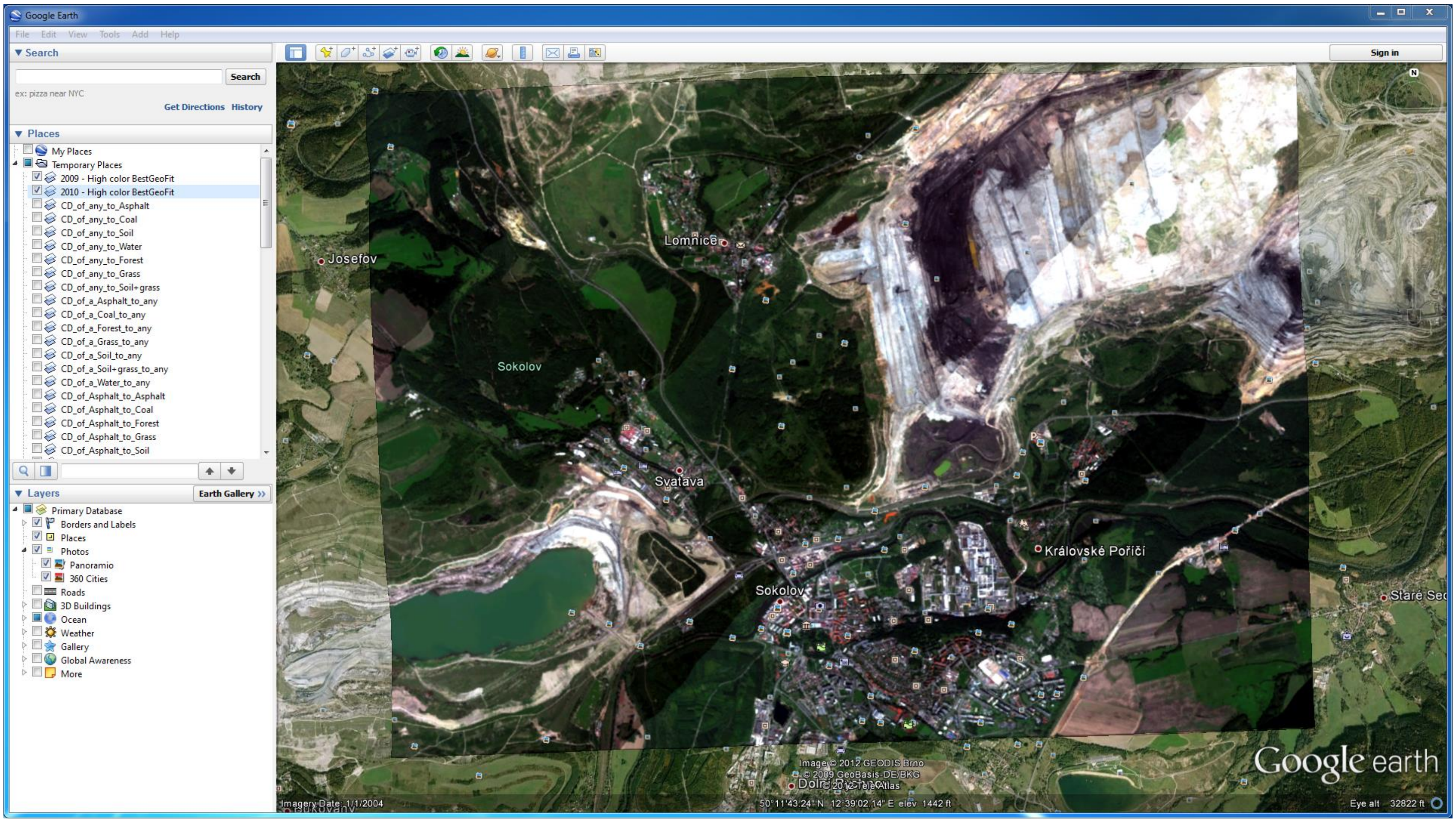
2010



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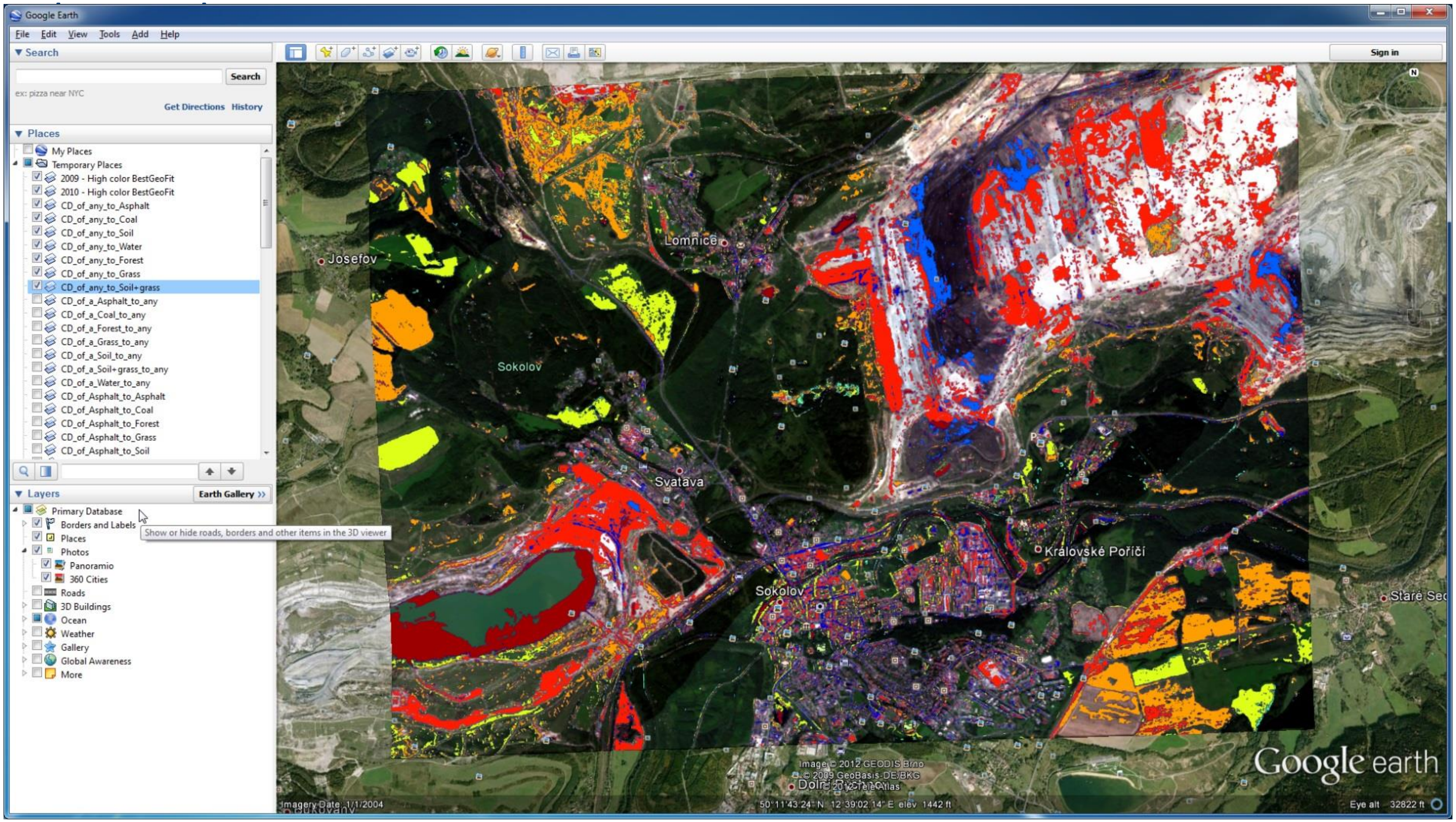
- Several changes according to spectral characters



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Problems and Solution

- **Soil degradation by oil spils** : Lose soil fertility
- **Lack of Information:** Exact content in the soil
- **Solution**: To use reflectance properties for remote sensing by spectral means (HSR)

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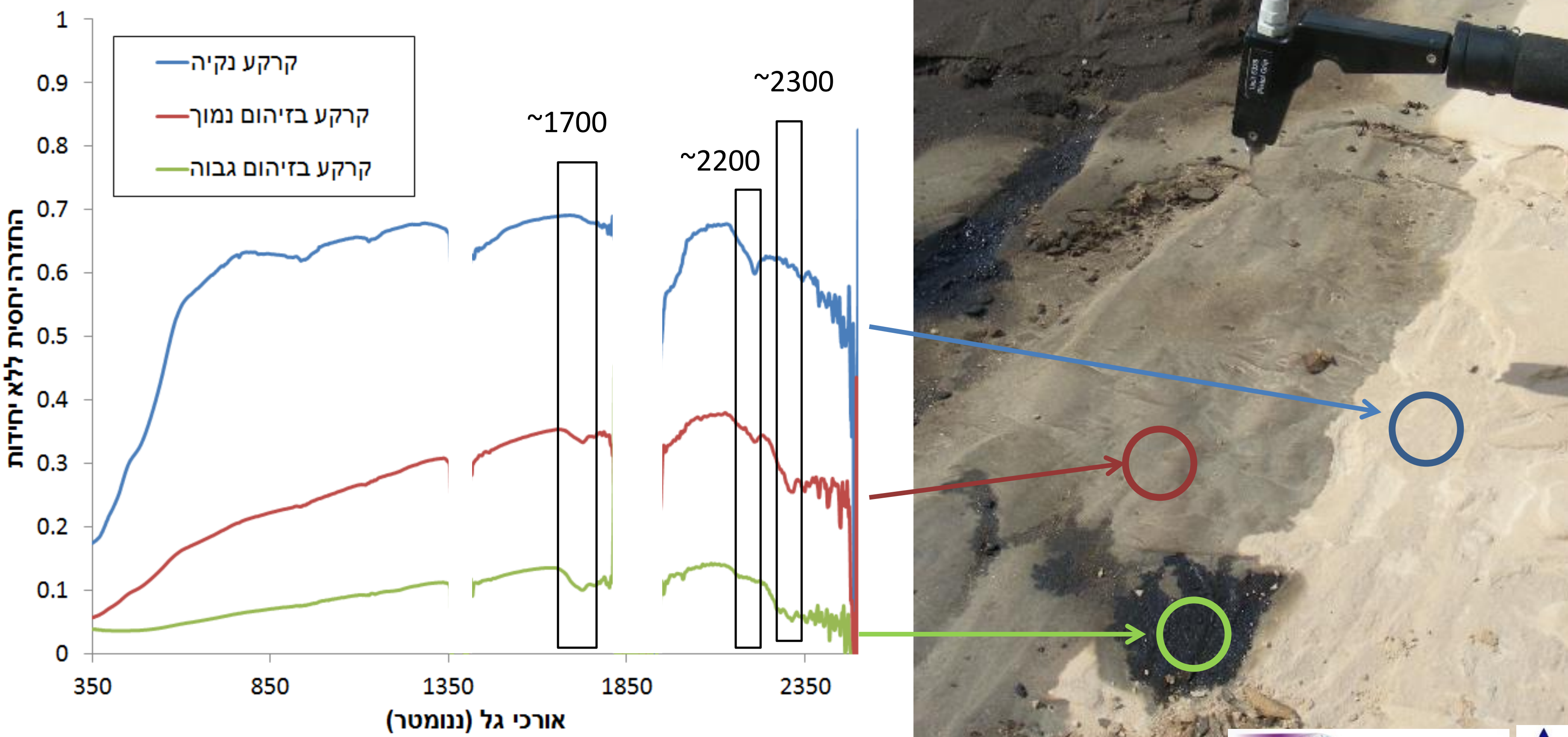
7 Dec. 2014 – Spectra

- סביב1700 ו 2300 ננומטר – בליעות קשר מימן פחמן – הבליעה מופיעה ומעמיקה ככל שהקרקע מזוהמת יותר בנפט.
- סביב 2200 ננומטר – בליעת קשר מימן חמצן – חרסית ממוסכת ע"י הזיהום.



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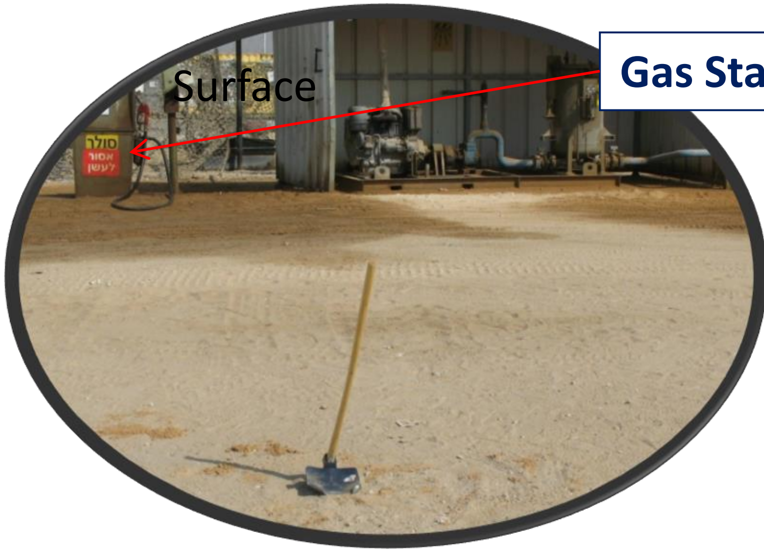
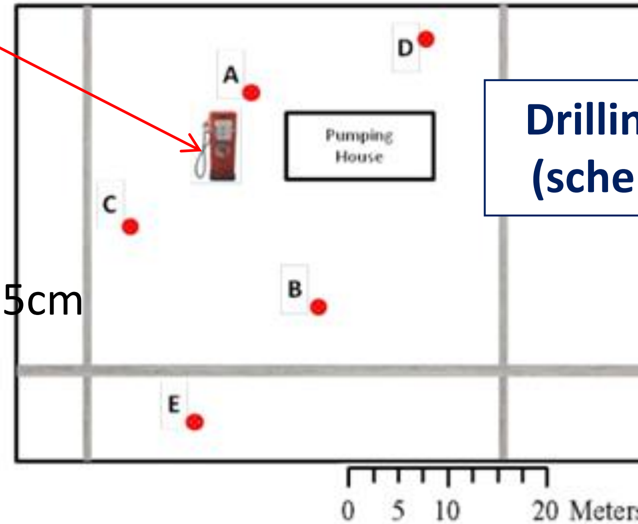


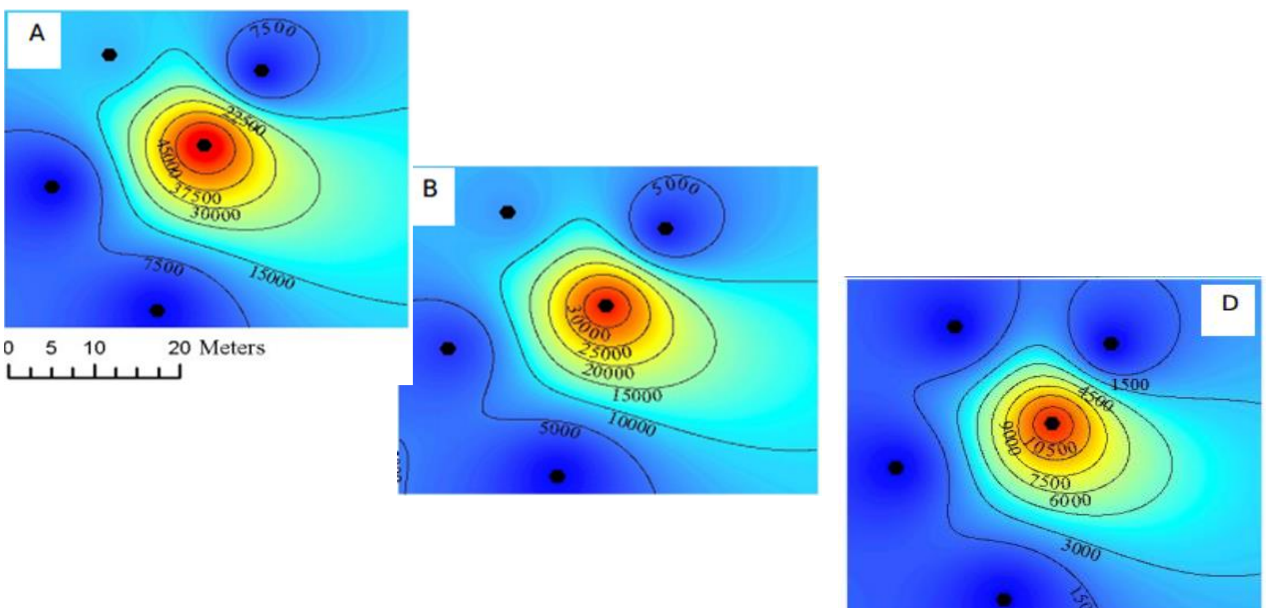
Gas Station



Drilling Locations (schematic map)

15cm

30cm



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Eros pan image
Dec. 20, 2014

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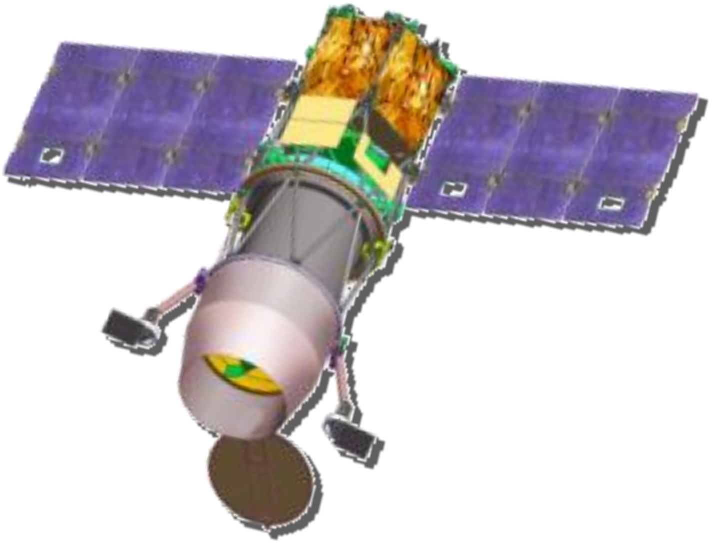
The image in the curtesy of ImageSat

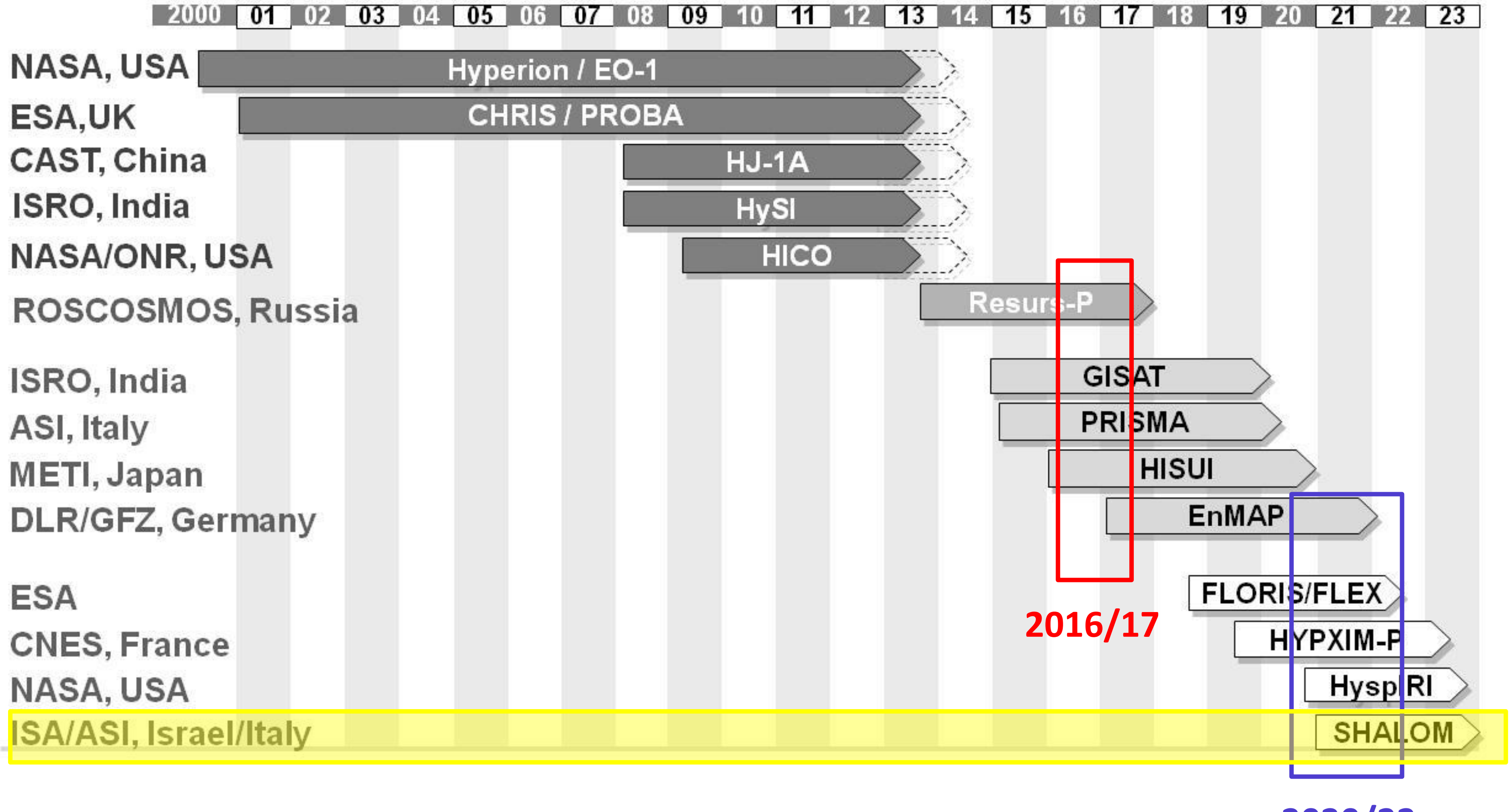
Future Innovative Solution

Hyperspectral sensor in orbit: upscaling the airborne applications to space domain

A number of hyperspectral missions already planned:

- PRISMA – ASI, 2016(GDS: 30 m)
- SHALOM – ISA 2020(GDS: 9 m)
- EnMap – DLR, 2017(GDS: 30 m)
- Hyper-J (JAXA) 2016(GDS: 30m)
- HyspIRI (NASA) 2024(GDS: 30m, 60m)





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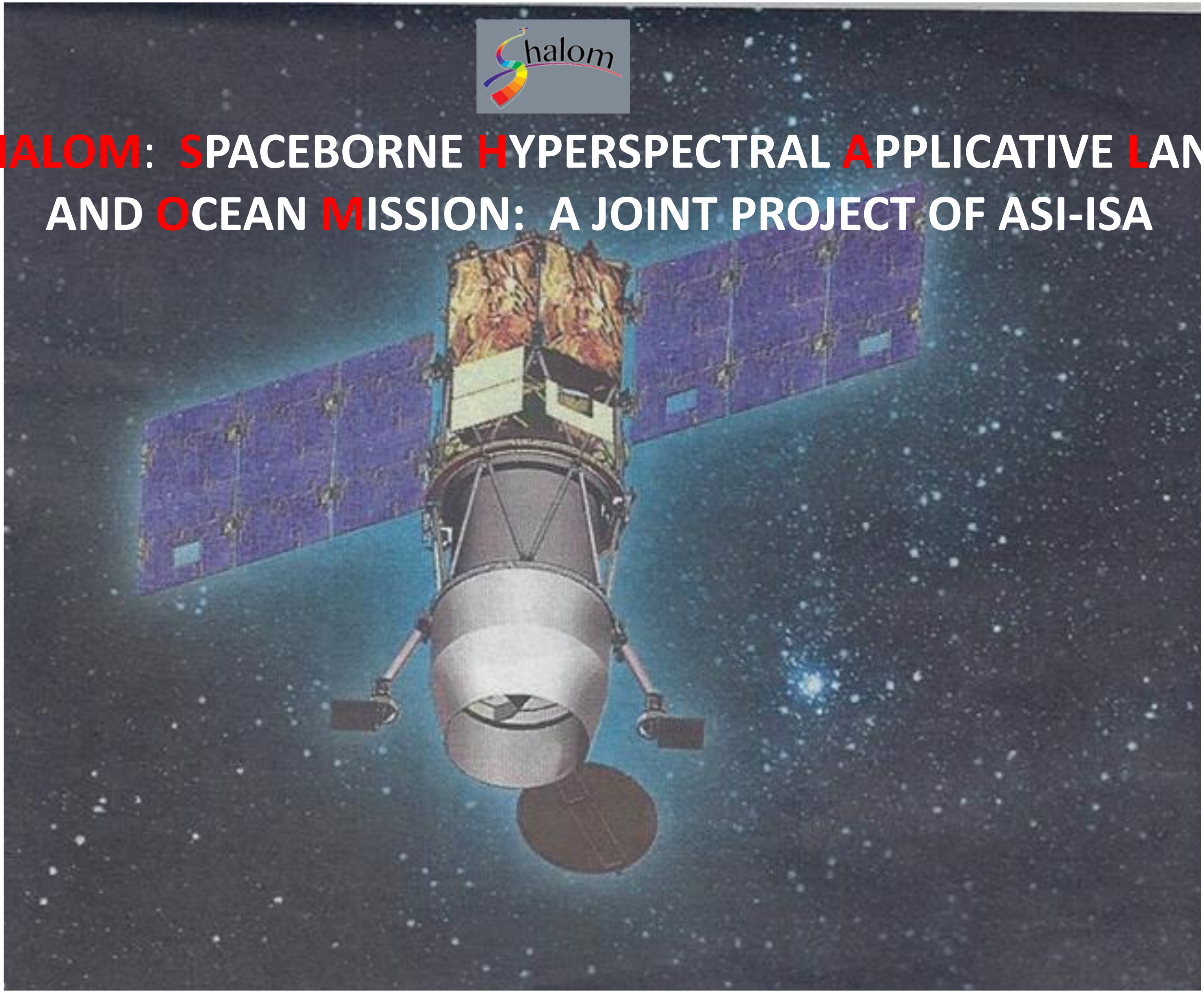
SHALOM: SPACEBORNE HYPERSPECTRAL APPLICATIVE LAND AND OCEAN MISSION: A JOINT PROJECT OF ASI-ISA



General Conclusions

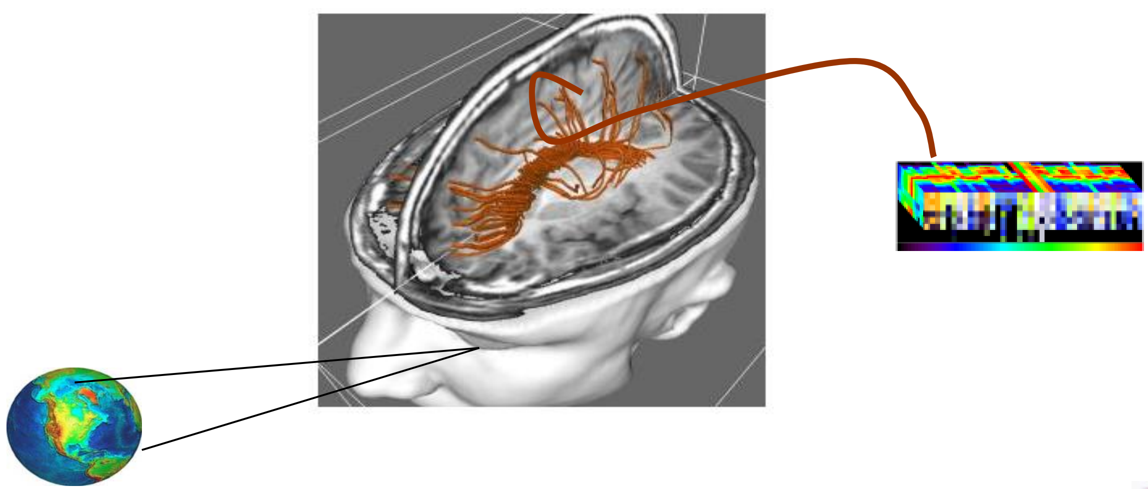
- Soil Spectroscopy is a powerful tool to assess several soil degradation factors

- Hyperspectral remote sensing providing a spatial view of the problems in question from a spectral perspective (quantitative and qualitative)

- HSR technology from orbit is very close: the soil degradation issues can be then provide global view of our degraded planet.

Hyperspectral Remote Sensing

thinking out side the box:
spectral imaging



Thank You For Your Attention

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Email: bendor@post.tau.ac.il