Introduction to Remote Sensing

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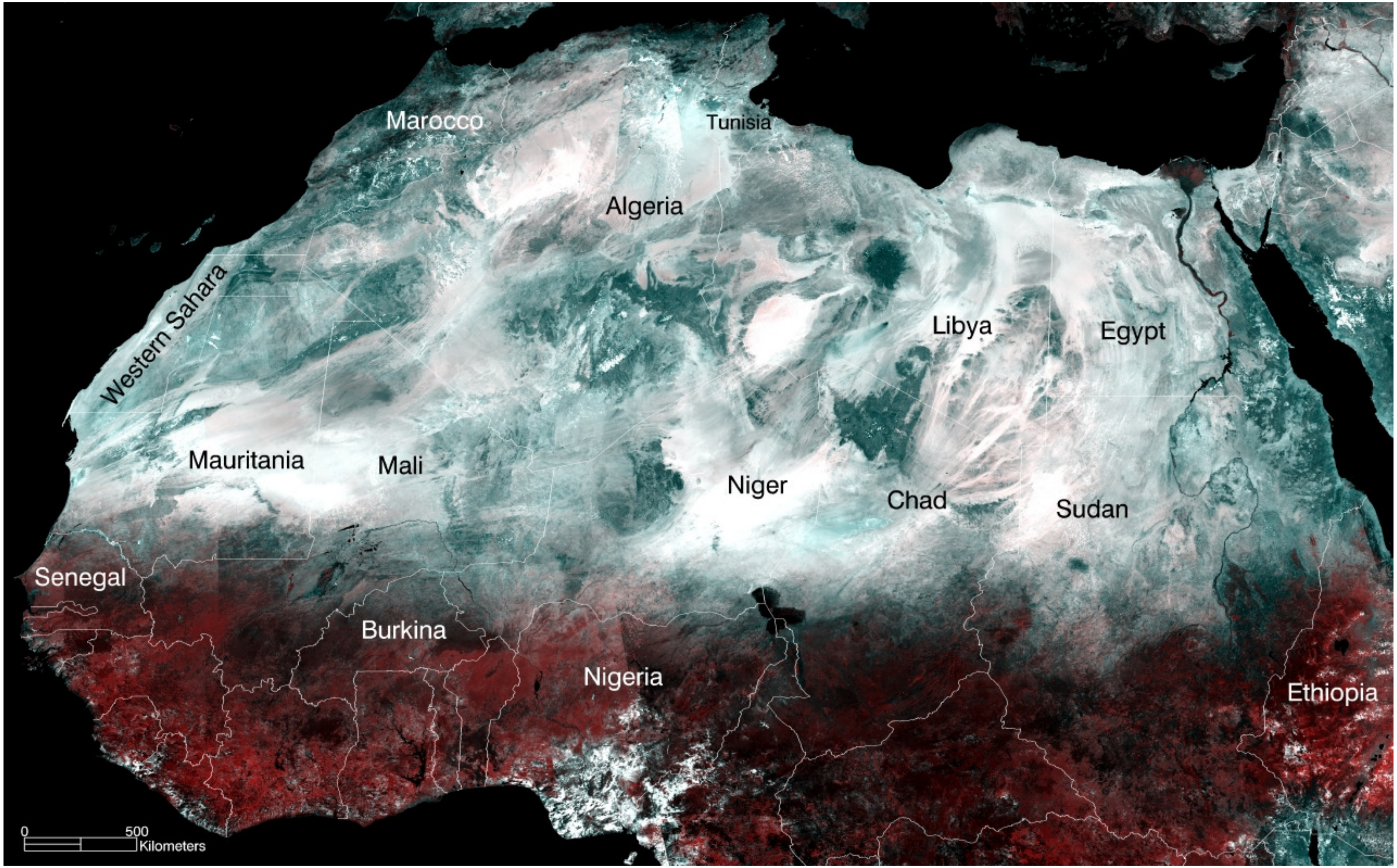
Arid Lands As Viewed From Space

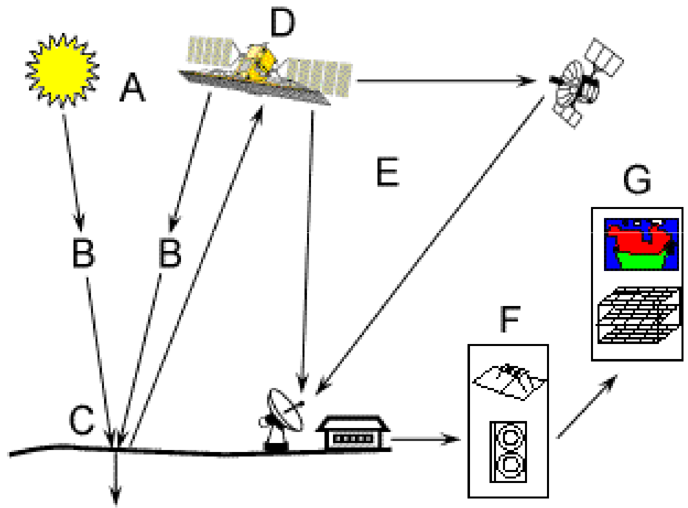


Use of Remote Sensing

- The unique perspective from above (space or airborne platforms) is ideal for understanding the changes to the environment in space and time.
- Information can be gathered without disturbing the site.
- Cultural resources can be monitored and protected.
- Natural resources can be explored and managed.
- Non-destructive Remote Sensing (RS) investigations range from site- specific to regional analysis (site detection; natural/cultural resources management).
- RS enables interdisciplinary research (geography, botany, forestry, soil sciences, hydrology, geology etc.). All contribute to a more complete understanding of the Earth, climate shifts, and how people make use of the environment and its resources.

Remote Sensing Systems

An orbiting platform containing imaging equipment gathers data from a specified section of the Earth and transmits the data to an earth-bound receiving station.



Remote Sensing Process: (A) energy source/illumination; (B) radiation and atmosphere; (C) interaction with target; (D) recording energy; (E) transmission, reception and processing; (F) interpretation and analysis; (G) application.

Remote Sensing

Definition:

Remote Sensing means obtaining information about an object without touching the object itself. It has two aspects:

- The technology of acquiring data through a device which is located at a distance from the object, and
- Analysis of the data for interpreting the physical attributes of the object.

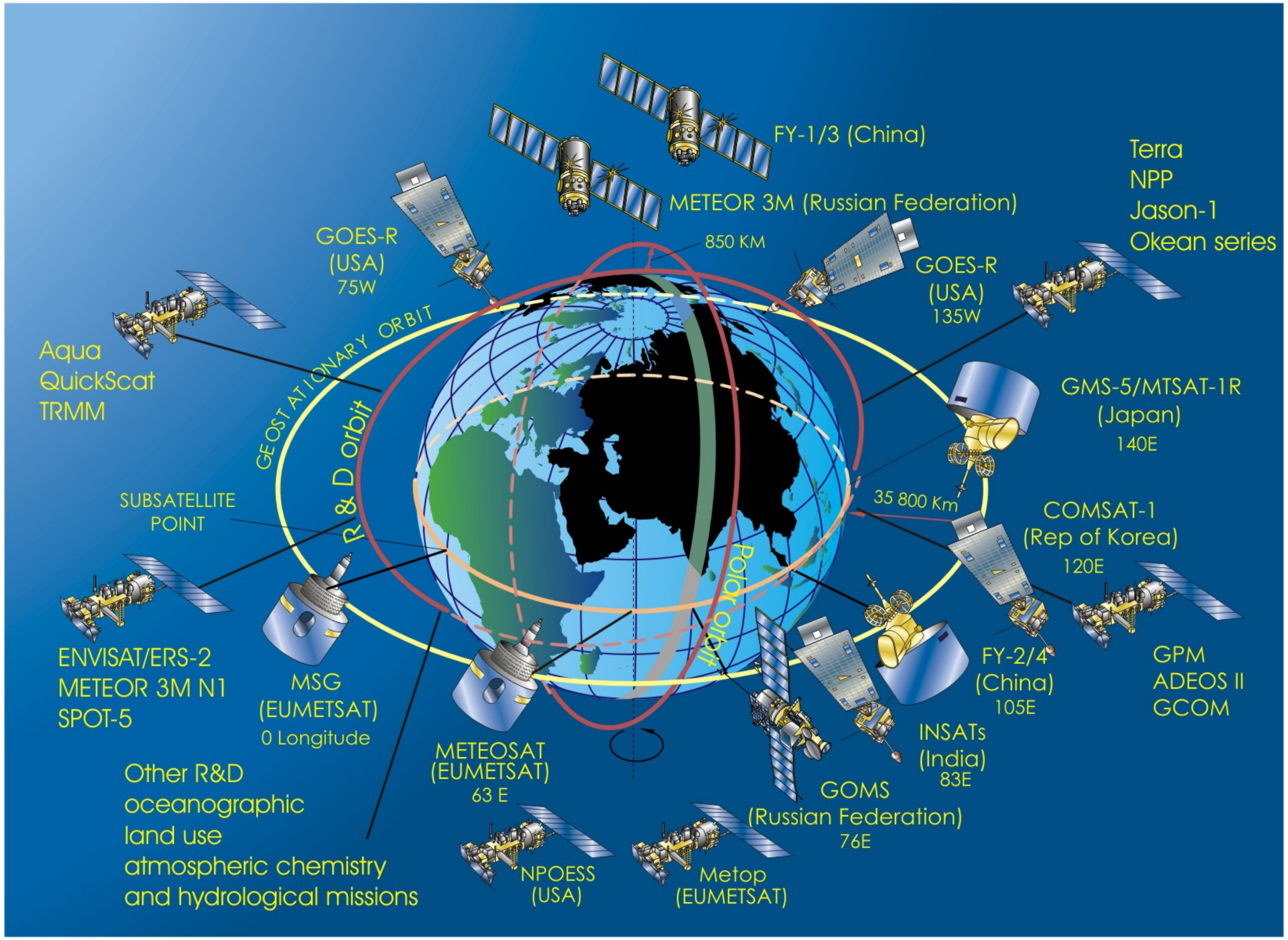
Both aspects are intimately linked with each other. Measurement of phenomena or objects can be obtained with devices that are sensitive to force/energy components.

Advantages of RS Technology

Major advantages of satellite borne RS techniques over other methods of ground investigations are:

1. ***Synoptic overview*****:** Remote sensing permits the study of various spatial features in relation to each other, as well as delineation of regional features/trends/phenomena.
2. ***Feasibility aspect*****:** as some areas may not be accessible to ground survey, the only feasible way is from remote-sensing platforms.
3. ***Time saving*****:** the technique saves time and manpower.
4. ***Multidisciplinary applications*****:** the same remote sensing data can be used by researchers/workers in different disciplines, like archaeology, geology, forestry, land use etc. => overall benefit to cost ratio is better.

Earth Observing Satellites



NASA

NOAA

USGS

Brazilian Space Agency (INPE)

Canadian Space Agency

Centre National d'Etudes spatiales (CNES, France)

Chinese National Space Admin.

European Space Agency (ESA)

Japan Aerospace Exploration Agency (JAXA)

Indian Remote Sensing Agency

Commercial satellites and many others

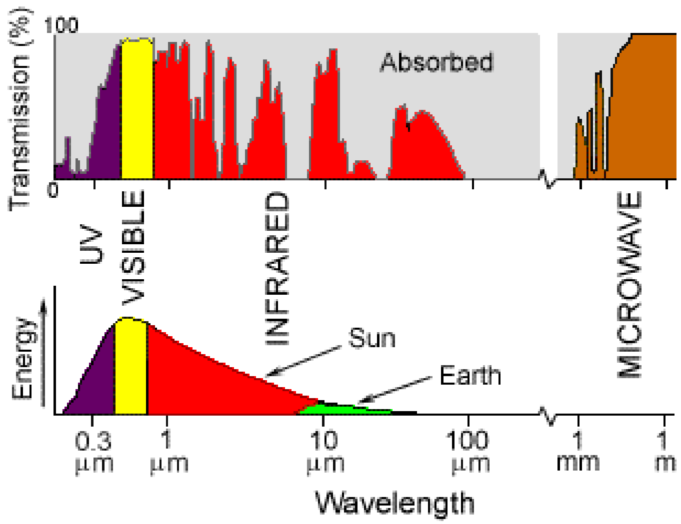
Sensor Characteristics

Optical and Infrared Sensors

ASTER
SPOT
LANDSAT
ALOS AVNIR-2
Quickbird
IKONOS

Microwave Sensors

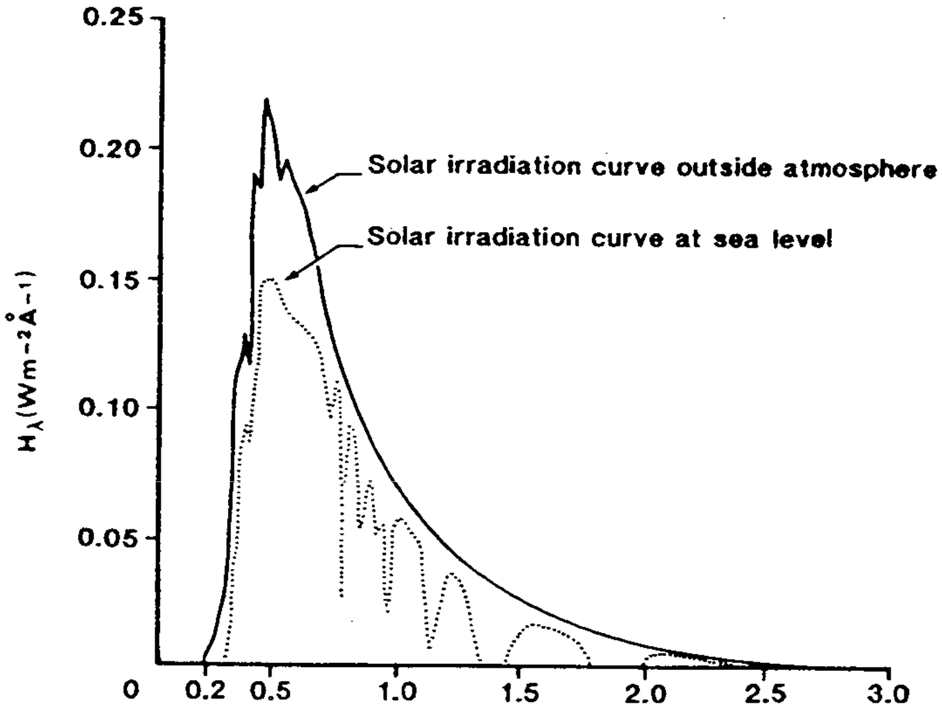
ENVISAT-1 ASAR
ALOS PALSAR
RADARSAT
Shuttle Imaging Radar



Hyperspectral Sensors

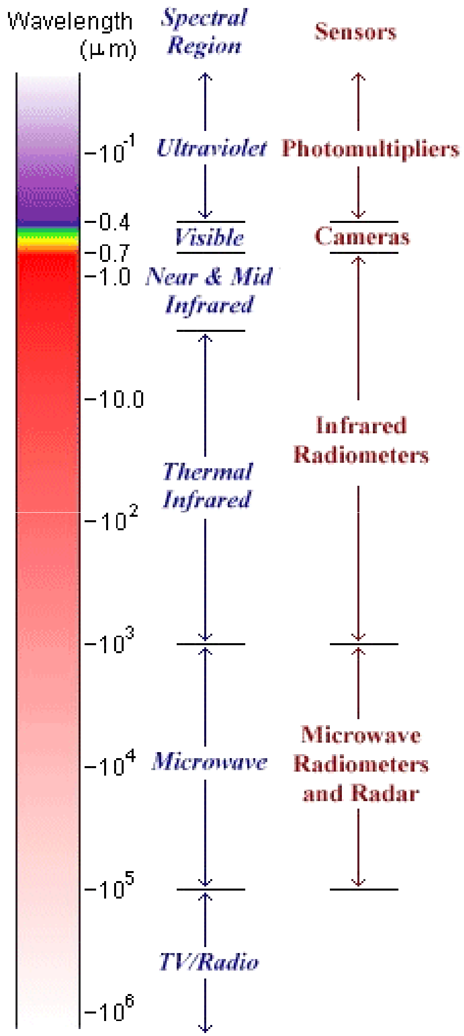
DAIS 7915
HYMAP
Hyperion
Proba-1 CHRIS

Solar Spectrum



Solar irradiance at the top of the atmosphere (solid line) and at sea level (dotted line). Differences are due to the atmospheric effects.

Solar Spectrum



What wavelengths say about the past.

***Blue:** Information on soil and plant types, forest types, buildings, roads, coasts, and water.*

***Green:** Borders between types of vegetation and traces of buildings and roads.*

***Red:** Chlorophyll absorption for plant identification and man-made features like buildings and roads.*

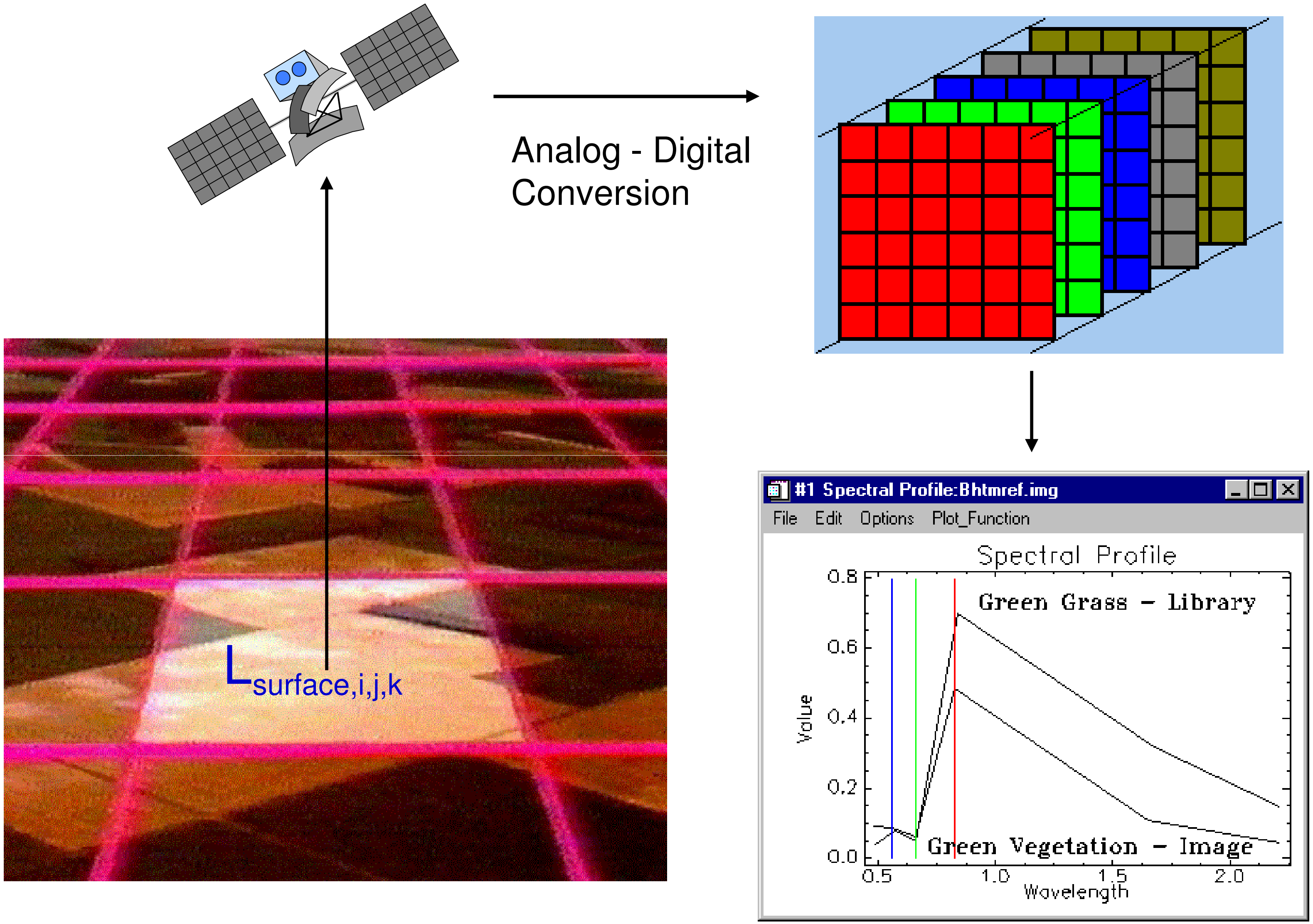
***Near-Infrared:** The amount of biomass, vegetation types, water body identification, and degrees of soil moisture.*

***Mid-Infrared:** The amount of moisture in vegetation and soils. Distinguishable differences among types of rocks.*

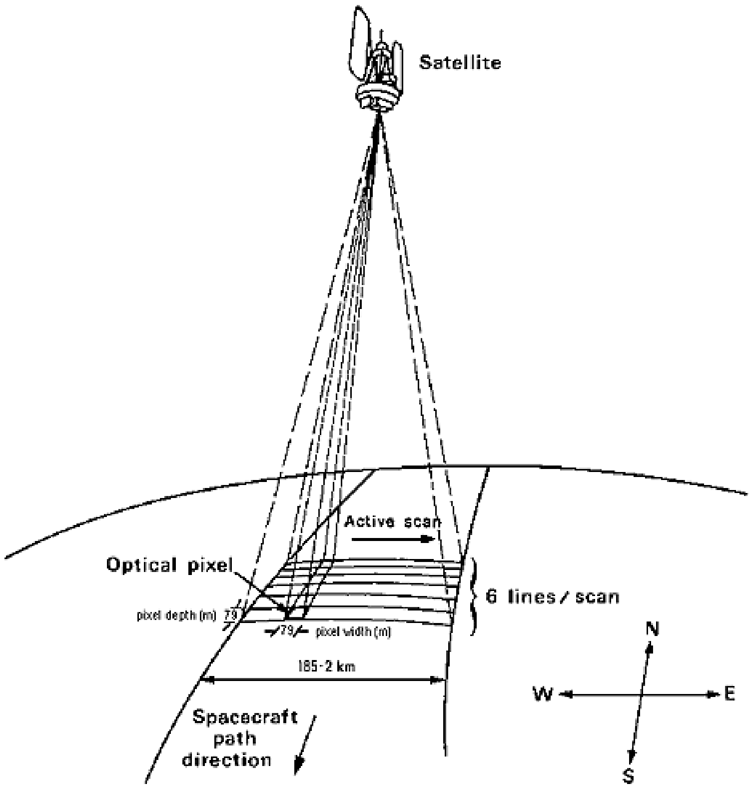
***Thermal Infrared:** Vegetation stress differences, soil moisture and relative amounts of heat.*

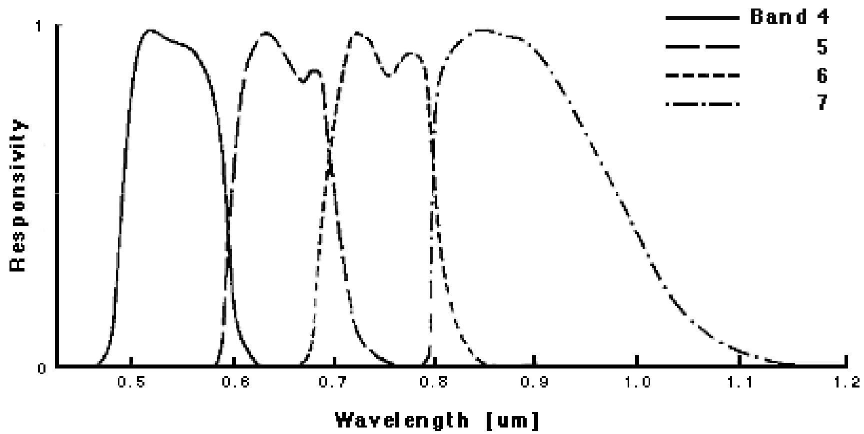
***Microwave:** buried artifacts in arid regions (water absorbs microwaves). Man-made objects tend to reflect microwaves.*

Imaging System



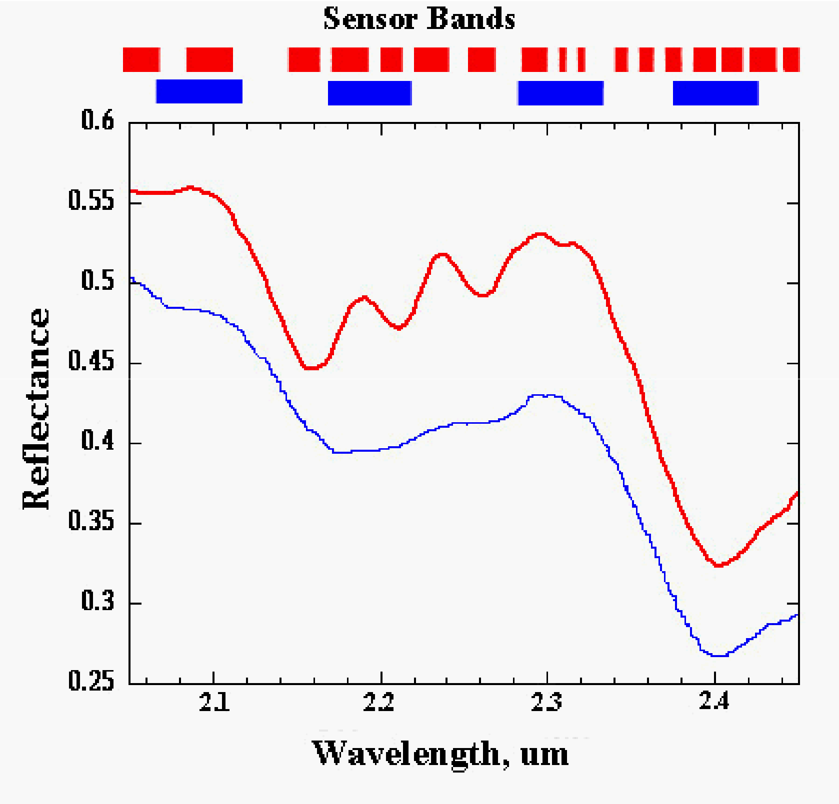
Landsat Multispectral Scanner (MSS)

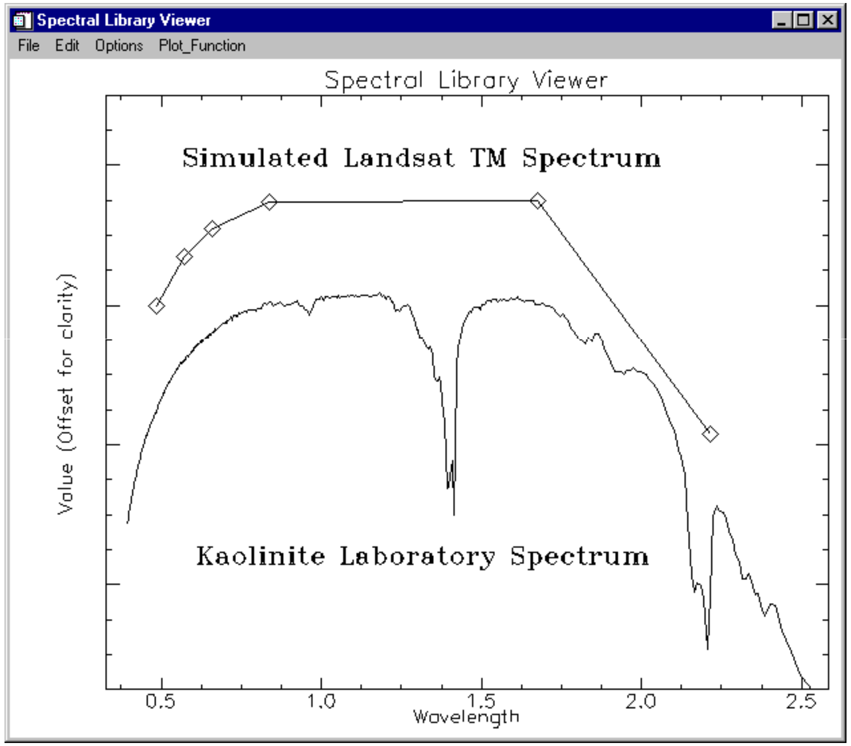




Landsat 1 was the first Earth-observing satellite launched (in 1972) to space for civilian use. It carried the multispectral MSS sensor.

Sensor Bands & Spectral Curves





Instantaneous Field Of View

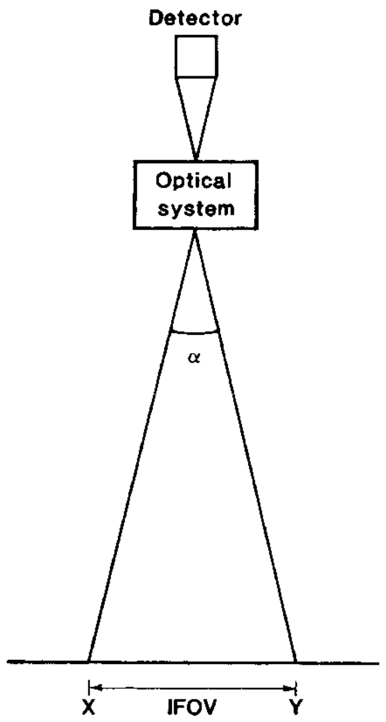


Figure 2.2 Angular instantaneous field of view (IFOV), α, showing the projection XY on the ground. Note XY is the diameter of a circle.

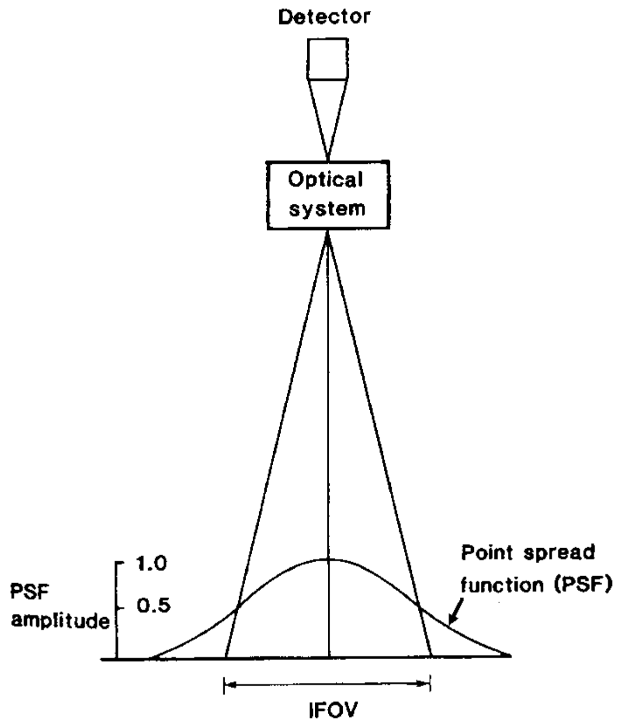


Figure 2.3 Instantaneous field of view based on the amplitude of the point spread function (PSF).

Characteristics of IFOV

IFOV (instantaneous field of view) is defined as the area on the ground that is visible by the instrument from a given altitude at a given instant of time.

IFOV is influenced by:

1. Changes in orbit altitude (pixel size of a given sensor varies);
2. The point spread function PSF (the way a sensor sees a reflective point source; recorded intensity distribution of the signal).

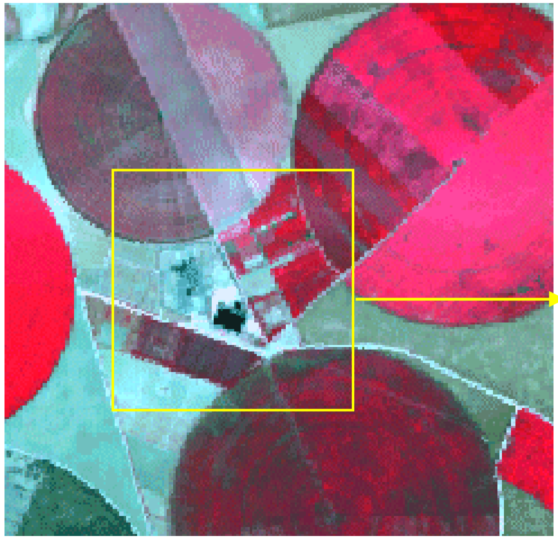
Spatial Resolution Spectral Resolution Radiometric Resolution	<—>	SNR (Signal-to-Noise Ratio) IFOV (Instant. Field of View)

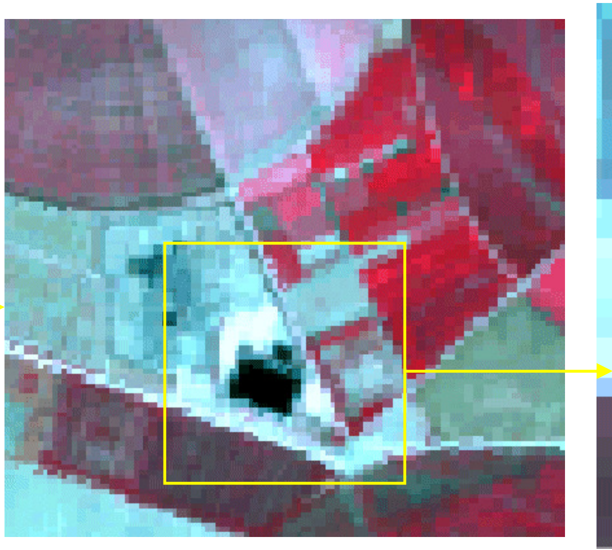
High spatial resolution (small pixel size) → smaller IFOV (lower SNR)

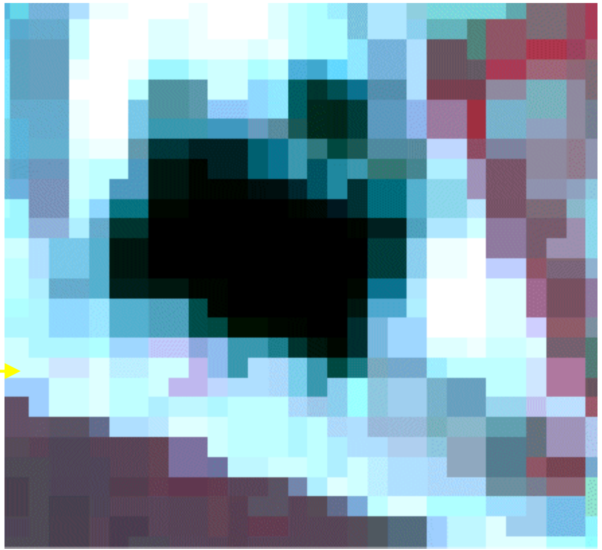
High spectral resolution (many narrow bands) → lower SNR (more noise)

High radiometric resolution (bytes per pixel) → larger IFOV (lower spatial res.)

Digital Image



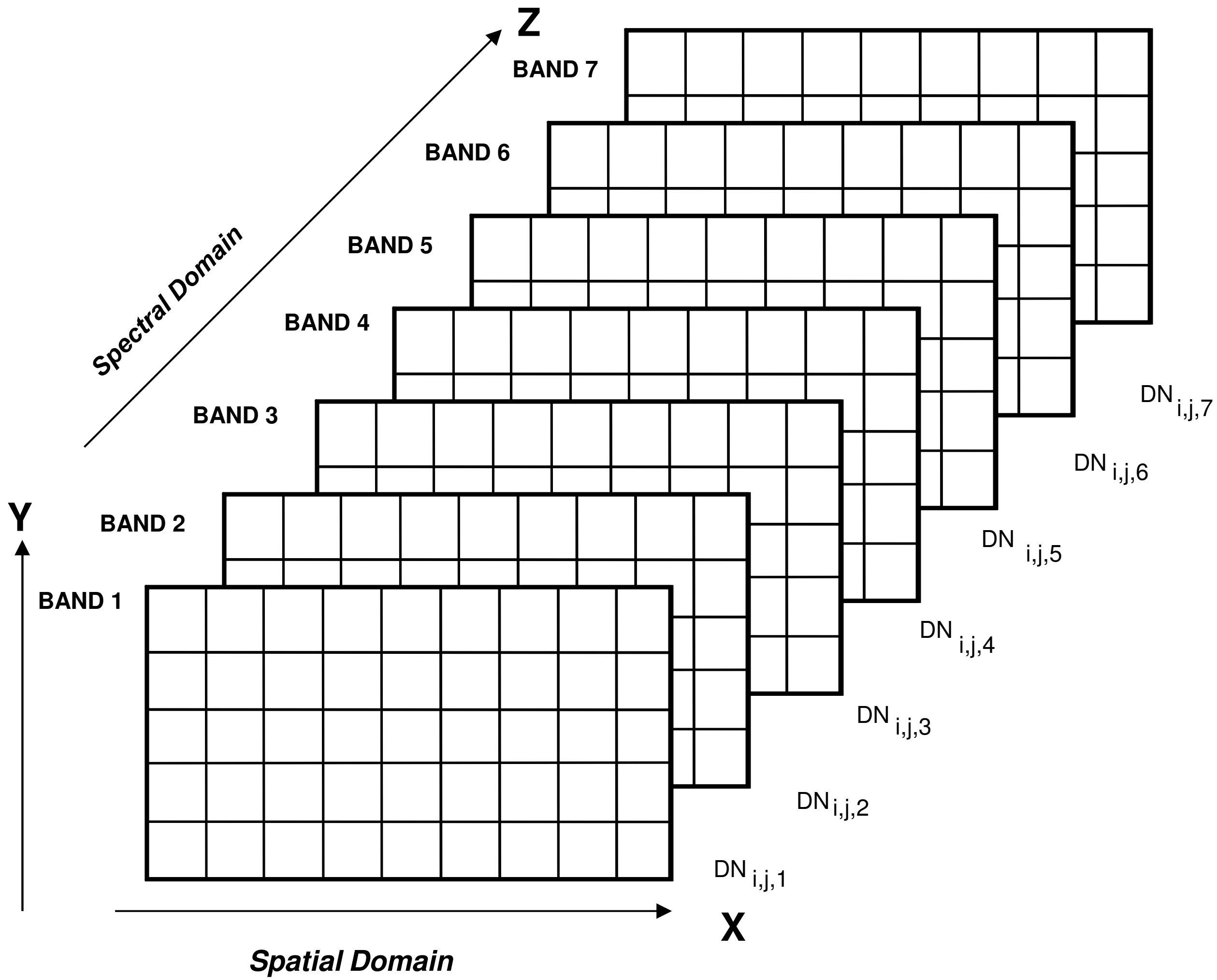




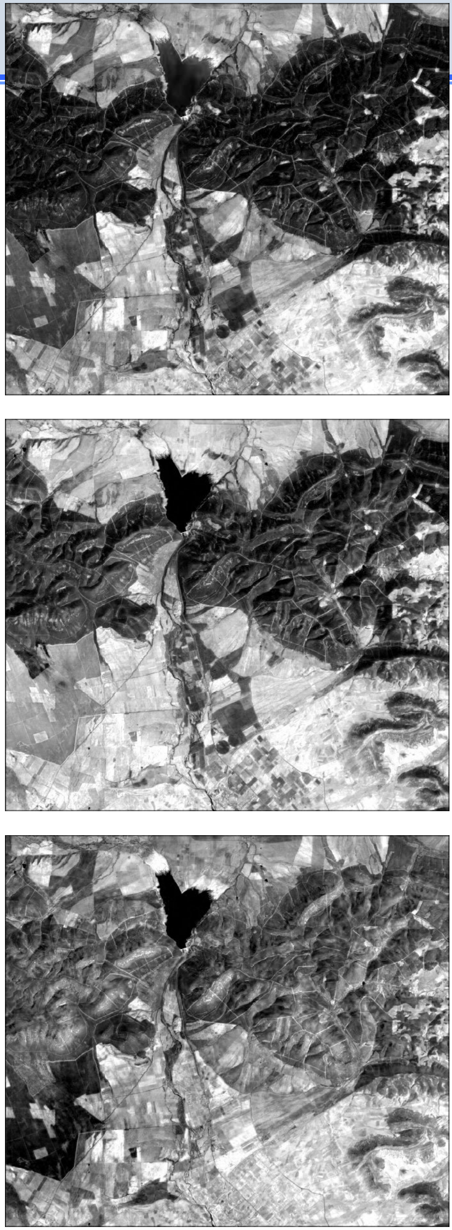
Row	193	194	195	196	197	198
244	2139	2108	2108	2122	2108	2108
245	2145	2124	2124	2133	2120	2120
246	2145	2124	2124	2133	2120	2120
247	2126	2106	2106	2100	2113	2113
248	2074	2068	2068	2091	2097	2097
249	2074	2068	2049	2078	2084	2084
250	2057	2049	2049	2078	2084	2084
251	2077	2057	2057	2083	2069	2069
252	2126	2088	2102	2102	2091	2091
253	2126	2107	2119	2119	2136	2136
254	2135	2107	2119	2119	2136	2136

Gray Levels
Digital Numbers
Pixel Values

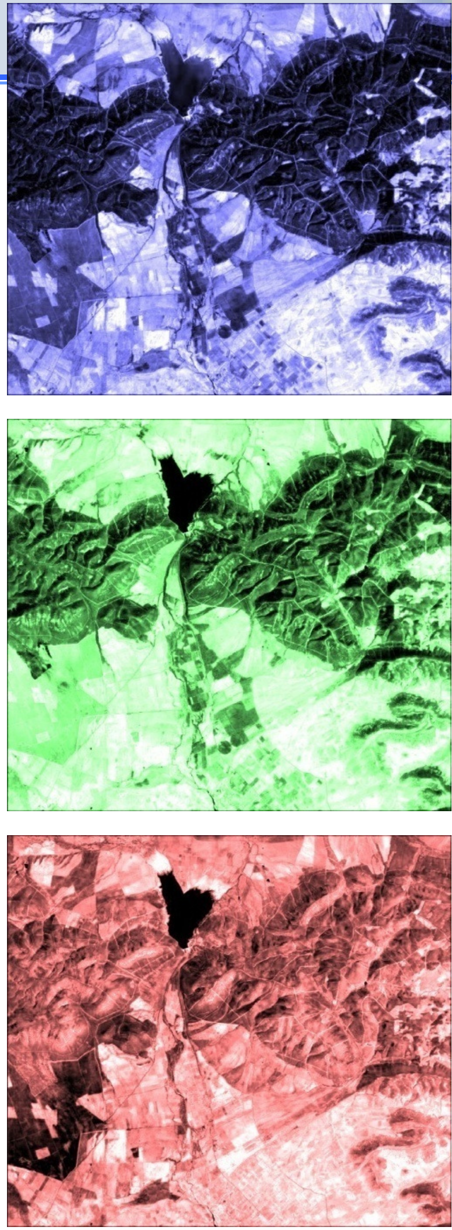
Image Structure



Spectral Band Combinations



Original bands



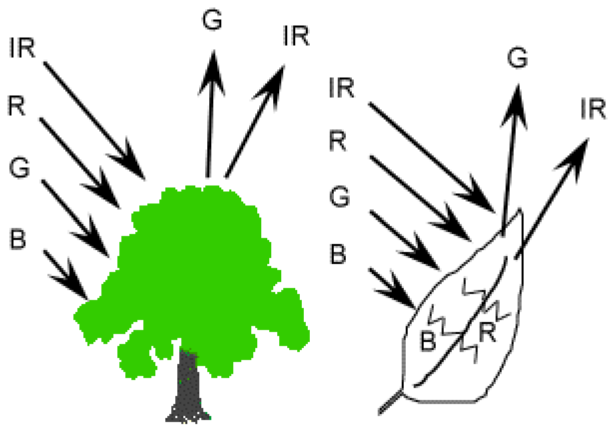
Bands assigned to RGB

False Color composite

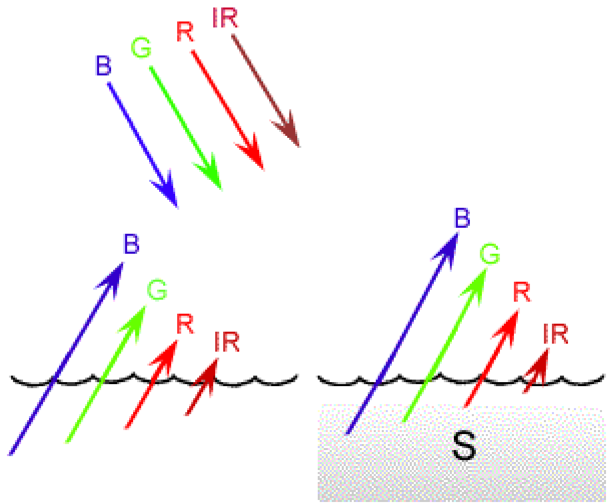
Spectral Curves

Spectral Reflectance Curve: describes the type or condition of the surface material, also called spectral signature of a specific material; it may change over time. Many earth surface features can be identified, mapped, and studied on the basis of their spectral characteristics.

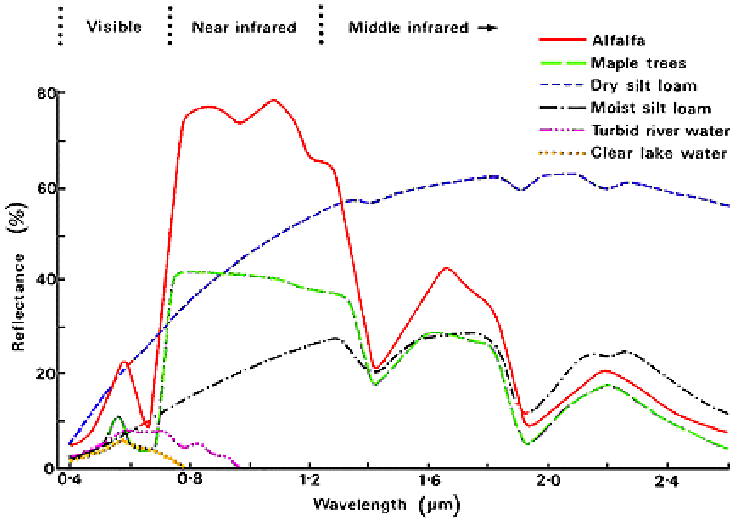
Vegetation



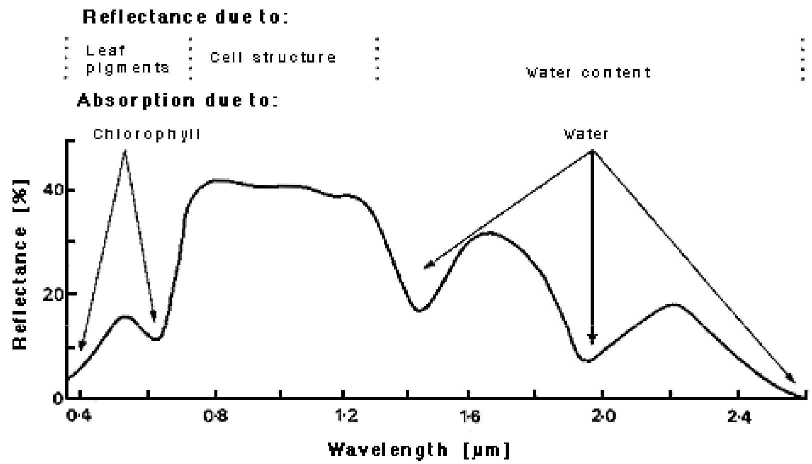
Water



Spectral Curves

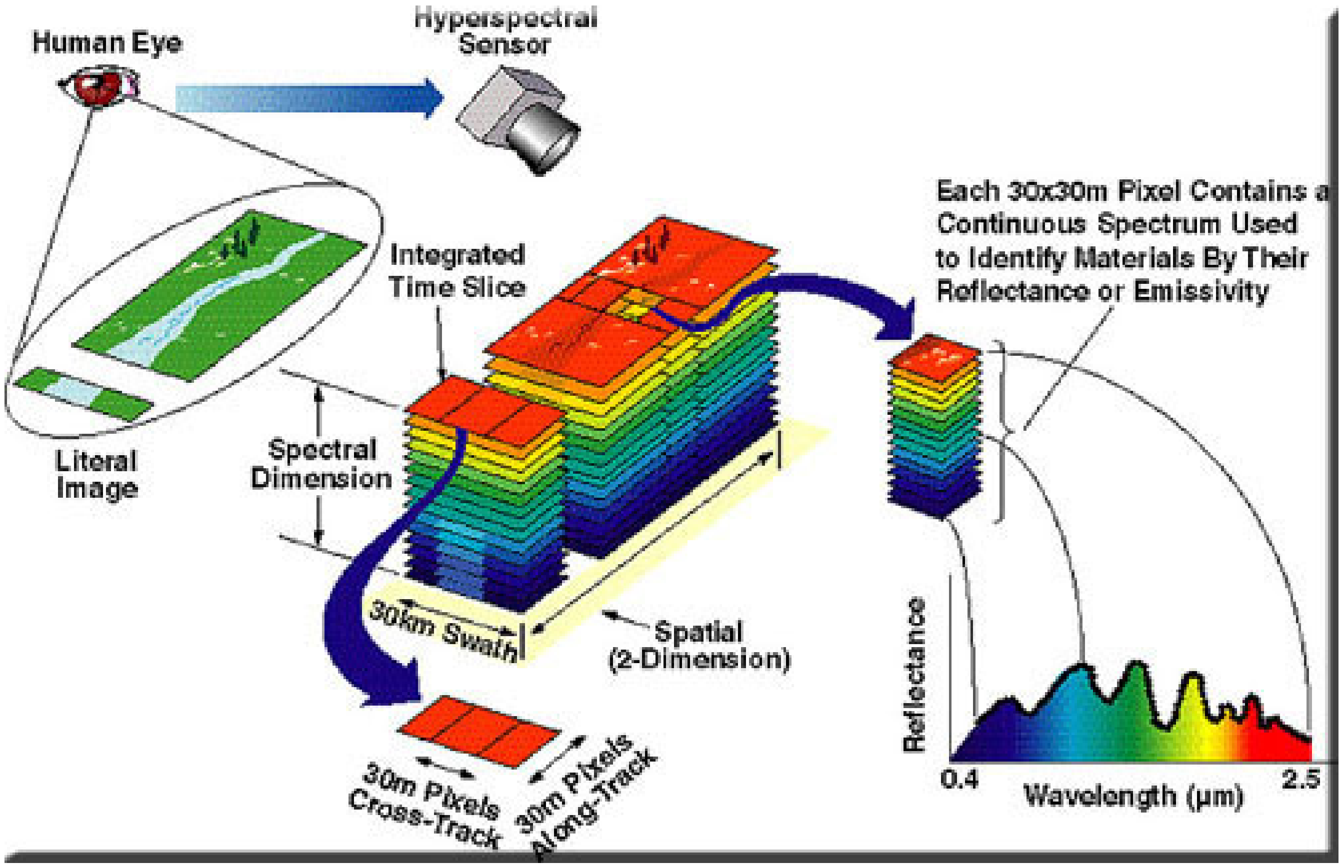


Spectral reflectance curves for two types of green vegetation, light and dark soils, and clear and turbid water.



Typical reflectance and absorption characteristics of green vegetation.

MULTI/HYPERSPECTRAL IMAGING SYSTEM



Digital Image Processing

Digital image processing techniques can be divided into four categories:

- **Image restoration**: involves processes to remove systematic errors in data such as noise or geometric distortion. Procedures include restoring periodic line dropouts, filtering random noise, and correcting for atmospheric scattering. They are also called *preprocessing* methods.
- **Image enhancement**: includes any alteration of the data that improves the interpretability of the image information. Procedures include contrast stretching, edge enhancement, false color composites and image transformations.
- **Image extraction**: involves spectral data analysis and the application of statistically based decision rules for determining feature identification. Procedures include density slicing, principal component separation and pattern recognition (classification).
- **Image merging**: aids interpretation by manipulating and merging several data sets together (multi-source and multi-temporal data)

Visual Image Interpretation

Remote sensing analysis involves *identification* of various targets (environmental and/or artificial features). Recognizing targets is the key to *interpretation* and *information extraction*.

<u>Visual elements used to differentiate between targets and their background:</u>

- **Tone**: relative brightness or color of objects
- **Shape**: general form, structure or outline of individual objects
- **Size**: is a function of scale and affects level of extractable information
- **Pattern**: spatial arrangement of visibly discernible objects
- **Texture**: arrangement and frequency of tonal variation (rough texture → gray levels change abruptly in a small area; smooth texture → little tonal variation)
- **Shadow**: provides an idea of the profile and relative height of targets
- **Association**: relationship between recognizable objects in proximity to target

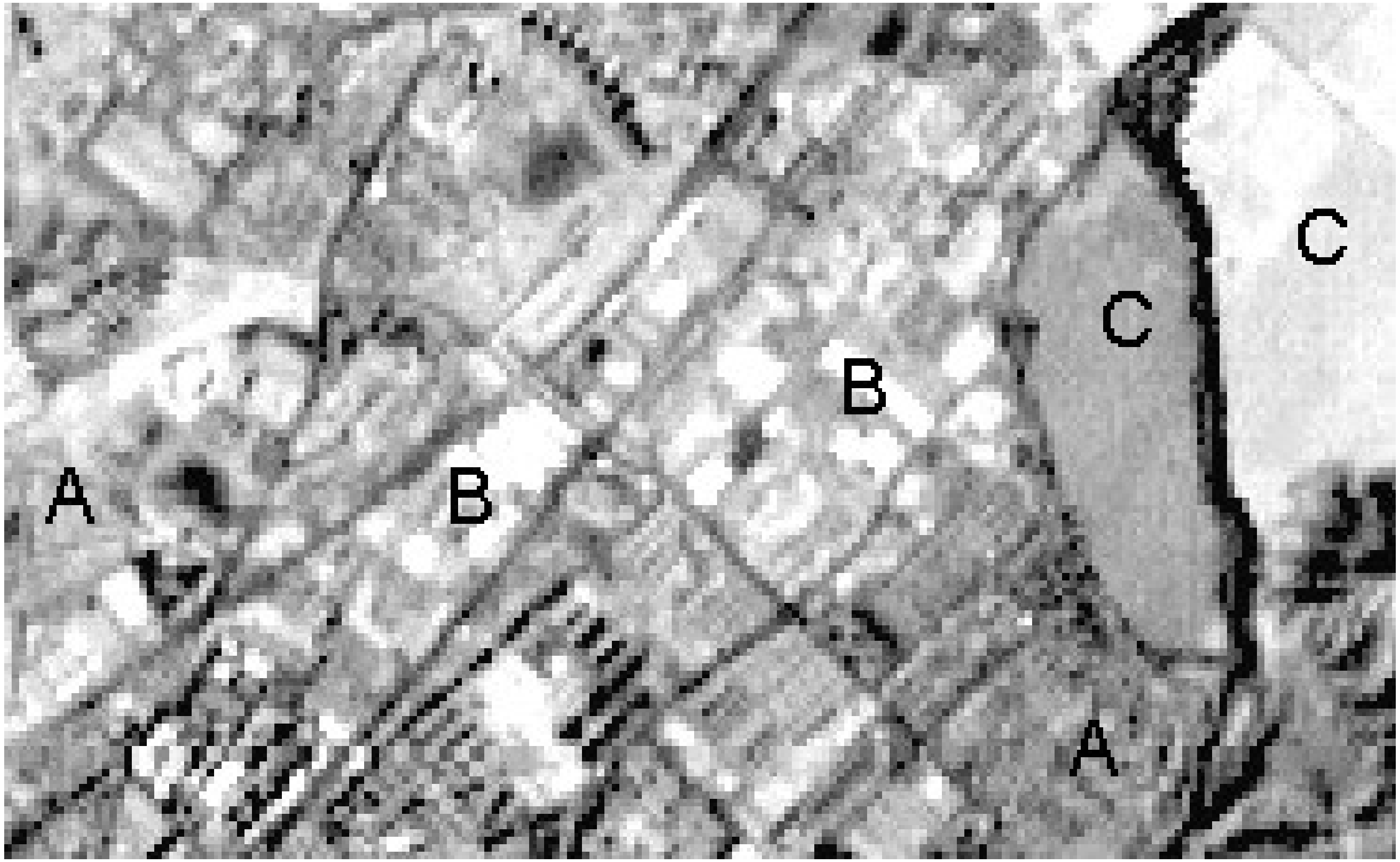
Shapes

Size

ETM MULTI – 30m

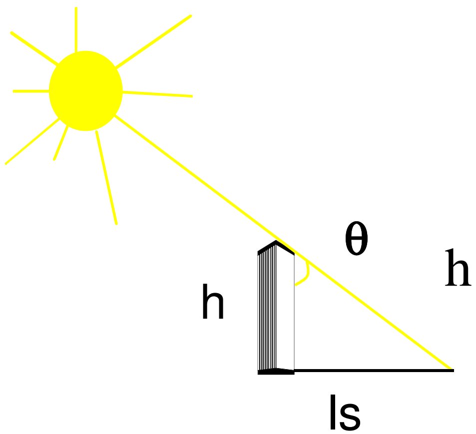
ETM PAN – 15m

Texture (Urban Area)



Shadows

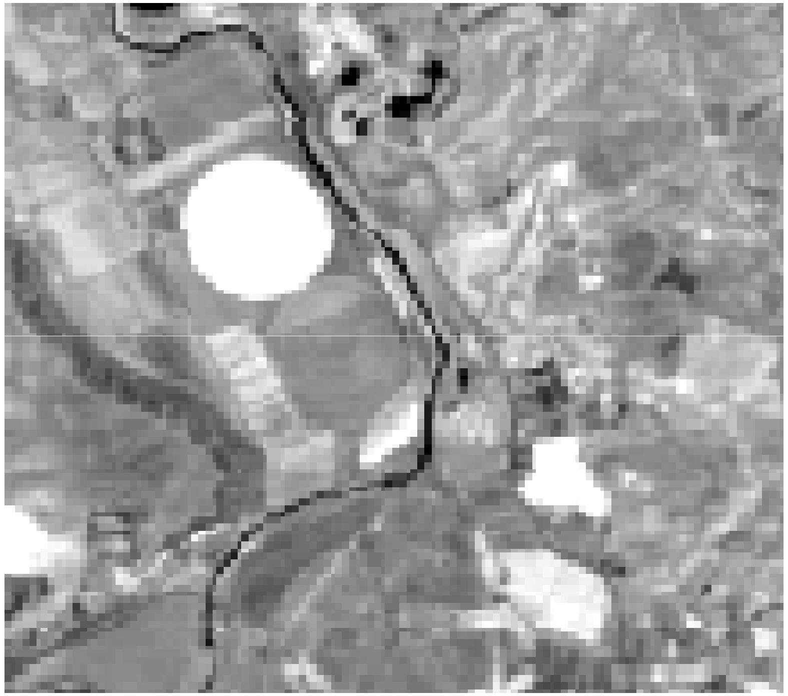
Alcalá, KVR-1000



$$h = \frac{ls}{\tan\theta}$$

Washington, D.C., IRS

Association



Visual Image Interpretation

Visual image interpretation: relies on a series of interactions involving shapes, patterns, assemblages of tones and colors, texture, scale and context.

Four steps:

1. Detection (perception that something of interest exists)
2. Localization (defining the position of this 'thing')
3. Recognition (that it is a particular category of 'thing')
4. Identification (of its unique attributes/features)