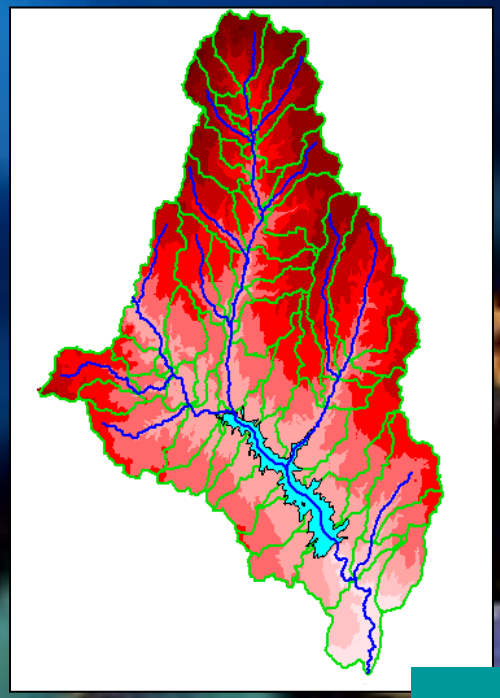
Course Title: Advances in Remote Sensing and GIS

Course Code: ENV-652

Topic: **Introduction to Remote Sensing**



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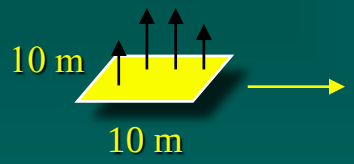
# 1. Remote Sensor Resolution Considerations

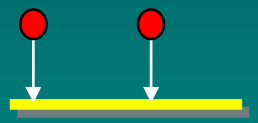
## Resolutions : Meaning

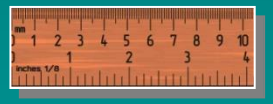
- **Resolution or Resolving Power** is defined as a measure of the ability of an optical system or other sensor to distinguish between signals that are spatially near or spectrally similar.
- Resolutions should be understood by the analyst in order to extract meaningful biophysical or hybrid information from the remotely sensed imagery.
- Following are the 4 types of Resolutions commonly used in Remote Sensing:
    1. Spatial Resolution
    2. Spectral Resolution
    3. Temporal Resolution
    4. Radiometric Resolution

# 1. Remote Sensor Resolution Considerations







8-bit
(0 - 255)
10-bit
(0 - 1023)

- Spatial - the size of the field-of-view, e.g., 10 × 10 m.

- Spectral - the *number* and *size* of spectral regions (or frequencies) the sensor records data in, e.g. blue, green, red, near-infrared, thermal infrared.

- Temporal - how often the sensor acquires data, e.g., every 30 days.

- Radiometric - sensitivity of detectors to small differences in electromagnetic energy.

# Spatial Resolution

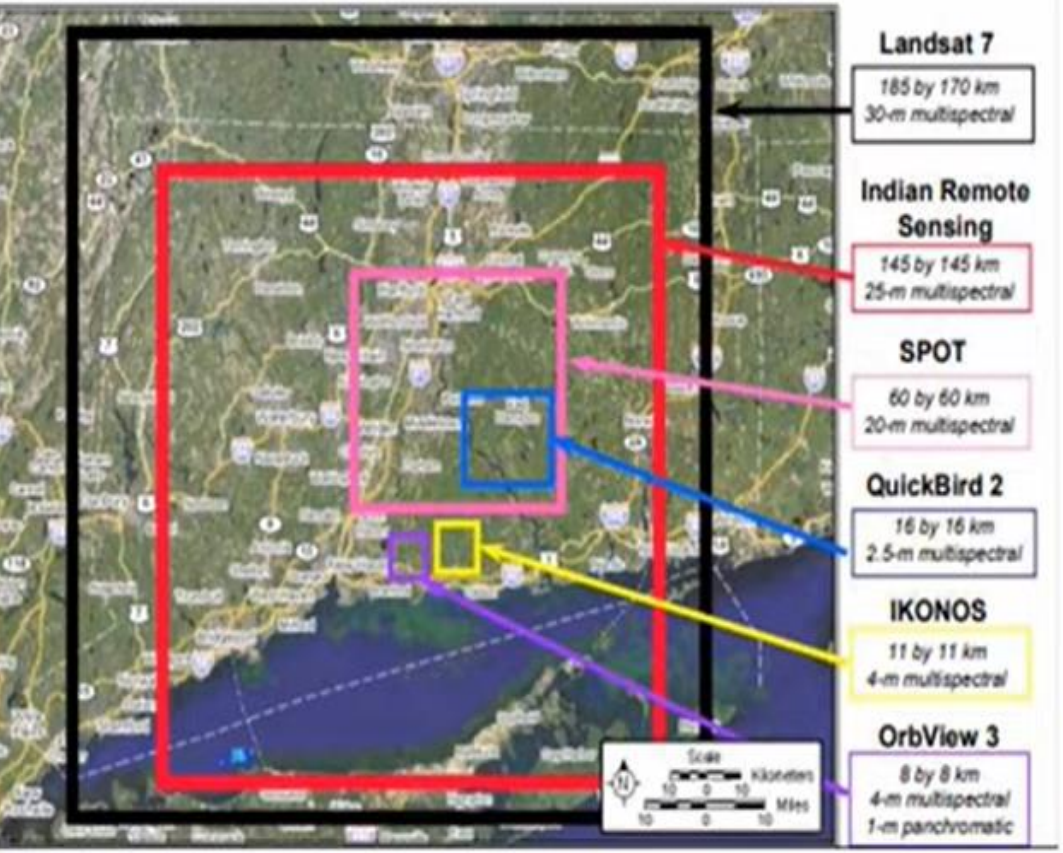
- Spatial Resolution describes how much detail in a photographic image is visible to the human eye.
- The ability to "resolve," or separate, small details is one way of describing what we call spatial resolution.
- Spatial resolution of images acquired by satellite sensor systems is usually expressed in meters.
- **For example**, we often speak of Landsat as having “30- meter" resolution, which means that two objects, thirty meters long or wide, sitting side by side, can be separated (resolved) on a Landsat image.
- In analog imagery (film), the dimension (or width) of the smallest object on the ground that can be distinguished in the imagery defines the spatial resolution.
- The spatial resolution of a raster is determined by sensor characteristics for digital imagery and film characteristics including field of view, altitude for film photography.


Each Landsat 8 pixel is 30m x 30m or 900m$^2$

| 30m Resolution | 15m Resolution | 1m Resolution |
|---|---|---|
|  |  |  |

- The higher the resolution of the image, the more expensive it is to capture, process, and distribute.
- The spatial resolution of sensors varies greatly and is usually inversely related to return time and coverage area. This means that a satellite that acquires daily images generally has a more coarse (larger) spatial resolution.

## Selected Satellite Footprints

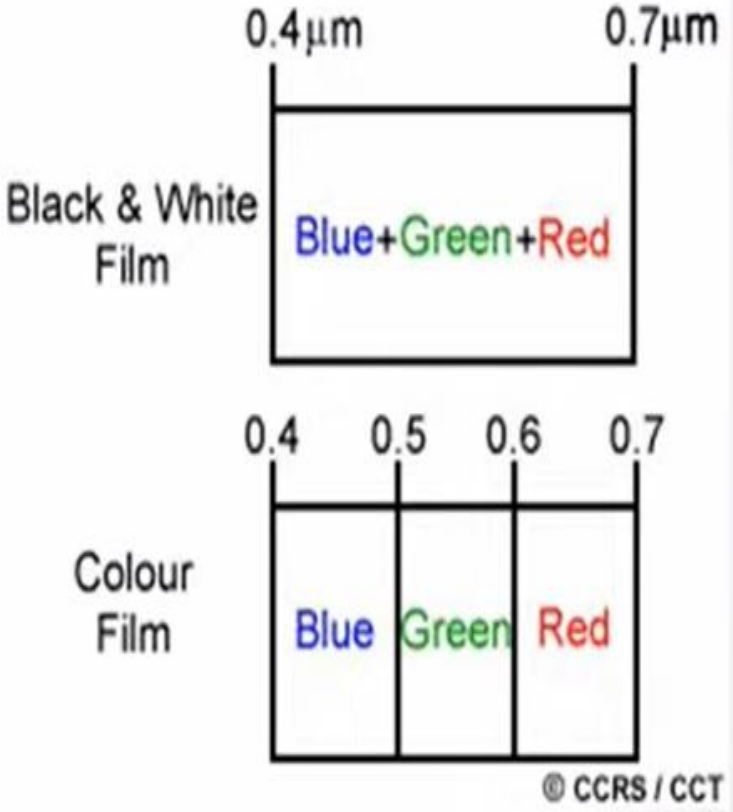



| Sensor | Spatial Resolution |
|---|---|
| MODIS | 250-1000 m |
| Landsat MSS | 60 m |
| Landsat TM, ETM+, OLI | 30 m |
| Sentinel-2 | 10-60 m |
| ASTER | 15 m |
| Digital Globe | 0.3 m (30 cm) |

# Spectral Resolution

- Spectral resolution refers to how many spectral "bands" an instrument records.
- Spectral resolution is also defined by how "wide" each band is or the range of wavelengths covered by a single band.
- Spectral Resolution is determined by: – the number of spectral bands and spectral response function of each band.
- Spectral responses from ground targets are recorded in separate spectral bands by sensors..
- Different classes of features and details in an image can often be distinguished by comparing their responses over distinct wavelength ranges.
- Broad classes, such as water and vegetation, can usually be separated using very broad wavelength ranges - the visible and near infrared. Other more specific classes, such as **different rock types**, may not be easily distinguishable using either of these broad wavelength ranges and would require comparison at much finer wavelength ranges to separate them. Thus, we would require a sensor with higher **spectral resolution**.

- The finer the spectral resolution, the narrower the wavelength range for a particular channel or band.
- Black and white film records wavelengths extending over much, or all of the visible portion of the electromagnetic spectrum. Its **spectral resolution** is fairly coarse, as the various wavelengths of the visible spectrum are not individually distinguished and the overall reflectance in the entire visible portion is recorded.
- Color film is also sensitive to the reflected energy over the visible portion of the spectrum, but has higher spectral resolution, as it is individually sensitive to the reflected energy at the blue, green, and red wavelengths of the spectrum. Thus, it can represent features of various colors based on their reflectance in each of these distinct wavelength ranges.



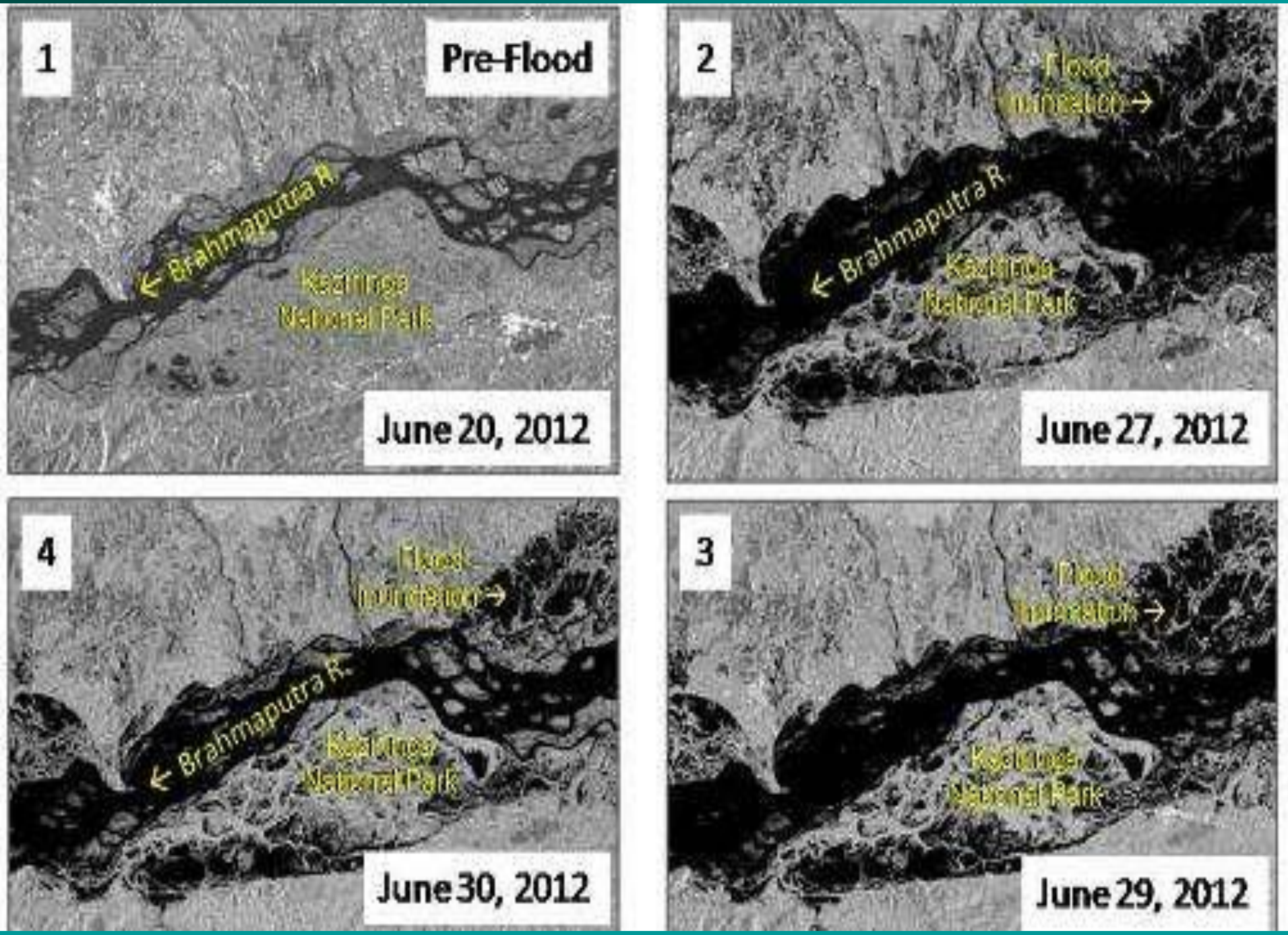
# Temporal Resolution

- Temporal resolution is the time between two subsequent data acquisitions for an area. This is also known as the “return time” or "revisit time“.
- The temporal resolution depends primarily on the **platform**, for example, satellites usually have set return times and while sensors mounted on aircraft or unmanned aircraft systems ( UAS ), have variable return times.
- For satellites, the return time depends on the **orbital characteristics** (low vs high orbit), the **swath width** and whether or not there is an ability to **point** the sensor.
- Landsat has a return time of approximately 16 days, while other sensors like MODIS have nearly daily return times.

Repeat Coverage Considerations

- Revisit period for satellites – how often can you make a measurement for the same area
  - Landsat – 16 days (continuous collection)
  - Quickbird – varies (point-and-shoot)
  - MODIS – daily (continuous collection)

- Airborne images – collected as needed


1
Pre-Flood
Brahmaputra R.
June 20, 2012
2
Brahmaputra R.
June 27, 2012
4
Brahmaputra R.
June 30, 2012
3
June 29, 2012

# Radiometric Resolution

- Radiometric resolution is how finely a satellite or sensor divides up the radiance it receives in each band.
- Or, Radiometric Resolution is the measure of a Sensor's ability to discriminate small differences in the magnitude of radiation within the ground area that corresponds to a single raster cell.
- Or, Every time an image is acquired by a sensor, its sensitivity to the magnitude of the electromagnetic energy determines the radiometric resolution.
- The greater the bit depth(number of data bits per pixels) of the images, that the sensor records, the higher will be the Radiometric Resolution.
- The greater the radiometric resolution the greater the range of intensities of radiation the sensor is able to distinguish and record.

# Radiometric Resolution

| 8 bit Resolution | 2 bit Resolution | 1 bit Resolution |
| --- | --- | --- |
| $2^8 = 256$ levels | $2^2 = 4$ levels | $2^1 = 2$ levels |
|  |  |  |

# Resolutions of Remote Sensing : Summary

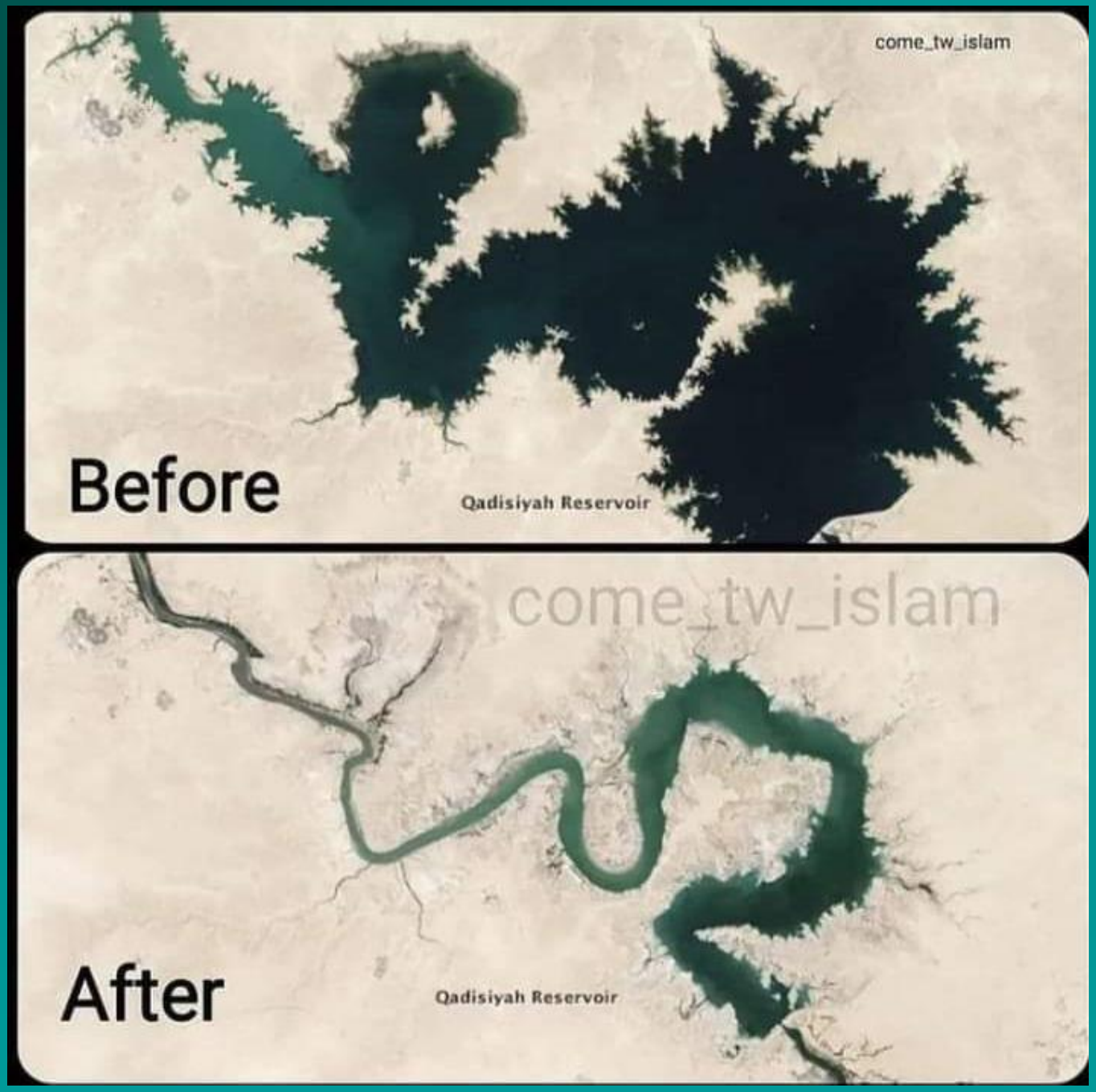
1. Spatial :(what area and how detailed)
2. Spectral : (what colors – bands)
3. Temporal : (time of day/season/year)
4. Radiometric : (color depth)

# Remote sensing data analysis

The analysis of remotely sensed data is performed using a variety of image processing techniques, including:

- analog (visual) image processing, and
- digital image processing.

Analog and digital analysis of remotely sensed data seeks to detect and identify important phenomena in the scene. Once identified, the phenomena are usually measured, and the information is used in solving problems. Finest results are often achieved using a collaborative combination of both visual and digital image processing.


come_tw_islam
Before
Qadisiyah Reservoir
come_tw_islam
After
Qadisiyah Reservoir


Google Earth
Imagery Date: 5/12/2021 lat 39.535988° lon -121.332253° elev 0 ft eye alt 3671 ft


Lake Oroville
Your-Mentioned Location
Google Earth
Imagery Date: 5/3/2021 lat 39.548277° lon -121.492330° elev 0 ft eye alt 12.58 mi

# 2. Advantages of Remote Sensing

- Provides a regional view (large areas)
- Provides repetitive looks at the same area
- Remote sensors "see" over a broader portion of the spectrum than the human eye
- Sensors can focus in on a very specific bandwidth in an image or several bandwidths simultaneously
- Provides geo-referenced, digital, data
- Some remote sensors operate in all seasons, at night, and in bad weather

# 3. Limitations of Remote Sensing

- Atmospheric conditions can distort the data, limiting the quality of the images obtained.
- Remote sensing is not a solution to all problems.
- Due to their restricted spatial resolution, remote sensing systems encounter limitations in discriminating fine details.
- Limited revisit times in some remote sensing systems hinder the monitoring of dynamic processes or rapid changes over time.
- Acquiring and operating remote sensing platforms can be expensive, limiting access for some researchers or organizations.

# 4. Remote Sensing Applications

- Land-use mapping
- Forest and agriculture applications
- Environmental applications
- Hydrology and coastal mapping
- Urban planning
- Emergencies and Hazards
- Global change and Meteorology