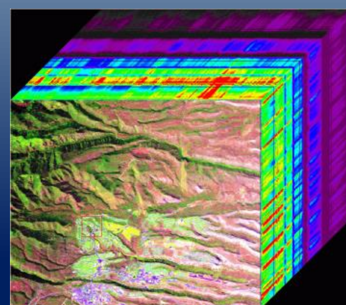
Hyperspectral Remote Sensing

Dr. Dipanwita Dutta



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Hyperspectral Remote Sensing

- A remote sensing technology
- “seeing” characteristics not recognized by the human eye
- Narrow and contiguous bands (usually 30-300 bands)

Increasing Wavelength (in meters)

10^{-11} Gamma Rays | 10^{-8} Ultraviolet | 10^{-6} Infrared | 10 Radio

X-Rays 10^{-9} | Visible 10^{-7} | Microwaves 10^{-2}

Electromagnetic Spectrum

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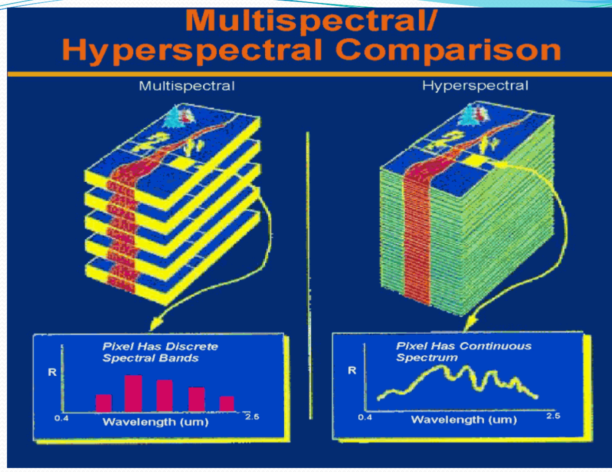
This gives a 2D view of the sample at each wavelength.



Multispectral – Many spectra (bands)

Hyperspectral – Huge numbers of continuous bands

Hyperspectral remote sensing provides a continuous, essentially complete record of spectral responses of materials over the wavelengths considered.

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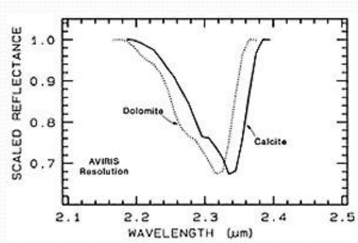
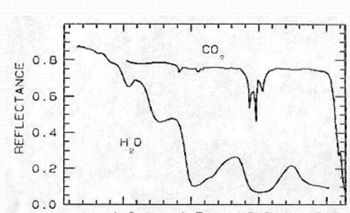
Hyperspectral Remote Sensing

Hyperspectral images can be analyzed in ways that multispectral images cannot



In the Visible-NIR range, water ice and dry ice give characteristic spectral curves, as shown here:



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Spaces in Remote Sensing

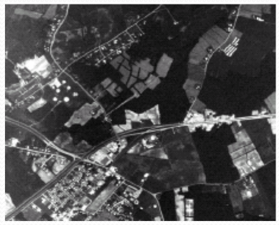
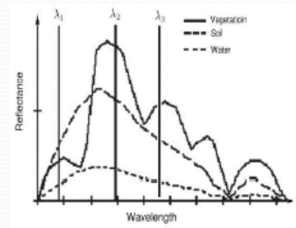
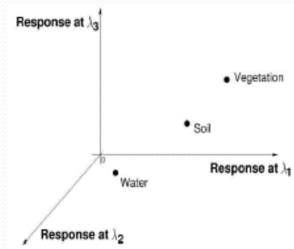


Image Space



Spectral Space



Feature Space

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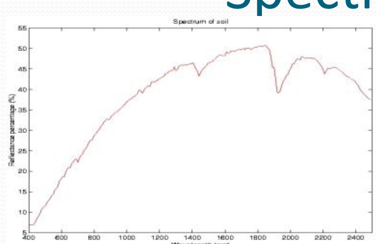
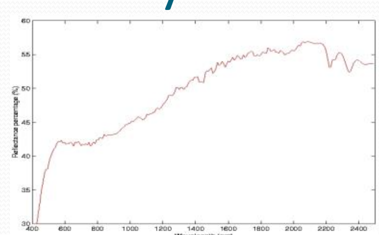
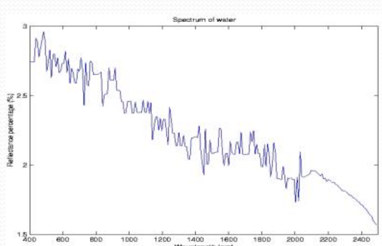
Spectral analysis



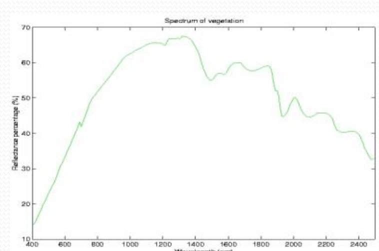
Soil



Rock



Water



Vegetation

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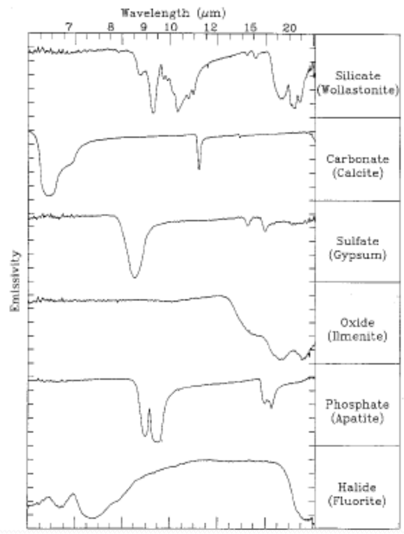
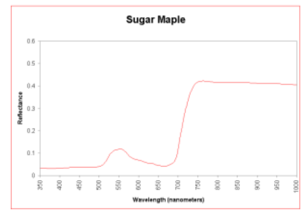
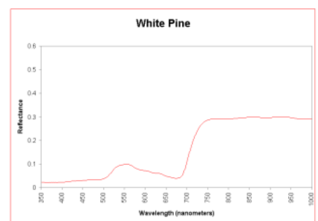
Identification of features







Advantages of Hyperspectral imaging

- An entire spectrum is acquired at each point
- The operator needs no prior knowledge of the sample
- Post-processing allows all available information from the dataset to be mined
- Utilizes the spatial relationships among the various spectra in a neighbourhood, thus allowing more elaborate spectral-spatial models for a more accurate segmentation and classification of the image.

Applications of Hyperspectral Imaging

- Hyperspectral images are required in several applications such as mineral exploration, resource management, and environmental monitoring
- In agriculture for monitoring the development and health of crops, identification of species in agriculture
- In geology for rapidly mapping nearly all minerals of commercial interest, identification of open mines
- In astronomy to determine a spatially-resolved spectral image
- In the military to provide a unique standoff detection, identification and imaging capability for chemical warfare agents, canvas, camouflage, military vehicles in defense applications
- In the oil industry to identify oil sources in the earth, oil spills in environmental monitoring
- For ecology, surveillance, and historical manuscript research
- For research in areas such as nano-drug delivery and nano-toxicology, toxic waste
- For use in many research areas, such as vegetation research, forensics, life sciences, food analysis, and mineral research.

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Hyperspectral Sensors

First hyperspectral scanners:

1982: AIS (Airborne Imaging Spectrometer)

1987: AVIRIS (Airborne Visible/infrared Imaging Spectrometer)

1995: Hyperspectral Digital Imagery Collection Experiment (HYDICE)

2000: Hyperion (EO-1)

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Airborne Sensors	Manufacturer	Number of Bands	Spectral Range
AVIRIS (Airborne Visible Infrared Imaging Spectrometer)	NASA Jet Propulsion Lab makalu.jpl.nasa.gov/	224	0.4 to 2.5 µm
HYDICE (Hyperspectral Digital Imagery Collection Experiment)	Naval Research Lab	210	0.4 to 2.5 µm
PROBE-1	Earth Search Sciences Inc. www.earthsearch.com	128	0.4 to 2.5 µm
casi (Compact Airborne Spectrographic Imager)	ITRES Research Limited www.itres.com	up to 228	0.4 to 1.0 µm
HyMap	Integrated Spectronics www.intspec.com	100 to 200	Visible to thermal infrared
EPS-H (Environmental Protection System)	GER Corporation www.ger.com	VIS/NIR (76), SWIR1 (32), SWIR2 (32), TIR (12)	VIS/NIR (.43 to 1.05 µm), SWIR1 (1.5 to 1.8 µm), SWIR2 (2.0 to 2.5 µm), and TIR

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Cont'

			(8 to 12.5 µm)
DAIS 7915 (Digital Airborne Imaging Spectrometer)	GER Corporation	VIS/NIR (32), SWIR1 (8), SWIR2 (32), MIR (1), TIR (6)	VIS/NIR (0.43 to 1.05 µm), SWIR1 (1.5 to 1.8 µm), SWIR2 (2.0 to 2.5 µm), MIR (3.0 to 5.0 µm), and TIR (8.7 to 12.3 µm)
DAIS 21115 (Digital Airborne Imaging Spectrometer)	GER Corporation	VIS/NIR (76), SWIR1 (64), SWIR2 (64), MIR (1), TIR (6)	VIS/NIR (0.40 to 1.0 µm), SWIR1 (1.0 to 1.8 µm), SWIR2 (2.0 to 2.5 µm), MIR (3.0 to 5.0 µm), and TIR (8.0 to 12.0 µm)
AISA (Airborne Imaging Spectrometer)	Spectral Imaging www.specim.fi	up to 288	0.43 to 1.0 µm

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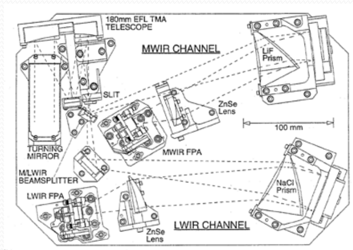
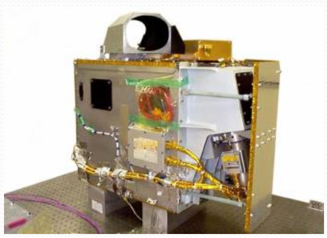
AVIRIS





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AVIRIS Specifications

•224 individual CCD (charge coupled device) detectors
• Spectral resolution of 10 nanometers
• Spatial resolution of 20 meters (at typical flight altitude)
• Flight platform: NASA ER-2 (modified U-2)
• Flight altitude: from 20,000 to 60,000, but usually flown at 60,000
• Typical swath width is 11 km.
• Dispersion of the spectrum against the detector array is accomplished with a diffraction grating.
• The total interval reaches from 380 to 2500 nanometers (roughly the same as TM band range).
• image, pushbroom-like, succession of lines, each containing 664 pixels.

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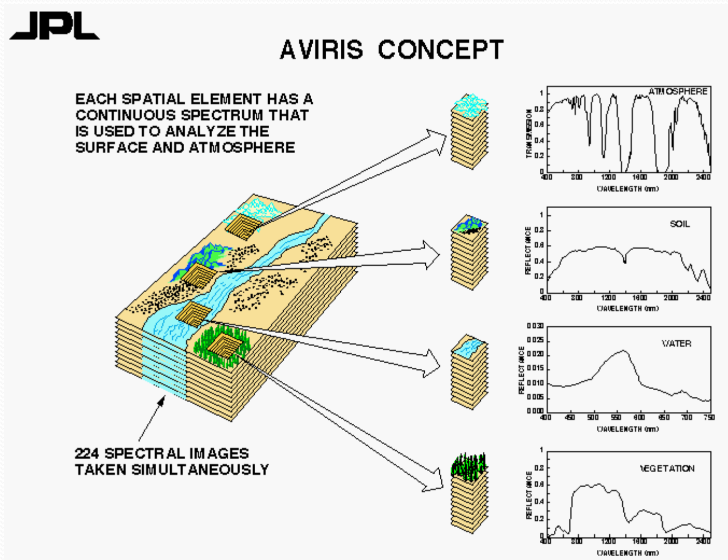

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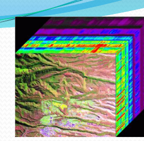
Limitations of Hyperspectral RS



•High cost and complexity.

•Fast computers, sensitive detectors, and large data storage capacities are needed for analyzing hyperspectral data.

•Significant data storage capacity is necessary since hyperspectral cubes are large multi-dimensional datasets, potentially exceeding hundreds of megabytes.

•All of these factors greatly increase the cost of acquiring and processing hyperspectral data.

•Also, one of the hurdles that researchers have had to face is finding ways to program hyperspectral satellites to sort through data on their own and transmit only the most important images, as both transmission and storage of that much data could prove difficult and costly.

• As a relatively new analytical technique, the full potential of hyperspectral imaging has not yet been realized.

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