Bharathidasan University
Tiruchirappalli, Tamil Nadu

Programme: M.Tech Geoinformatics
Course: Remote Sensing

Unit 3: Resolutions

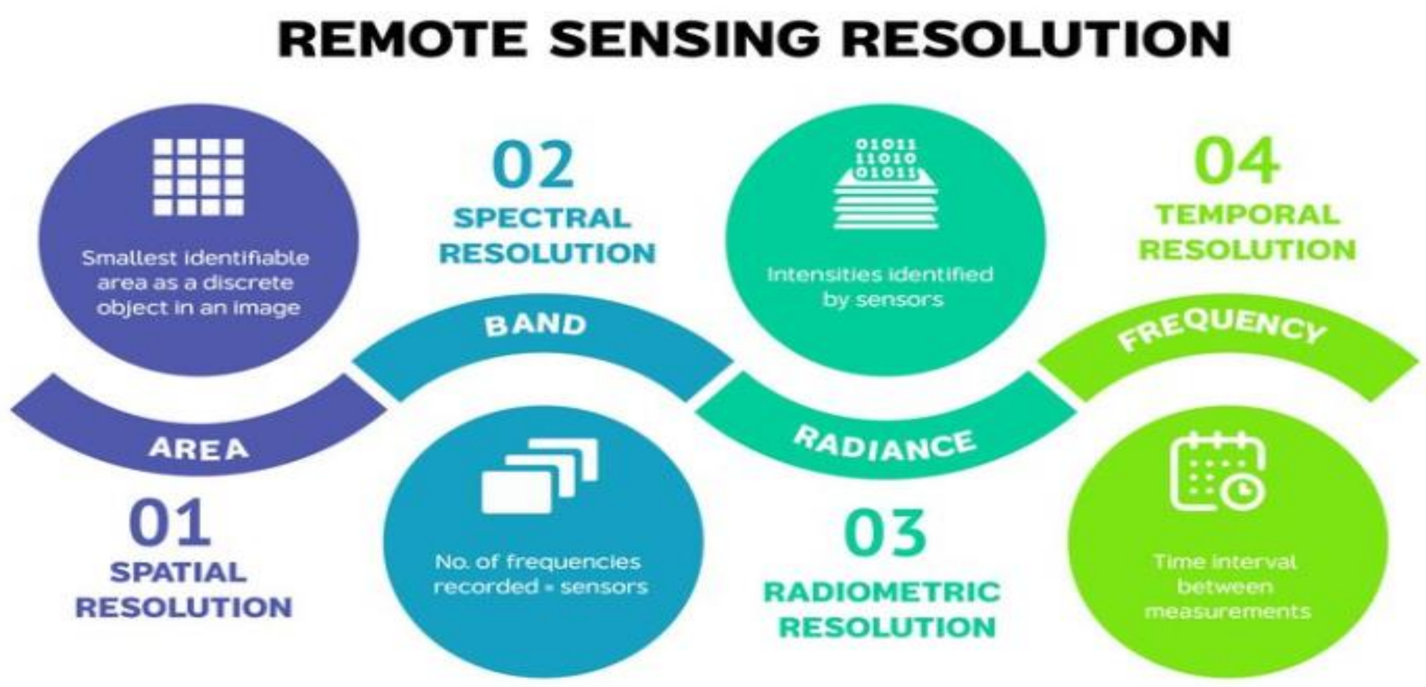
Dr. R. Jegankumar. M.Sc., M.Tech., Ph.D
Professor & Head
Department of Geography
Bharathidasan University , Tiruchirappalli

Resolutions

In remote sensing **resolution** means the **resolving power**

- ➢Capability to identify the presence of two objects
- ➢Capability to identify the properties of the two objects

An image that shows finer details is said to be of finer resolution compared to the image that shows coarser details



Spatial Resolution

- Spatial resolution: Size of the smallest dimension on the Earth's surface over which an independent measurement can be made by the sensor
  - Expressed by the size of the pixel on the ground in meters
  - Controlled by the Instantaneous Field of View (IFOV)

Coarse Spatial Resolution

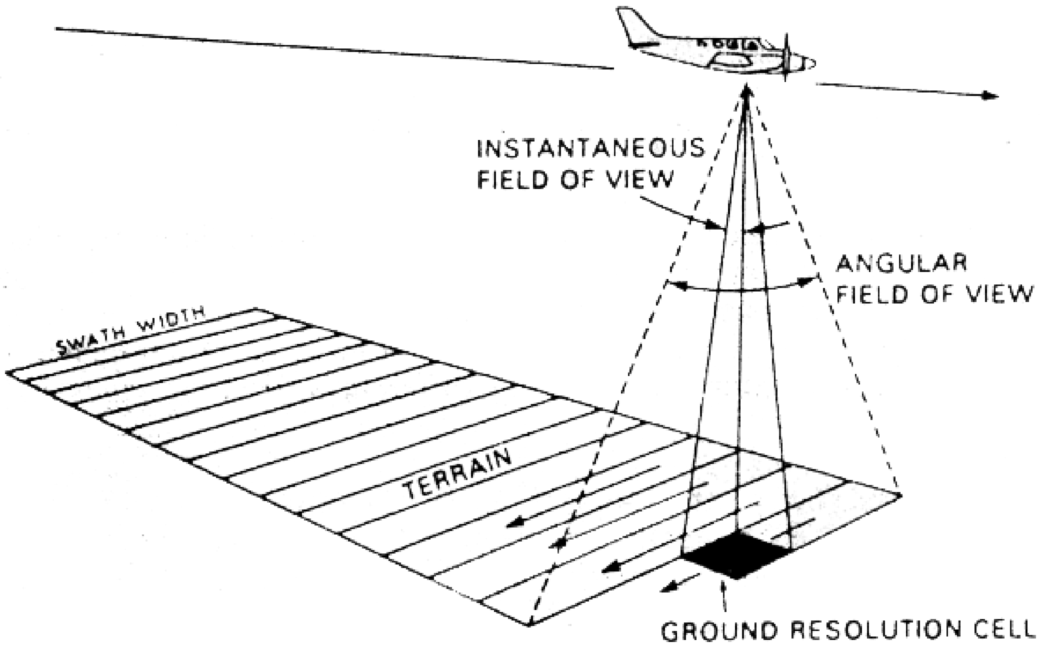
Fine Spatial Resolution

Instantaneous Field of View

- **IFOV: Instantaneous Field of View**
  - ❖ Angular cone of visibility of the sensor
  - ❖ Area on the Earth's surface that is seen at one particular moment of time

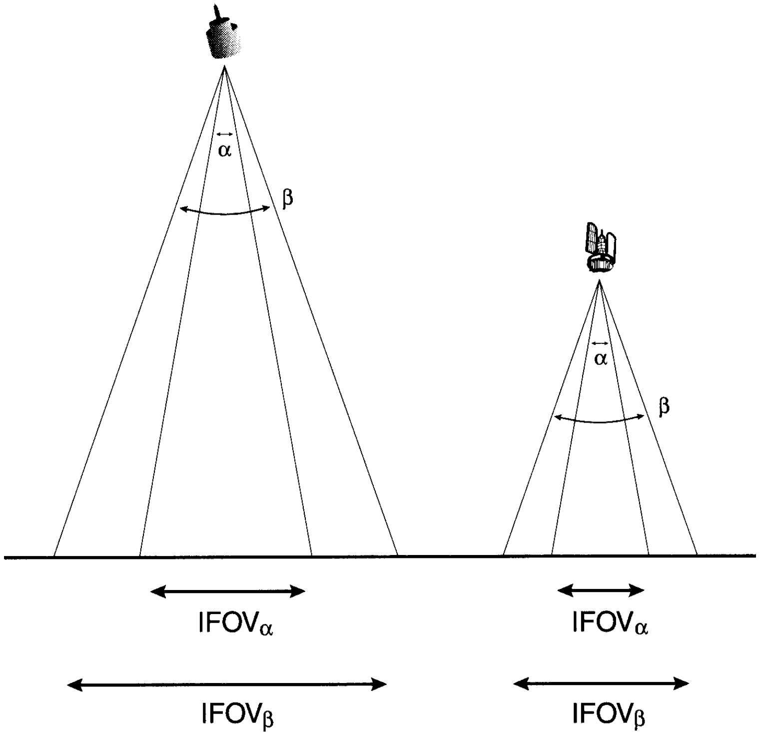
❖ IFOV depends on

- ➢ Altitude of the sensor above the ground level
- ➢ Viewing angle of the sensor



Instantaneous Field of View…

- ***A narrow viewing angle produces a smaller IFOV***
- ***IFOV increases with altitude of the sensor***



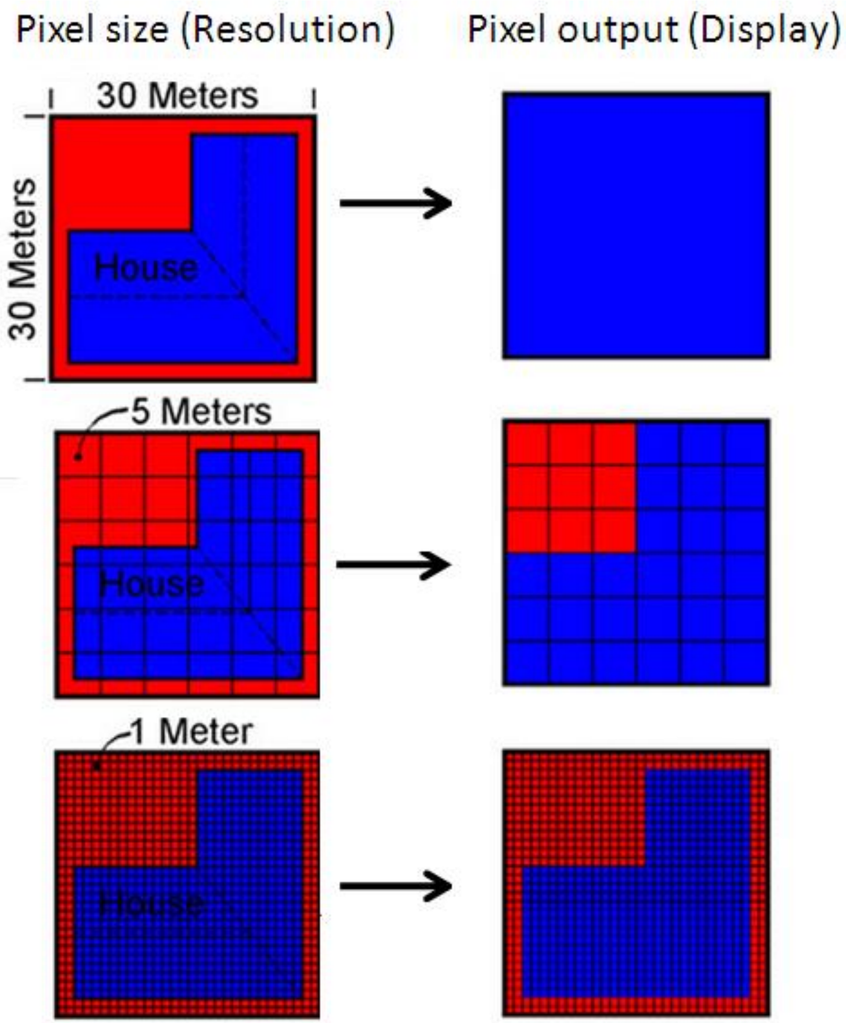
Ground Resolution Cell

- ***Ground Resolution or Ground Resolution Cell : Size of the area viewed by the sensor on the ground at one particular moment of time***
- ***Depends on***
  - ***Altitude of the sensor***
  - ***IFOV of the sensor***
- ***Obtained by multiplying the IFOV (in radians) by the distance from the ground to the sensor.***
- ***It is also referred as the spatial resolution of the remote sensing system***

Spatial Resolution and Feature Identification

- For a feature to be detected, its size generally has to be equal to or larger than the resolution cell
- If more than one feature is present within ground resolution cell, the signal response is a mixture of the signals from all the features
  - From the average brightness recorded, any one particular feature among them may not be detectable
  - Smaller features may sometimes be detectable if their reflectance dominates within a particular resolution cell

Spatial Resolution and Feature Identification…



Example

Signature from the “house” dominates for the cell and hence the entire cell is classified as “house”

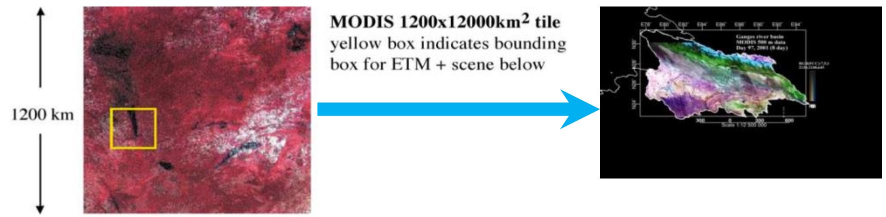
Shape and spatial extent of the feature is better captured. However, some discrepancy is present along the boundary

Feature shape and the spatial extent is more precisely identified

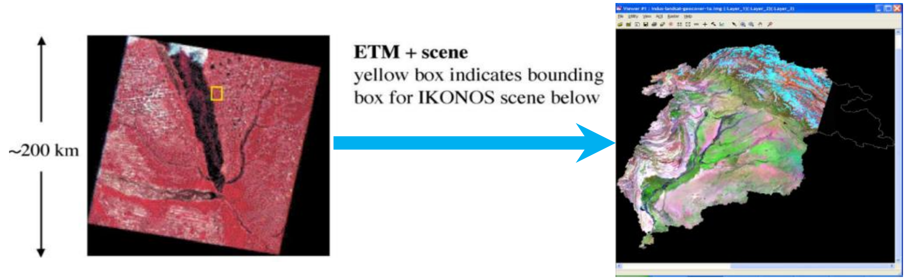
Classes of Spatial Resolution

- **Low resolution systems**
  - **Spatial resolution > 1km**
  - **MODIS, AVHRR**
- **Medium resolution systems**
  - **Spatial resolution is 100m – 1km**
  - **IRS WiFS (188m), Landsat TM–Band 6 (120m), MODIS–Bands 1-7 (250-500m)**
- **High resolution systems**
  - **Spatial resolution approximately in the range 5-100m**
  - **Landsat ETM+ (30m), IRS LISS-III (23m MSS, 6m Panchromatic), IRS AWiFS (56-70m), SPOT 5(2.5-5m Panchromatic)**
- **Very high resolution systems**
  - **Spatial resolution less than 5m**
  - **GeoEye (0.45m for Panchromatic, 1.65m for MSS), IKONOS (0.8-1m Panchromatic), Quickbird (2.4-2.8 m)**

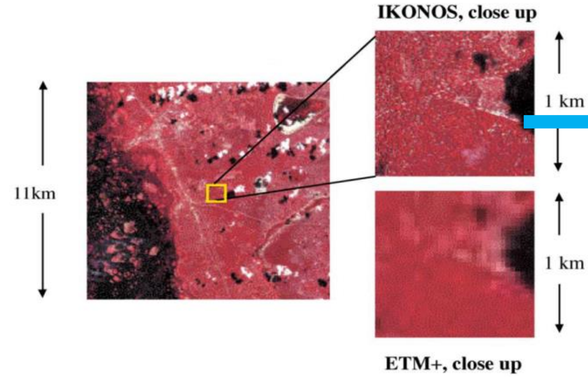
Spatial Resolutions and Scale of Applicability

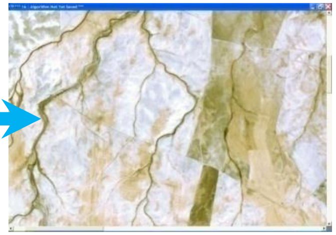


Ganges basin from MODIS 500 m



Indus basin from Landsat 30 m





Karkeh sub-basin watershed from IKONOS

(Courtesy: Morisette, 2002)

Scale of an Image

- **Scale : Ratio of distance on an image or map, to actual ground distance**
- **Maps or images with small "map-to-ground ratios" are referred to as small scale (e.g. 1:100,000), and those with larger ratios (e.g. 1:5,000) are called large scale.**
- **Example**

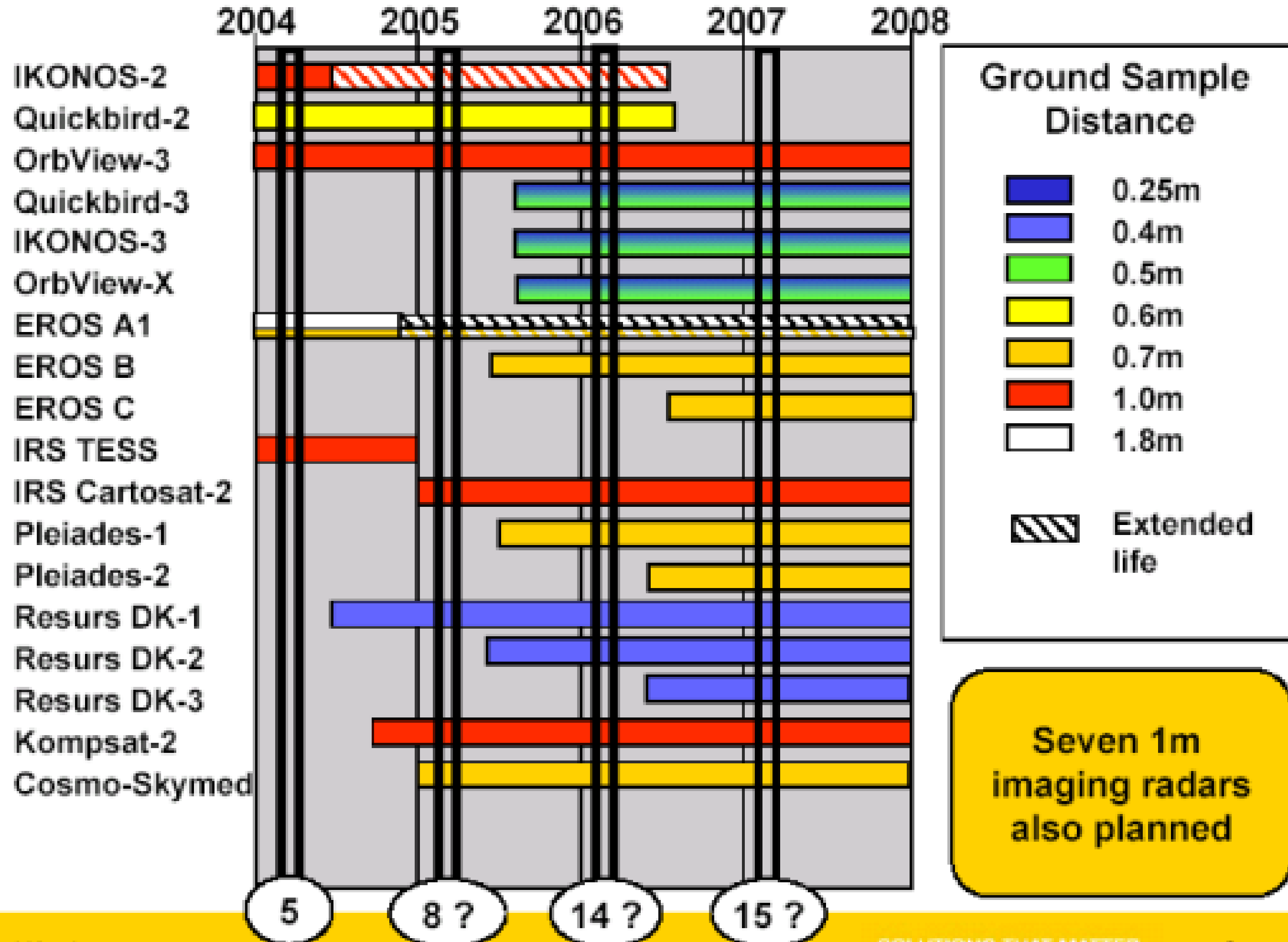
What is the actual length of an object which is 1cm long in a map of scale 1:100,000?

Scale = 1:100,000

Object length in map = 1cm

Actual length on the ground = 1 cm x 100,000 = 100,000 cm = 1 km

- Here to stay
- Continuity
- Higher Res
- Increasing Competition



Spectral Resolution

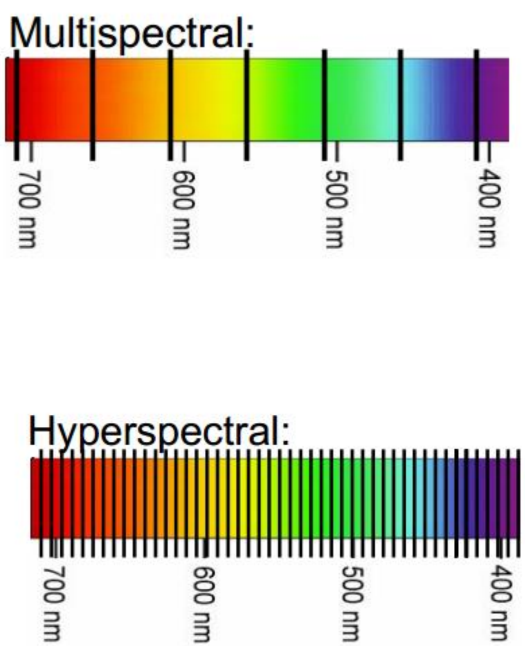
- Spectral resolution
  - Ability of a sensor to define fine wavelength intervals
  - Ability of a sensor to resolve the energy received in a spectral bandwidth to characterize different constituents of earth surface

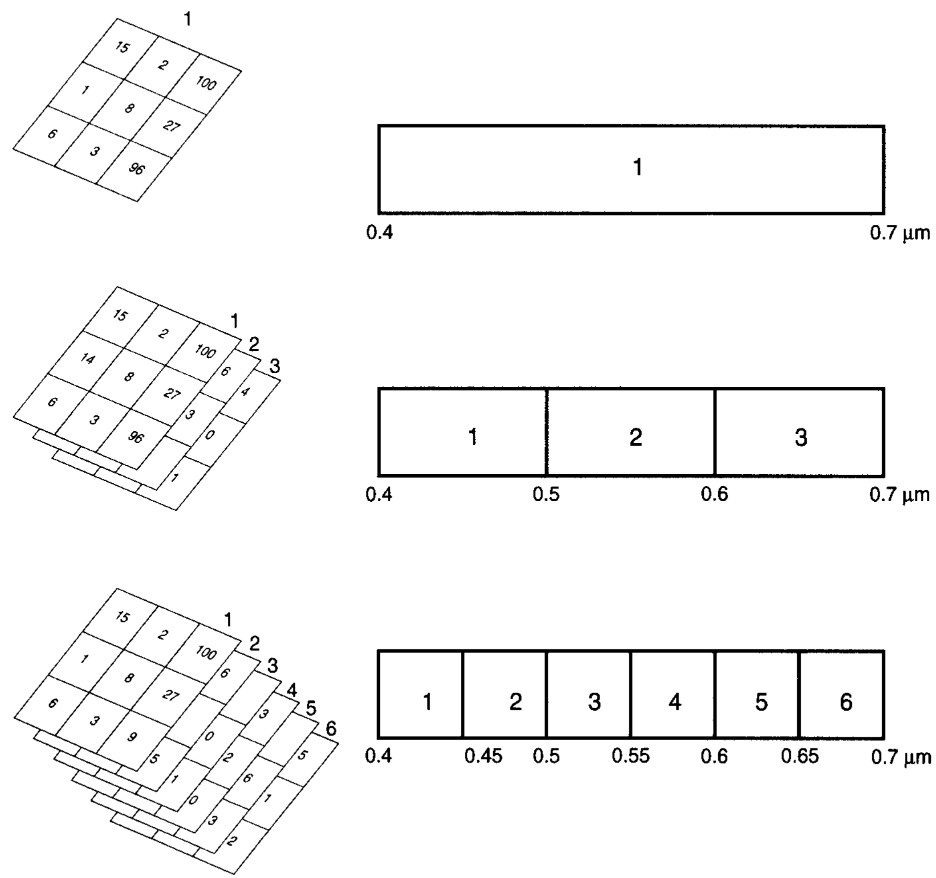
- Depends on
  - Spectral band width of the filter
  - Sensitiveness of the detector

- The finer the spectral resolution, the narrower the wavelength range for a particular channel or band

Spectral Resolution…

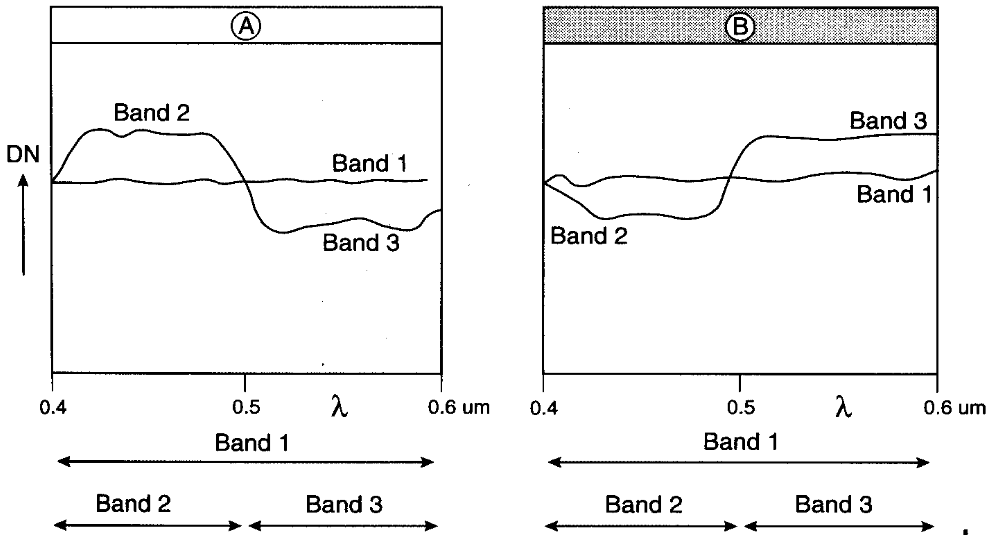
Finer the spectral resolution, the narrower the wavelength range for a particular channel or band





Spectral Resolution and Feature Identification

- **Generally surface features can be better distinguished from multiple narrow bands, than from a single wide band**



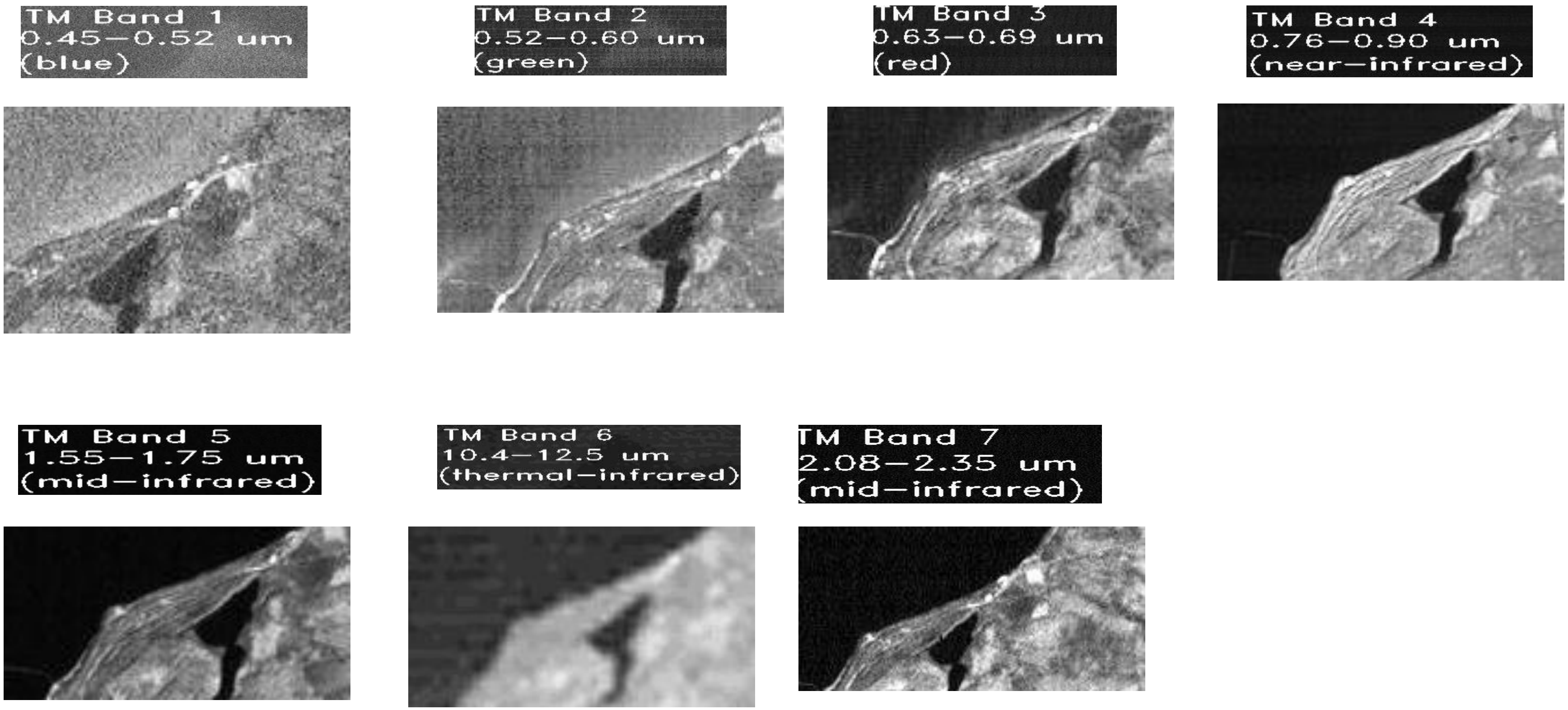
Using the broad wavelength band 1, the features A and B cannot be differentiated

Spectral reflectance of A and B are different in the narrow bands 2 and 3, and hence can be differentiated

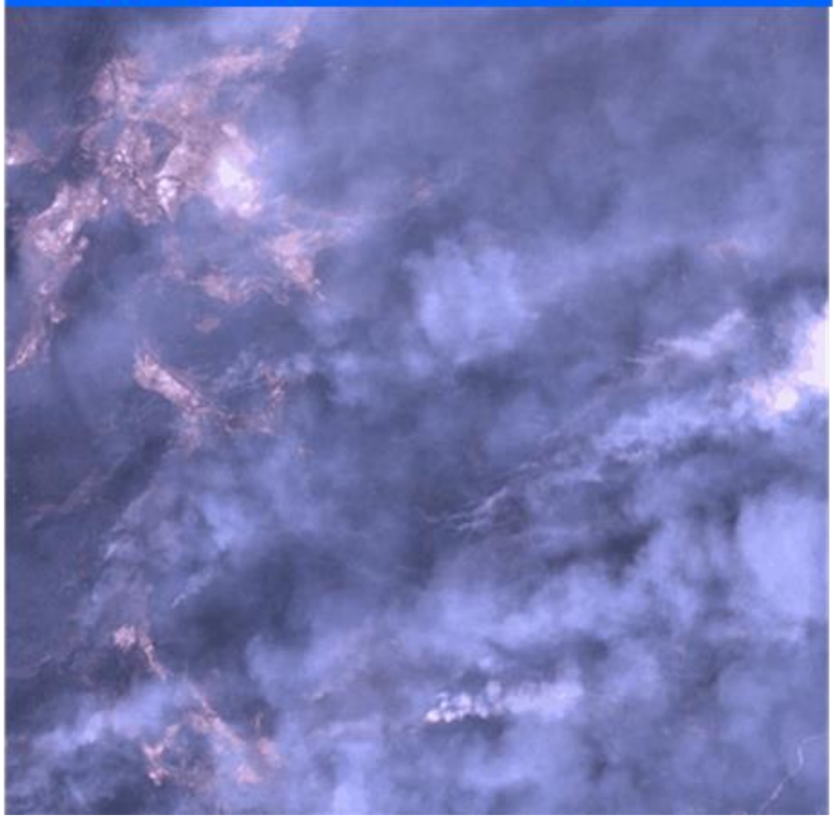
Spectral Resolution in Remote Sensing

- Different features are identified from the image by comparing their responses over different distinct spectral bands
- Broad classes, such as water and vegetation, can be easily separated using very broad wavelength ranges like visible and near-infrared
- For more specific classes viz., vegetation type, rock classification etc, much finer wavelength ranges and hence finer spectral resolution are required

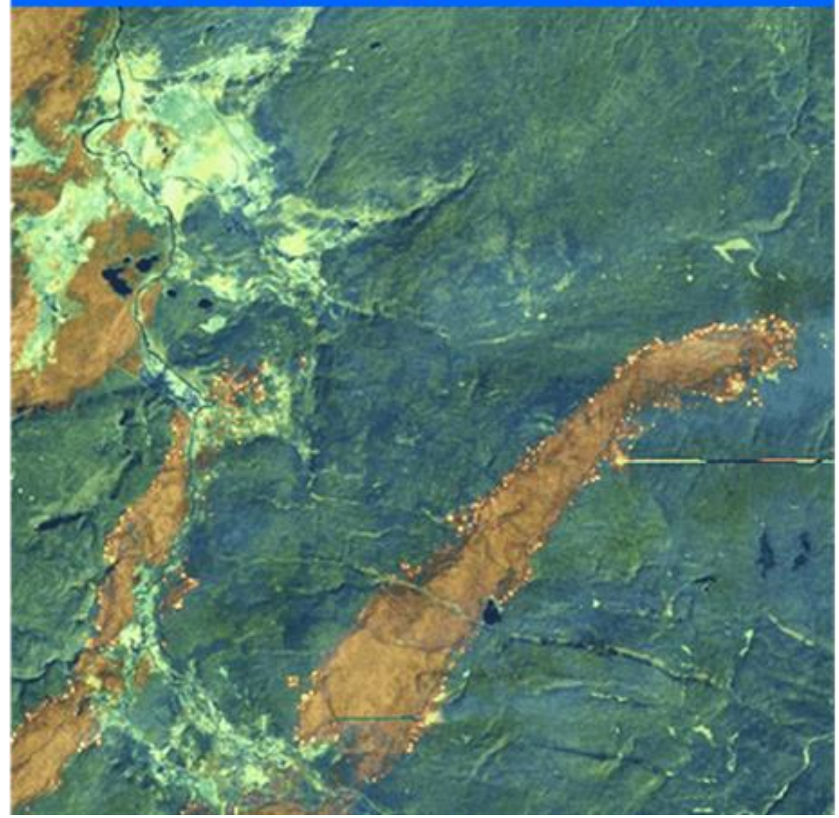
Difference in the spectral responses of an area in different bands of Landsat TM image



Yellowstone NP, TCC (TM 321)



Yellowstone NP, FCC (TM 754)



Radiometric Resolution

Radiometric resolution: Sensitivity of the sensor to the magnitude of the electromagnetic energy

- **How many grey levels are measured between pure black (no reflectance) to pure white (maximum reflectance)**
- **The finer the radiometric resolution of a sensor the more sensitive it is in detecting small differences in the energy**
- **The finer the radiometric resolution of a sensor the system can measure more number of grey levels**

Radiometric Resolution…

- Radiometric resolution is measured in Bits
  - Each bit records an exponent of power 2
- Maximum number of brightness levels available depends on the number of bits used in representing the recorded energy

Radiometric resolution and the corresponding brightness levels available

Radiometric resolution	Number of levels	Example
1 bit	2^1 – 2 levels	
7 bit	2^7 – 128 levels	IRS 1A & 1B
8 bit	2^8 – 256 levels	Landsat TM
11 bit	2^{11} – 2048 levels	NOAA-AVHRR

Poor resolution → 1 bit

High resolution → 11 bit

Radiometric Resolution and Level of Information

- **Finer radiometric resolution**
  - ➢ **More the number of grey levels**
  - ➢ **More details can be captured in the image**

- **Finer radiometric resolution**
  - ➢ **Increases the data storage requirements**

2 Bit Data (Coarse)

8 Bit Data (Fine)

Temporal Resolution

- **Temporal resolution**

Number of times an object is sampled

or

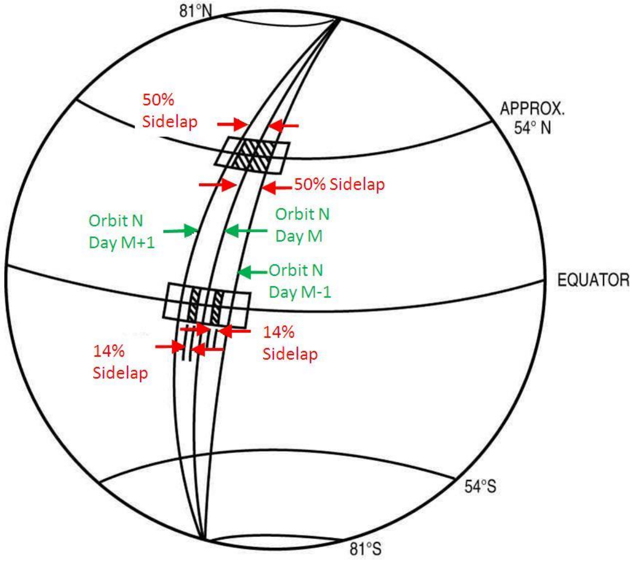
How often data are obtained for the same area

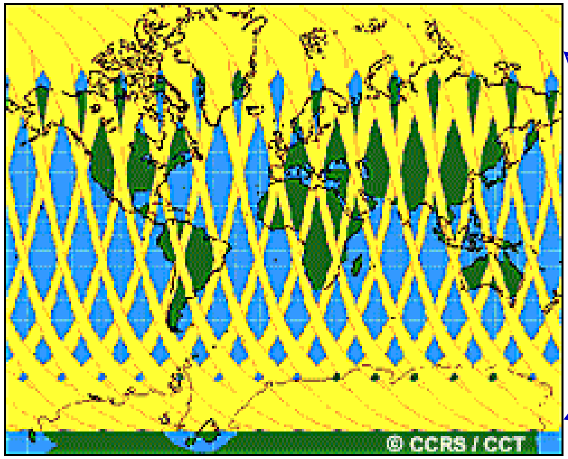
- ❖ **The absolute temporal resolution of a remote sensing system to image the same area at the same viewing angle a second time is equal to the repeat cycle of a satellite.**
- ❖ **The repeat cycle of a near polar orbiting satellite is usually several days**

  Example: 24 days for IRS-1C and Resourcesat-2, 18 days for Landsat, 14days for IKONOS
- ❖ **Actual temporal resolution (or revisit period) of a sensor depends on**
  - ➢ **The satellite/sensor capabilities**
  - ➢ **Swath overlap and Latitude**

Swath Overlap and Latitude

- Sidelap in the swaths of the adjacent orbits increases the frequency of imaging
- Sidelap increases with latitude, increasing the frequency of images available for the polar region





Paths of a Typical Near-Polar Satellite

Towards the polar region, satellite orbits come closer to each other. More frequent images are available for the polar region

Satellite Capabilities and Temporal Resolution

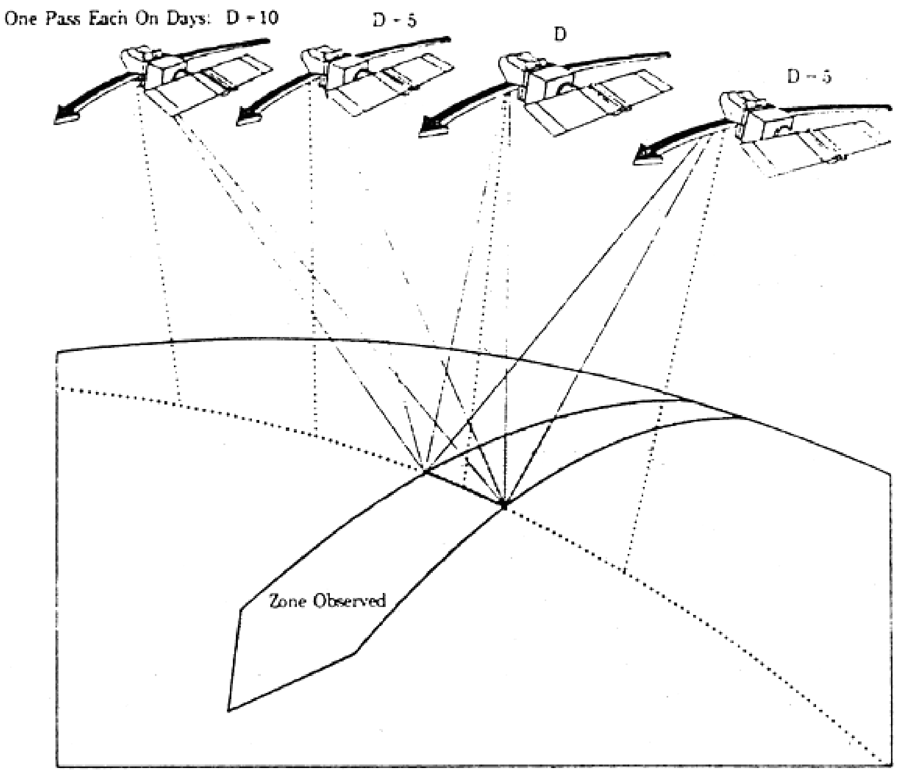
More frequent imaging is possible by off-nadir viewing capabilities

Example : IKONOS

Sensor characteristics: Pointable optics

Repeat cycle : 14 days

Revisit period : 1-3 days



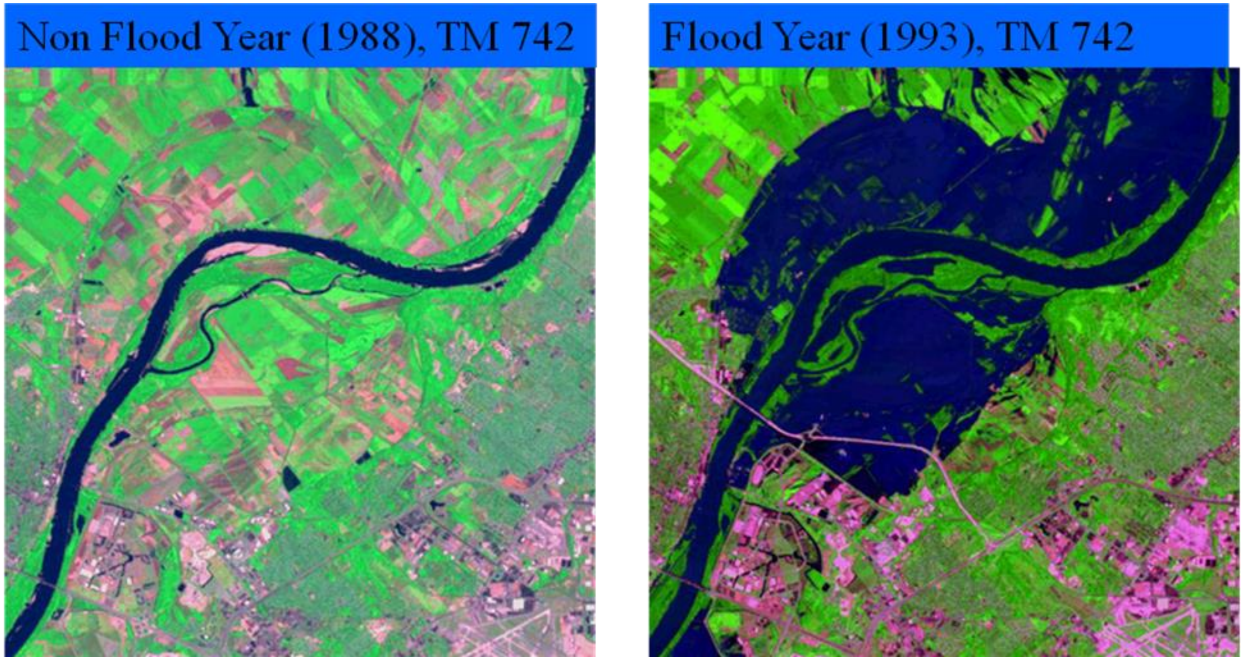
Importance of Temporal Resolution

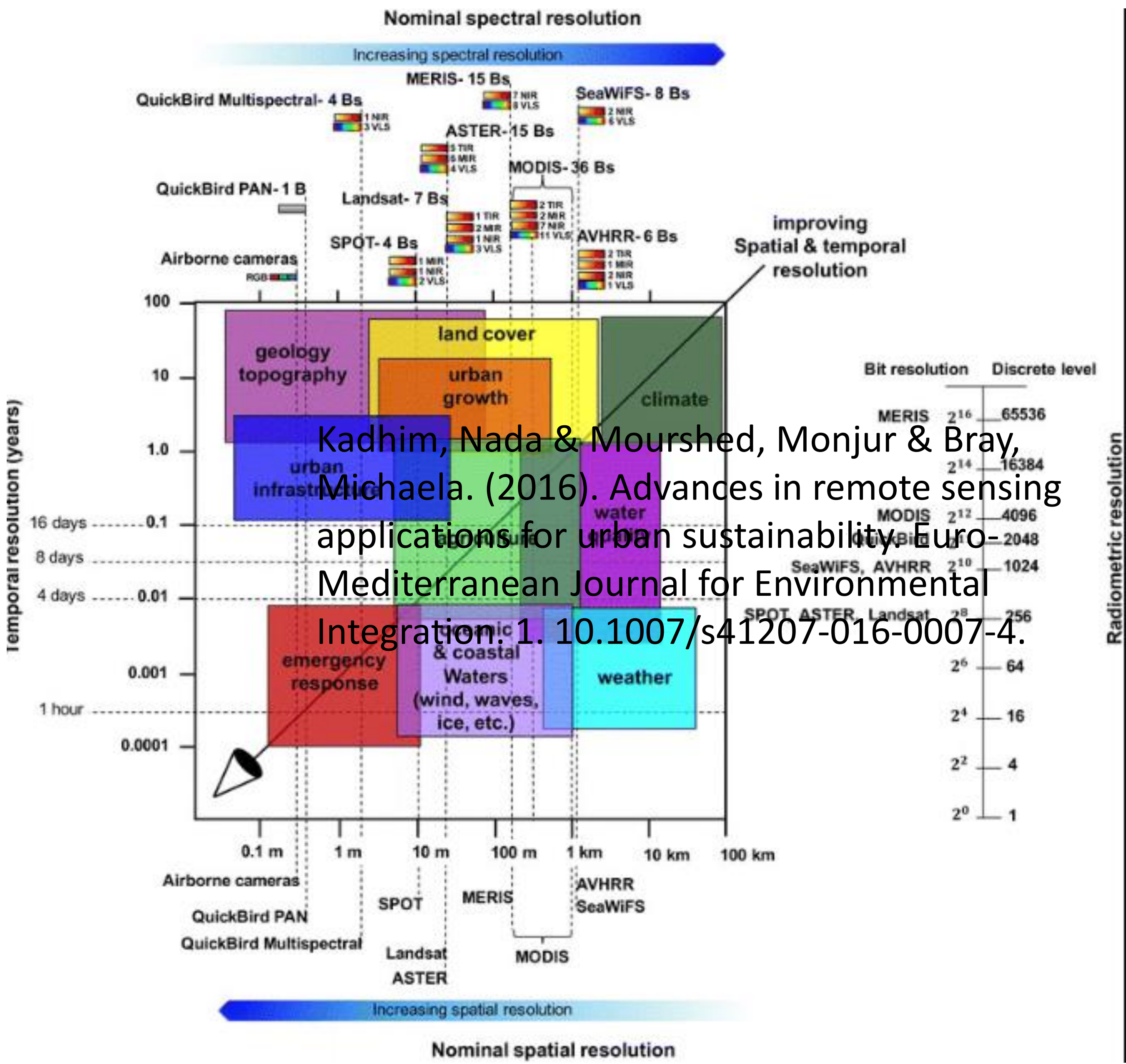
- Images at different time periods show the variation in the spectral characteristics of different features over time
- Applications
  - Land use/ land cove classification
  - Temporal variation in land use / land cover
  - Monitoring of a dynamic events like
    - Cyclone
    - Flood
    - Volcano
    - Earthquake

Flood Studies

- Satellite images before and after the flood event help to identify the aerial extent of the flood during the progress and recession of a flood event

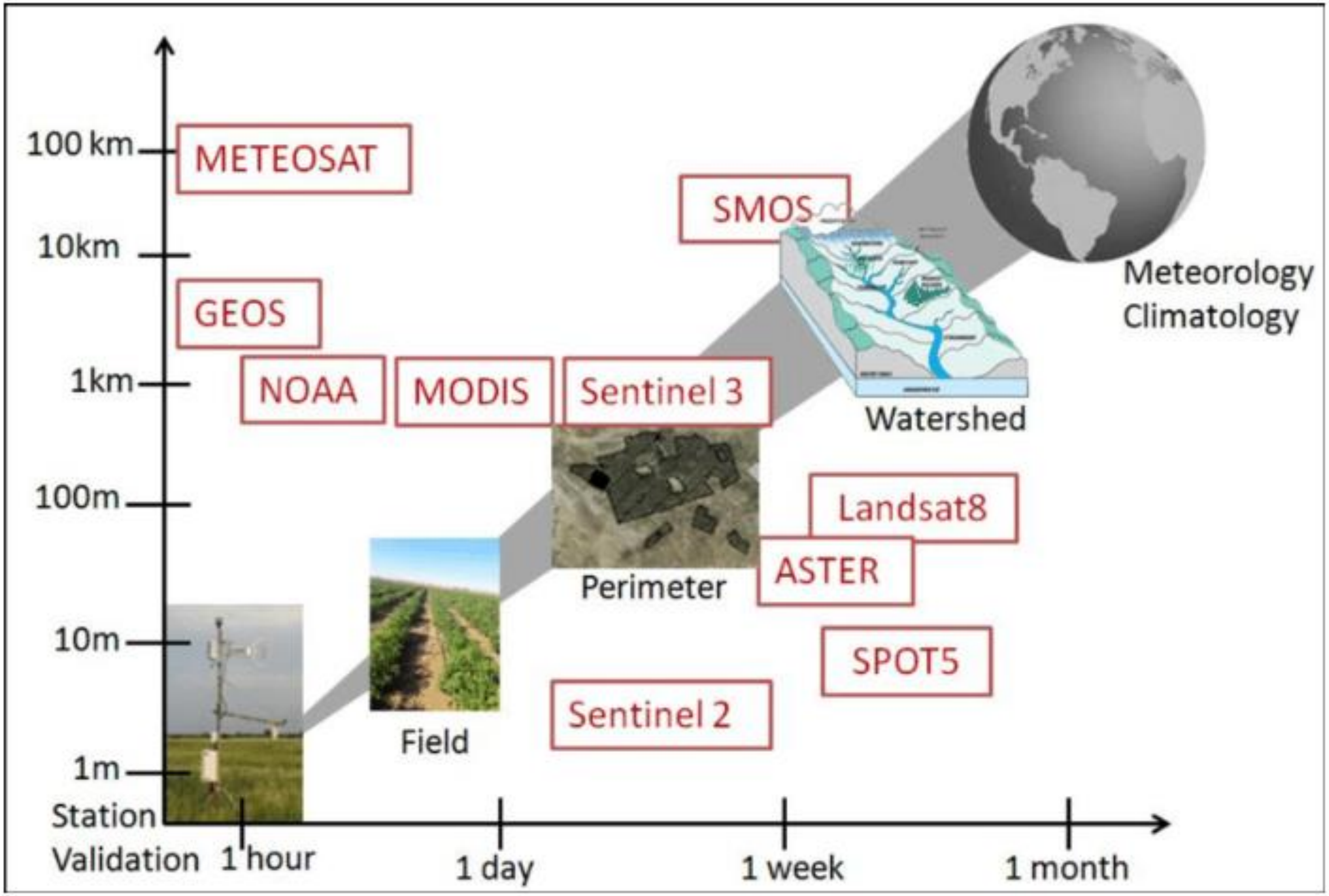
Landsat TM images of the Mississippi River taken during a normal period and during the great flood of 1993





Kadhim, Nada & Mourshed, Monjur & Bray, Michaela. (2016). Advances in remote sensing applications for urban sustainability. Euro-Mediterranean Journal for Environmental Integration. 1. 10.1007/s41207-016-0007-4.

DOI:10.1007/s41207-016-0007-4



Multi-sensor / multi-resolution remote sensing data for crop monitoring and agrohydrological applications (inspired from Malbéteau, (2016)) Thank You