

Lesson 4

- **Resolution in Remote Sensing**

We have Learnt:

- **Definition of Remote sensing**
- **Planck's law of radiation**
- **Peak emitted wavelength from sun and earth .**
- **Electromagnetic radiation or wave**
- **Advantages of remote sensing**
- **Classification of Remote sensing: Based on spectral region and based on technique**
- **Spectral Signature of vegetation, water and soil**
- **Panchromatic/multispectral/ Hyper spectral remote sensing**

Resolution in Remote sensing

- Ability to distinguish smallest feature in remote sensing image

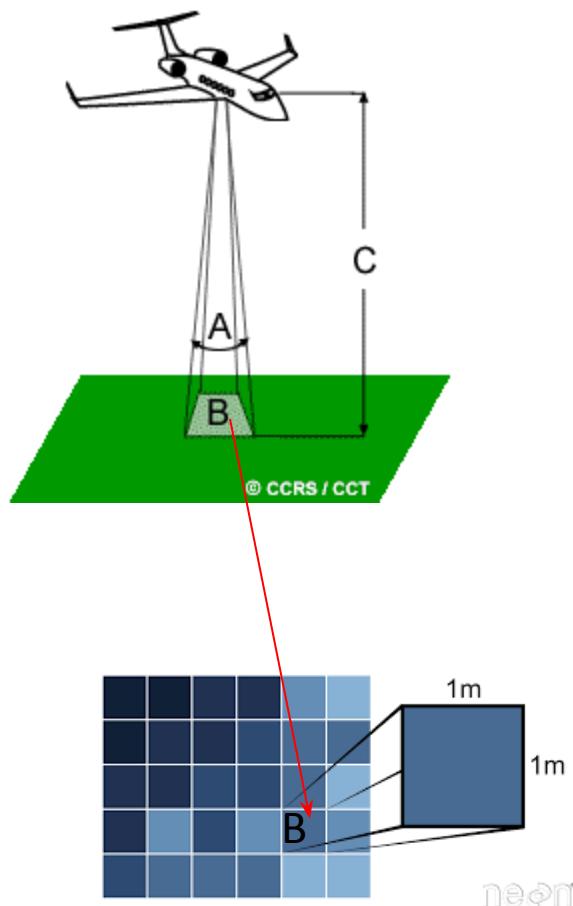
Human eyes? .02 mm

DETECTION OF FEATURES depends: RESOLUTION

THERE ARE FOUR RESOLUTIONS IN REMOTE SENSING

- **Spatial resolution (what details)**
- **Spectral resolution (What colour and band)**
- **Radiometric resolution (no. of bits)**
- **Temporal resolution (Time interval between successive observations)**

Spatial resolution and coverage



- Spatial resolution
 - Instantaneous field-of-view (IFOV)
 - Pixel: smallest unit of an image
 - Pixel size

- Spatial coverage
 - Field of view (FOV), or
 - Area of coverage or **swath**

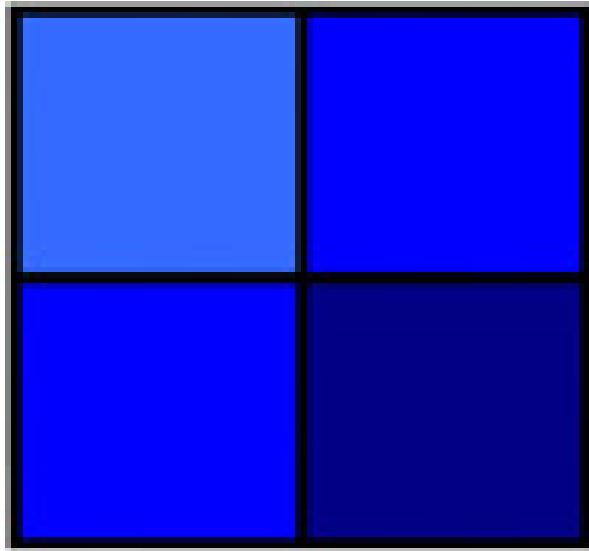
In practice, objects 0.04mm wide (the width of a fine human hair) are just distinguishable by good eyes, objects 0.02mm wide are not.

Pixel size ranges from 1.1 microns in the smallest smartphone sensor, to 8.4 microns in a Full-Frame sensor.

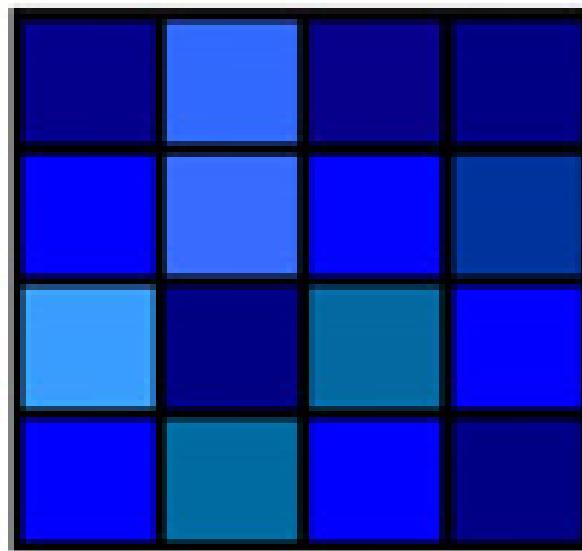
Spatial resolution

- Spatial: pixel size; The size of the smallest possible feature that can be detected.
- In a digital image, the resolution is limited by the pixel size, i.e. the smallest resolvable object cannot be smaller than the pixel size.
- **Fine or high resolution** image refers to one with a small resolution size. Fine details can be seen in a high resolution image.
- **Coarse or low resolution** image is one with a large resolution size, i.e. only coarse features can be observed in the image.
- **Aerial photo has higher resolution**
- The image resolution and pixel size are not equivalent.

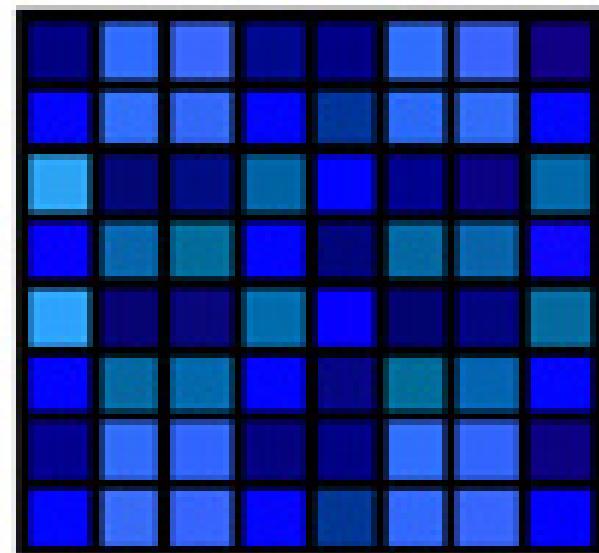
Pixel Size (Spatial Resolution)



Low
Resolution



Medium
Resolution



High
Resolution



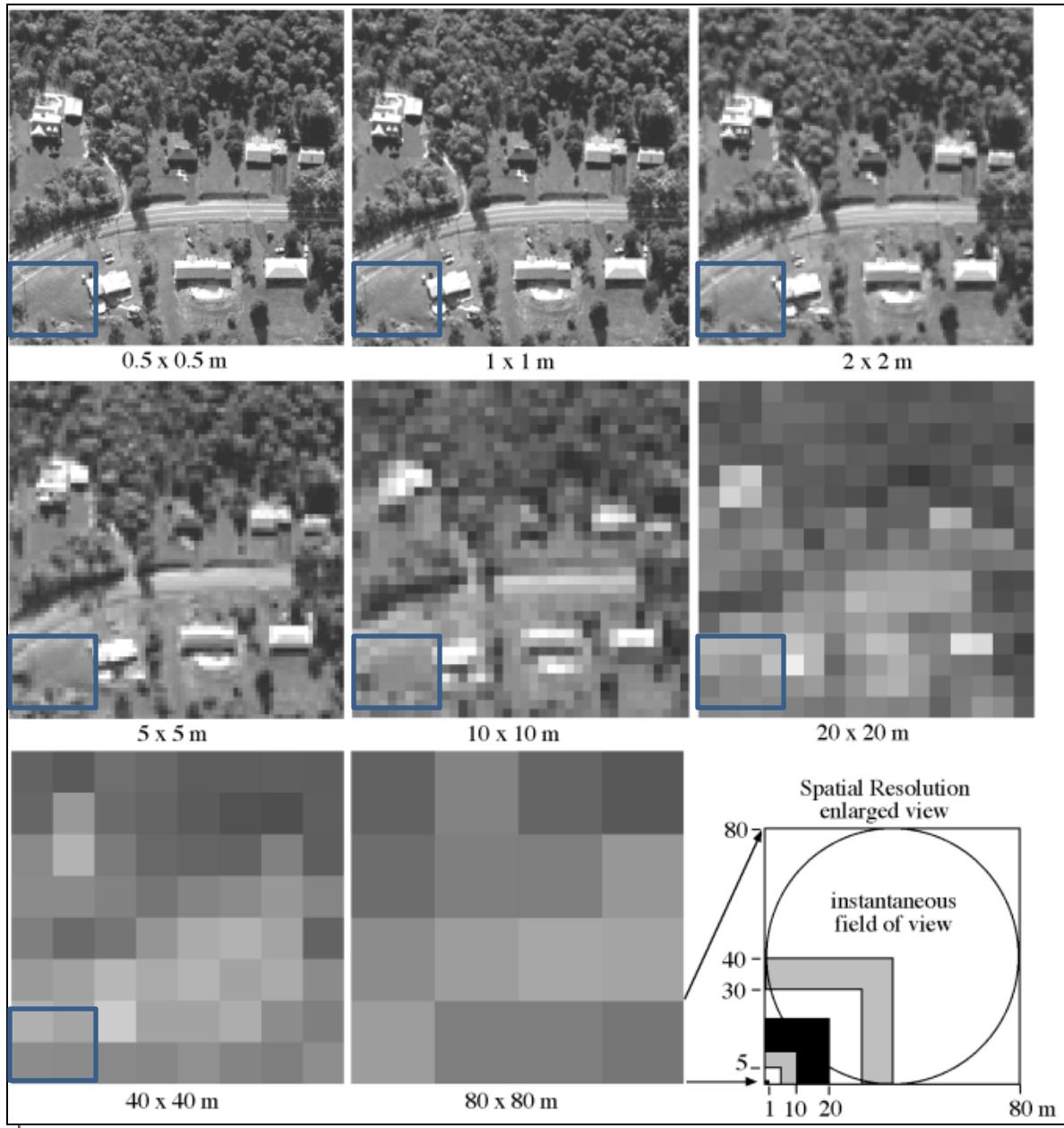
**High Spatial
Resolution**



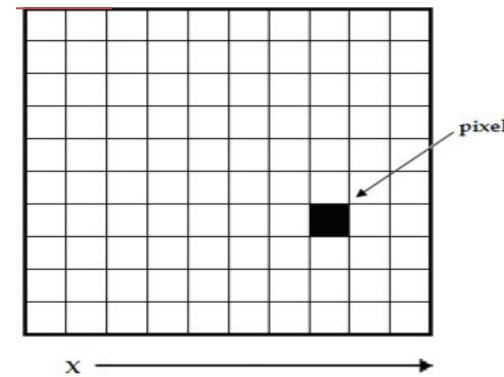
**Medium Spatial
Resolution**



**Low Spatial
Resolution**



Spatial Resolution



29 microns.
= .003 mm

Jensen, 2000

Object identification depending upon pixel size



original image

1m pixel



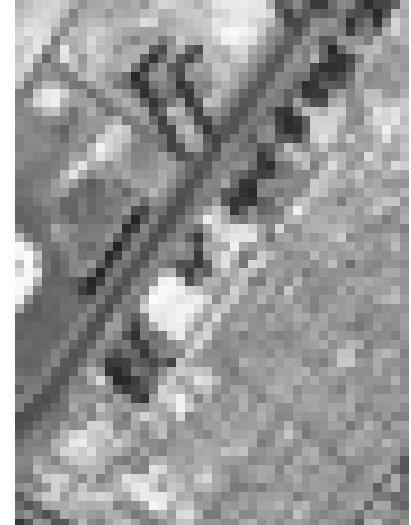
2m pixel



5m pixel

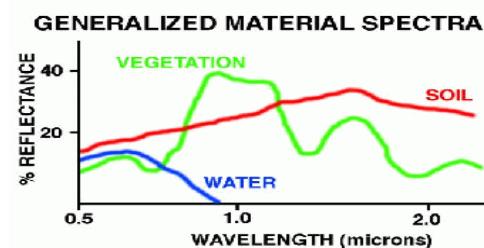
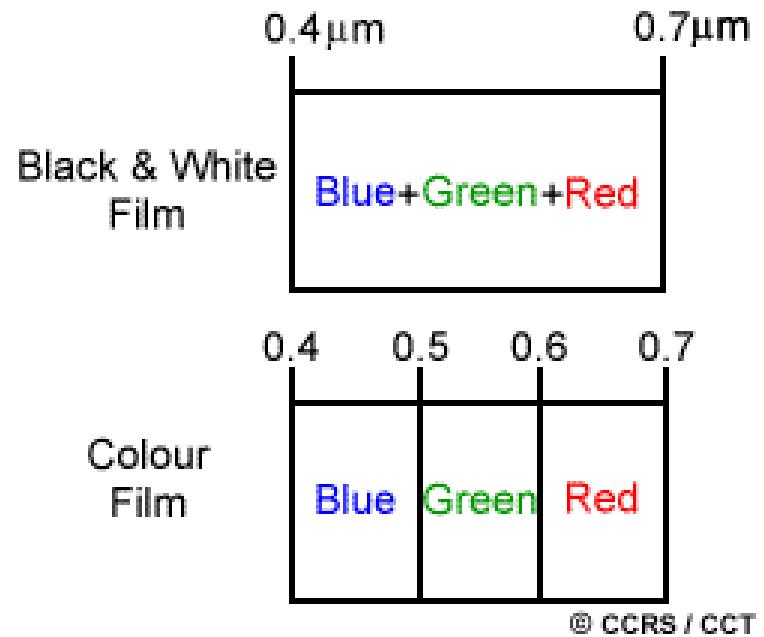


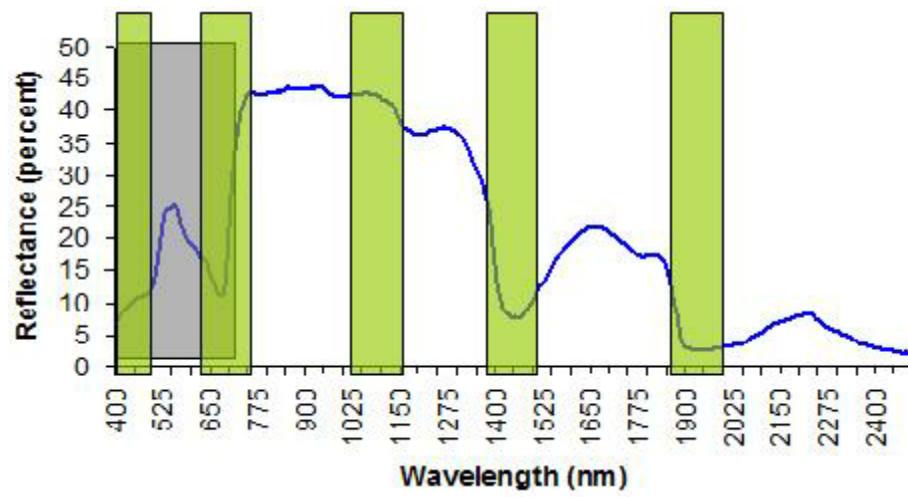
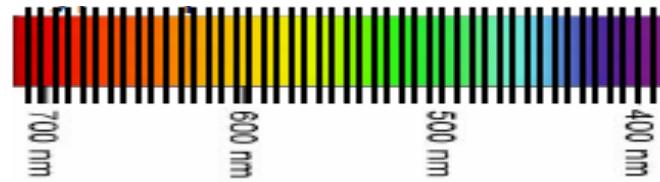
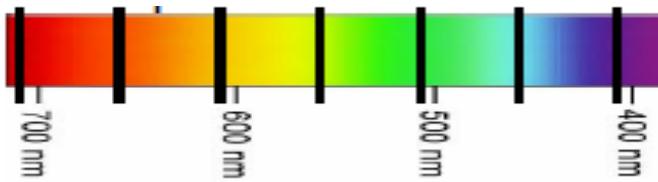
30m pixel ?



Spectral resolution ($\Delta\lambda$) and coverage (λ_{\min} to λ_{\max})

- Spectral resolution describes the ability of a **sensor to define fine wavelength intervals**
- The finer the spectral resolution, the narrower the wavelength range for a particular channel or band

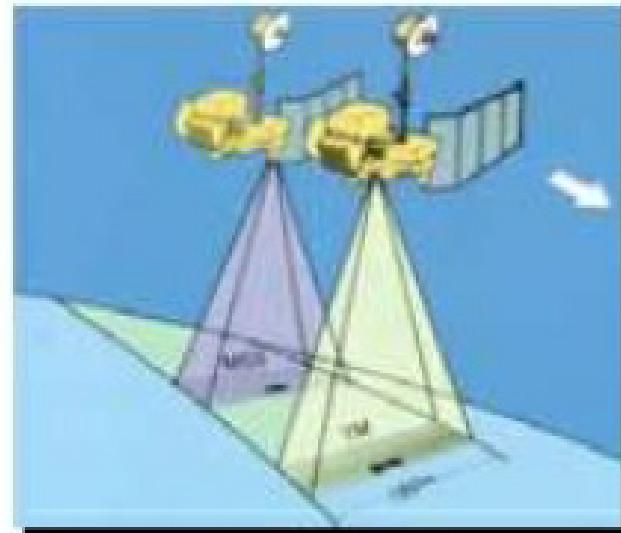




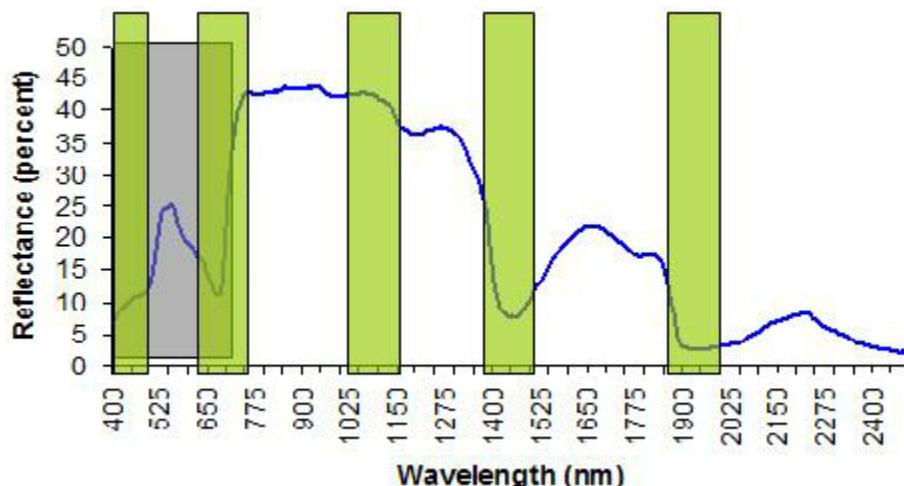
A sensor with **higher spectral resolution** is required for detailed distinction.

Spectral resolution describes the ability of a sensor to **define fine wavelength intervals**.

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

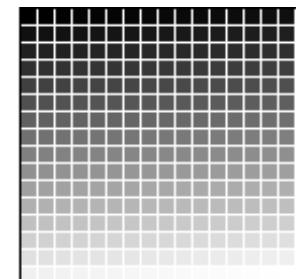


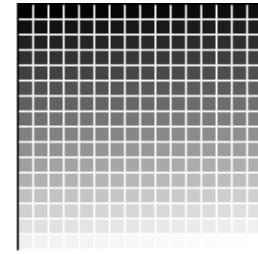
Landsat/TM 5



Radiometric resolution and coverage

- Sensor's sensitivity to the magnitude of the electromagnetic energy,
- **Sensor's ability to discriminate very slight differences in (reflected or emitted) energy,**
- The finer the radiometric resolution of a sensor, the more sensitive it is to detecting small differences in energy





What is GREYSCALE/ GREYLEVEL?

Grayscale is a range of shades of gray without apparent color. The darkest possible shade is black, which is the total absence of transmitted or reflected light.

The lightest possible shade is white, the total transmission or reflection of light at all visible [wavelength](#)s. Intermediate shades of gray are represented by equal [brightness](#) levels of the three primary colors (red, green and blue) for transmitted light, or equal amounts of the three primary pigments (cyan, magenta and yellow) for reflected light.

Gray level resolution refers to the predictable or deterministic change in the shades or levels of gray in an image.

Leaf

Dark Forest

Pine

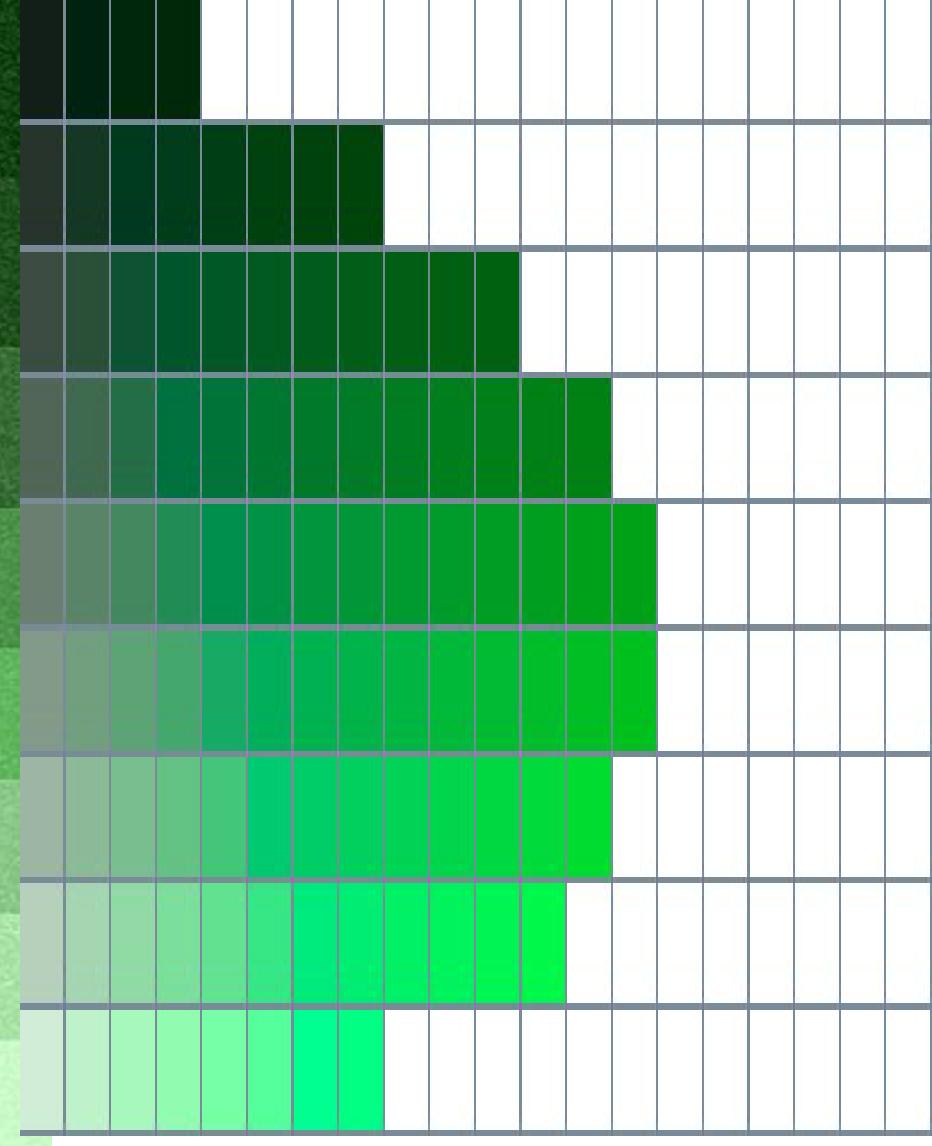
Ivy

Shamrock

Lettuce

Celery

Key Lime



A healthy human eye has three types of cone cells, each of which can register about **100 different colour shades**.

1Bit

$$2^1 = 2 \text{ (0-1)}$$



4Bit

$$2^4 = 16 \text{ (0-15)}$$



8Bit

$$2^8 = 256 \text{ (0-255)}$$



The radiometric resolution of image data in remote sensing stands for **the ability of the sensor to distinguish different grey-scale values**. It is measured in **bit**. The more bit an image has, the more grey-scale values can be stored, and, thus, more differences in the reflection on the land surfaces can be spotted.

Range of numbers that sensor uses for recording reflected light => Quantisation level

Basics of Bit

- Computer store everything in 0 or 1

Bit no.	7	6	5	4	3	2	1	0
0	0	0	0	0	0	0	0	0
25	1	1	1	1	1	1	1	1

8 bits as an example

bits	Max. num. (2^{bits})
1	2
2	4
3	8
6	64
8	256
11	2048
12	4096

Resolution: 12 bits
Coverage: 0 - 4095

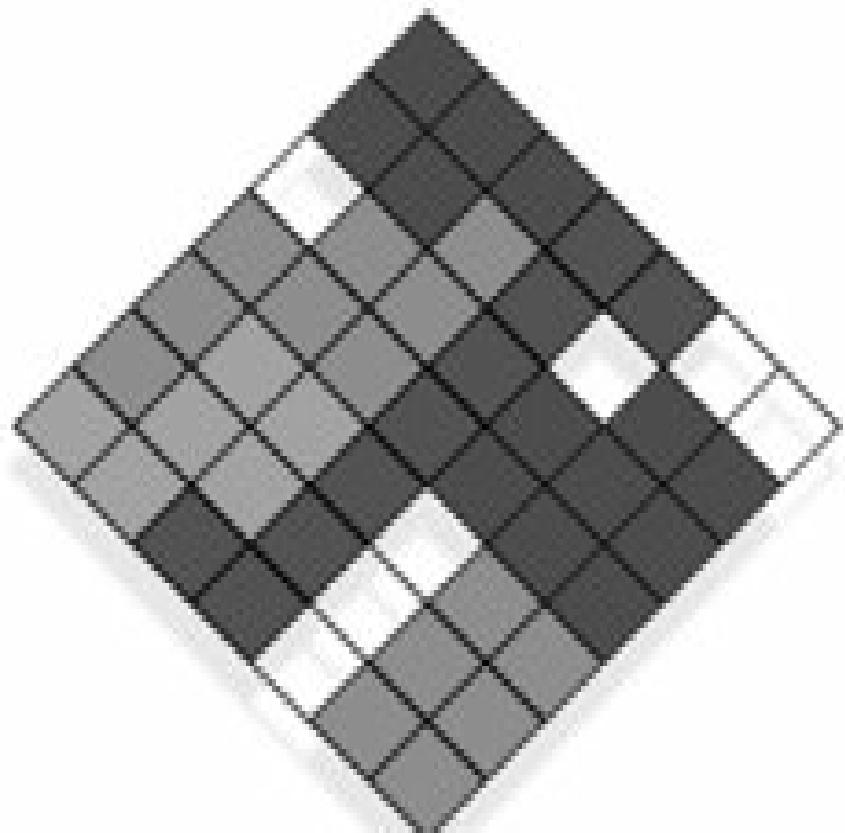
8-bit = 256 Grayscale

Pixel-values:

0 = black, 255 = white

140	235	200	20	33
40	130	85	75	12
105	85	30	10	100
85	10	10	10	10
85	10	10	10	10

Grayscale raster image



Bit Depth and Gray Levels in Digital Images

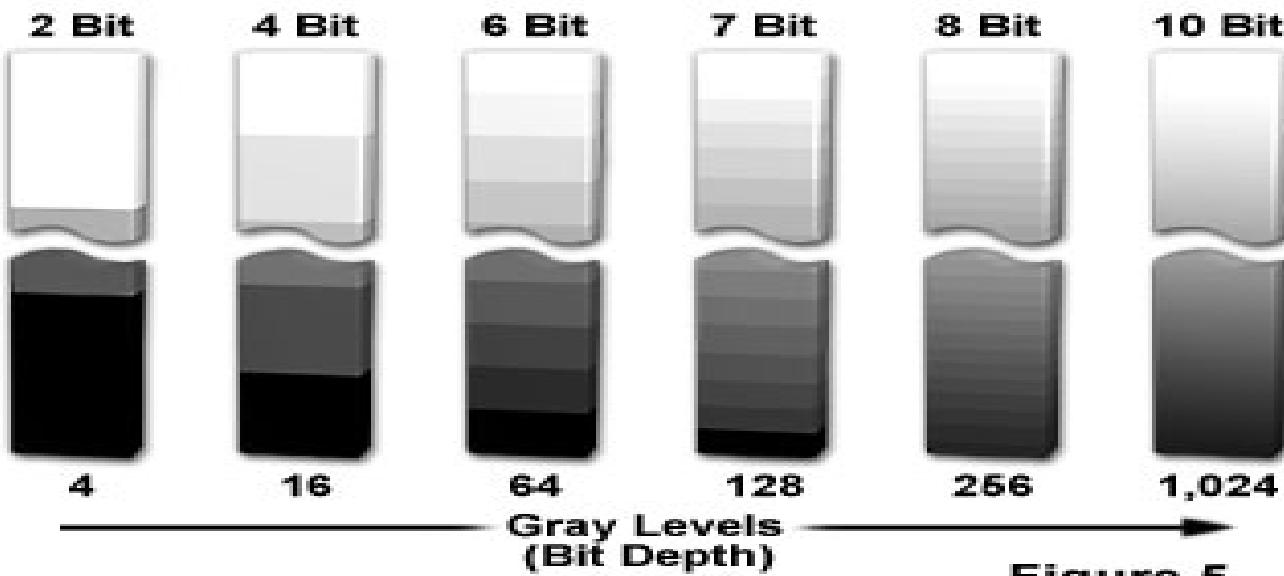


Figure 5

Grayscale Resolution and Digital Image Appearance

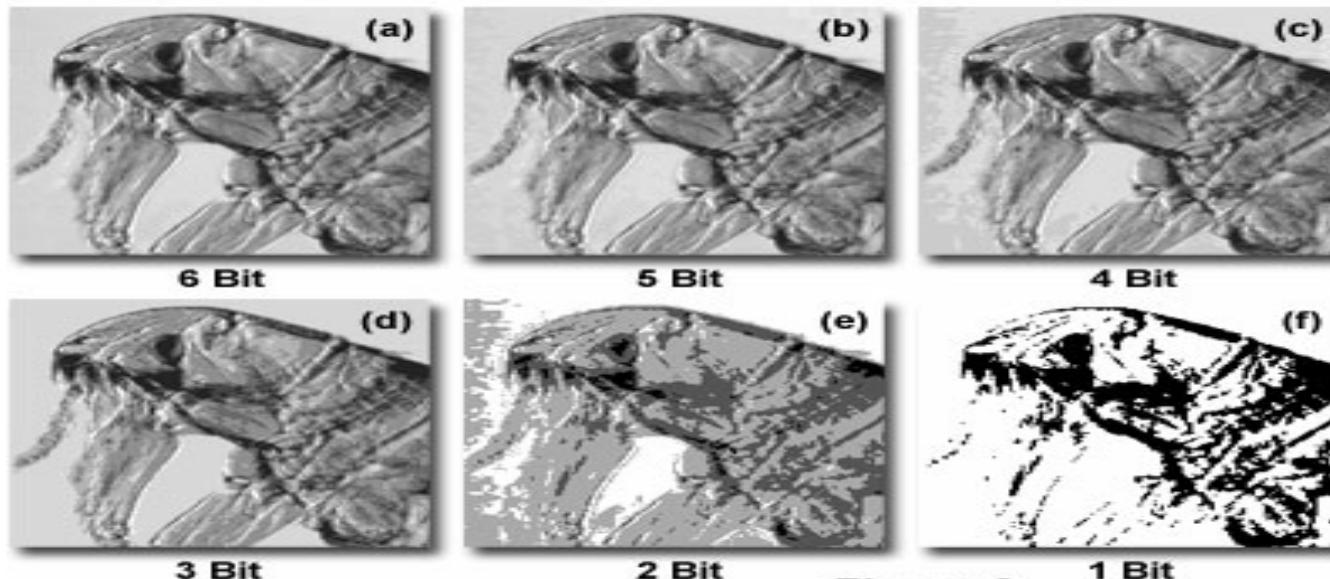


Figure 6



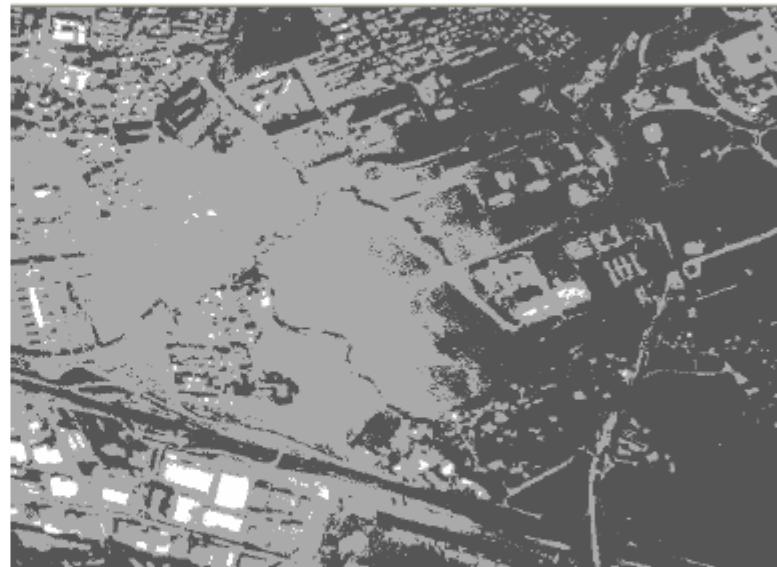
Comparing a 2-bit image with an 8-bit image

Radiometric Resolution

The **radiometric resolution** of an imaging system describes its ability to discriminate very slight differences in energy



Tor Vergata Campus 8 bit



Tor Vergata Campus 2 bit

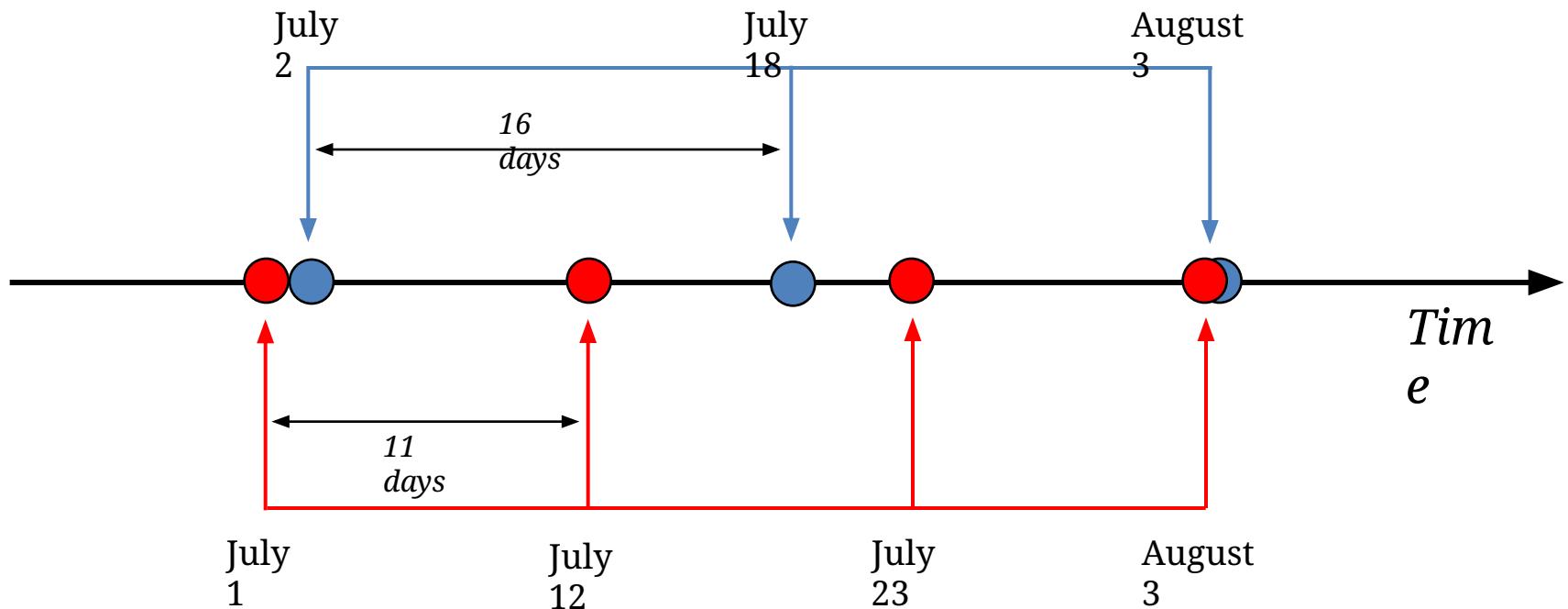
8 bit From 0 to 255 values of radiances

2 bit From 0 to 3 values of radiances

Temporal resolution and coverage

- Temporal resolution is the revisit period, and is the length of time for a satellite to complete one entire orbit cycle, i.e. start and back to the exact same area at the same viewing angle. For example, Landsat needs 16 days, MODIS needs one day,.
- Temporal coverage is the time period of sensor from starting to ending.

Temporal Resolution



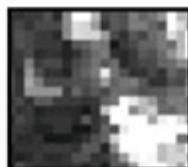
4 Resolutions of Remote Sensing

- Spatial:
 - X and Y resolution
- Spectral:
 - Number of bands
- Temporal:
 - Number of samples per time unit
- Radiometric:
 - Number of bits or bytes per sample

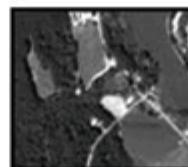


SUMMARY

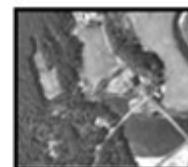
Spatial resolution
(pixel size)



Landsat 30m

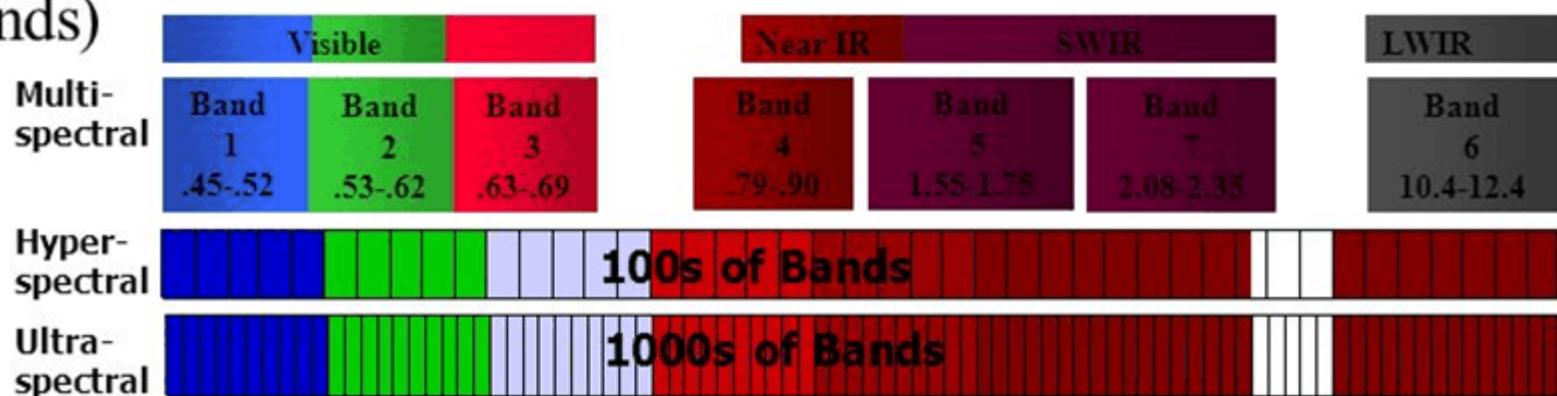


IKONOS 4m



Orthophoto 0.5m

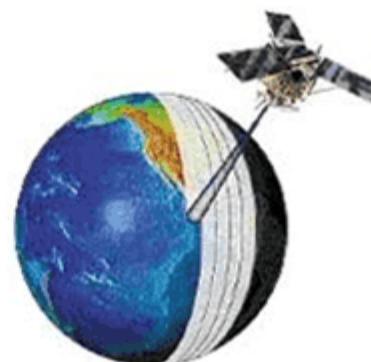
Spectral resolution
(# bands)



Radiometric resolution – bit depth



Temporal resolution – orbital period
(return rate)



Question bank

Explain:

- Spectral resolution
- Spatial resolution
- Radiometric resolution
- Temporal Resolution