

Processing and Analysis of hyperspectral image.



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Hyperspectral Overview

- Hyperspectral (Imaging spectroscopy) - Analysis and evaluation of the reflected (also emitted) radiation detected by a high number of narrow, contiguous and continuous spectral bands.
- Hyperspectral different from that of multispectral instruments thus it produce enormous number of wavebands recorded.
- Geographical area imaged the data produced can be viewed as a cube, having two dimensions that represent spatial position and one that represents wavelength.

RGB vs Hyperspectral Imaging

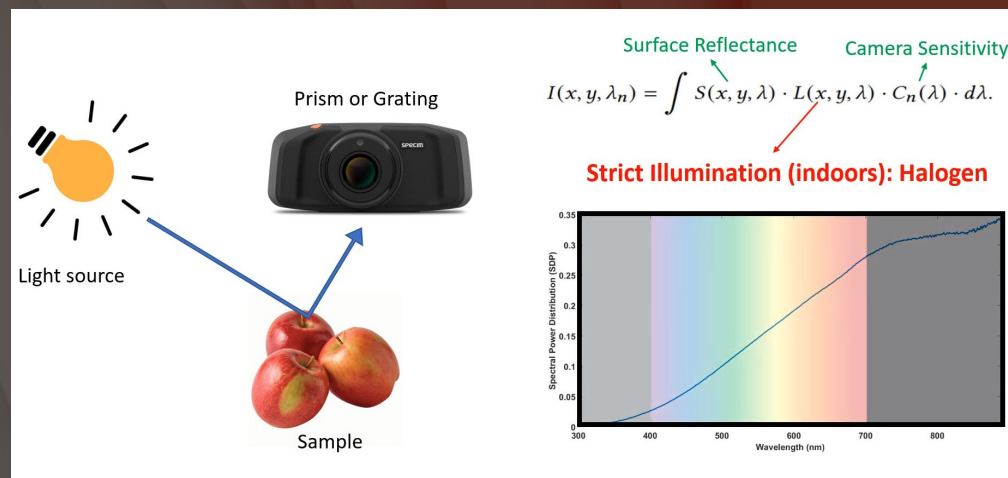
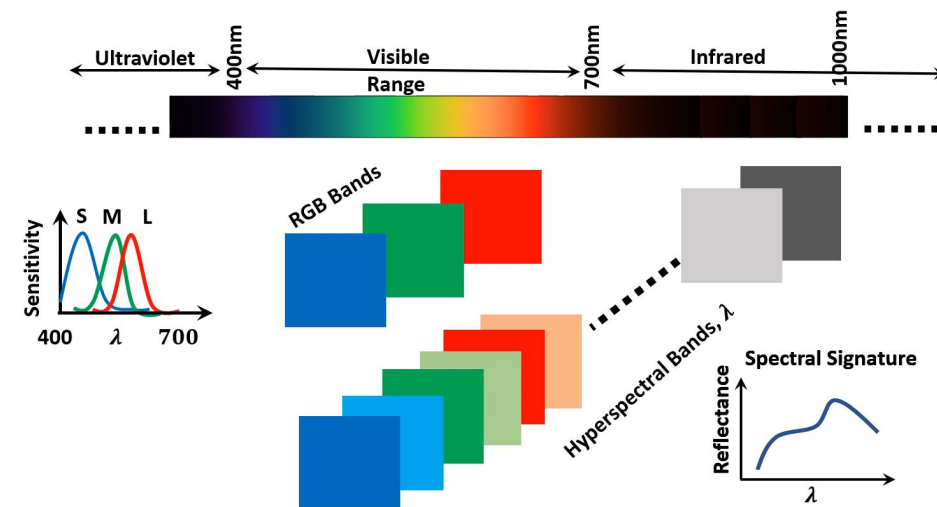


Fig: Emw spectrum Hyperspectral imaging system, ref-ACM MS2021

Hyperspectral Background

- Capability for many years, but computer power struggled with large size of data
- That has been overcome and onboard processing is a reality
- Hyperspectral imagery (HSI) usually has at least 30 bands, as compared to multispectral
- Whereas multispectral imagery, like a Landsat image, can give you a class like iron bearing minerals, HSI can give the exact type of mineral
- Think of it like a zoom button, multispectral is viewing a very blurred scene, where you can maybe pick out specific objects, with hyperspectral as the zoomed version, where you can much more easily discern what is in the image.

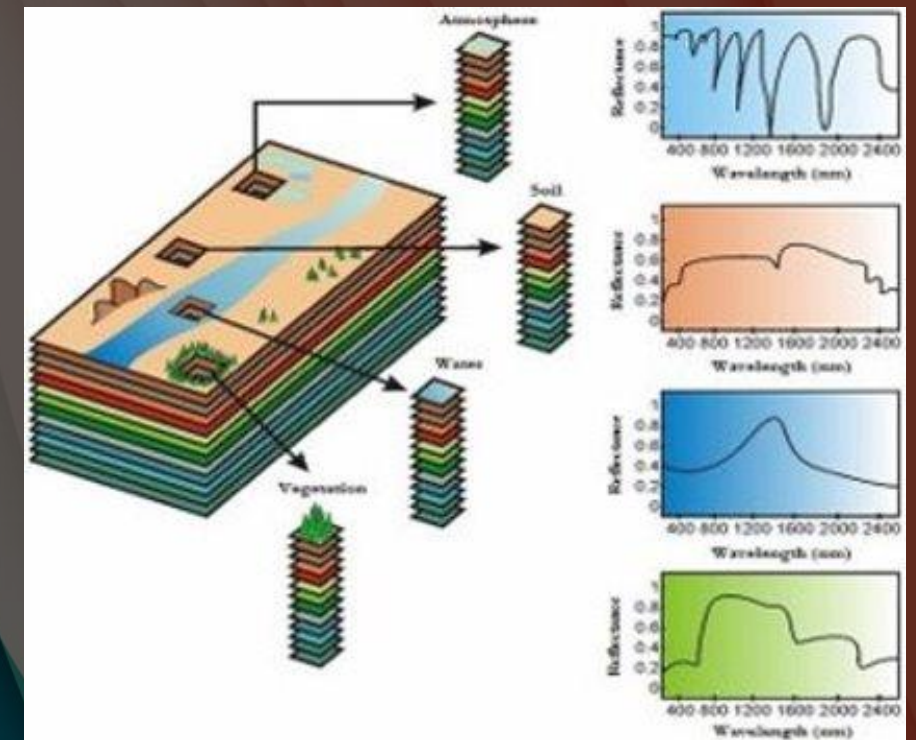
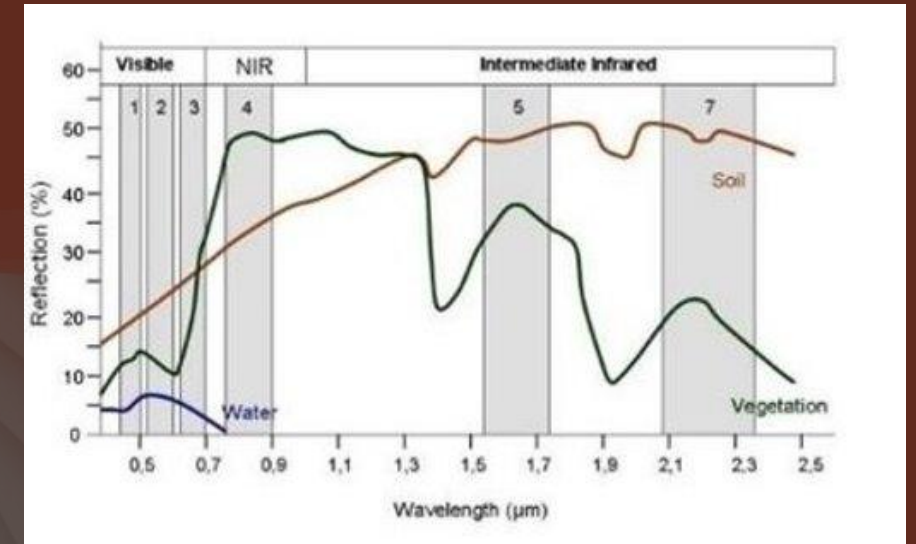


Fig:Datacube , Ref: ACM MMsys

List of Hyperspectral Sensors available



Satellite based



Airplane - based



UAV-Based

Sensor	Hyperion	PROBA-CHRIS		PRISMA	AVIRIS	CASI	AISA	HyMap	Headwall Hyperspec	UHD 185 - Firefly
Spectral range	357-2576	415-1050		400-2500	400-2500	380-1050	400-970	440-2500	400-1000	450-950
No. of Spectral bands	220	19	63	238	224	288	244	244	270(Nano) 324(Micro)	138
Spectral Resolution(nm)	10	34	17	12	10	<3.5	3.3	3.3	6 Nano 2.5(Micro)	4
Operational altitudes(km)	705	830		615		1 to 20			<0.15	
Spatial resolution(m)	30	17	36	30		1 to 20			0.01-0.5	

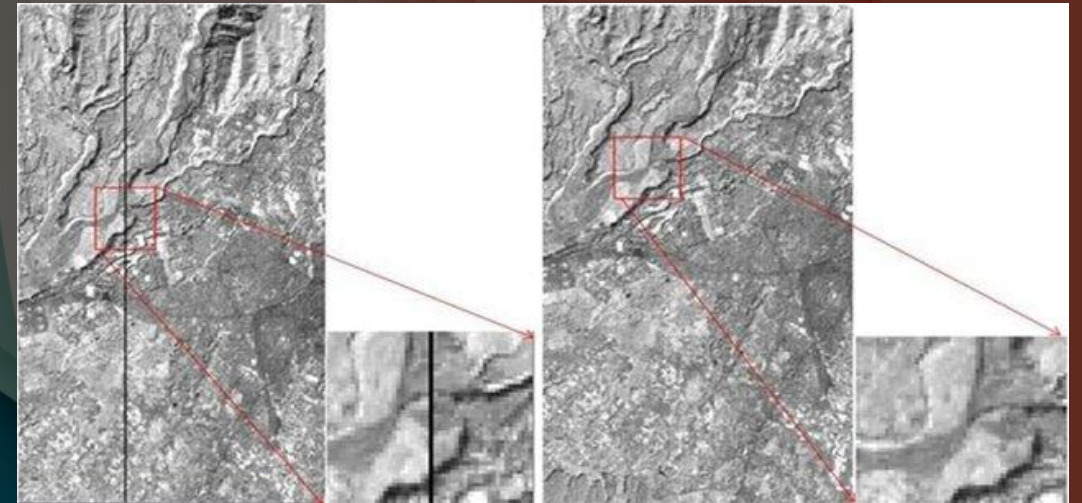
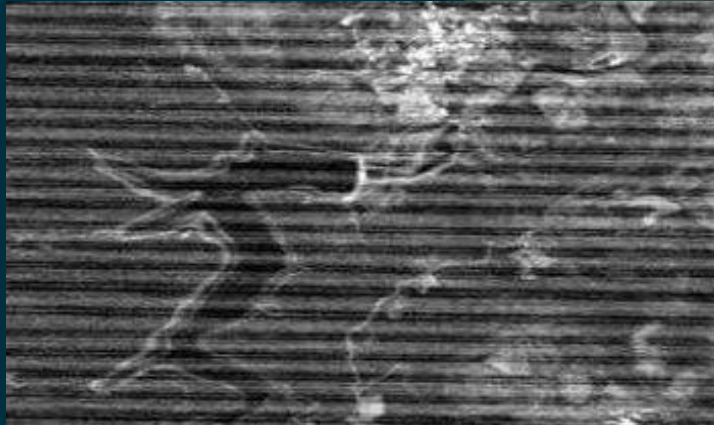
Hyperspectral Data Quality and Issue

Quality of Hyperspectral data is hampered by the noise present in the data. Sources of noise include:-

- i. Sensor calibration
- ii. Sensor drift which results in change of sensor sensitivity over time
- iii. Irradiance variation
- iv. Atmospheric attenuation
- v. Atmospheric path radiance

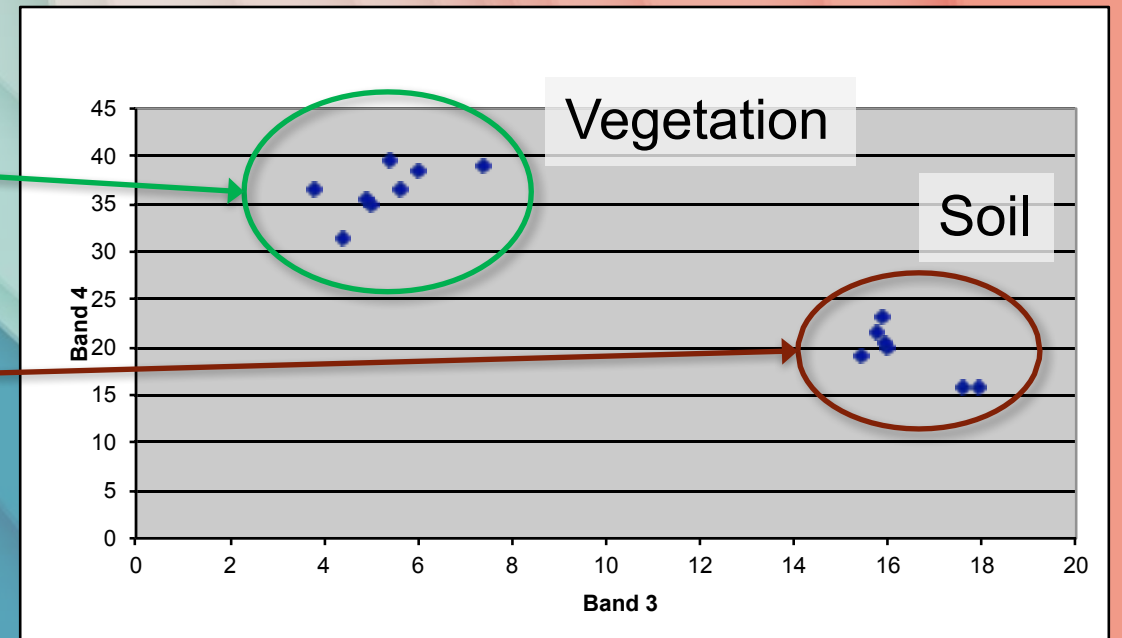
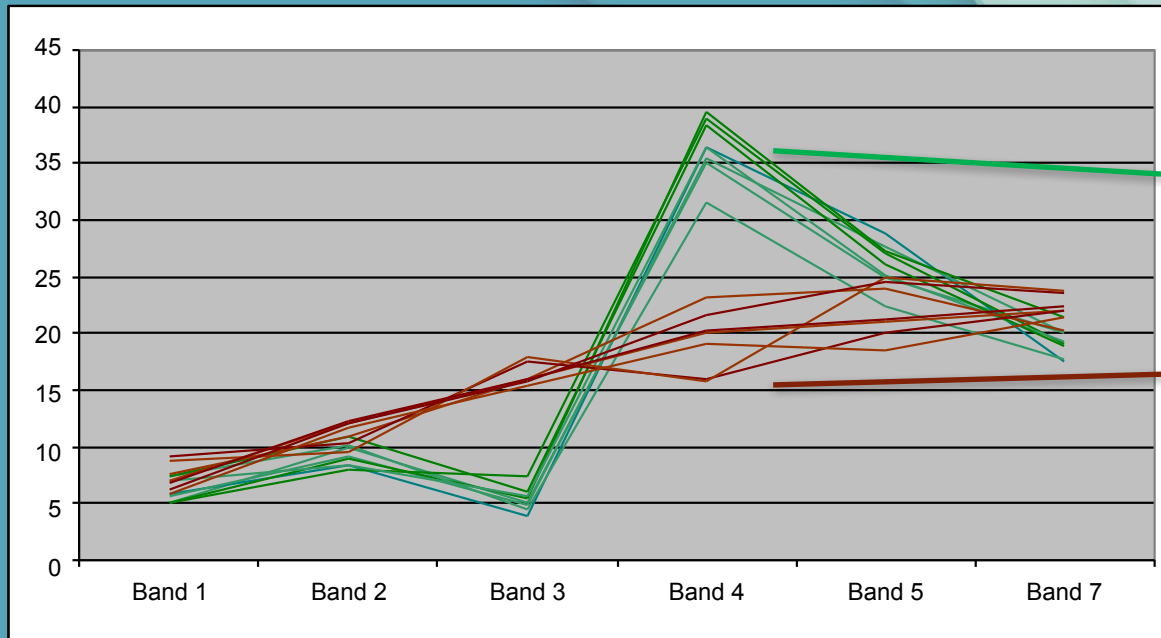
Types of noise:-

- 1.Bad bands
- 2.Striping errors



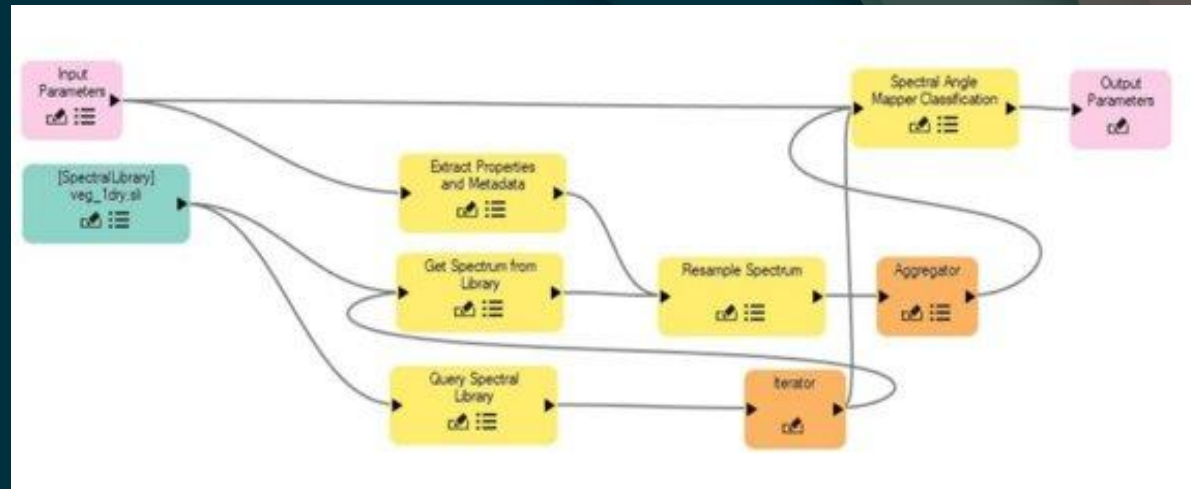
Spectral Variation

- Easier: distinguishing between broad classes
 - e.g. vegetation and soil
- Harder: distinguishing *within* broad classes
 - e.g. vegetation types

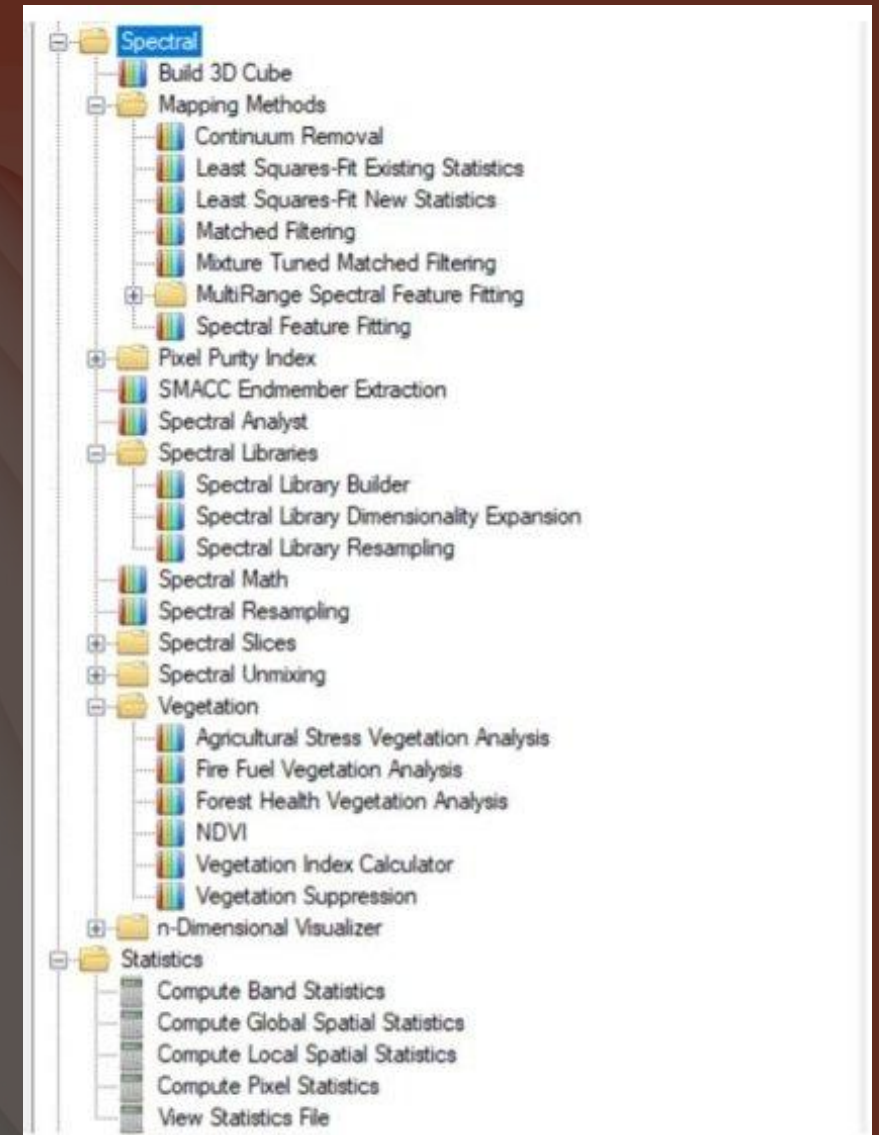


Hyperspectral Analysis in ENVI

- ENVI was developed originally for working with hyperspectral imagery because it is so fast at processing large data
- ENVI has curated many tools specific to hyperspectral imagery as well as all the pre-processing tools such as: – Radiometric calibration – Atmospheric correction – Careful pixel care—preserve the original signal so spectra aren't muddled



Automated Workflow with ENVI modeler, ref: esriindia



Hyperspectral Image Processing Workflow

Radiometric Correction

Data Reduction (Spectral / Spatial)

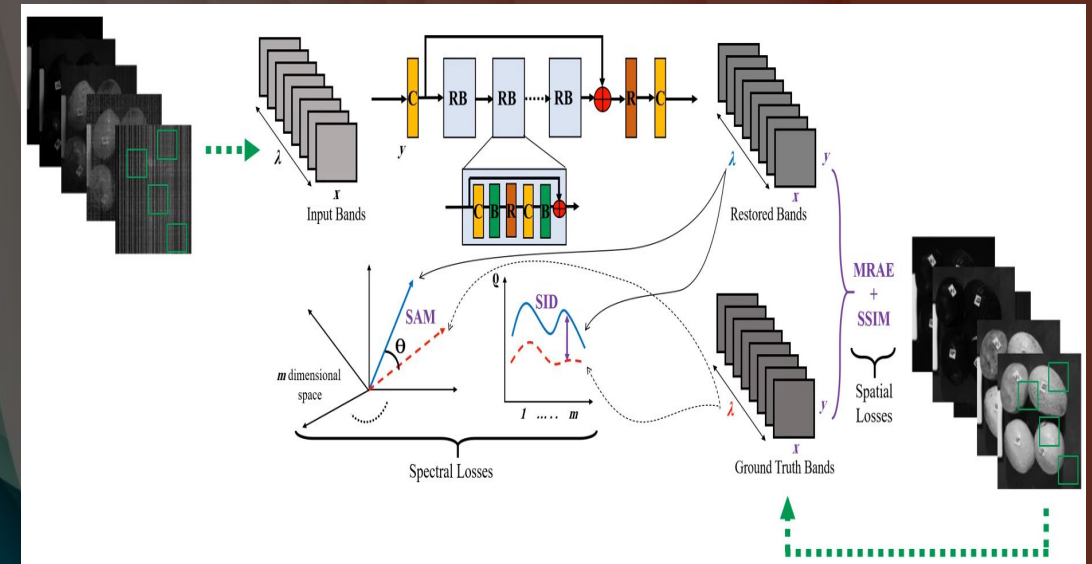
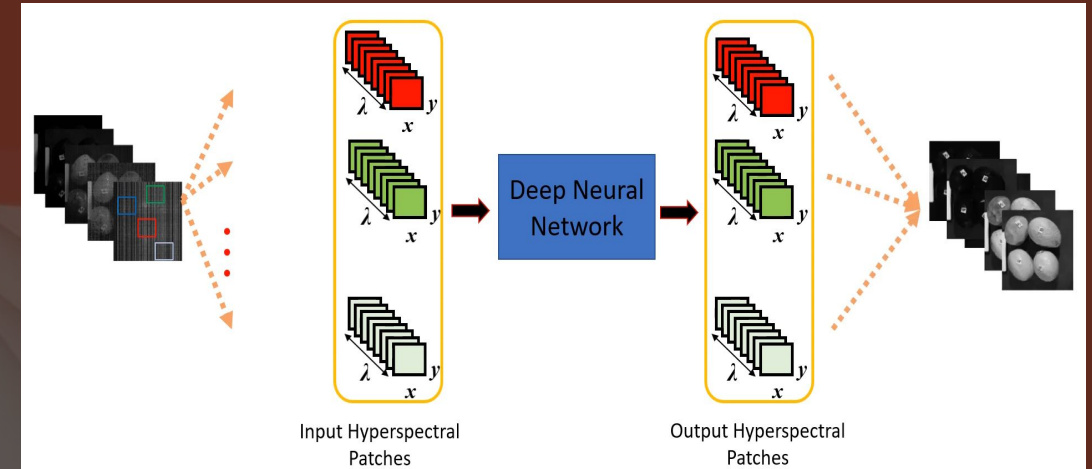
Endmember Selection

Hyperspectral Classification

- Material Identification
- Target Detection

Application-specific Analysis

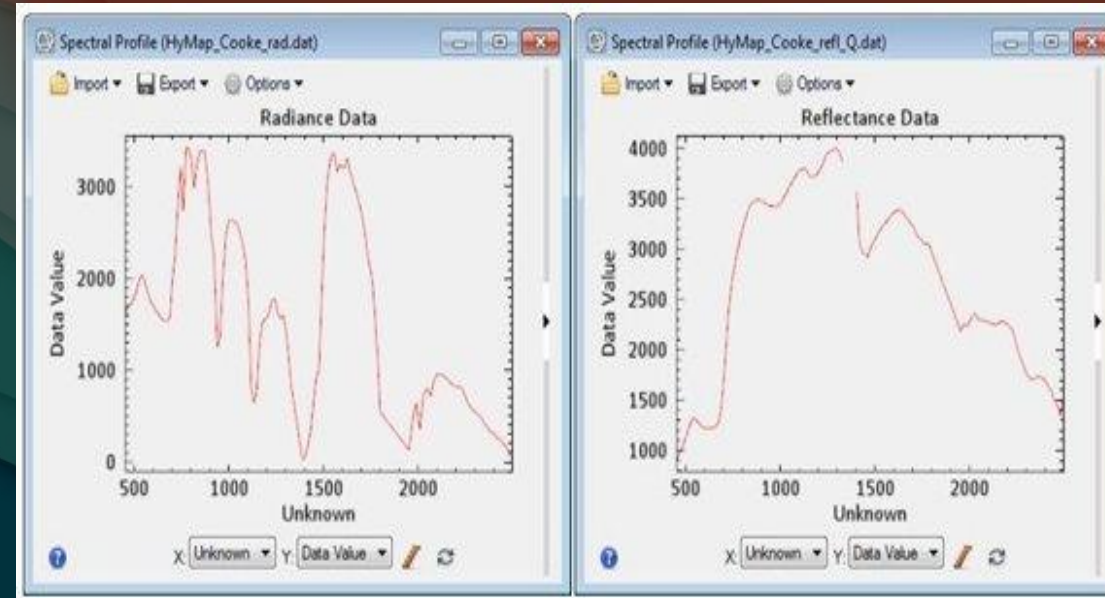
- Vegetation Indices
- Minerals identification



Radiometric Correction

Raw data includes:

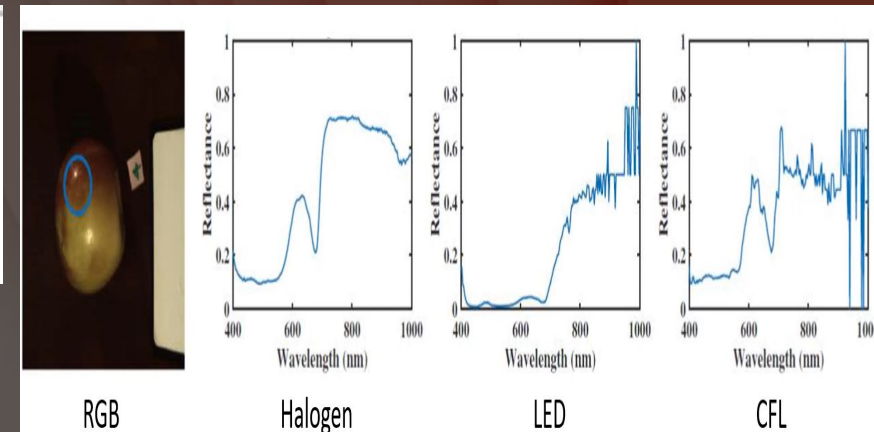
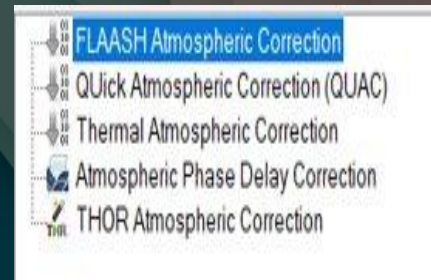
- Surface reflectance
- Solar irradiance
- Atmospheric effects
- Illumination variations
- Instrument error



Addressing sensor and atmospheric interference is a critical preprocessing step.

Calibration and atmospheric correction

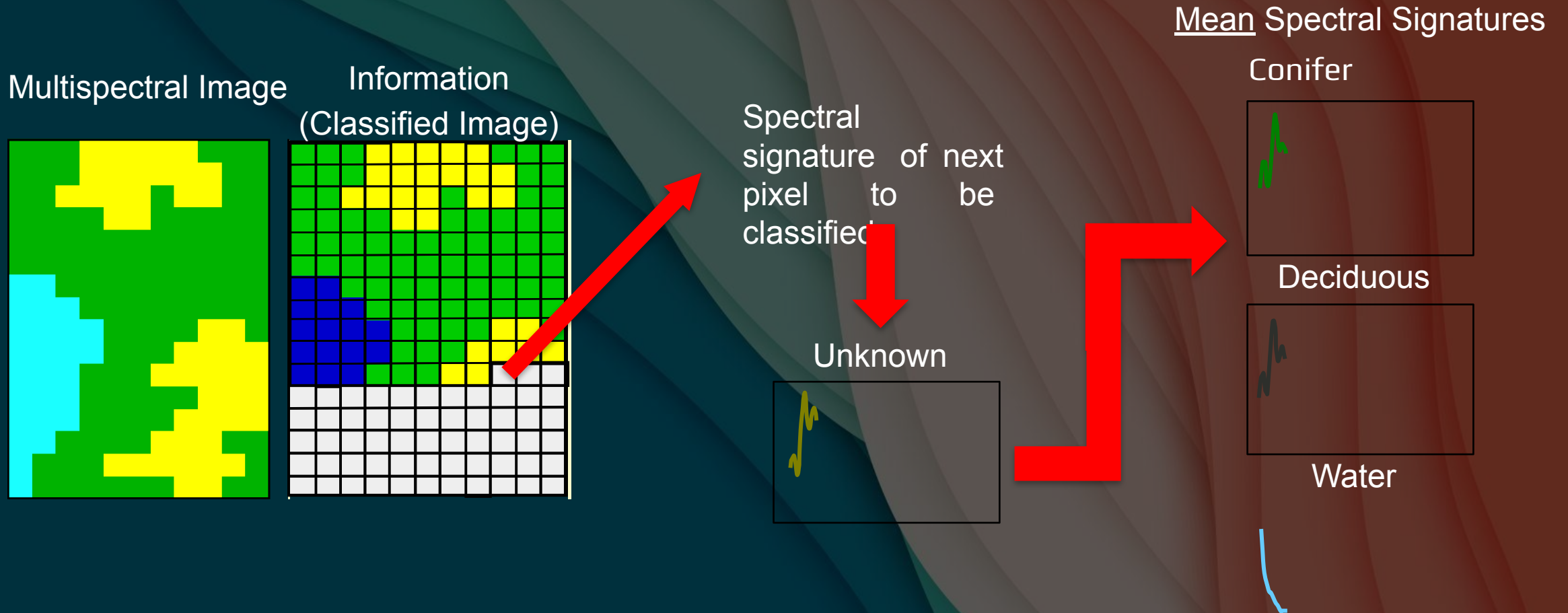
- Necessary for accurate quantitative analysis.
- Allow for multi-temporal image-to-image analysis.
- Allow for image-to-image analysis between two sensors.



Damaged Spectral Signature -> Low accuracy in Hyperspectral image analysis

Image Classification

The spectral signature of each pixel gets matched with the training signatures and the image is classified accordingly



Wavelength Range

Most of the earth surface material have diagnostic absorption feature in the 400-2500 nm range of electromagnetic spectrum. The surface material can be identified if the spectrum is sampled at sufficiently high spectrum.

Wavelength range (um)	observable
0.4-1.4	Fe bearing minerals, carbonate sulphate
1.5-1.85 2.0-2.5	Carbonate and OH group of carbonate, clay
0.43-0.65 0.90-1.40 1.40-1.90 2.00-2.40	Vegetation, chlorophyll a+b pigment, plant water content, cellulose, protein, starch, lignin, nitrogen, micronutrients etc

Bands	Band width	Application
445-670 nm	10-20 nm	Vegetation, water, fe
683-720 nm	5-10 nm	Vegetation/crop/herb
745-765 nm	5-10 nm	Vegetation, atom
780 nm	5-10 nm	veg/atom/pheric correction
880-1035 nm	5-10 nm	Vegetation, fe minerals

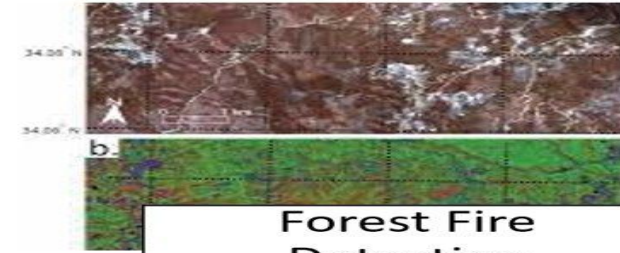
Application



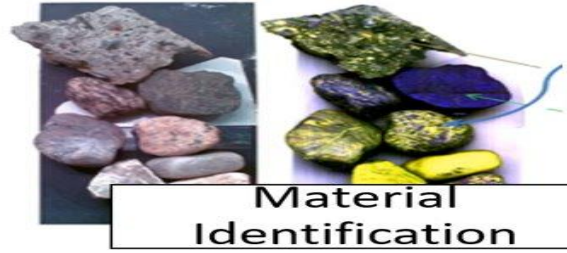
Remote Sensing



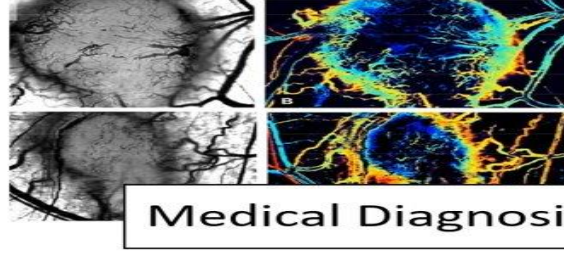
Detection of toxic air pollutants



Forest Fire Detection



Material Identification



Medical Diagnosis



Food Quality

Limitation of hyperspectral imaging

1. Cost of camera - the cost of hyperspectral camera is too high .
1. Very sensitive to noise.
2. Difficult to interpret.
3. Storage and transmission.
4. The need of calibration.

Summary

- Hyperspectral Data Processing
- Bad Band Removal
- Data Striping
- Hyperspectral Analysis Workflow
- Hyperspectral Analysis in ENVI
- Hyperspectral Analysis in Mineral, Vegetation, Forest Mapping

Ref: ACM MMsys

Sources and References:

www.google scholar.com

www.youtube.com

Esri india

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Thank you