ENVIRONMETAL CASE STUDIES AS MONITORED BY IMAGING SPECTRSOCOPY TECHNOLOGY IN ISRAEL

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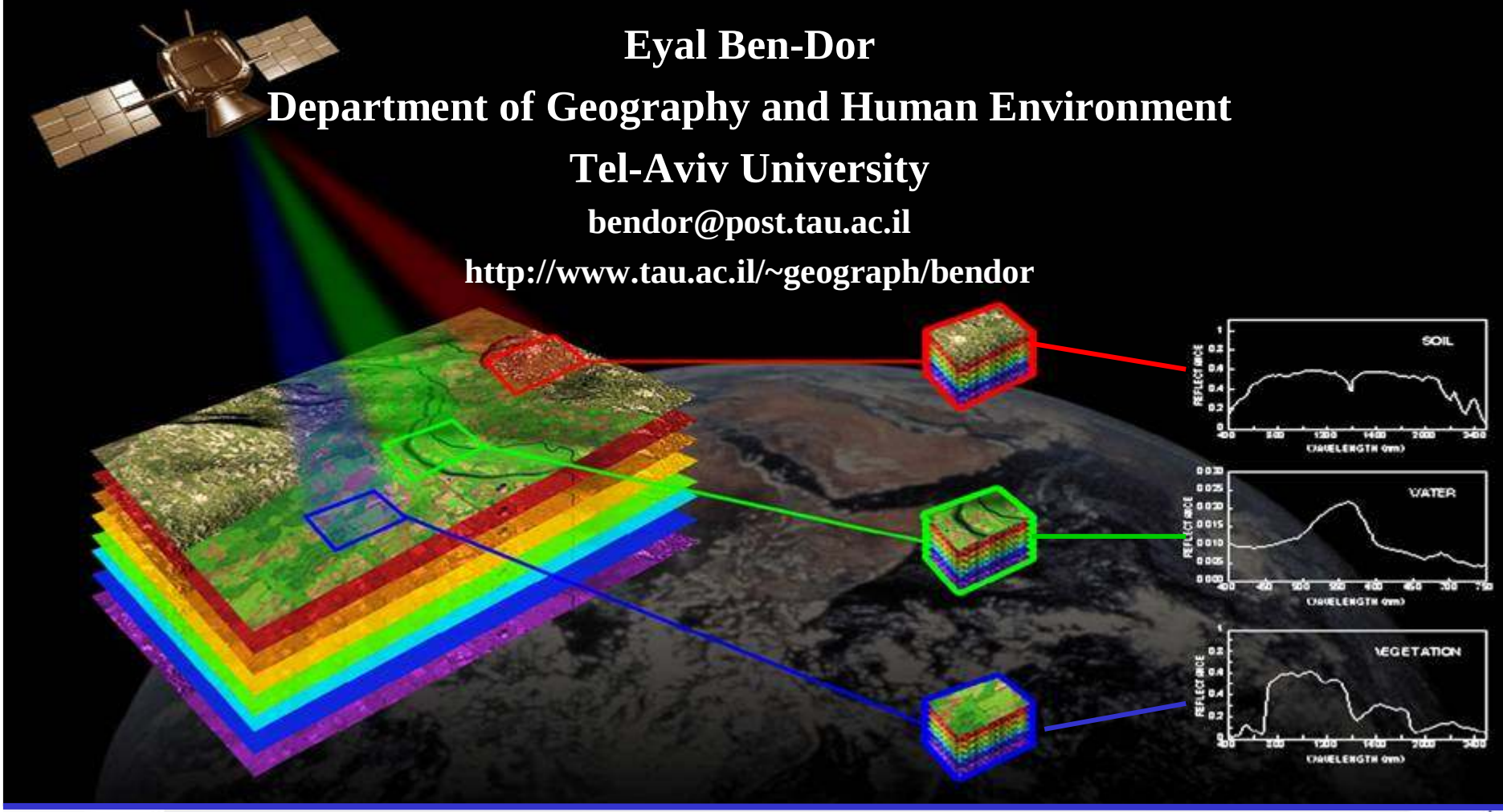


IMAGING SPECTROSCOPY EVOLUTION

HISTORICAL DEVELOPMENT

MRS →

(*Multi spectral Remote Sensing)*

HRS →

Israel

World

Airborne Multispectral Scanners	1960's
Satellite MSS	1972
Field Spectrometer (PFRS)	1974
Collins Airborne Spectrometer Profiler	1978
Shuttle Multispectral Infrared Radiometer (SMIRR)	1981
Landsat Thematic Mapper	1982
Airborne Imaging Spectrometer	1983
GER Imaging Spectrometer	1986
AVIRIS	1987
ITRES Research CASI	1989
HYDICE, MIVIS	1994
Hyperspectral Imager (HIS)	1997
EO-1, Hyperion	2000
NEMO-COIS	200?
AIRES	200?

AISA-ES → **2003**

Taken from Goetz et al. 2002

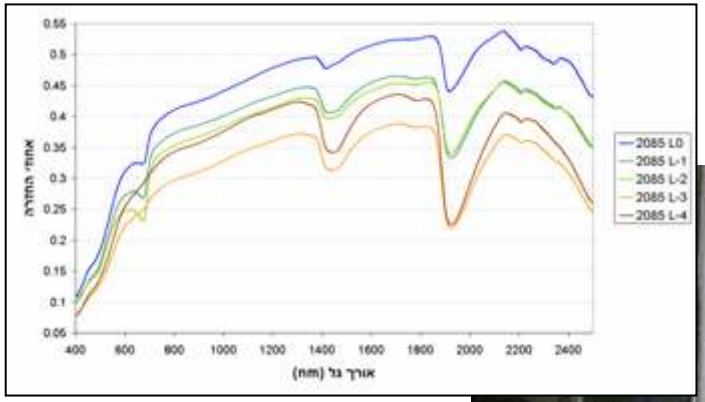
IMAGING SPECTROSCOPY ACTIVITY IN ISRAEL

- Pure Spectroscopy
- Simulation
- Developing Algorithm for Automated End Member Selection

- Flight Campaigns (Environmental Oriented)

PURE SPECTROSCOPY

Laboratory and Field



Pure Spectroscopy

Spectral Libraries (with chemical characterization)

Soil

Urban Materials

Dust

Quantitative Spectroscopy

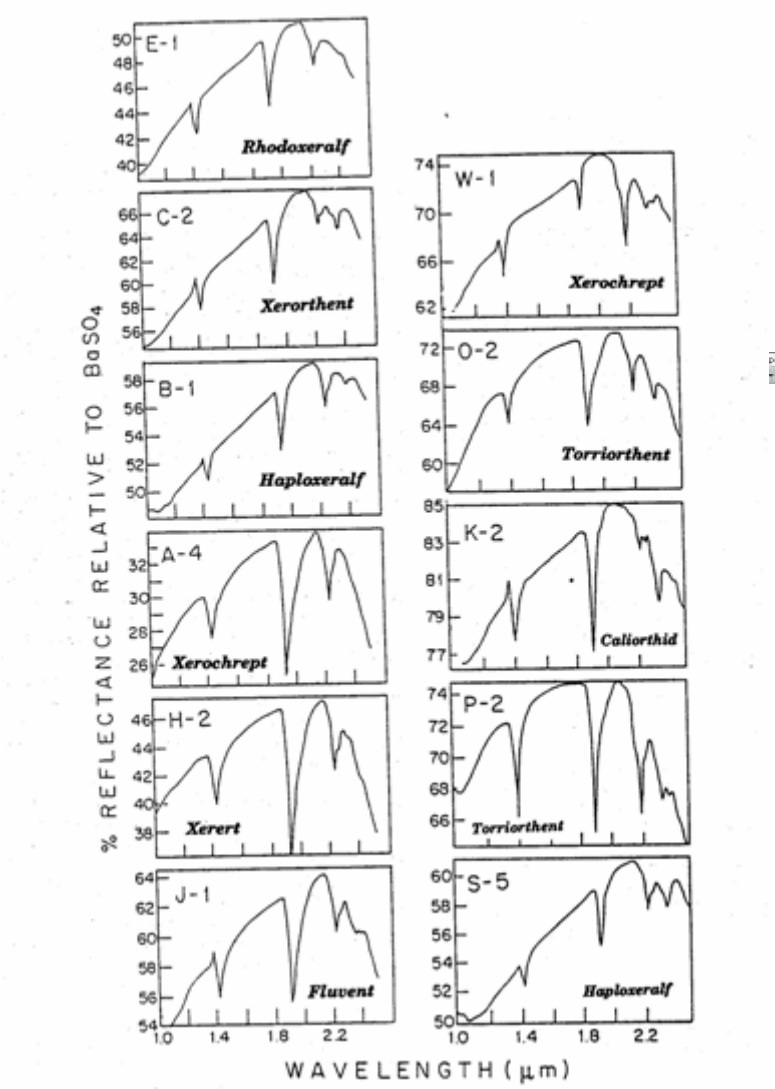
Sediment Dust accumulation

Soil Chemistry

Organic Matter

Pure Spectroscopy

Spectral Libraries



Soil *100 spectra + chemistry*

http://www.tau.ac.il/~geograph/RSL/SLIS/libraryn.html

Ben-Dor E. and A. Banin, 1995, Near infrared analysis (NIRA) as a rapid method to simultaneously evaluate, several soil properties. *Soil Science Society of American Journal*, 59:364-372

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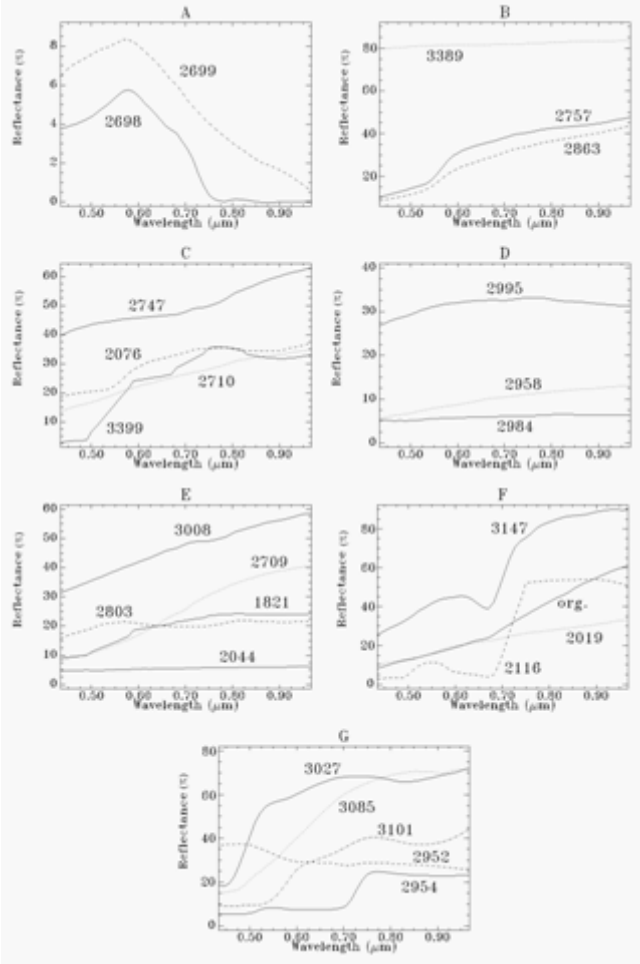
Pure Spectroscopy

Spectral Libraries

Urban

350 spectra

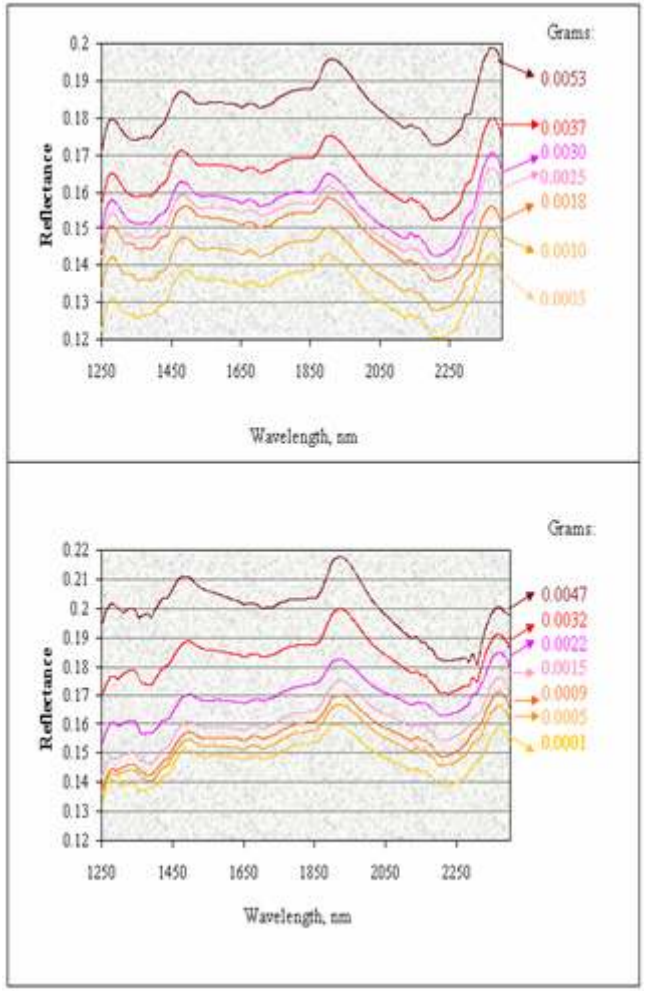


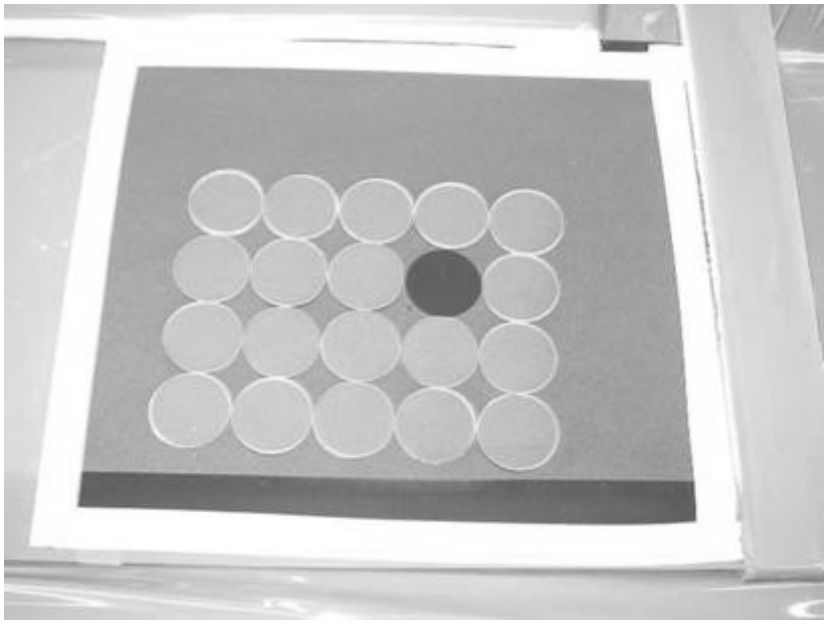
Ben-Dor E. 2001, Imaging Spectroscopy for Urban Applications in *Imaging Spectroscopy* (F. van Der Meer. And S.M. de Jong Eds) , Kluwer Academic Press Chapter 9: 243-281

Pure Spectroscopy

Spectral Libraries

Sediment Dust *145 spectra*



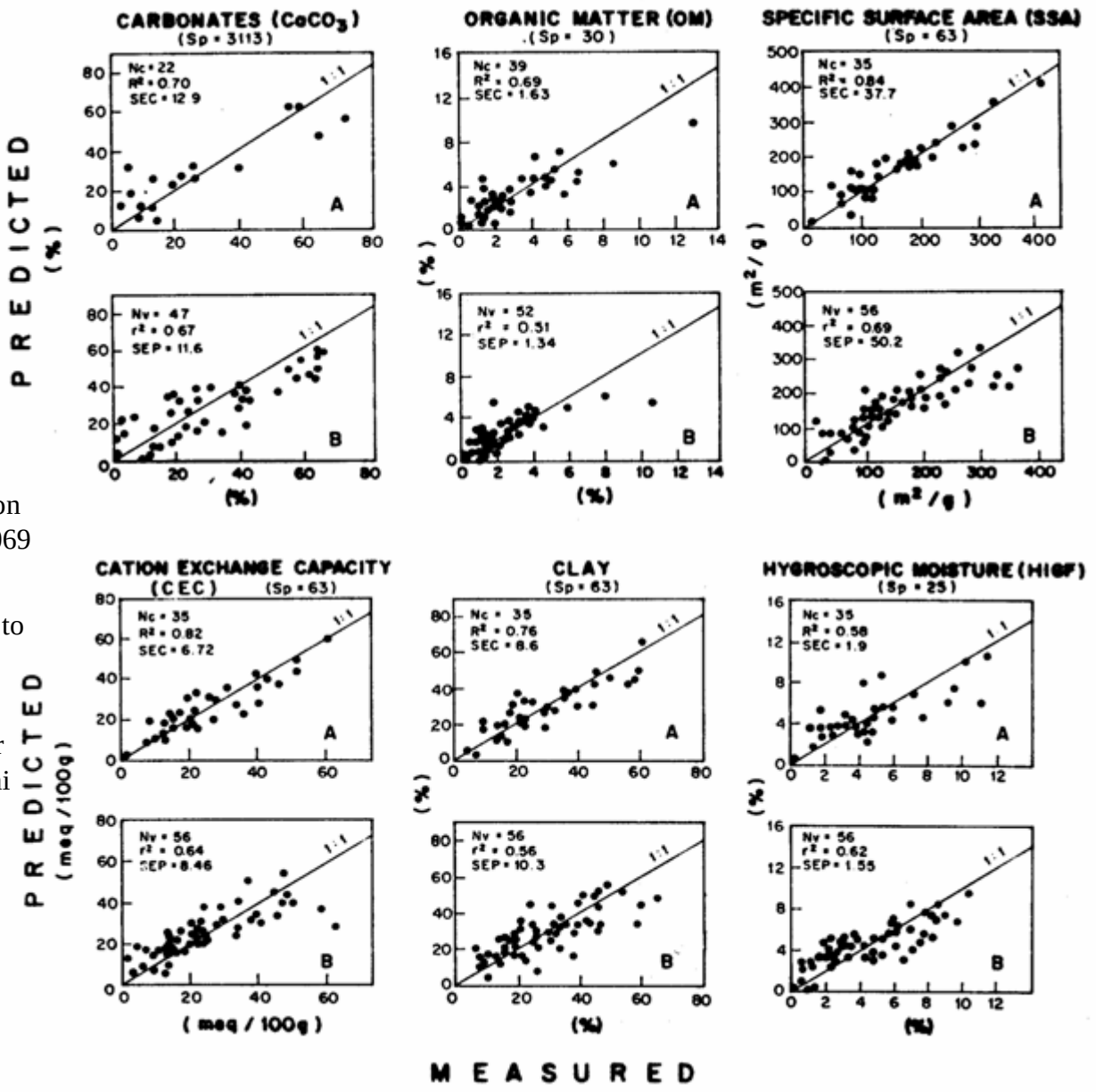


Ben-Dor E., Chudnovsky S. and E. Paz 2004, Indoor sediment dust load as monitored by reflectance spectroscopy in the VNIR-SWIR region (0.4-2.5μm) Proceedings of the 11th SPIE International Symposium on Remote Sensing 13-15 September 2005 Maspalomas, Grand Canaria, Spain (in press).

Pure Spectroscopy

Quantitative Spectroscopy

Soil



Ben-Dor E., and A. Banin, 1990, Near infrared reflectance analysis of carbonate concentration in soils. *Applied Spectroscopy*, 44, 6:1064-1069

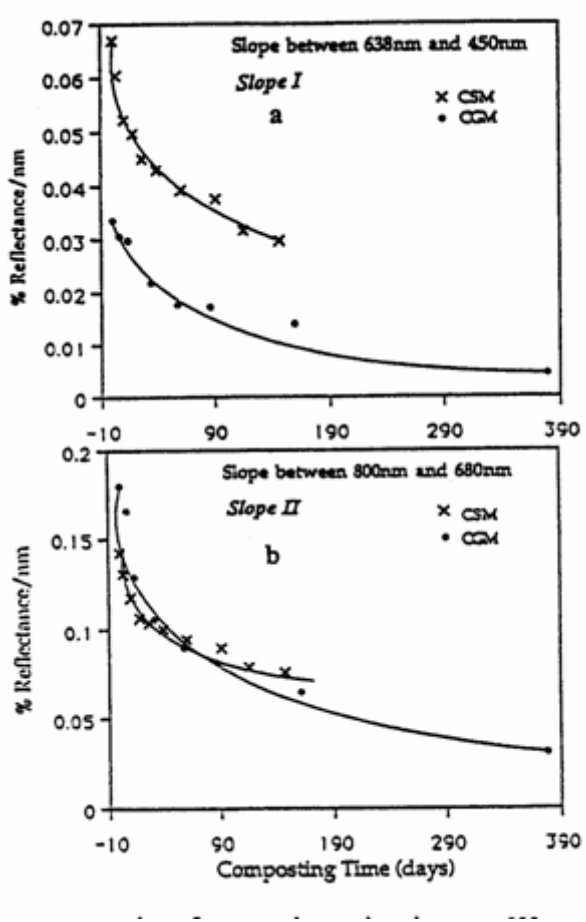
Ben-Dor E. and A. Banin 1995, Near infrared analysis (NIRA) as a simultaneously method to evaluate spectral featureless constituents in oils., *Soil Science,159:259-268* 159:259-269

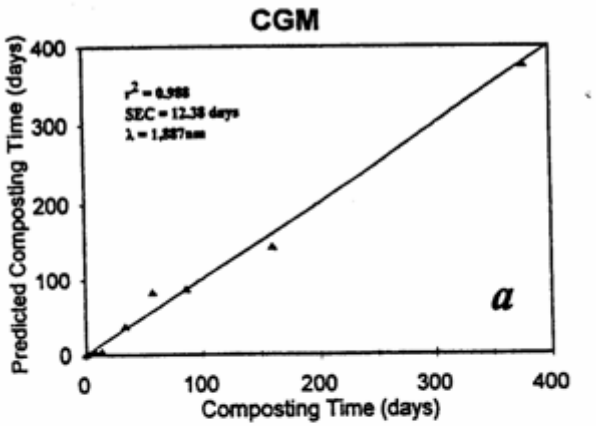
Ben-Dor E., and A. Banin, 1994, Visible and near infrared (0.4-1.1µm) analysis of arid and semi arid soils. *Remote Sensing of Environment*, 48:261-274

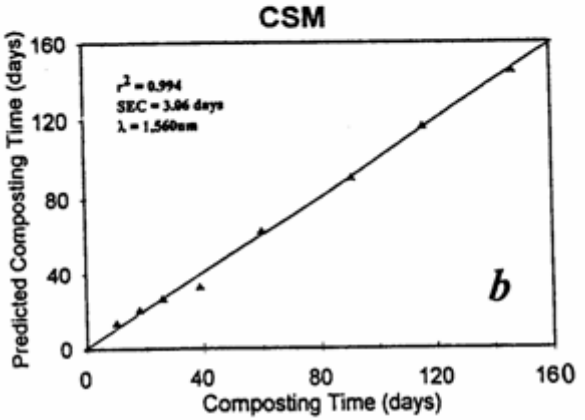
Ben-Dor E., Y. Inbar and Y. Chen, 1997 The reflectance spectra of organic matter in the visible near infrared and short wave infrared region (400-2,500nm) during a control decomposition process. *Remote Sensing of Environment* 61:1-15.

Quantitative Spectroscopy

Organic Matter



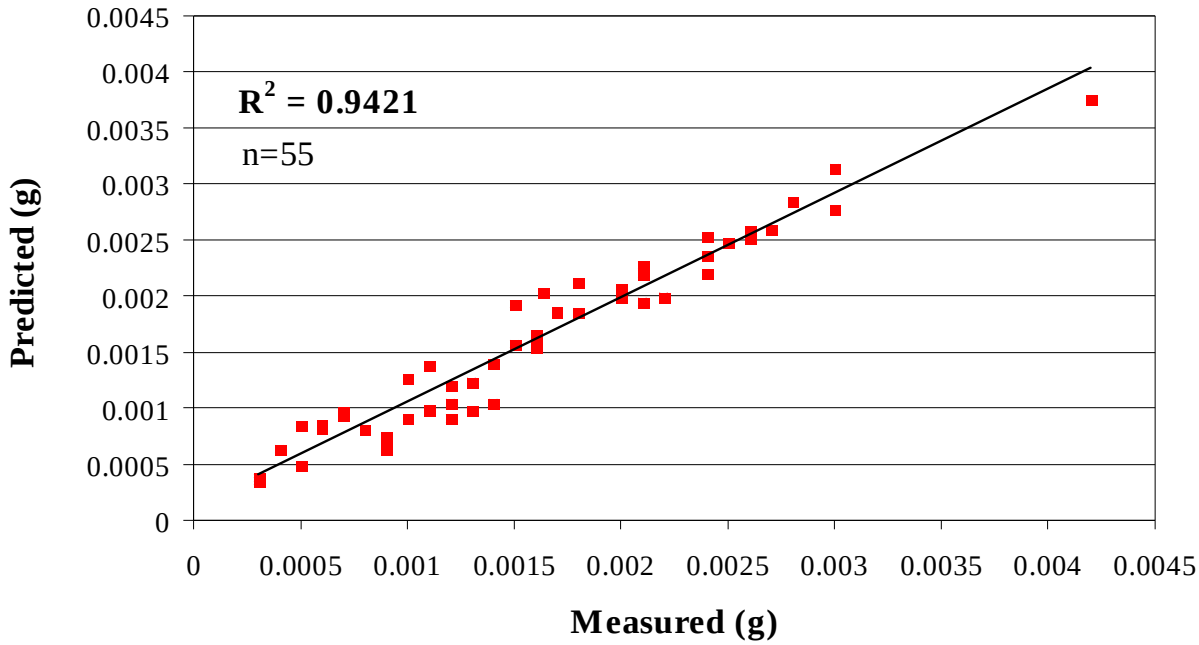




Ben-Dor E., Y. Inbar and Y. Chen, 1997 The reflectance spectra of organic matter in the visible near infrared and short wave infrared region (400-2,500nm) during a control decomposition process. *Remote Sensing of Environment* 61:1-15

Quantitative Spectroscopy

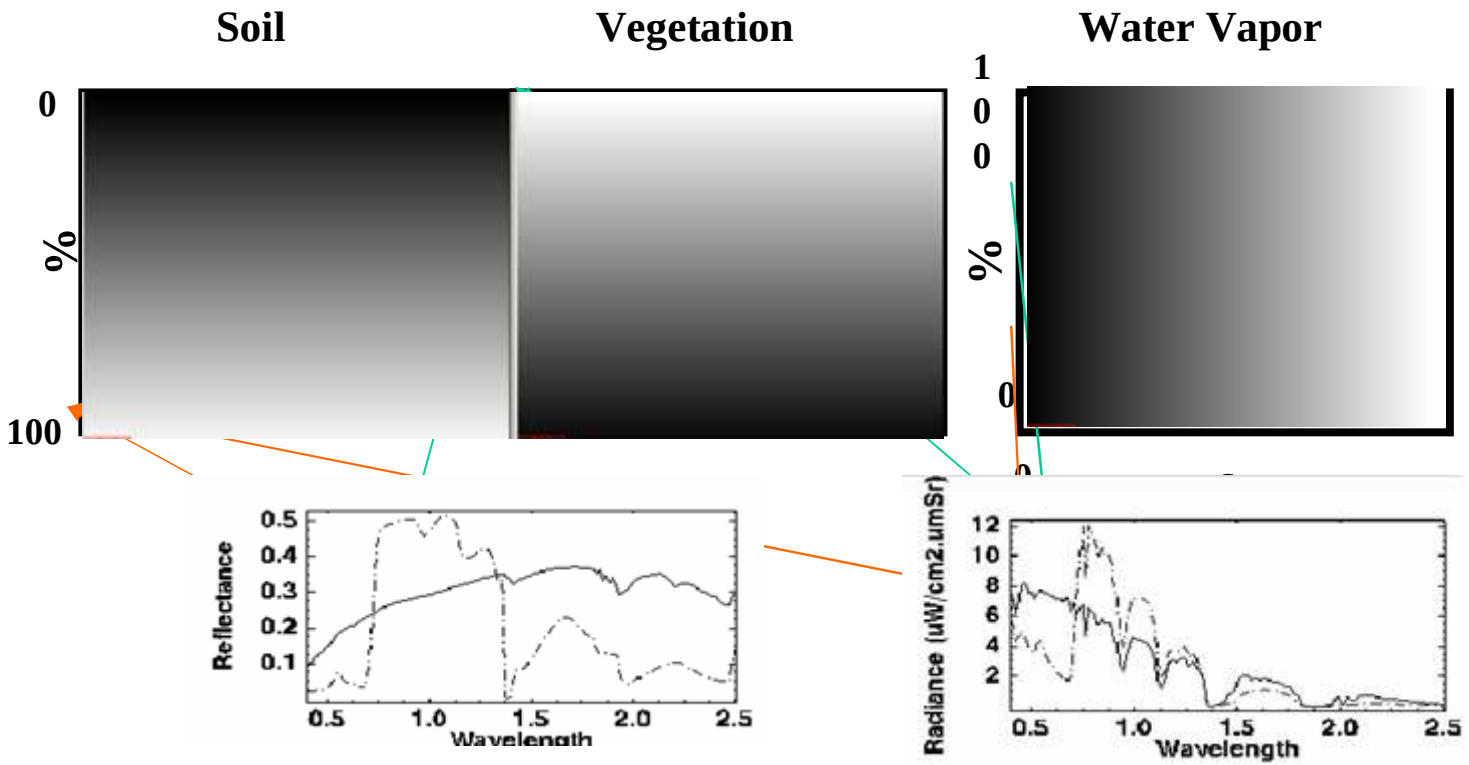
Sediment Dust



Chudnovsy S, Ben-Dor E. and E. Paz, 2004 Quantitative assessment of small amounts of sediment dust using reflectance spectroscopy in the NIR-SWIR region. Remote Sensing of Environment *(submitted)*

SIMULATION digital environment - a

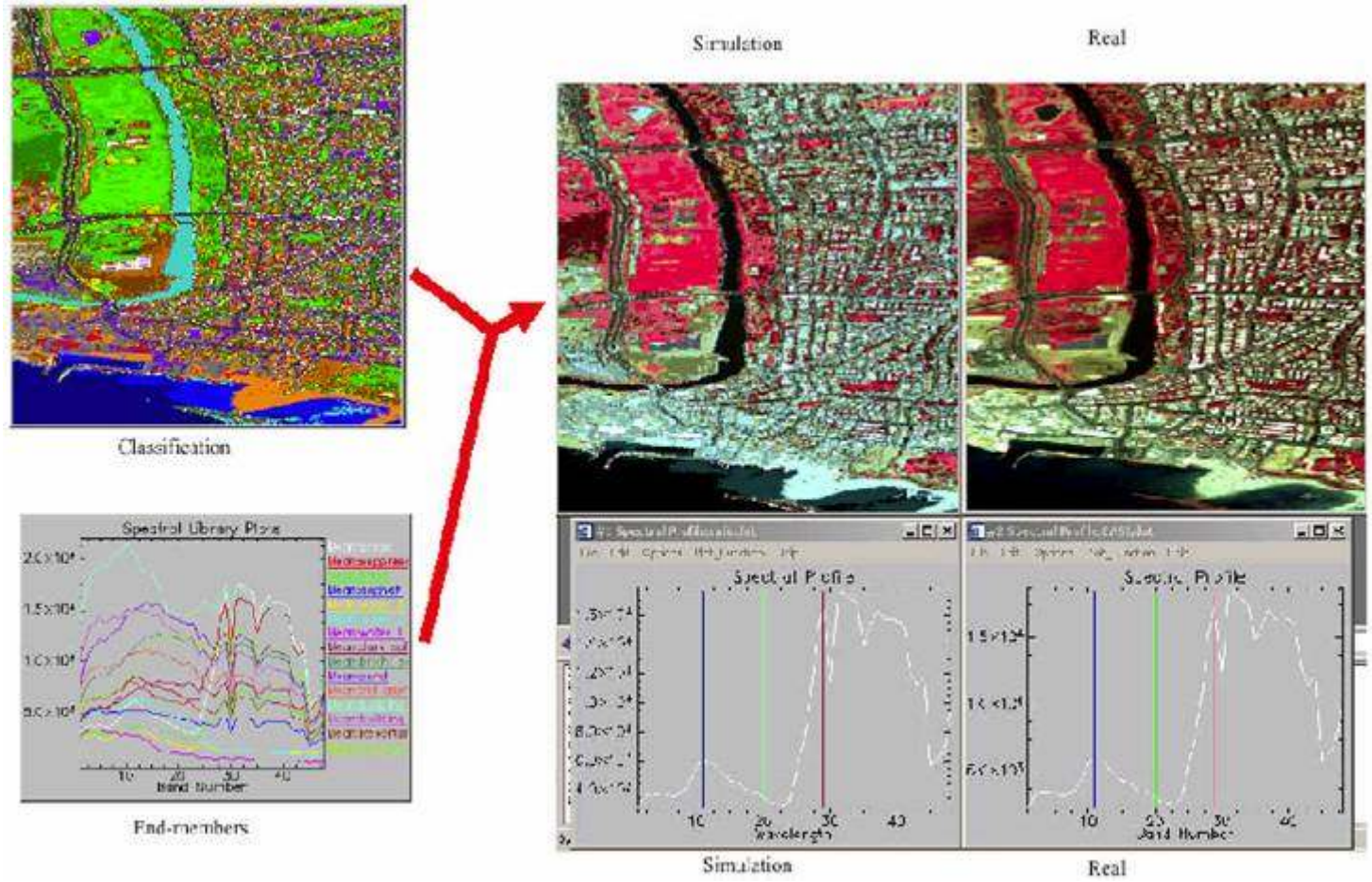
Simulated Environment to study Reflectance Retrieval and Atmosphere Composition



Ben-Dor E., B. Kindel, and A.F.H Goetz 2004 Quality Assessment of Several Methods to Recover Surface Reflectance I using Synthetic Imaging Spectroscopy (IS) Data, *Remote Sensing of Environment 90: 389-404*

SIMULATION digital environment - b

Scene Generator of Imaging Spectroscopy Images



Feingersh T, Ben-Dor E. amd J. Portugali 2004, Construction of synthetic spectral reflectance imagery for monitoring of urban sprawl *Environmental Modeling and Software Journal* (*under review)*

SIMULATION laboratory environment - a

Rain Strom (soil)

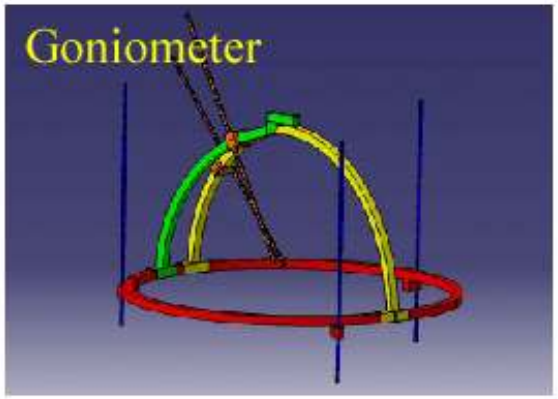
Ben-Dor E , N. Goldshlager, Y. Benyamini, M. Agassi and D. Blumberg 2002, Soil Crusting and Infiltration Processes as Monitored by Soil Reflectance Spectroscopy in the SWIR region. *Remote Sensing of Environment Journal 23:3909-3920*

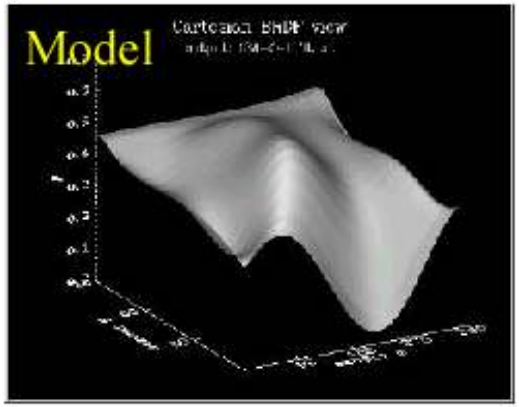
Dust Strom (surfaces)

Chudnovsy S, Ben-Dor E. and E. Paz, 2004 Quantitative assessment of small amounts of sediment dust using reflectance spectroscopy in the NIR-SWIR region. Remote Sensing of Environment *(submitted*)

SIMULATION laboratory environment b

BRDF





- Improved simulation & Calibration

- Correction for real imagery
  (HyMap / DLR paper coming)

Developing innovative approaches: automatic classification

Automated End Member Selection

Cotton Field

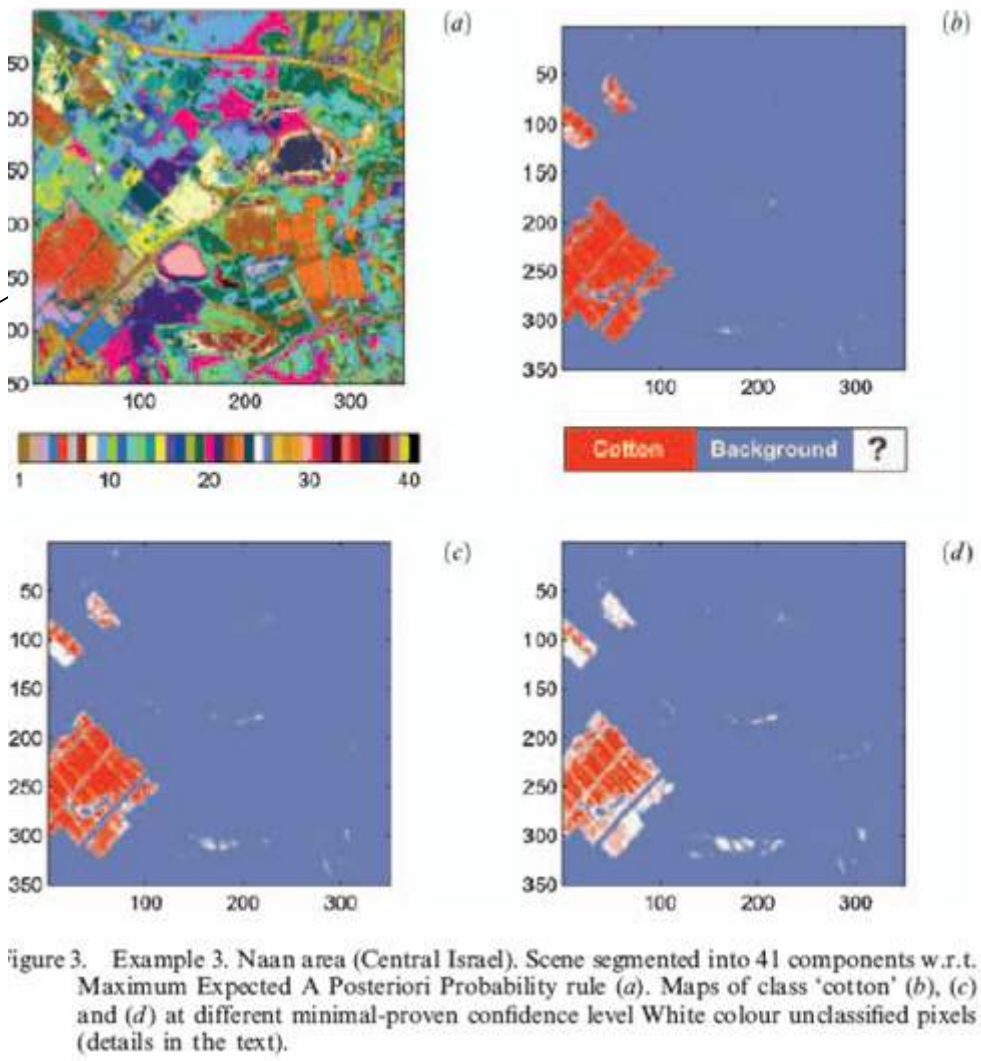


Figure 3. Example 3. Naan area (Central Israel). Scene segmented into 41 components w.r.t. Maximum Expected A Posteriori Probability rule (*a*). Maps of class 'cotton' (*b*), (*c*) and (*d*) at different minimal-proven confidence level White colour unclassified pixels (details in the text).

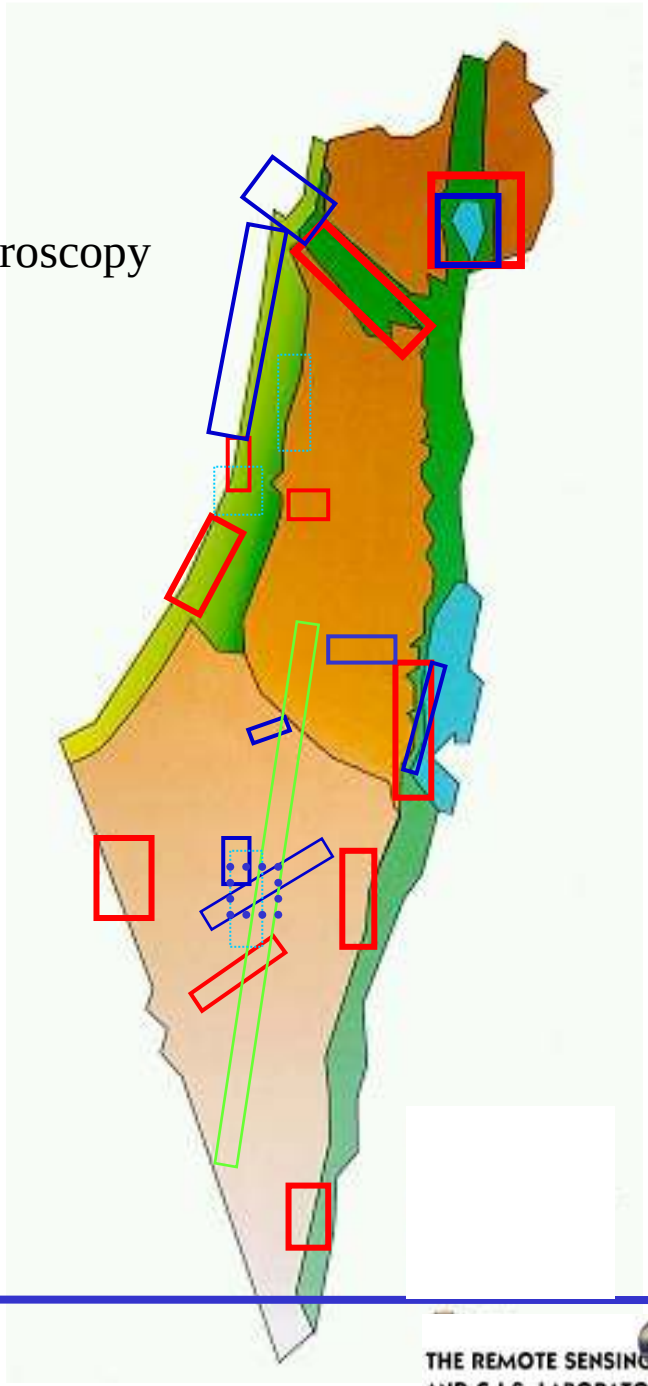
Koltunov A. and **Ben-Dor E.** 2003 Mixture density separation a tool for high quality interpretation of multi-source remote sensing data and related issues *International Journal of Remote Sensing* 24: 1-26

FIELD *IS* CAMPAIGNS

Based on the “theoretical “ studies of Pure Spectroscopy

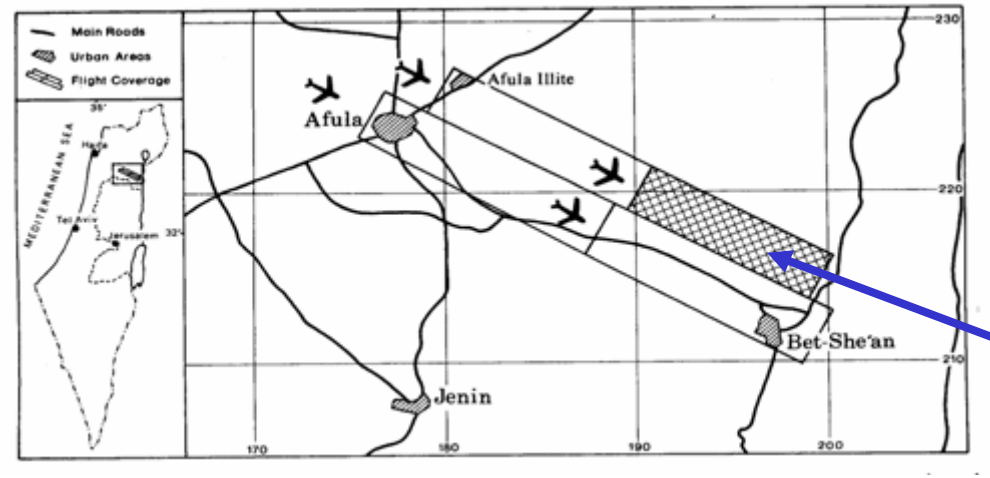
And Simulation

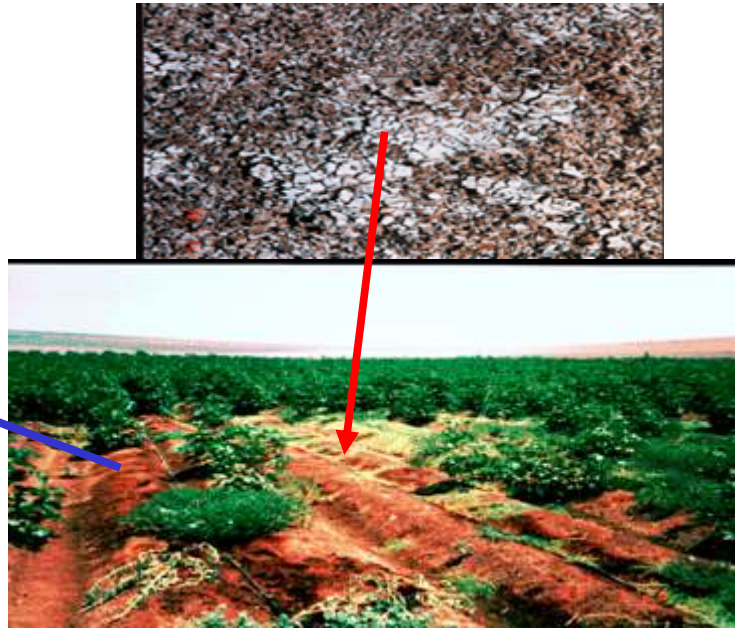
Hyperion
CASI
GER
DAIS
AISA
AISA-ES
CHRIS-PROBA



Soil Salinity, Soil Moisture and Soil Organic matter

Salinity Reduces Soil Production





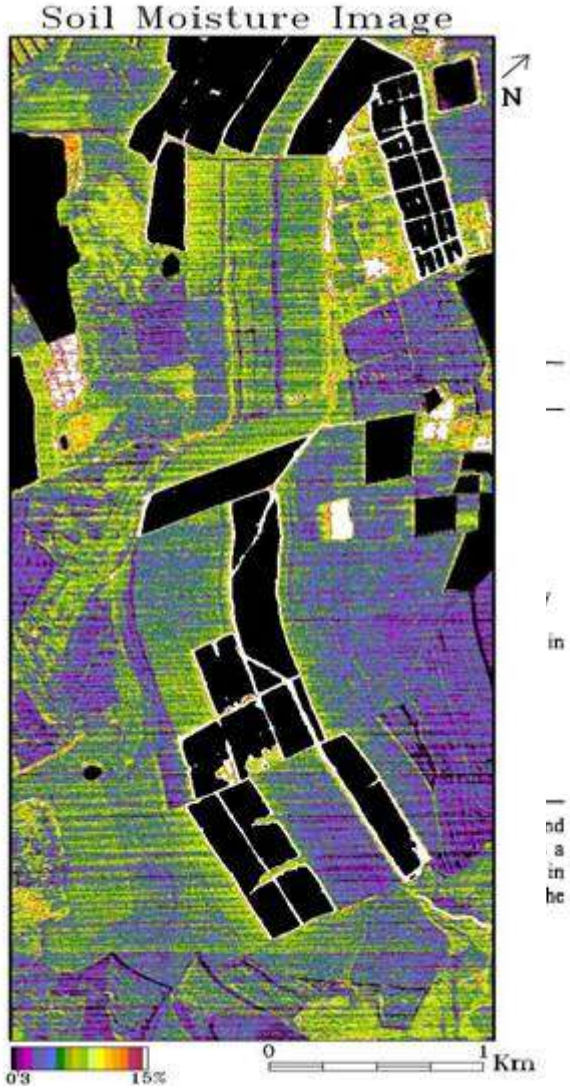
Ben-Dor E., K. Patkin, A. Banin and A. Karnieli *2002 Mapping of several soil properties using DAIS-7915 hyperspectral scanner data. A case study over clayey soils in Israel. International Journal of Remote Sensing 23:1043-1062*

Soil Salinity, Moisture and Organic matter

uations obtained for

Predict
wl_0.739*0.378179 + wl_0.689*0.184370 +
wl_0.722*0.135211 + wl_0.705*0.117264 + 0.052084 wl_2.085*0.136384 + wl_2.183*0.220235-w 0.115681 + 0.500373
wl_0.739*28.936957 + wl_2.166*26.44311-7.
wl_0.722*0.517083 + 8.040777

$C = \square\ [[\Sigma\ (C_m - C_$
from running the VN
where C_s is the cons
$DL = \square\ [\Sigma\ \Sigma\ (C_{si} -$
cations of sample i.



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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, 0.002 0.0012@
Soil-Saturated Moisture SPM	0.019, 0.021, 0.005 0.0006@
Electrical Conductivity (EC)	4.36, 4.58, 0.1 2.57@
PH	0.146, 0.26, 0.1 0.073@

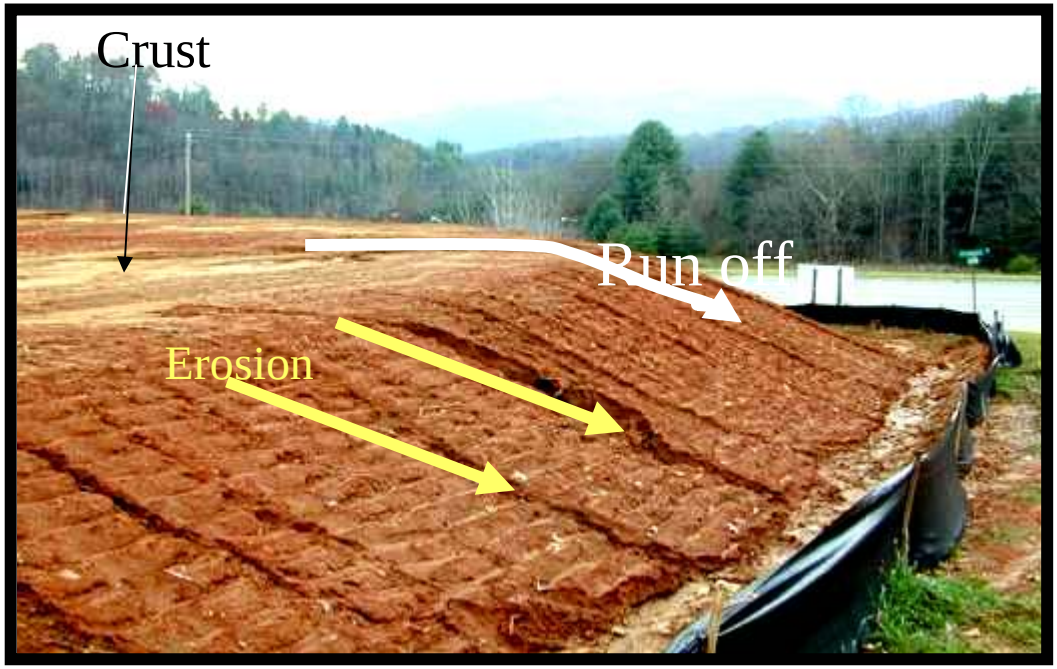
wl stands for the wavelength (μm) i
predicted ($x=p$) domains. @ stands for
multiple regression coefficient. SEP = □
samples were not involved in the calibr
laboratory of sample i and AVE_i is the a

ıore details).

Assignments
65 μm-reflectance slope
688 μm-reflectance slope
739 μm-reflectance slope/chlorophyll
722 μm-chlorophyll remaining
678 μm-C-H in cellulose
328 μm-Humic acid, Pectin, Lignin
085 μm–adsorbed water OH
183 μm-OH combination of $\upsilon' + \delta$ in clay
ineral lattice
538, 1.563 μm-OH combination of 2□□ in
ay mineral lattice
739 μm-organic-matter assignments
65 μm-adsorbed water OH
166 μm-adsorbed water OH
ot determined

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

Soil Infiltration Runoff and Water Erosion



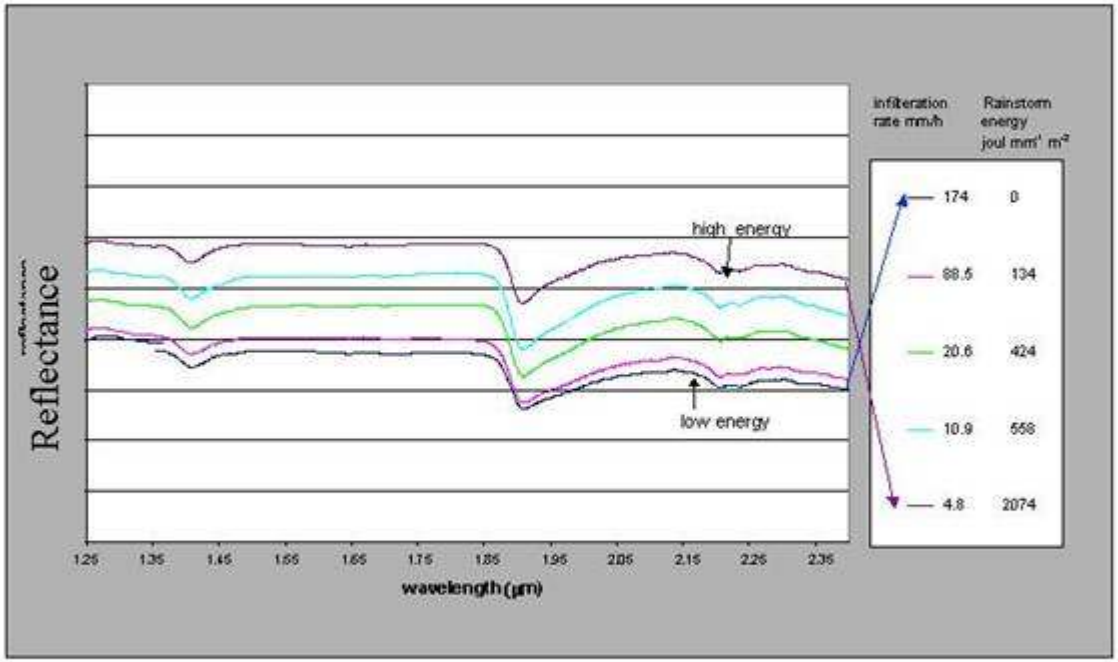
Ben-Dor E. , N. Goldshalager, O. Braun , B. Kindel , A.F.H.Goetz , D. Bonfil ., M. Agassi, N. Margalit , Y. Binayminy and A. Karnieli 2004 Monitoring of Infiltration Rate in Semiarid Soils using Airborne Hyperspectral Technology *International Journal of Remote Sensing 25:1-18*

Soil Infiltration Runoff and Water Erosion

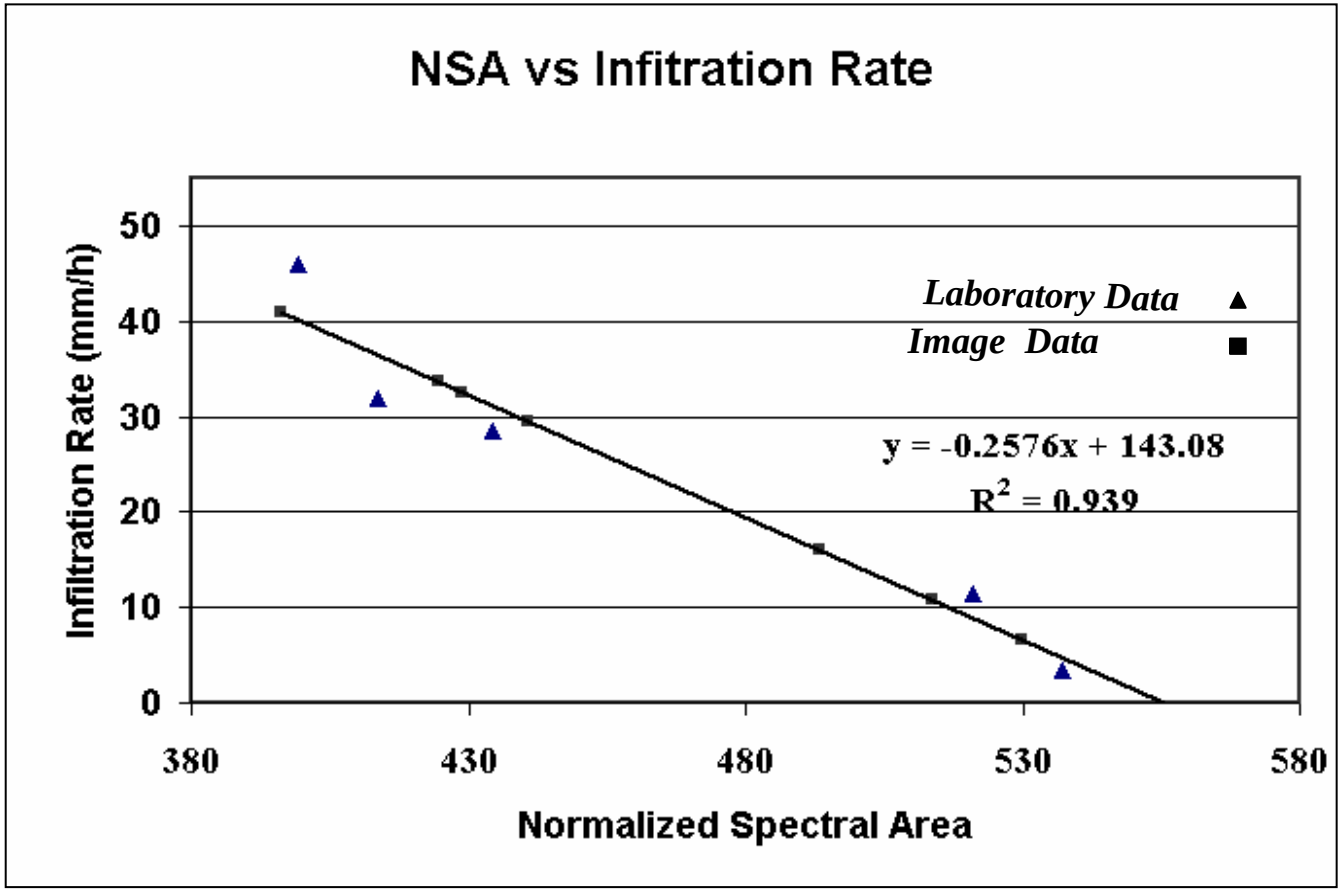
0 joule

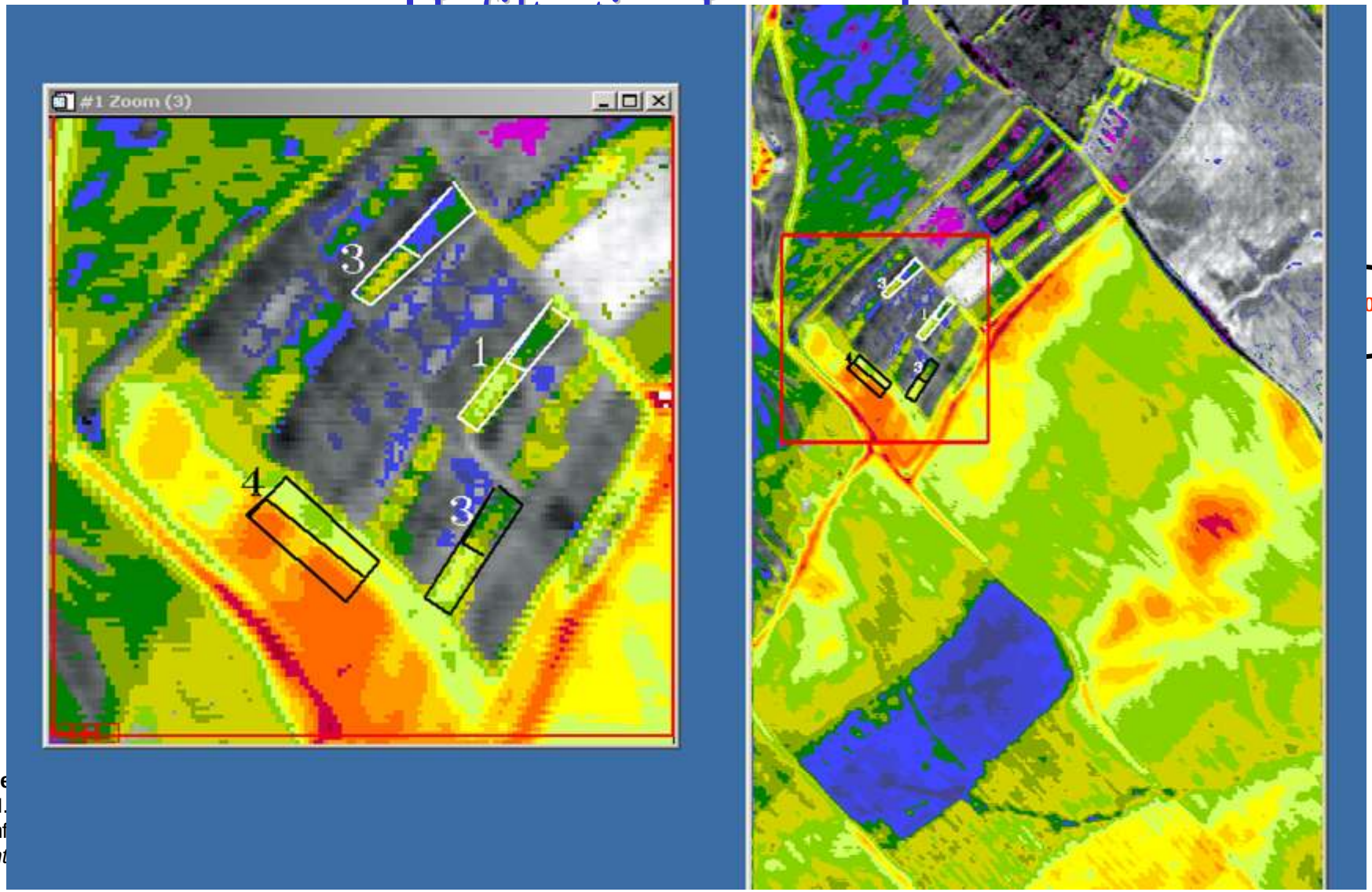
650 joule

1842 joule

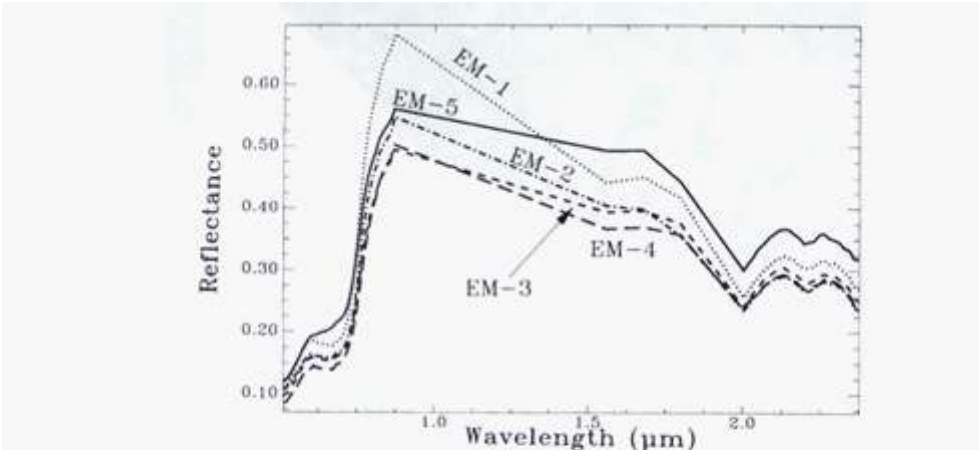


Ben-Dor E , N. Goldshlager, Y. Benyamini, M. Agassi and D. Blumberg 2002, Soil Crusting and Infiltration Processes as Monitored by Soil Reflectance Spectroscopy in the SWIR region**.** ***Remote Sensing of Environment Journal 23:3909-3920***


NSA vs Infitration Rate
Infiltration Rate (mm/h)
50
40
30
20
10
0
380
430
480
530
580
Normalized Spectral Area
Laboratory Data
Image Data
y = -0.2576x + 143.08
R2 = 0.939


#1 Zoom (3)
3
1
4
3

Fine Tuning Classification based on Acceptable Atmospheric Correction Results



Ben-Ben Dor E. and N. Levin, 1999 Determination of surface reflectance from raw hyperspectral data with out simultaneous ground truth measurements. A case study of the GER 63- channel sensor data acquired over Naan Israel. International Journal of Remote Sensing of Environment. 21:2053-2074

***Ben-Dor E.**, and F.A. Kruse, 1994, The relationship between the sub spatial subset of GER 63 channel scanner and the quality of the Internal Average Relative Reflectance (IARR) correction technique. International Journal of Remote Sensing, 3:683-690.*

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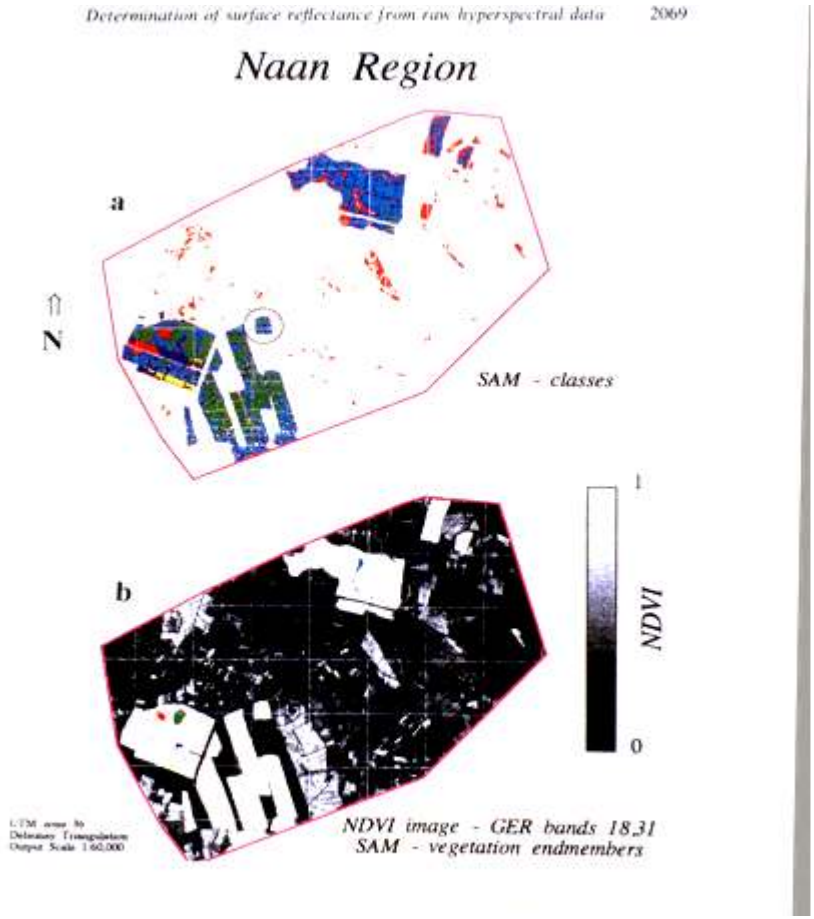
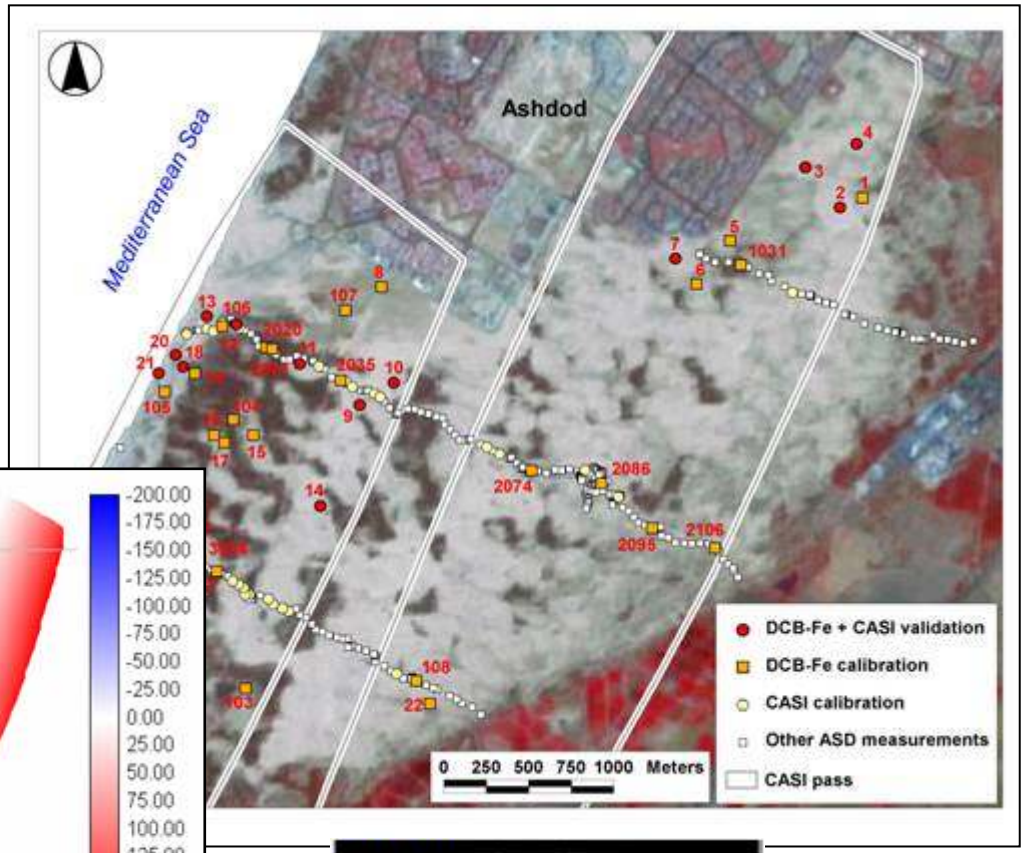


Sand Dune Stability

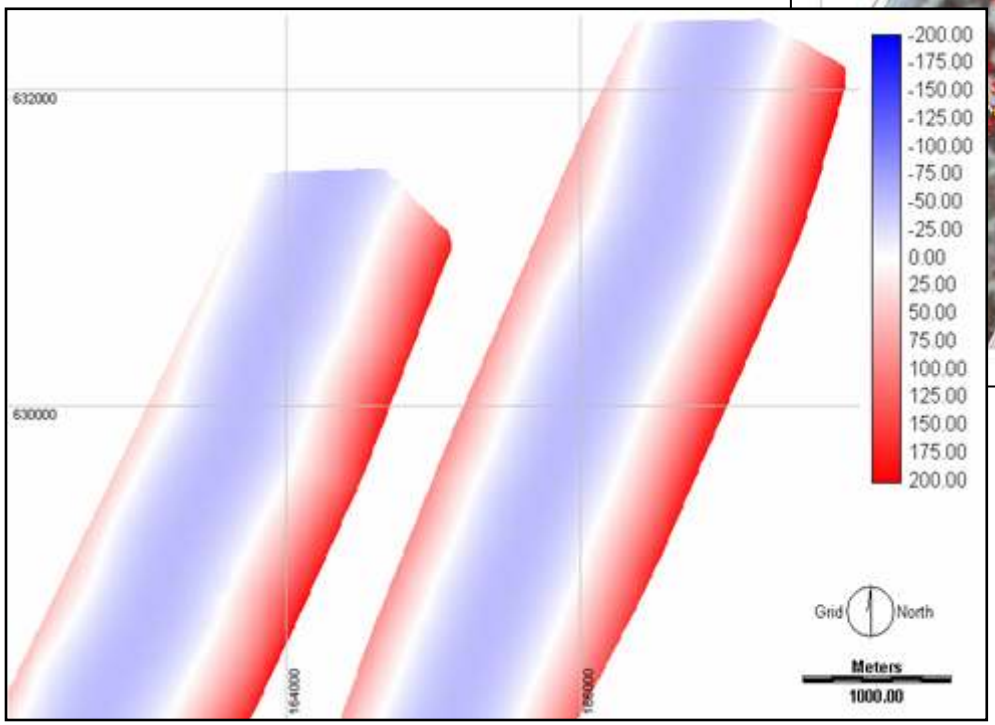
Ben-Dor E., Levin N., Singer A. Braun O. and A. Karineli 2001, Soil Rubificatoin processes as determined from hyper spectral sensor. *The 29th Remote Sensing International Conference, April 2001, Argentina.*

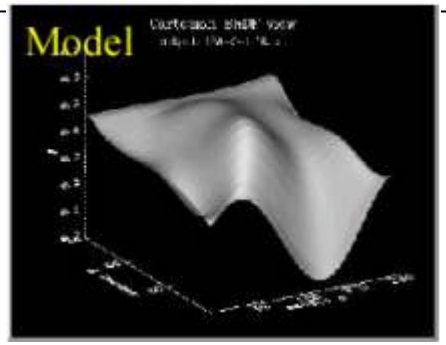
Sand Dune Stability

Ground Sampling Location

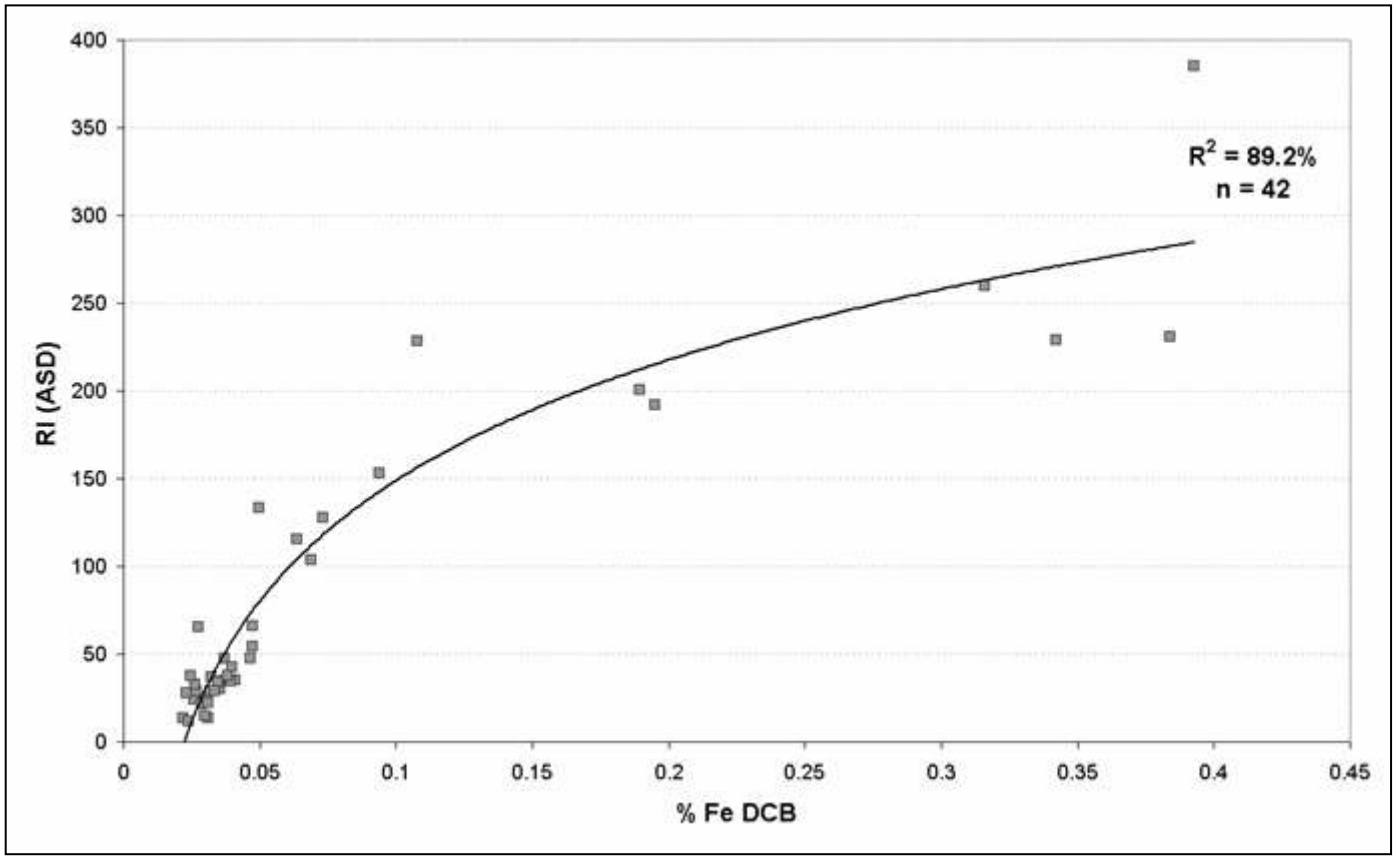


BRDF correction





Model for Iron Oxide Estimation from Spectroscopy

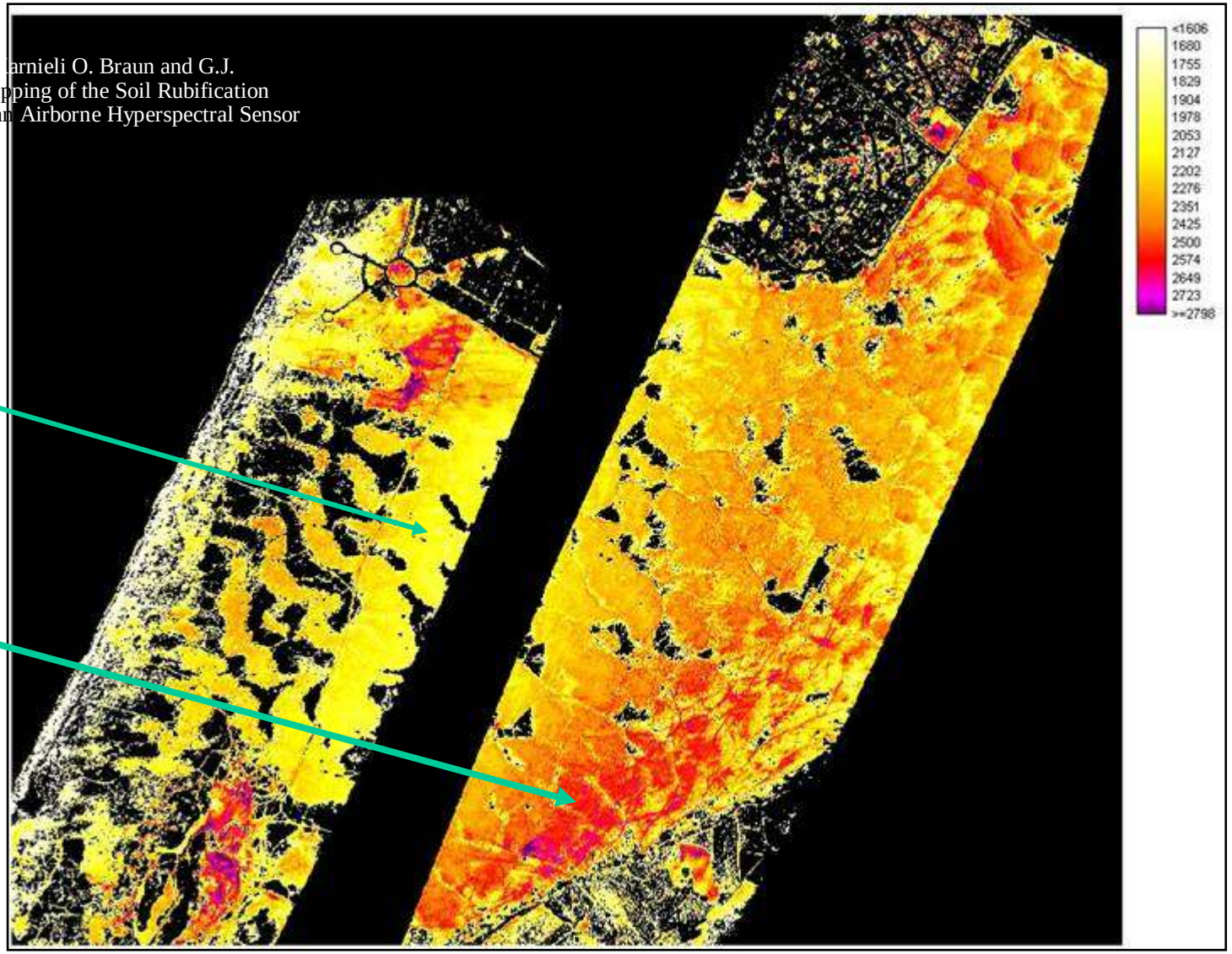


Sand Dune Stability (applying the spectral model)

Ben-Dor E, N. Levin A. Singer, A. arnieli O. Braun and G.J. Kidron 2004, Quantitative Mapping of the Soil Rubification Process on Sand DunesUsing an Airborne Hyperspectral Sensor *Geoderma* (under review)

Non Stable

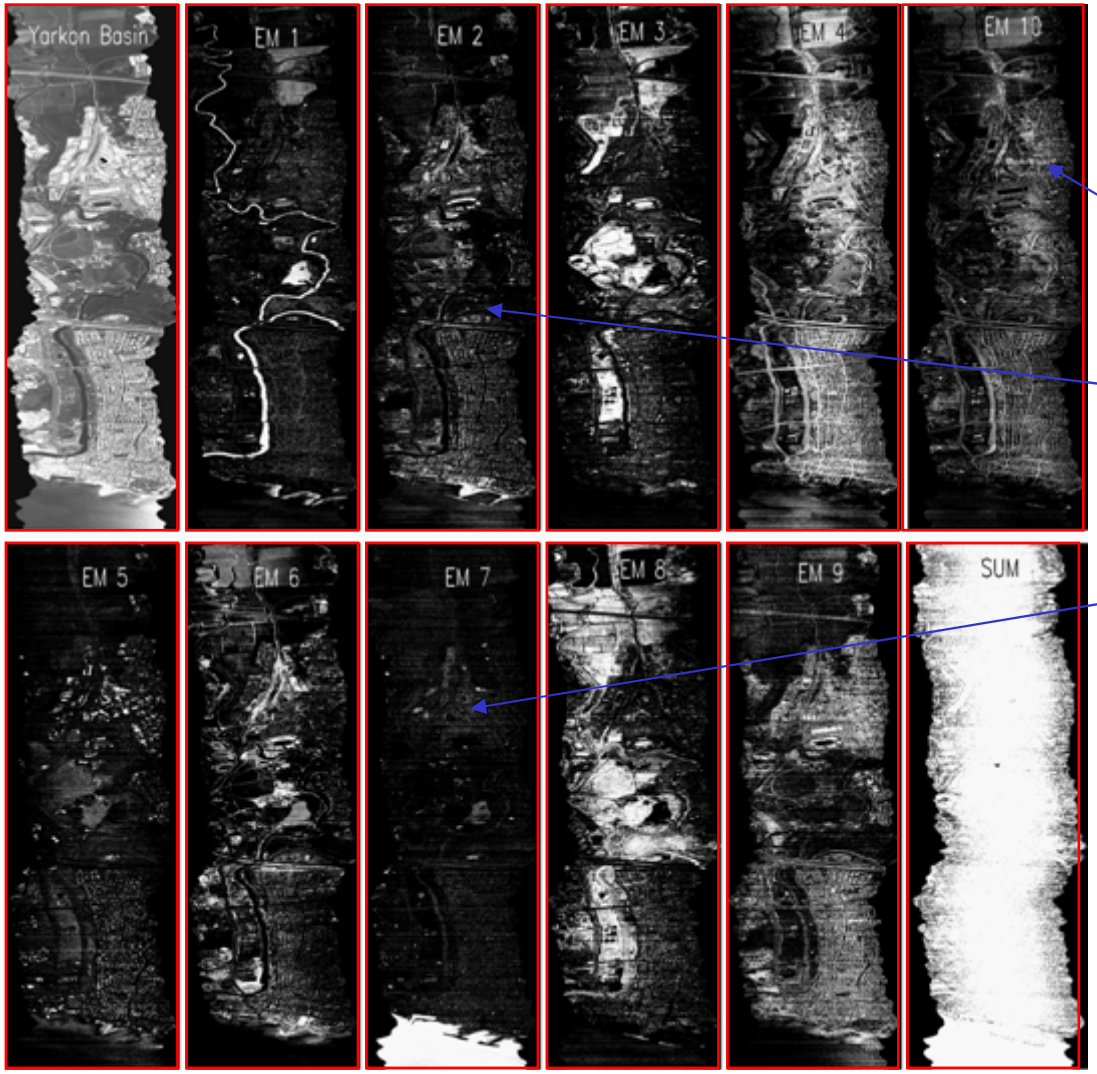
Stable

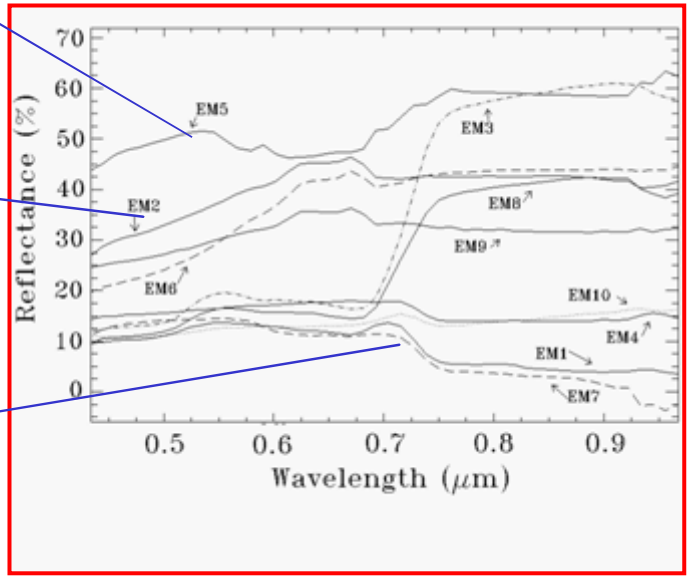


Urban Mapping

Tel-Aviv

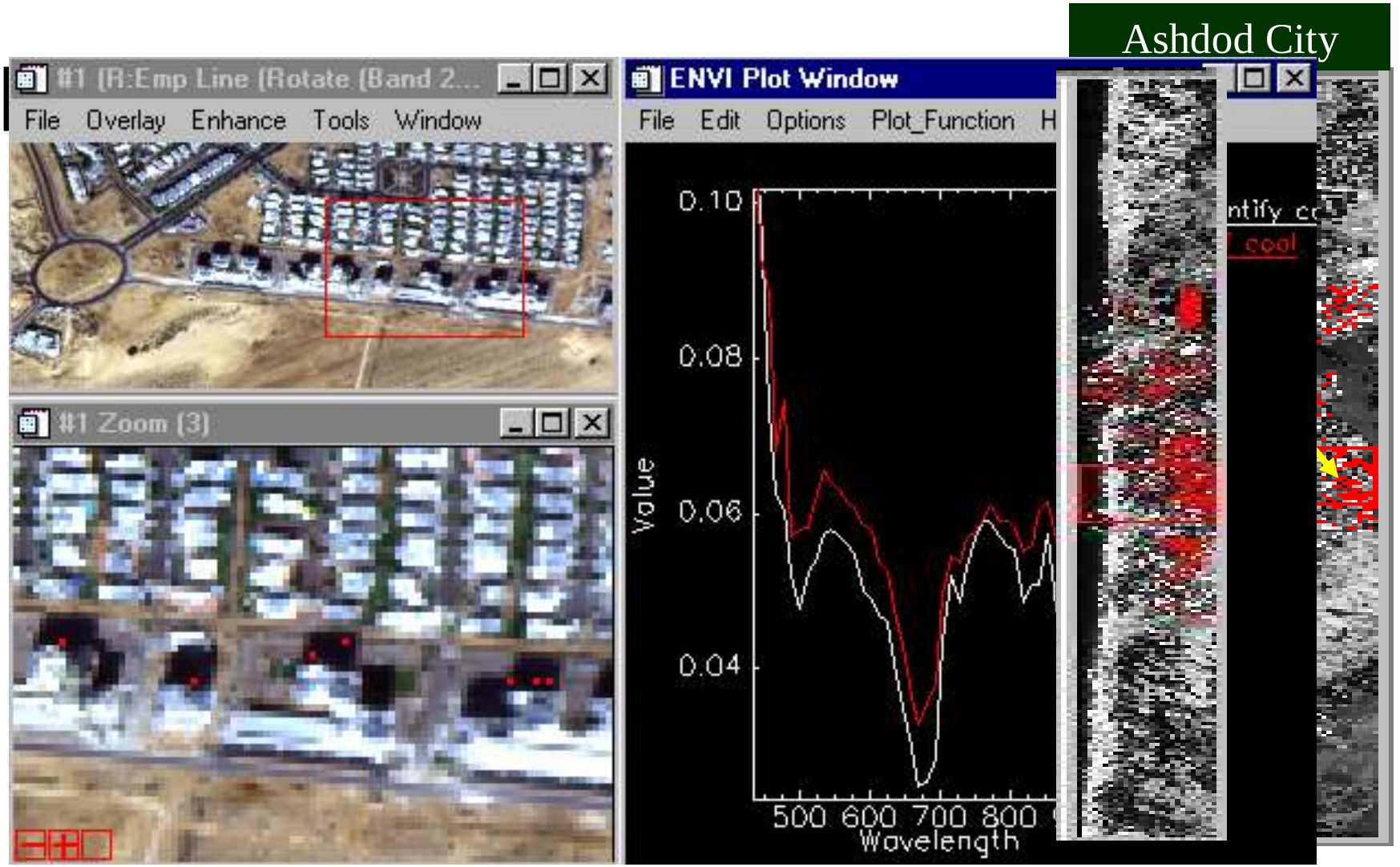
Urban Mapping (a) Classification by Spectroscopy





Ben-Dor E., N. Levin and H. Saaroni 2001 A spectral based recognition of the urban environment using the visible and near infrared spectral region (0.4-1.1μm). A case study over Tel-Aviv, Israel. *International Journal of Remote Sensing* 22: 2193-2218

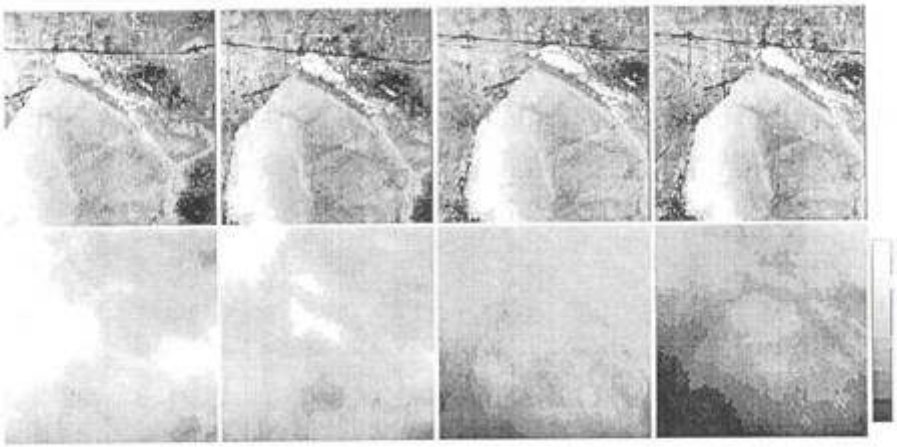
Urban Mapping (c) Dark Pixels: Coal Dust



Atmosphere

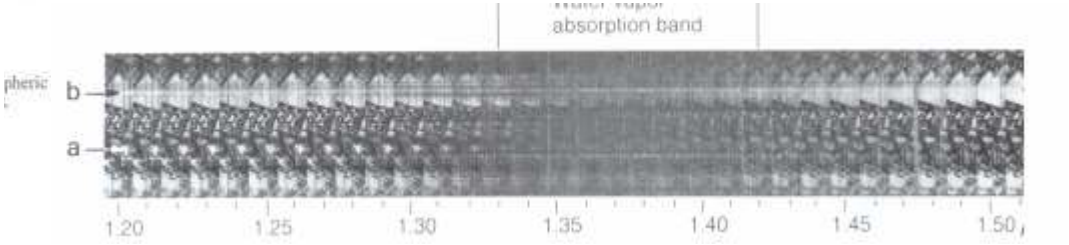
Dust storm over arid environment (Negev Israel)

Clear day over arid environment (Negev Israel)



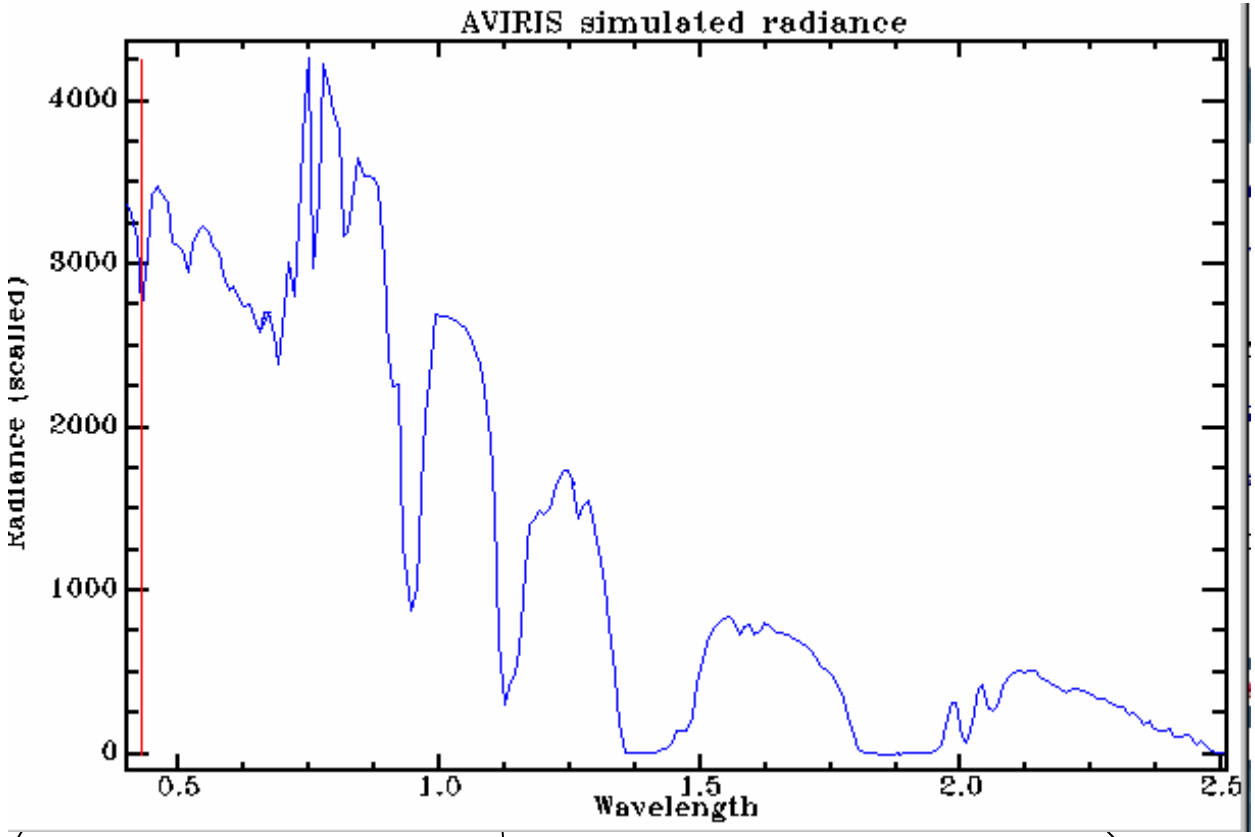
Water Vapor over Rogers Dry Lake

Bands over Water Vapor active Regions



Atmosphere

Atmosphere Components from IS



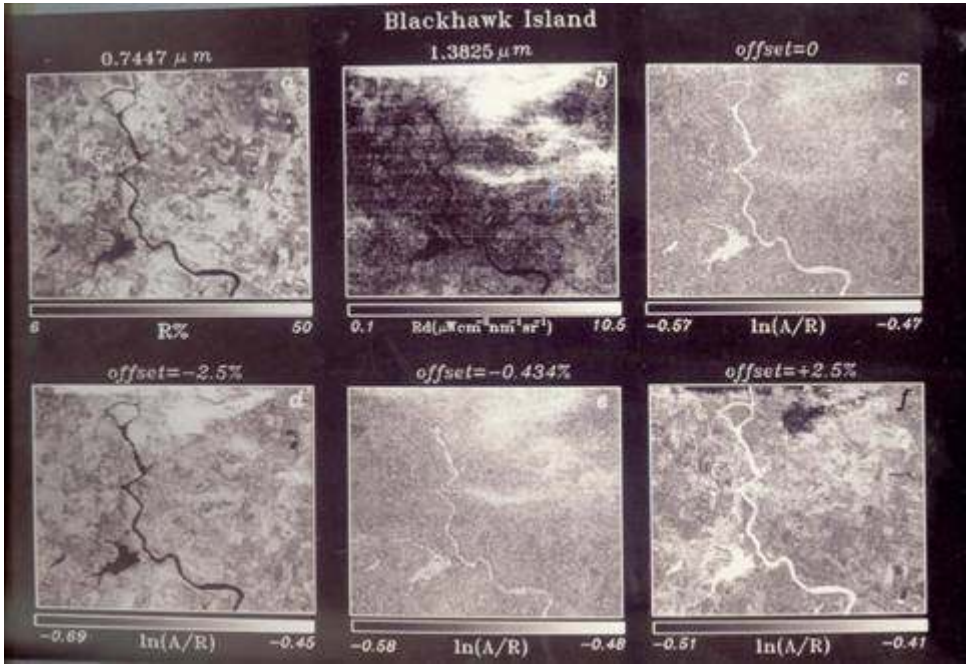
Ben-Dor et al, 1994

Many workers

Ben-Dor et al, 1996

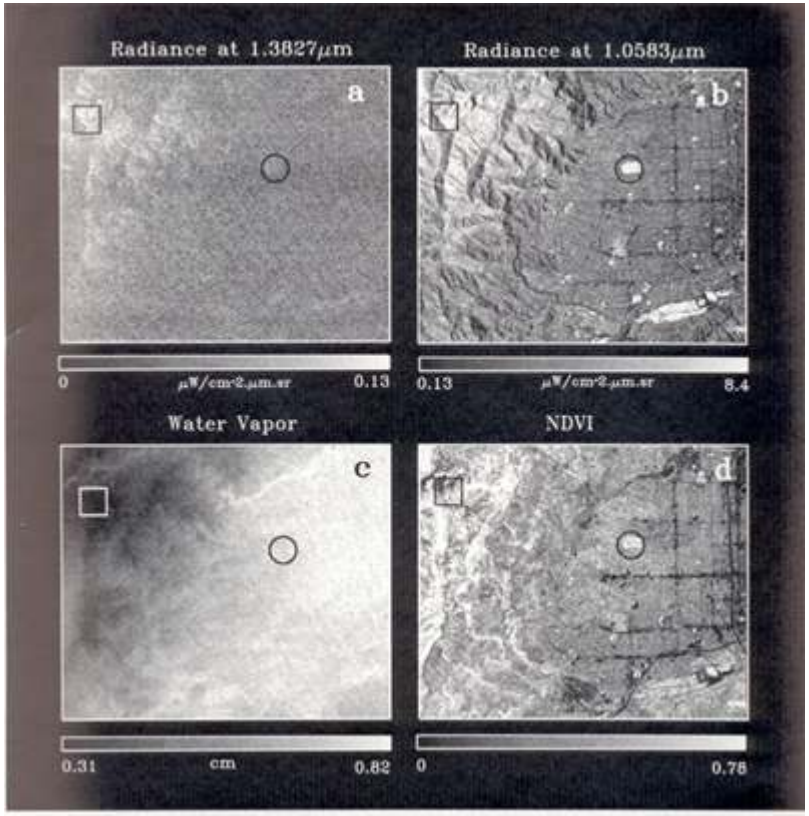
Green et al, 2001

Cirrus Cloud Detection Using O2 Band



Ben-Dor E., A.F.H Goetz and A.T. Shapiro, 1994, Estimation of cirrus cloud and aerosol scattering in hyperspectral image data, *Proceedings of the International Symposium on Spectral Sensing Research*, 2:582-593, San Diego, California, USA.

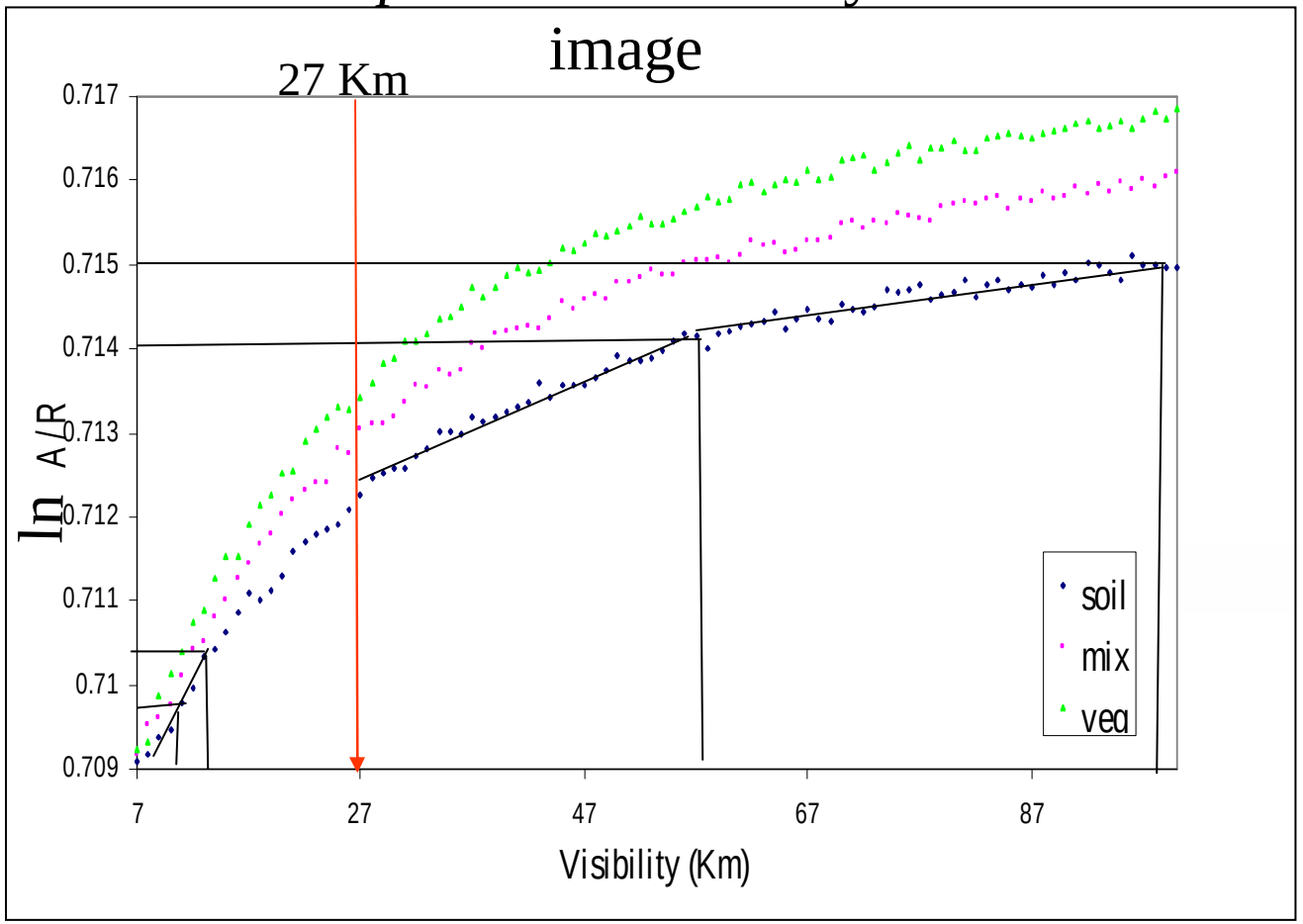
Precaution in Cirrus Cloud Detection



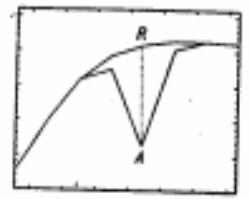
Ben-Dor E., 1994, A precaution regarding cirrus cloud detection from Airborne Imaging Spectrometer data using the 1.38μm water vapor band. *Remote Sensing of Environment*, 50:346-350

Oxygen Peak for Aerosol Evaluation on a Pixel Basis

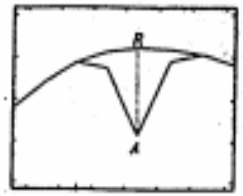
Look up Table from the synthetic image



$$\ln (A/R) = f(\tau)$$



vegetation



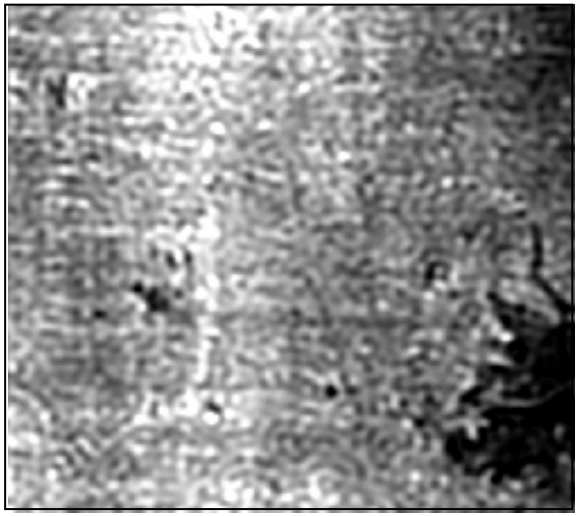
soil

760 nm

Oxygen Peak for Aerosol Evaluation

Natural RGB

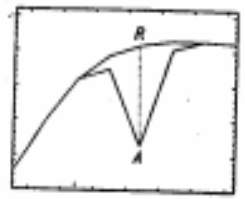
Aerosol Distribution



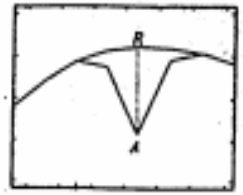
← Santa Monica

← Dead Sea Factory

$$\ln (A/R) = f(\tau)$$



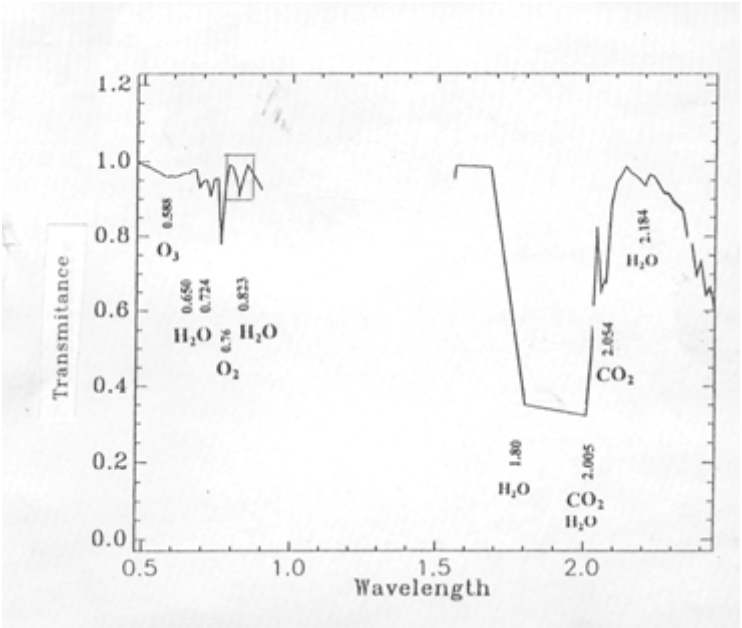
egetation

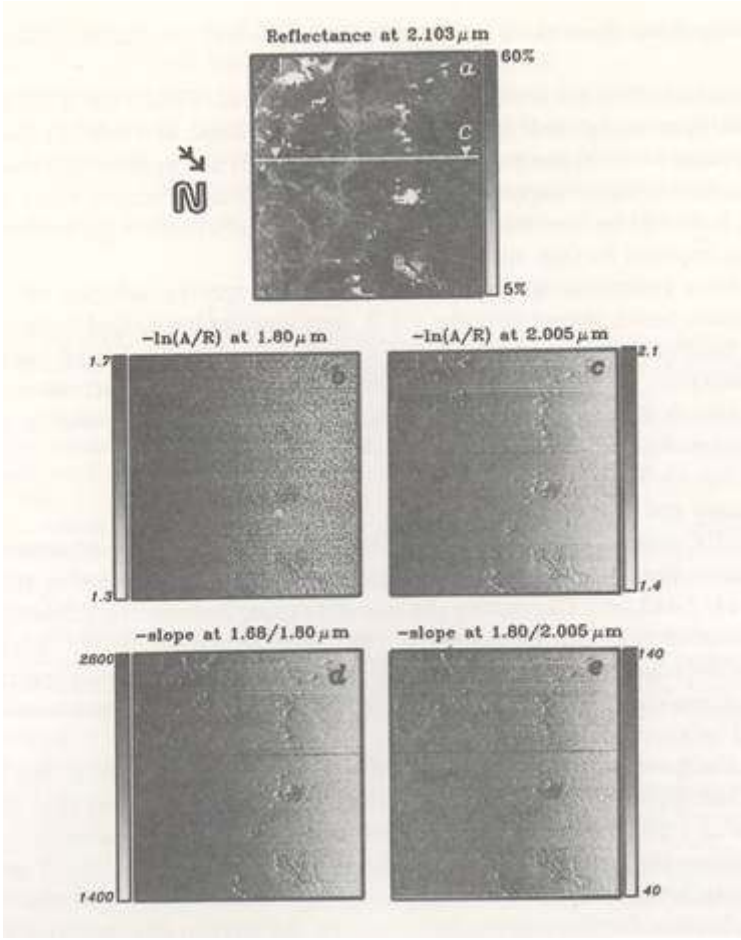


soil

760 nm

Elevation Mapping Using Gases Signal



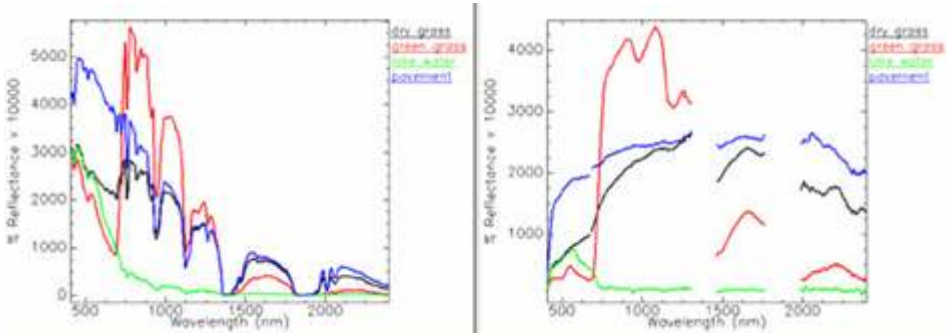


Ben-Dor E. and F.A. Kruse, 1996, Detection of atmospheric gases using GER 63 channel scanner data acquired over Makhtesh Ramon, Negev Israel. *International Journal of Remote Sensing*, 17:1215-1232.

Atmosphere Correction: Selection of Best Method to Remove Atmospheric-Attenuation

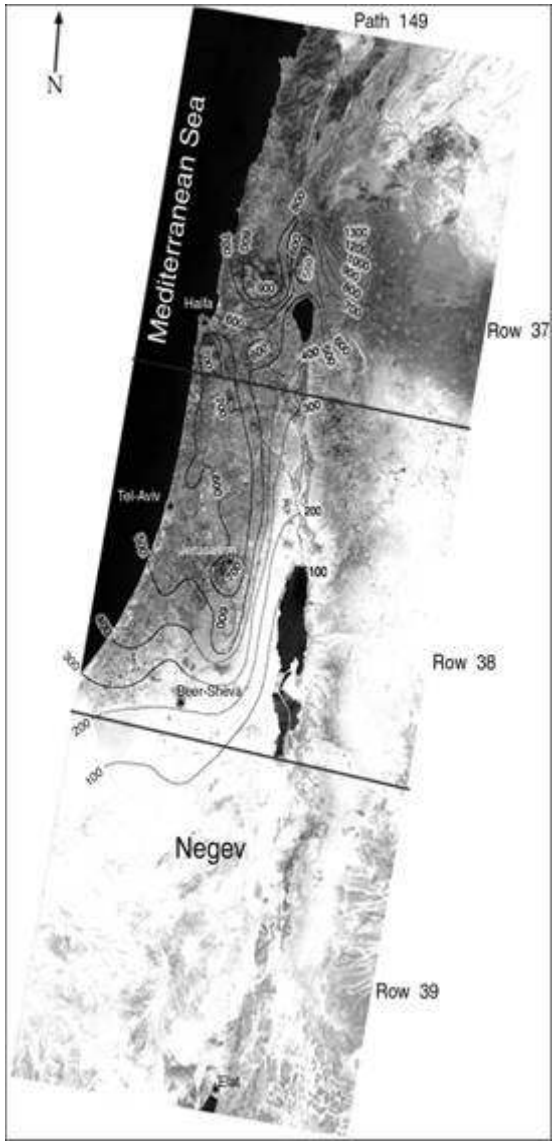
			First Order Programm (lowest ASD) Water Vapor				
		0.5cm	1.5cm	2.5cm	3.5cm	4.5cm	
	veg	Acron	Acorn	Acorn	CCRS	Acorn	
	veg+soil	Aterm	Atrem	Acron	Atrem	Atrem	VIS
	soil	Atrem	Atrem	Atrem	Atrem	Atrem	
	veg	Flash	Flash	Flash	CCRS	CCRS	
Target	veg+soil	Flash	Flash	Flash	Atcor	CCRS	NIR
	soil	Atcor	Atcor	Atcor	Atcor	Atcor	
	veg	Atcor	Atcor	Atcor	Atcor	Atcor	
	veg+soil	Atcor	Atcor	Atcor	Atcor	Atcor	SWIR-1
	soil	Atcor	Atcor	Atcor	Atcor	Atrem	
	veg	Atcor	Atcor	Atcor	Atcor	CCRS	
	veg+soil	Atcor	Atcor	Atcor	Atcor	CCRS	SWIR-2
	soil	Atcor	Atcor	Atcor	Atcor	CCRS	

			Second Order Prograr (second lowest ASDS)				
		0.5cm	1.5cm	2.5cm	3.5cm	4.5cm	
	veg	Atrem	Atrem	Atrem	Acorn	Atrem	
	veg+soil	Acron	Acorn	Atrem	Acorn	Acron	VIS
	soil	CCRS	CCRS	CCRS	CCRS	Atcor	
	veg	Hatch	Acron	Hatch	Hatch	Acorn	
Target	veg+soil	Atcor	Atcor	Atcor	CCRS	CCRS	NIR
	soil	Flash	Flash	Flash	CCRS	CCRS	
	veg	Hatch	Hatch	Hatch	Hatch	Hatch	
	veg+soil	Hatch	Hatch	Hatch	Hatch	Atrem	SWIR-1
	soil	Hatch	Hatch	Htach	Atrem	Atrem	
	veg	Hatch	Hatch	Hatch	CCRS	Hatch	
	veg+soil	Hatch	Hatch	Hatch	CCRS	Hatch	SWIR-2
	soil	Hatch	Hatch	Hatch	CCRS	Acron	



Ben-Dor E., B. Kindel, and A.F.H Goetz 2004 Quality Assessment of Several Methods to Recover Surface Reflectance I using Synthetic Imaging Spectroscopy (IS) Data, *Remote Sensing of Environment 90: 389-404*

POINTS THAT MAKE ISRAEL A UNIQUE AREA FOR SUPER SITE SESNOR CALIBRATION (Nature gift)



➢ ***Climate*** : Mediterranean to arid regimes (35-1300mm in 350km distance)

➢ ***Water***: Extreme saline to fresh water bodies (35% to 0.02%)

➢ ***Elevation***: -400m to 1600m

➢ ***Vegetation***: Large biodiversity of natural vegetation, from dense coniferous forest to biogenic soil crusts.

➢ ***Rocks***: Sand stones, carbonate sedimentary rocks, magmatic and metamorphic rocks

➢ ***Soil***: Alfisol, Vertisol, Aridisol, Oxisol, Mollisol, Entisol (from 10 soil orders worldwide)

➢ ***Atmosphere*** :Desert dust, maritime, as well as anthropogenic pollution. Cloudless areas (in the south) most of the year.

➢ ***Snow***: 1-5m depth in high elevation zones

➢ ***Landscape***: Smooth to rough

Summary and Conclusions

- Imaging Spectroscopy is a promising and challenging tool to study the environment from far distances
- Spectral based foundation is strongly required
- Imagination and Imaging Spectroscopy are together the key for success
- Israel offers technology, experiences and ideal site for IS sensors' calibration

THE REMOTE SENSING
AND G.I.S. LABORATORIES

THE LESTER AND SALLY ENTIN FACULTY OF HUMANITIES

DEPARTMENT OF GEOGRAPHY AND THE HUMAN ENVIRONMENT

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Thank You For Your Attention