# SNS COLLEGE OF TECHNOLOGY

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## DEPARTMENT CIVIL ENGINEERING

## 19CEE303 – REMOTE SENSING

## III YEAR / V SEMESTER

# Unit 2 : Radiometric and Temporal Resolutions

# Remote Sensing Systems

## (iii) Radiometric and Temporal Resolutions



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# Types of Resolution

- **4 types** of resolutions are defined for the remote sensing systems
  - Spatial resolution
  - Spectral resolution
  - Temporal resolution
  - Radiometric resolution

# Resolution…

- Spatial resolution
  - Size of the smallest dimensions on the earth’s surface over which an independent measurement can be made by the sensor
- Spectral resolution
  - Ability of a sensor to define fine wavelength intervals
- Temporal resolution
- Radiometric resolution

**This lecture covers the details of Temporal and Radiometric resolution**

# 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

Poor resolution

High resolution

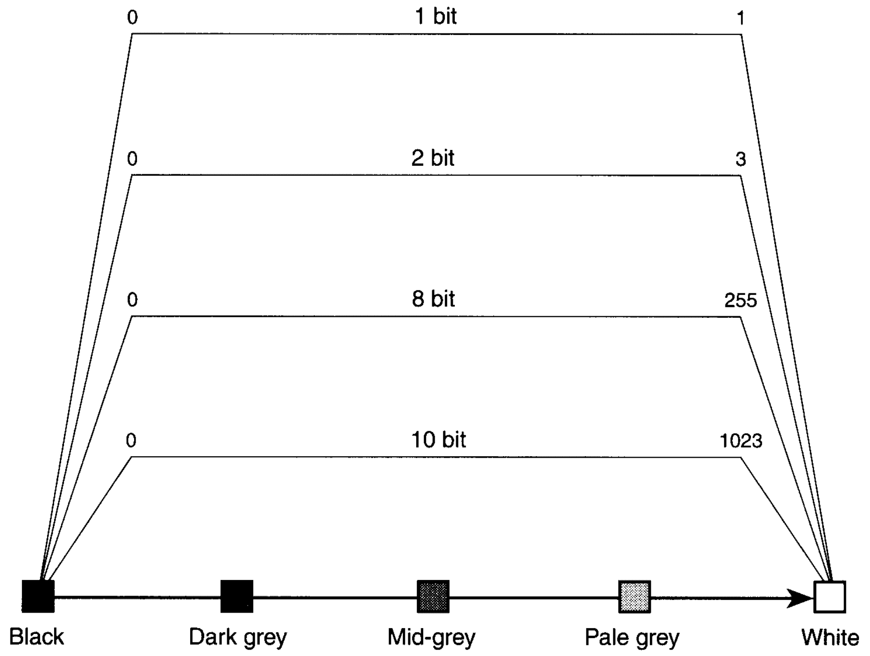
| Radiometric resolution | Number of levels | Example |
|---|---|---|
| 1 bit | $2^1$ – 2 levels | |
| 7 bit | $2^7$ – 128 levels | IRS 1A & 1B |
| 8 bit | $2^8$ – 256 levels | Landsat TM |
| 11 bit | $2^{11}$ – 2048 levels | NOAA-AVHRR |

# Radiometric Resolution and Number of Grey Levels

- Tones in an image vary from black to white
- Black → Digital Number = 0 → No reflectance
- White → Digital Number is the maximum

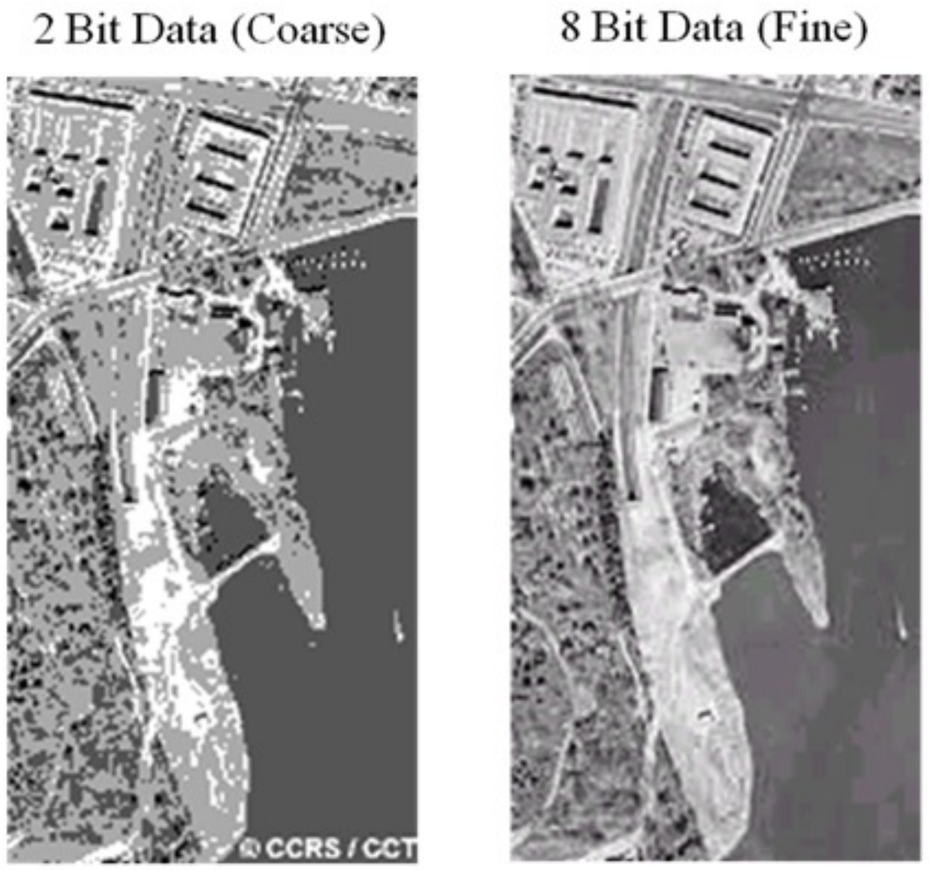
=1 for a 1-bit data

=255 for a 8-bit data



# 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



# Radiometric Resolution and Digital Number

- Digital number (DN) depends on the number of brightness levels
  - Lower DN value in a coarse resolution image
  - Higher DN value in a fine resolution image

Example

- DNs recorded by the 3-bit system range from 0 to 7
- This range is equivalent to 0-63 for the 6 bit system

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | (3 bit) |
| 0 | 9 | 18 | 27 | 36 | 45 | 54 | 63 | (6 bit) |

DN of 45 (6-bit) → 5 (3-bit)

To compare two images, their radiometric resolution should be the same

# Temporal Resolution

- Temporal resolution

Number of times an object is sampled

or

How often data are obtained for the same area

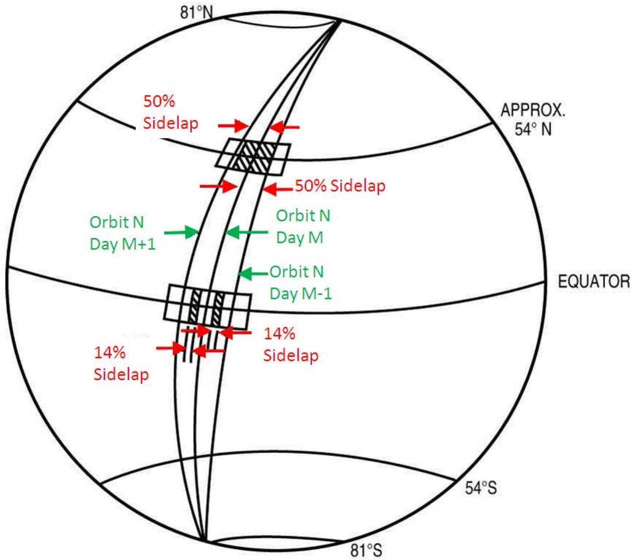
- ❖ The absolute temporal resolution of a remote sensing system to image the same area at the same viewing angle a second time is equal to the repeat cycle of a satellite.
- ❖ The repeat cycle of a near polar orbiting satellite is usually several days

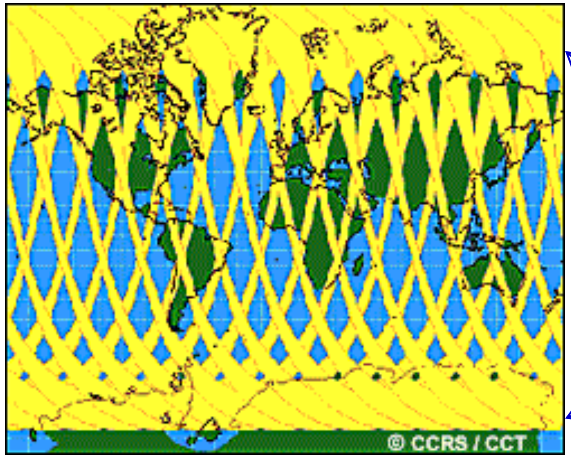
Example: 24 days for IRS-1C and Resourcesat-2, 18 days for Landsat, 14days for IKONOS

- ❖ 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

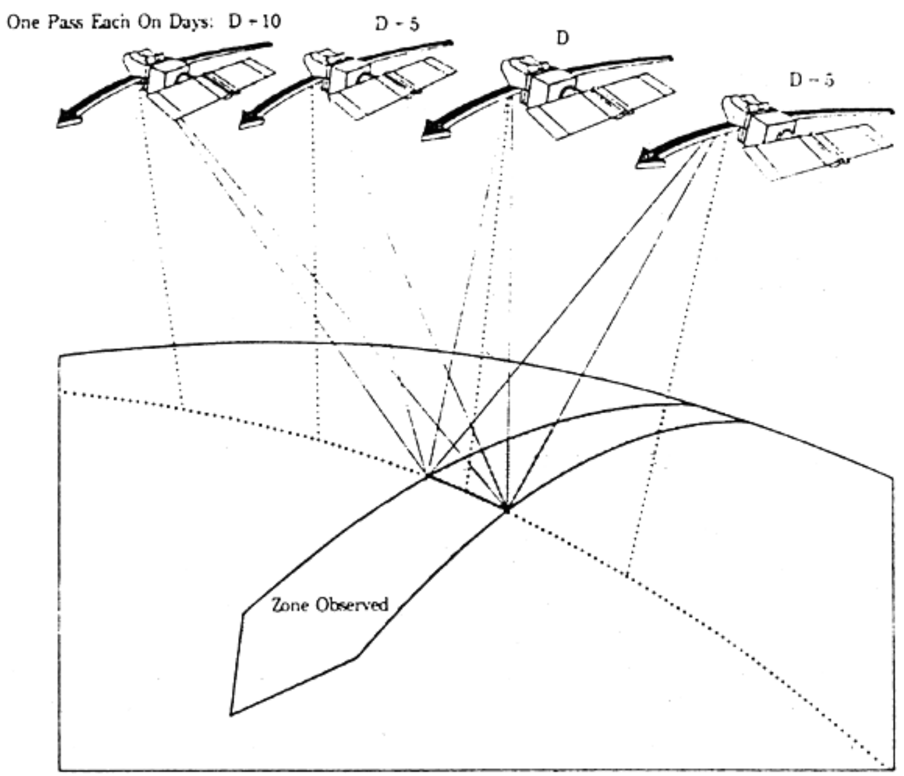
- More frequent imaging is possible by off-nadir viewing capabilities

Example : IKONOS

Sensor characteristics: Pointable optics

Repeat cycle : 14 days

Revisit period : 1-3 days



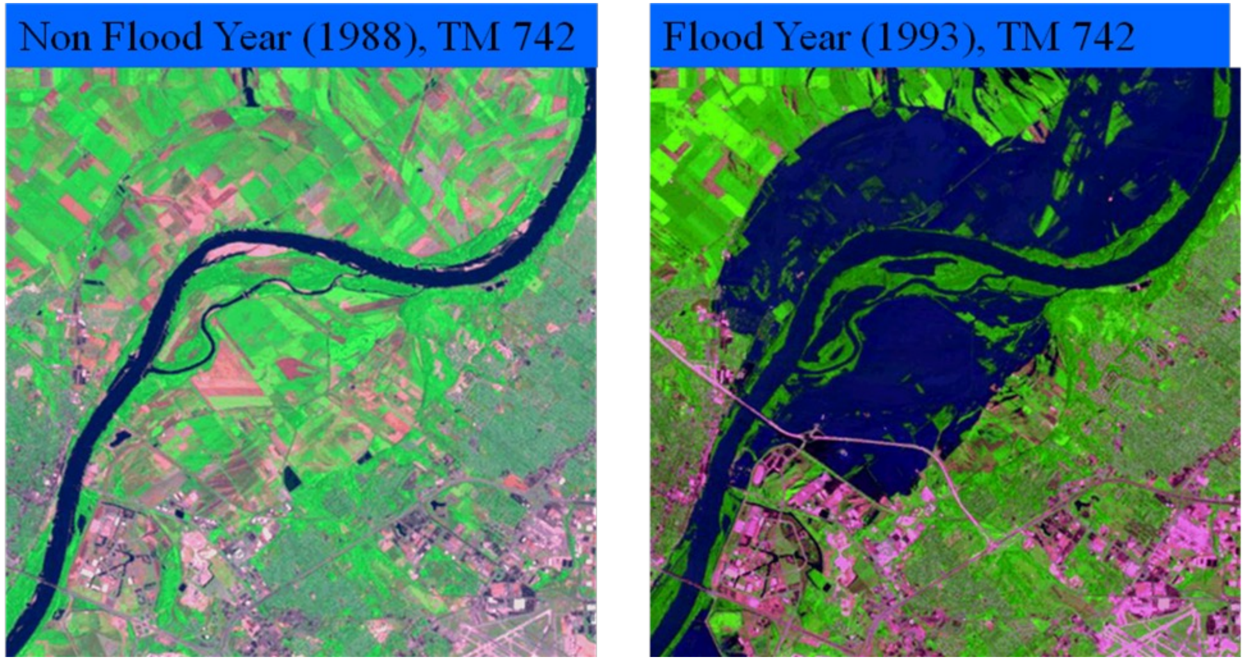
# Importance of Temporal Resolution

- 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

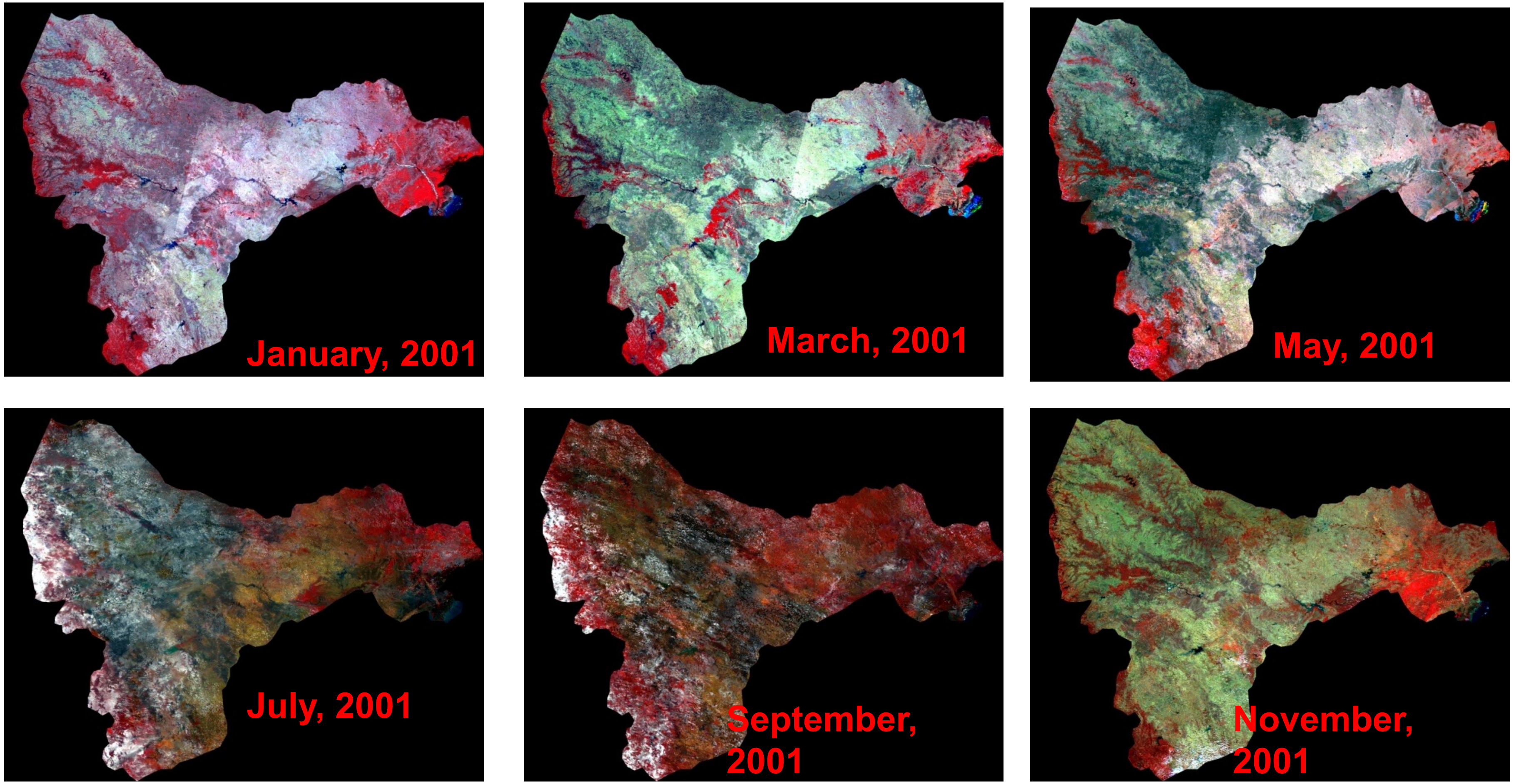
Landsat TM images of the Mississippi River taken during a normal period and during the great flood of 1993



# Land Use/ Land Cover Classification

- Temporal variation in the spectral signature can be estimated
- Presence of features over time can be identified
- Continuous change in the vegetation characteristics can be monitored
  - Used to classify the crop types viz., perennial crops, long or short duration crops

## Land Use/ Land Cover Classification:
## MODIS data product for the Krishna River Basin




**FCC (RGB): 2,1,6 (NIR, red, MIR1) Krishna river basin, India**

# Signal-to-Noise Ratio

- Signal-to-noise ratio (SNR) depends on strength of signal and the noise of the system
  - Signal (say reflectance)
  - Noise from aberrations in the electronics, moving parts or defects in the scanning system
- Higher the SNR → Differentiation of the noise from the actual signals is easier

- Finer spatial, spectral and radiometric resolutions of a system may decrease the SNR to such an extent that the data may not be reliable
  - Higher spectral and spatial resolution reduces the energy (signal strength) → reduces the SNR
  - Finer radiometric resolution →larger number of grey levels
    - If the difference in the energy level between the two levels is less than the noise, reliability of the recorded grey level diminishes.

# Trade-off Between Resolutions

Fine spatial resolution → small IFOV → less energy

- Difficult to detect fine energy differences → Poor radiometric resolution
- Poor spectral resolution

Narrow spectral bands →High spectral resolution → Less energy

- Difficult to detect fine energy differences → Poor radiometric resolution
- Poor spatial resolution

Wide spectral band → Poor spectral resolution→ more reflected energy

- Good spatial resolution
- Good radiometric resolution

These three types of resolutions must be balanced against the desired capabilities and objectives of the sensor

# THANK YOU