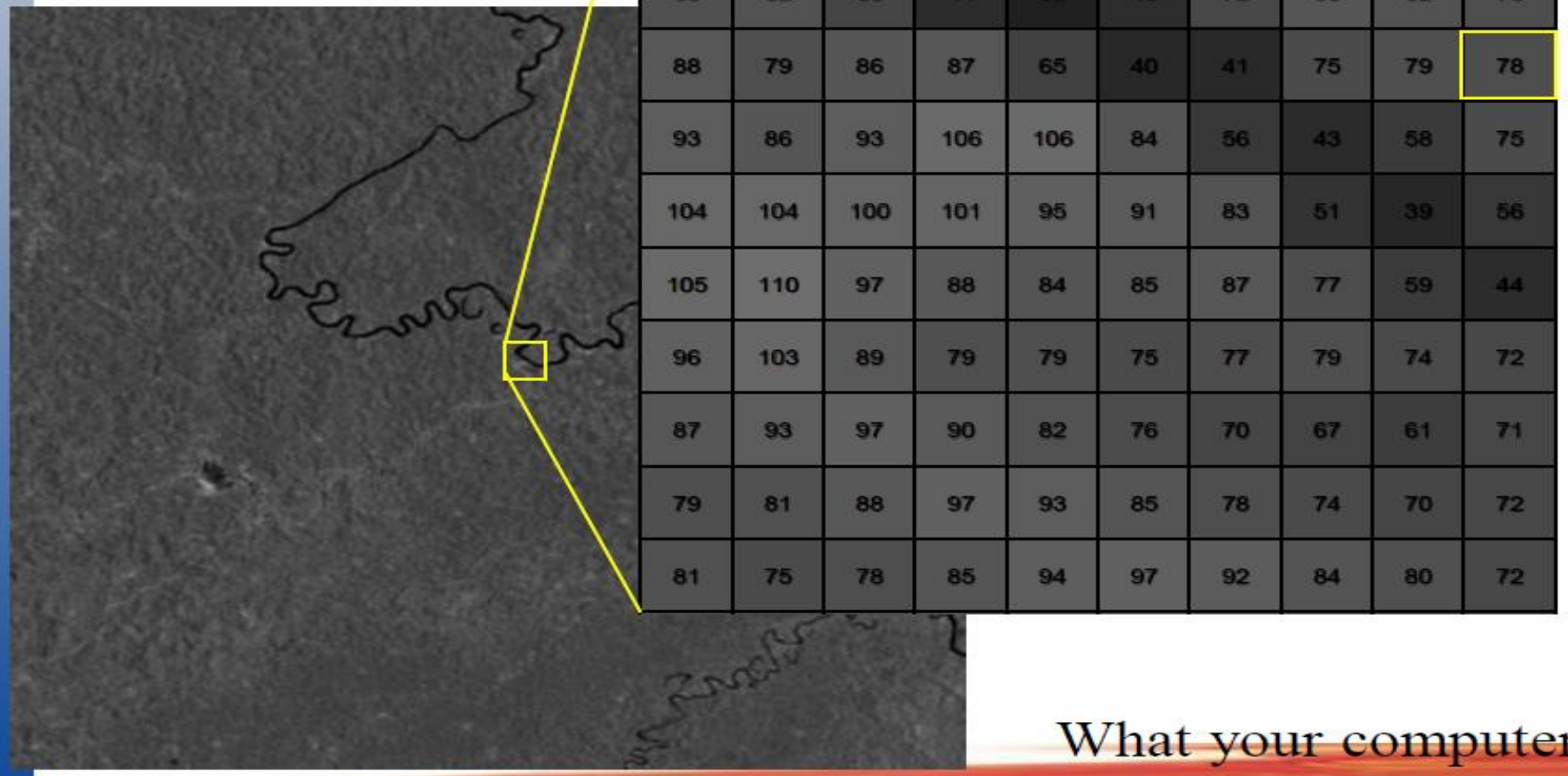
Concept of Resolutions in Remote Sensing

What is a digital image?

- Grid cells or pixels
- Each pixel has a digital number (DN) which represents:

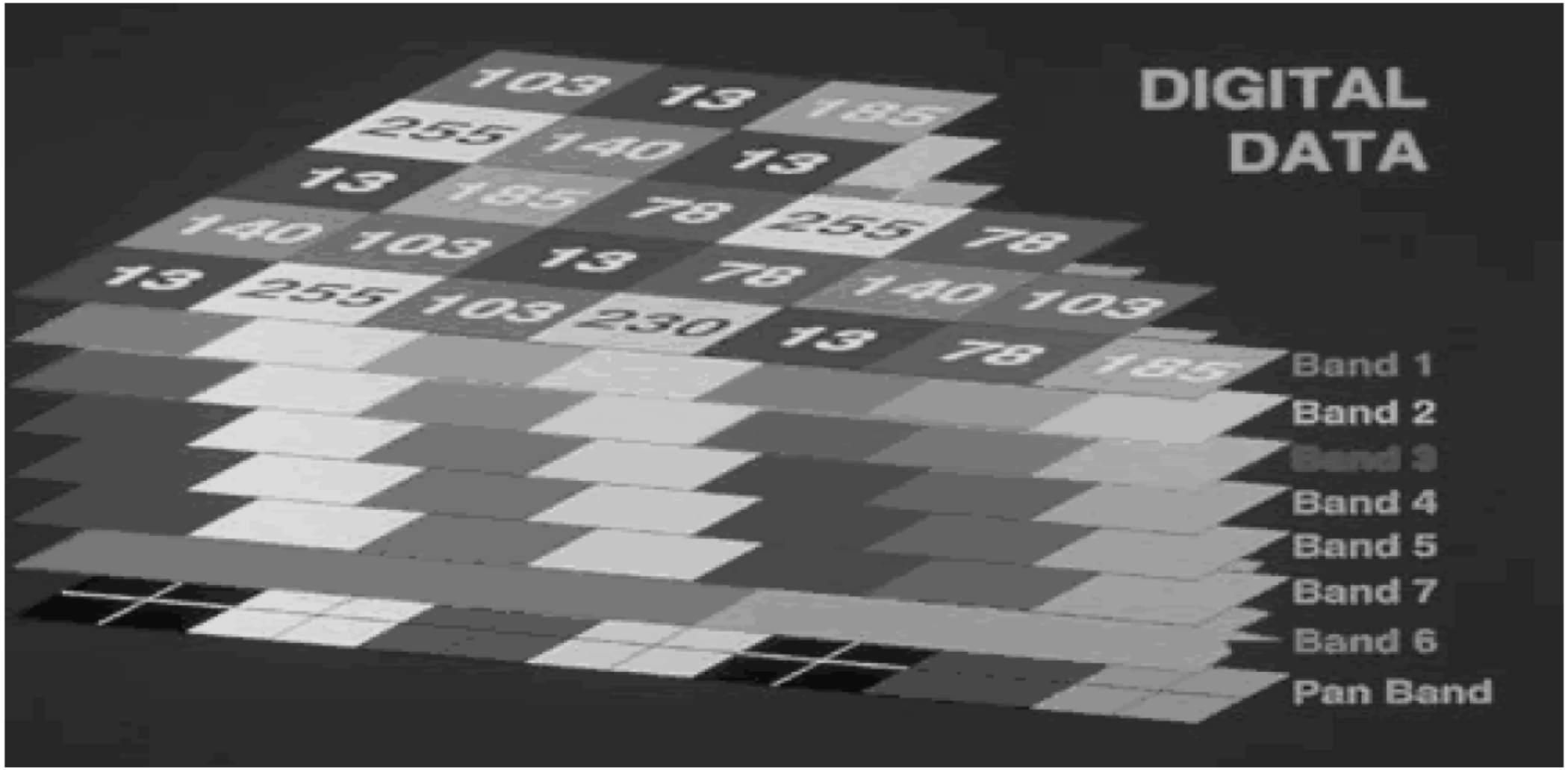
Spectral Reflectance Value



70	53	41	64	84	85	81	88	91	87
79	77	45	38	59	77	84	86	85	85
80	82	69	44	32	45	72	86	82	78
88	79	86	87	65	40	41	75	79	78
93	86	93	106	106	84	56	43	58	75
104	104	100	101	95	91	83	51	39	56
105	110	97	88	84	85	87	77	59	44
96	103	89	79	79	75	77	79	74	72
87	93	97	90	82	76	70	67	61	71
79	81	88	97	93	85	78	74	70	72
81	75	78	85	94	97	92	84	80	72

Digital Number (DN)

What your computer sees…



The amount of the reflected energy (intensity) is recorded for each pixel, in each band.

Resolution

Ability of the system to render the information at the **smallest discretely separable quantity** in terms of wavelength band of EMR (spectral), distance (spatial), time (temporal) and radiation (radiometric)

The Four Resolutions of Remote Sensing

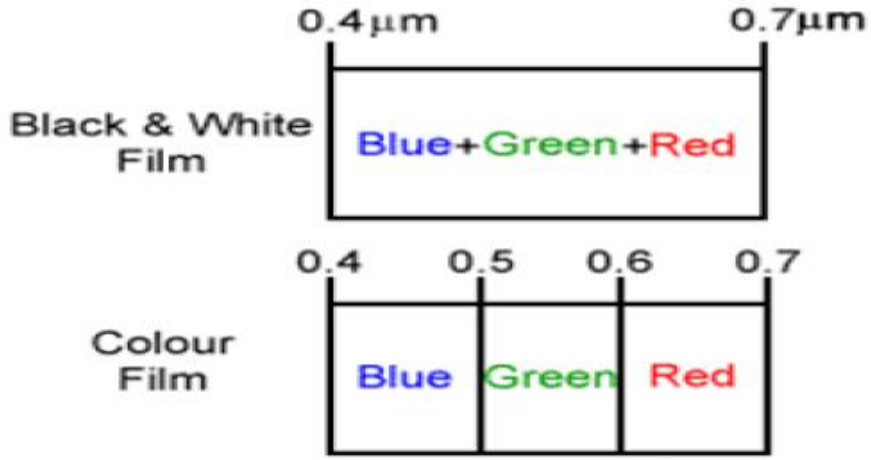
- Spectral
- Spatial
- Temporal
- Radiometric

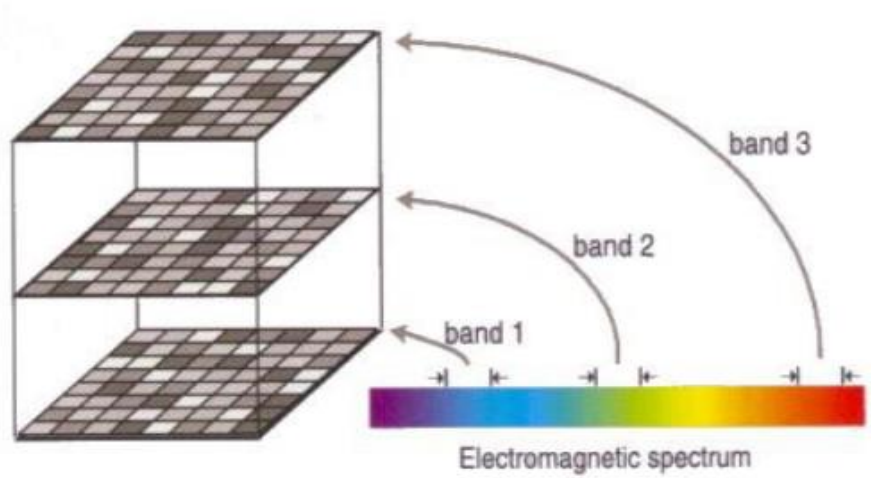
Spectral Resolution

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

•This refers to the **number of bands in the spectrum** in which the instrument can take measurements.

•Higher spectral resolution = better ability to exploit **differences in spectral signatures**





- **panchromatic**
- **multispectral**
- **hyperspectral**

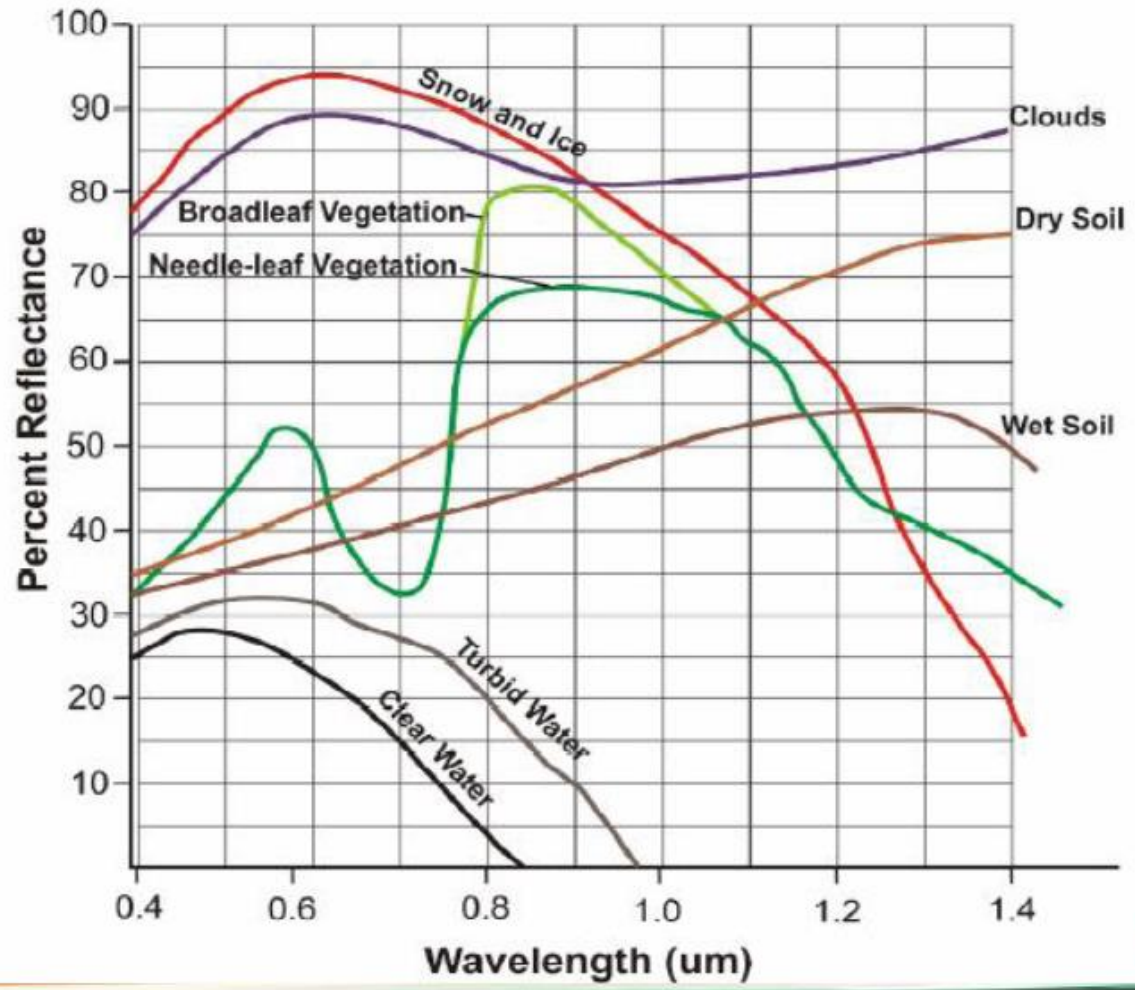
Optical Remote Sensing

Optical record energy in the visible/IR portion of the electromagnetic radiation

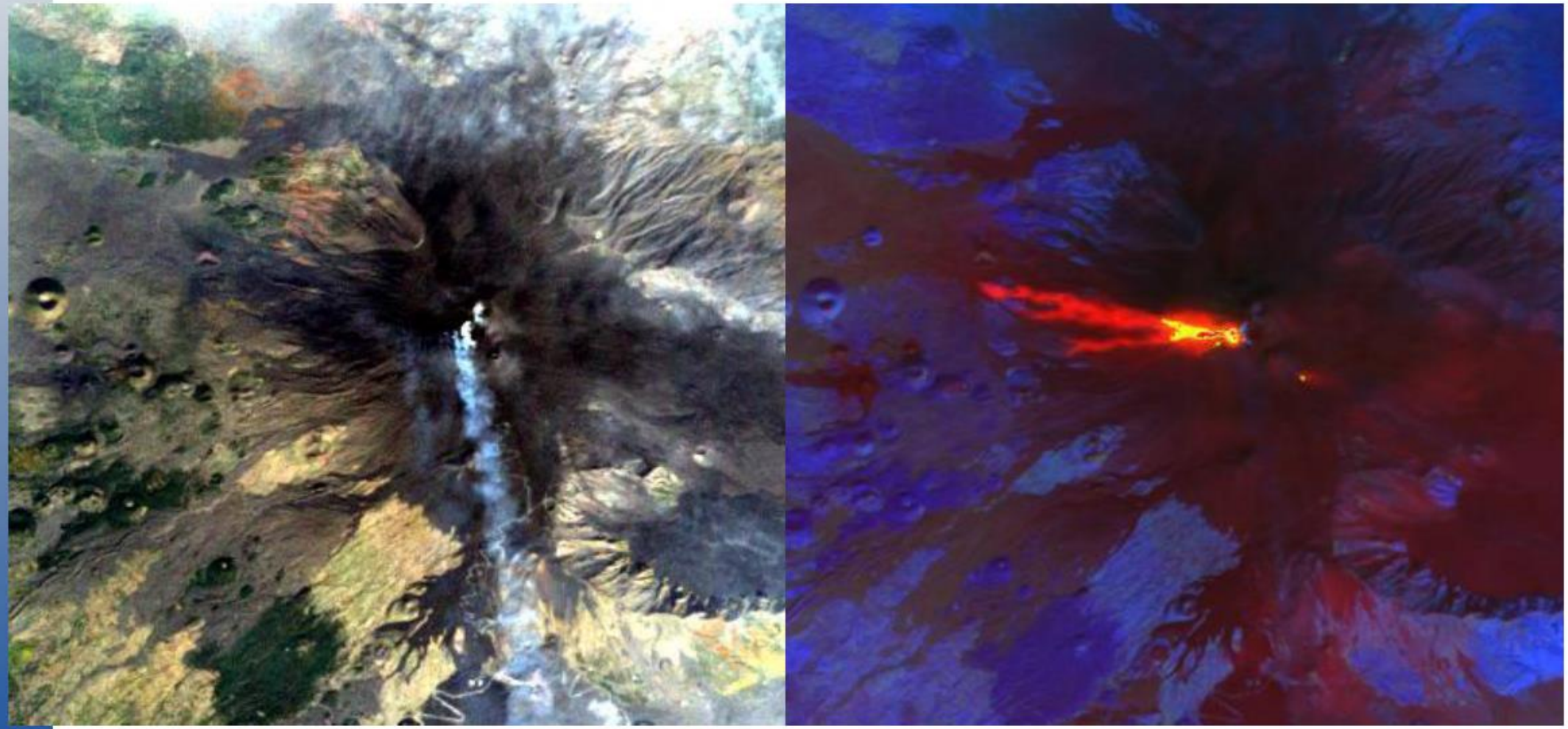
Energy recorded in bands: multi/hyper spectral

Spectral signature: How features reflects/absorbs radiation per wavelengths.

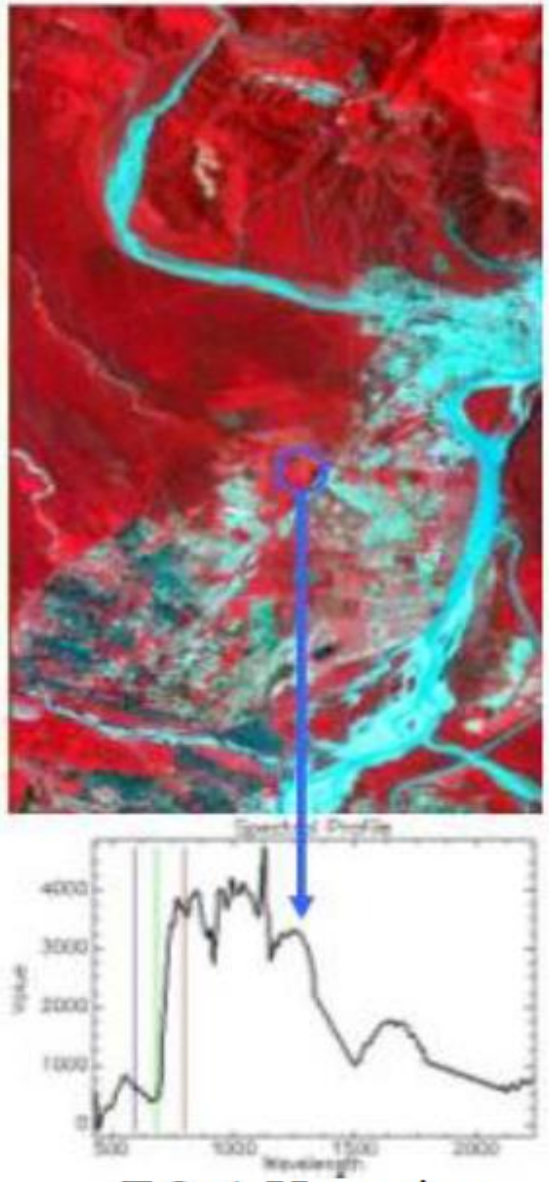
Spectral Signature of different Land cover Features



So we see more than we could otherwise.

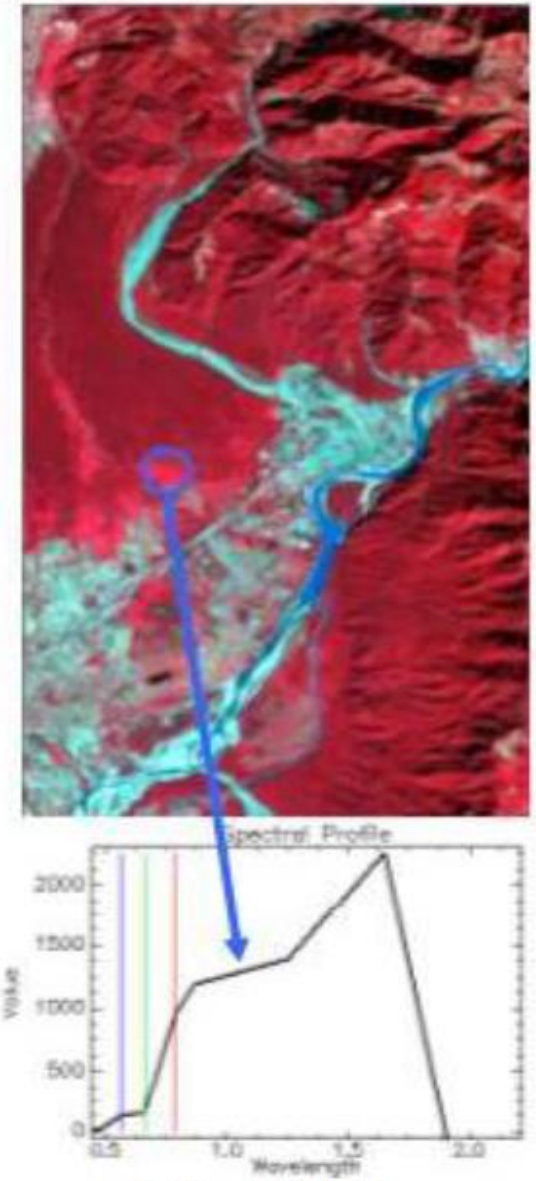


Spectral bands Vs spectral signature



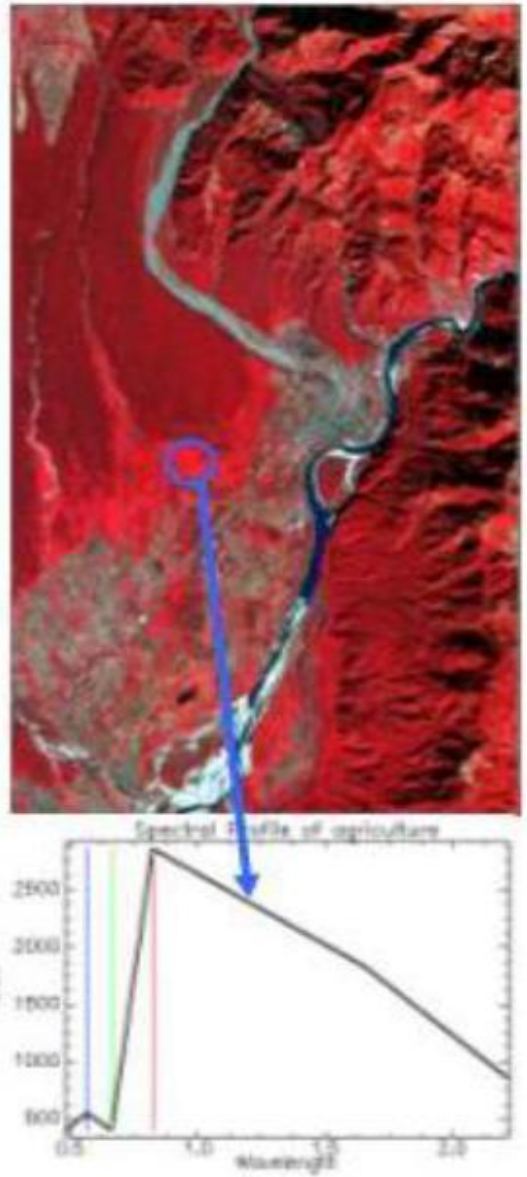
EO-1 Hyperion

Bands-140



EO-1 ALI

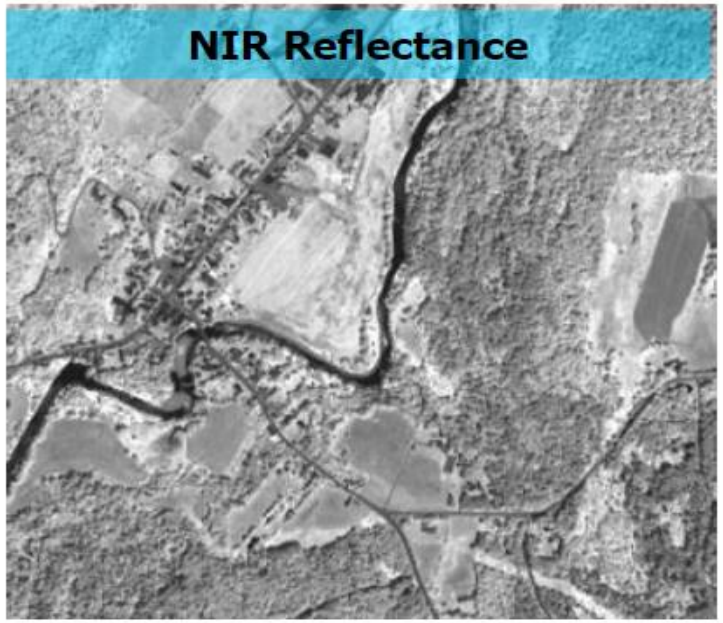
Bands-9

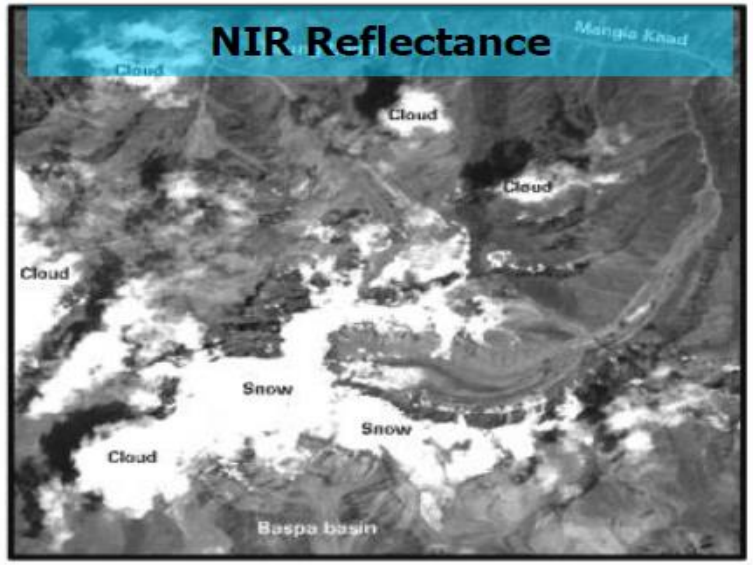


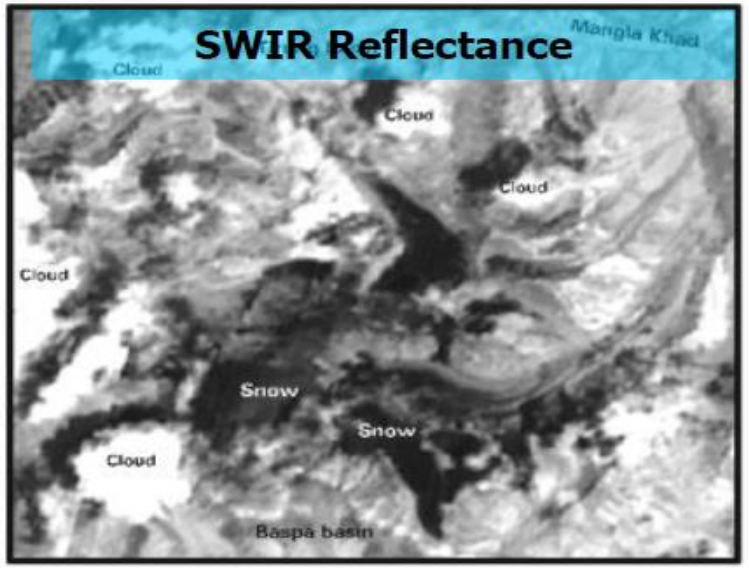
Landsat-7 ETM+

Bands-6

Reflectance differs by wavelength

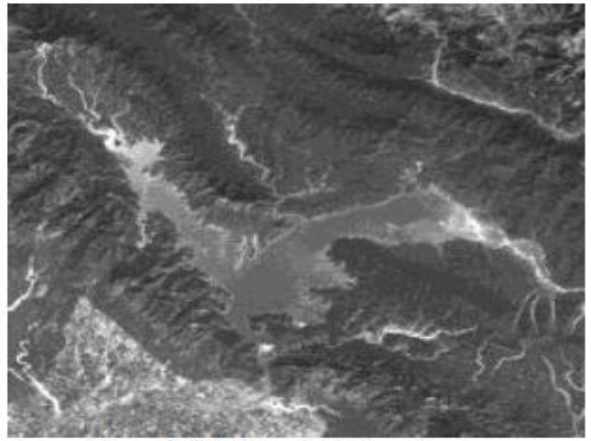




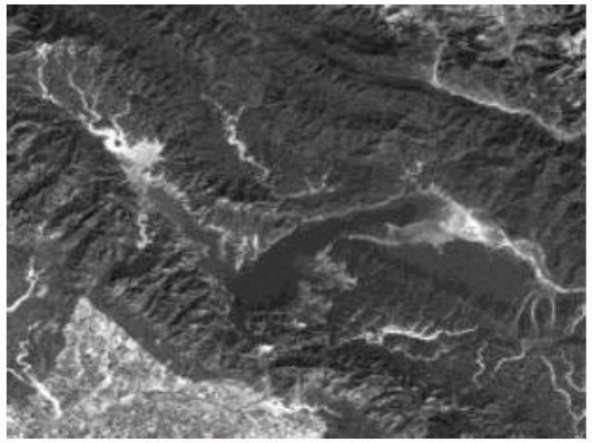


IRS LISS-3 Both cloud and snow have higher reflectance in visible and hence cannot be discriminated (except from shadow). In SWIR, low reflectance of snow can discriminate snow from cloud.

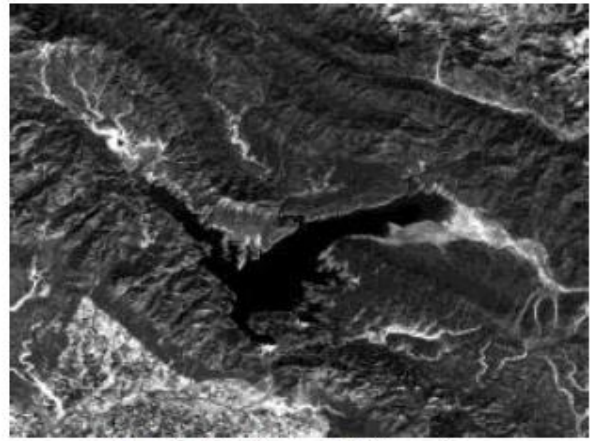
Spectral Resolution



Band (.45 to .515µm)



Band (.525 to .605 µm)



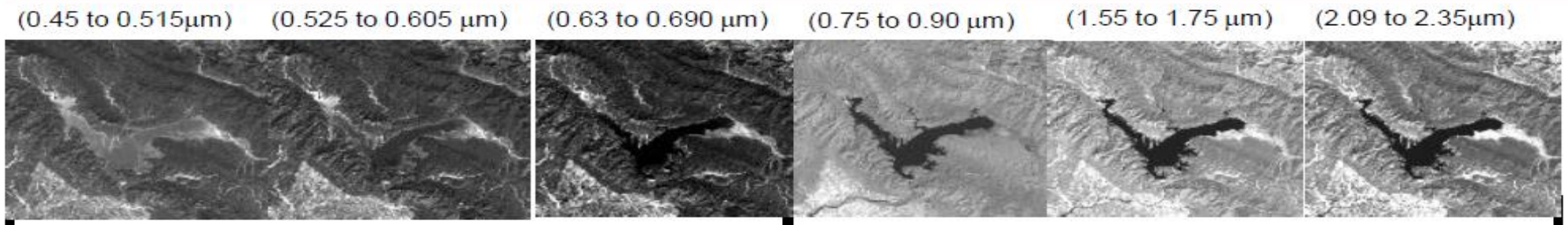
Band (.63 to .690 µm)

Band (.75 to .90 µm)

Band (1.55 to 1.75 µm)

Band (2.09 to 2.35µm)

Band	Wavelength (μm)	Principal applications
1	0.45 – 0.52 (blue)	Penetration of clear water: bathymetry; mapping of coastal waters; chlorophyll absorption; distinction between deciduous and coniferous vegetation.
2	0.52 – 0.60 (green)	Records the green reflectance peak of vegetation; assesses plant vigor; reflectance from turbid water.
3	0.63 – 0.69 (red)	This band operates in the chlorophyll absorption region and is best for detecting roads, bare soil.
4	0.76 – 0.90 (near-infrared)	This band is used to estimate biomass. Although it separates water bodies from vegetation and discriminates soil moisture, it is not as effective as B3 for road identification.
5	1.55 – 1.75 (mid-infrared)	Band 5 is considered to be the best single band overall. It discriminates roads, bare soil, and water. It also provides a good contrast between different types of vegetation and has excellent atmospheric and haze penetration. Discriminates snow from clouds,
6	2.08 – 2.35 (mid-infrared)	This band is useful for discriminating mineral and rock types and for interpreting vegetation cover and moisture.

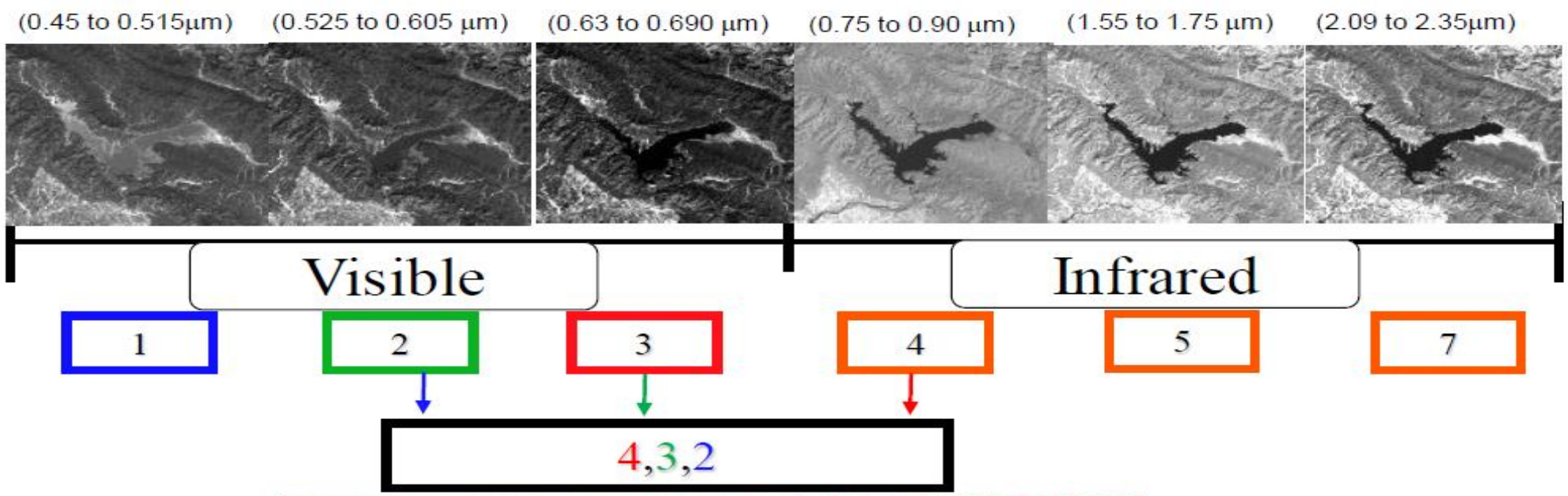


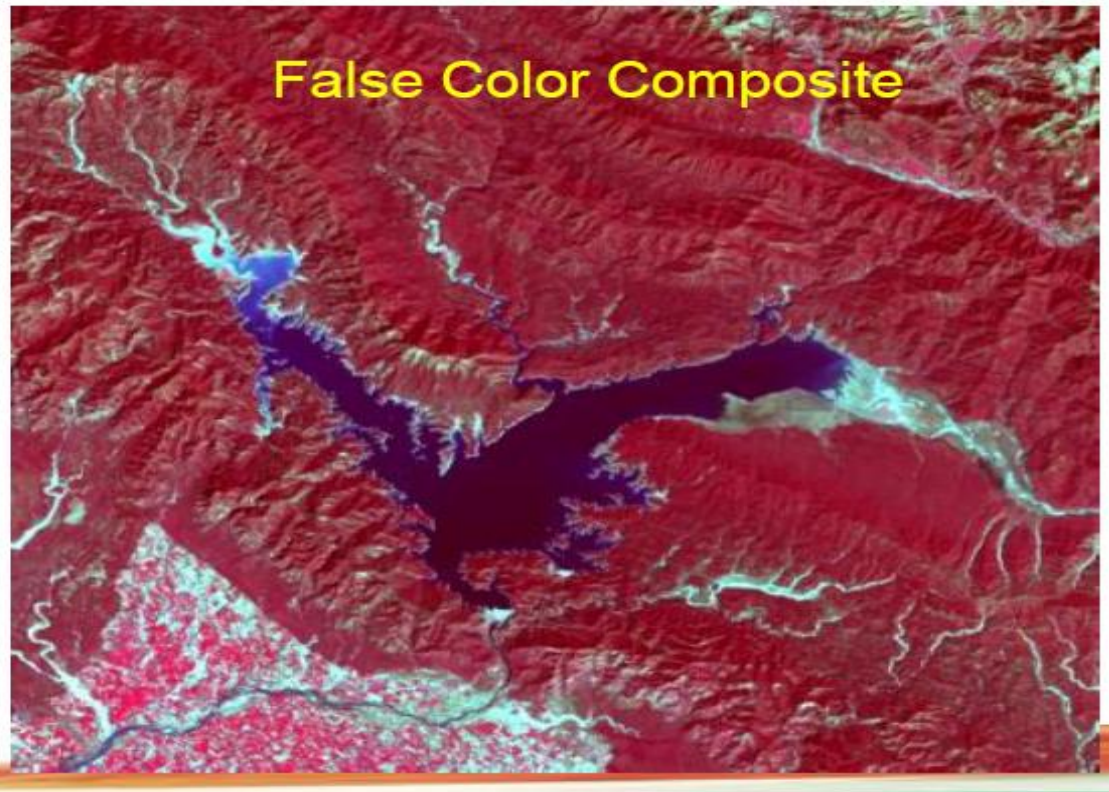
Visible

Infrared

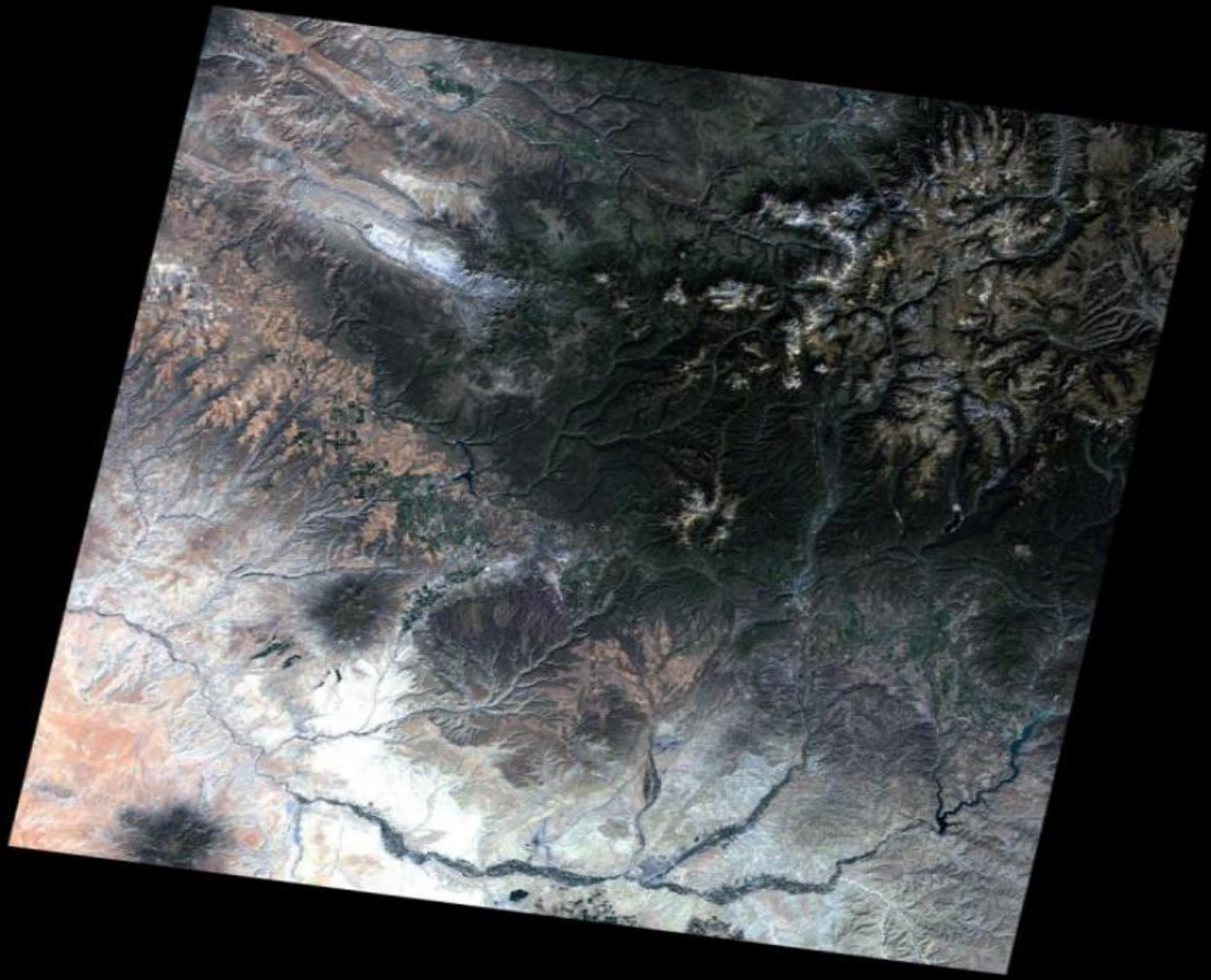
1 2 3 4 5 7

3,2,1

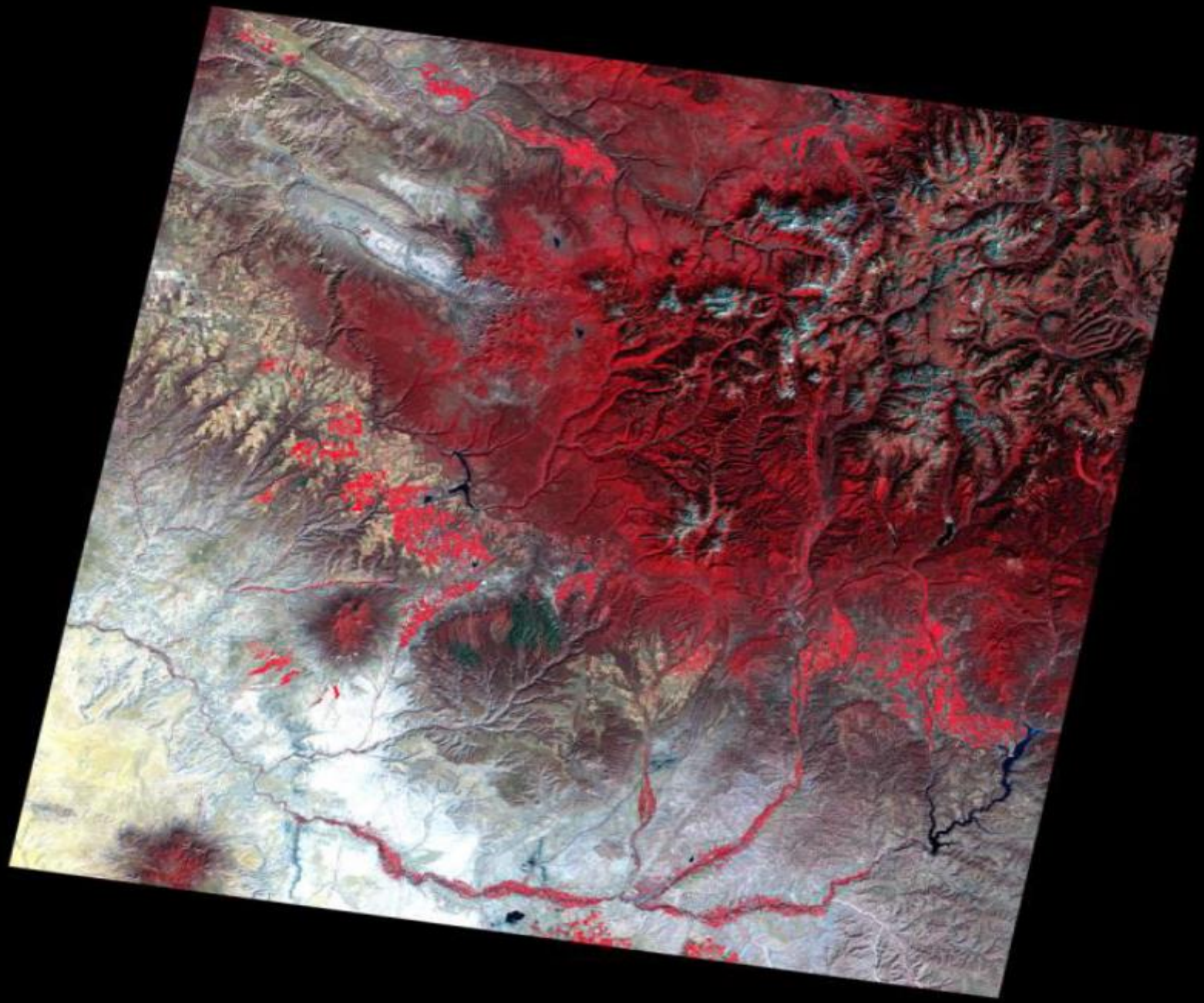

(0.45 to 0.515µm)
(0.525 to 0.605 µm)
(0.63 to 0.690 µm)
(0.75 to 0.90 µm)
(1.55 to 1.75 µm)
(2.09 to 2.35µm)
Visible
Infrared
1
2
3
4
5
7
4,3,2


False Color Composite

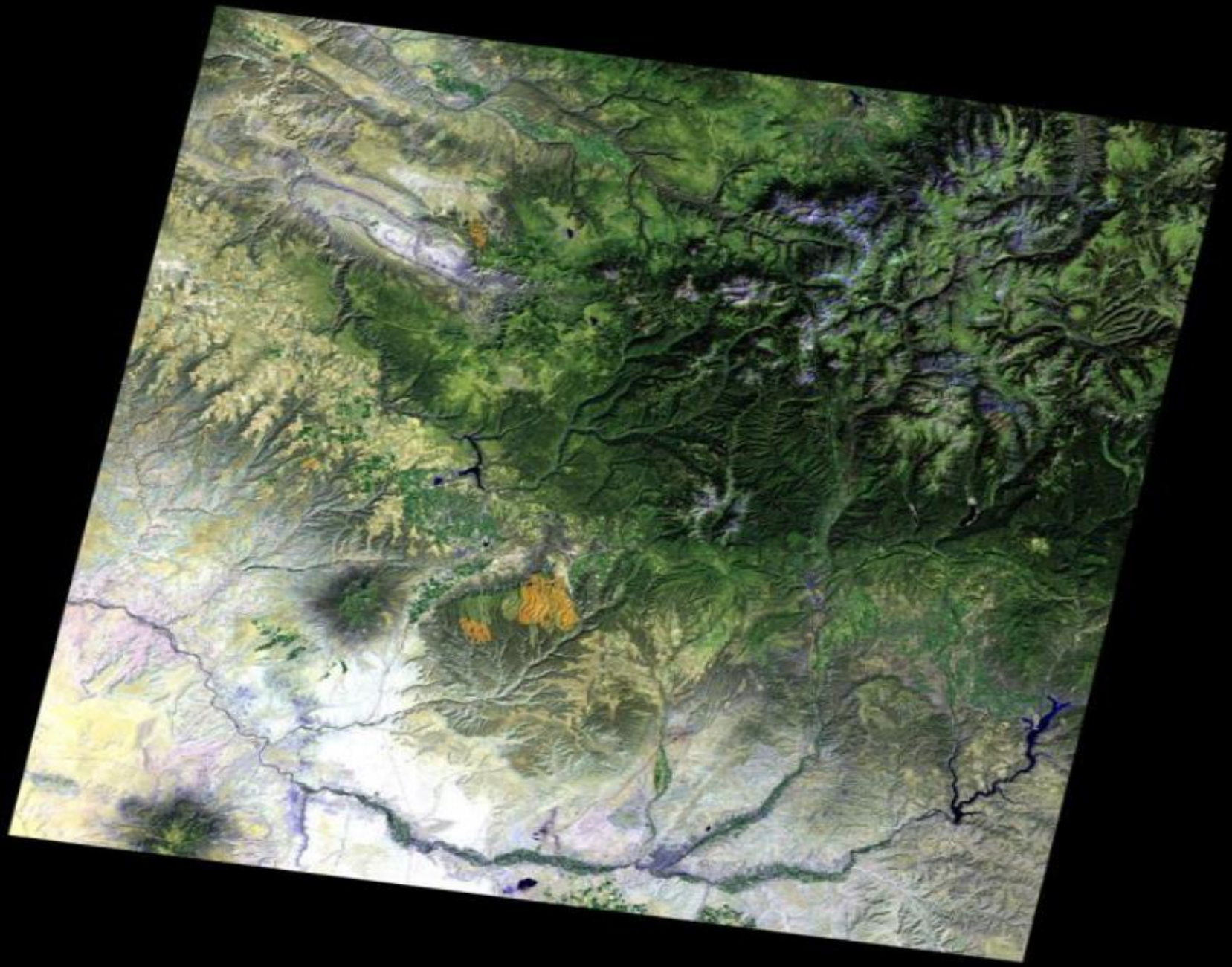
Landsat 7, Path 35 Row 34, 09.12.00



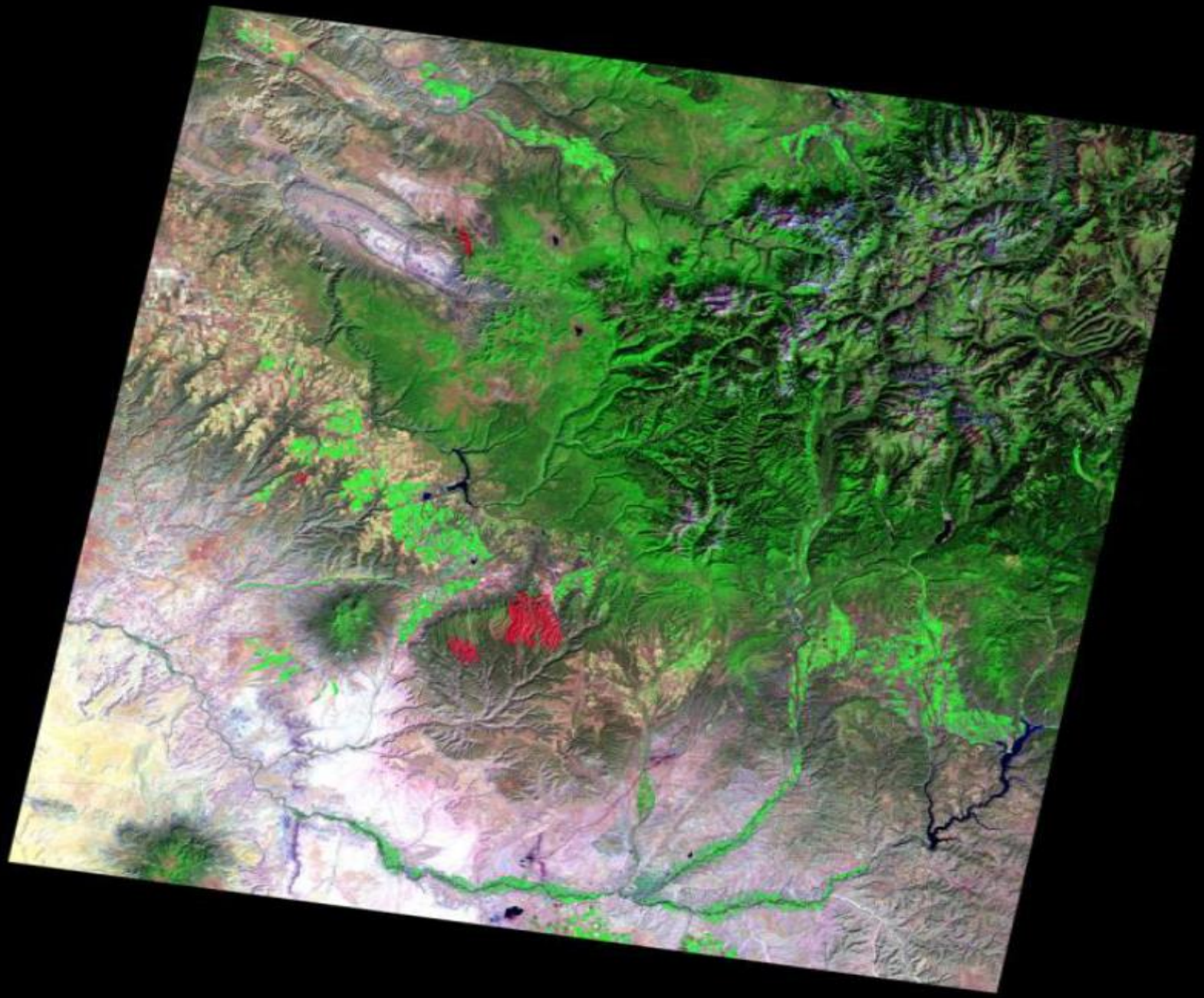
3,2,1



4,3,2



7,5,2



7,4,2

Spatial Resolution

SPATIAL RESOLUTION: THE PHYSICAL DIMENSION ON EARTH IS RECORDED

- It refers to the amount of detail that can be detected by a sensor.

- Detailed mapping of land use practices requires a much greater spatial resolution

Spatial Resolution

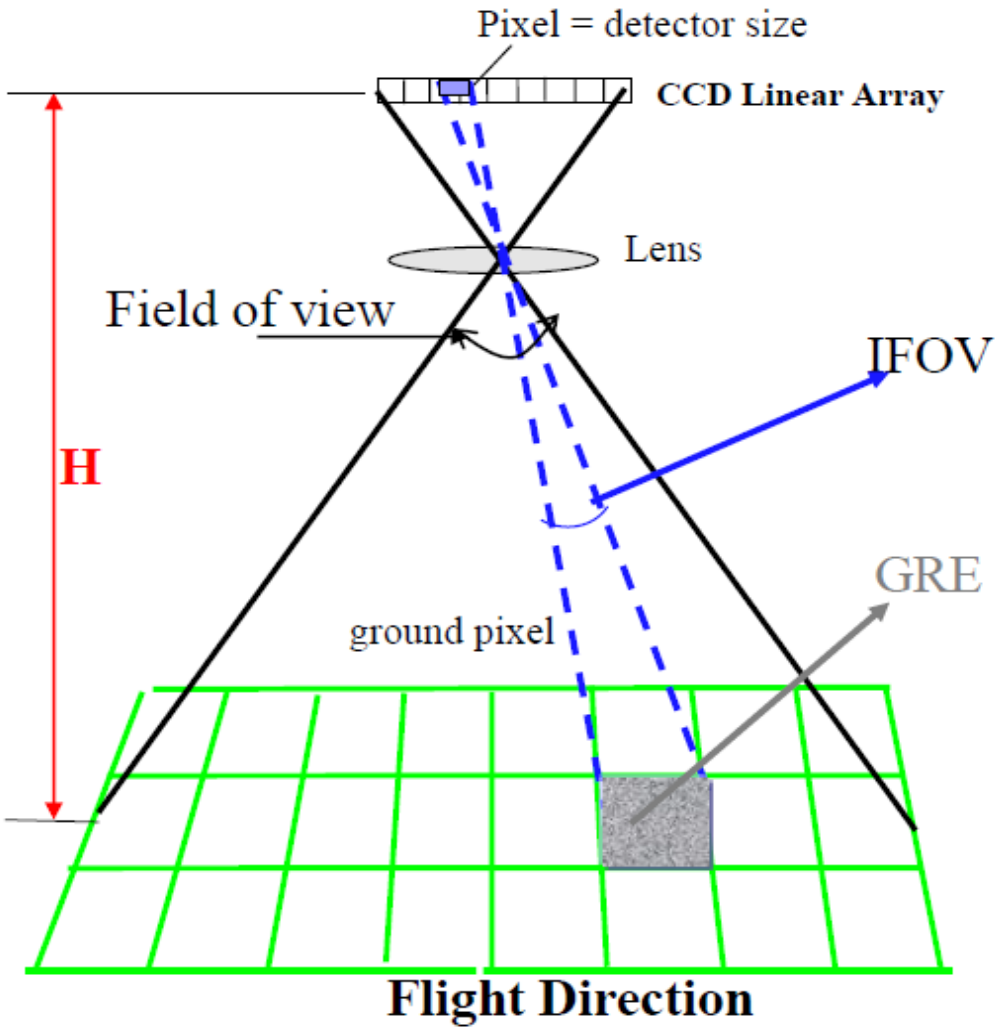
Instantaneous Field of View (IFOV)

It is defined the solid angle through which a detector is sensitive to radiation.

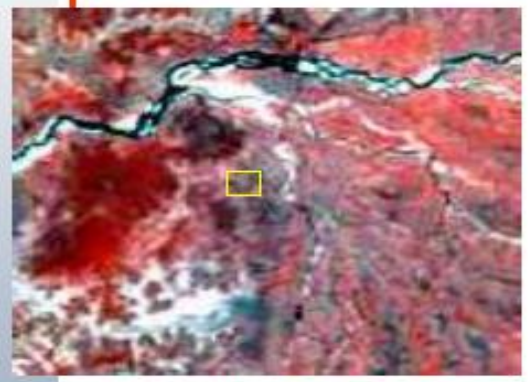
IFOV = D/F radian

GRE (Ground Resolution Element)= IFOV x H

Where, D=detector dimension,
F=focal length, and
H=flying height



INFORMATION CONTENT VS RESOLUTION

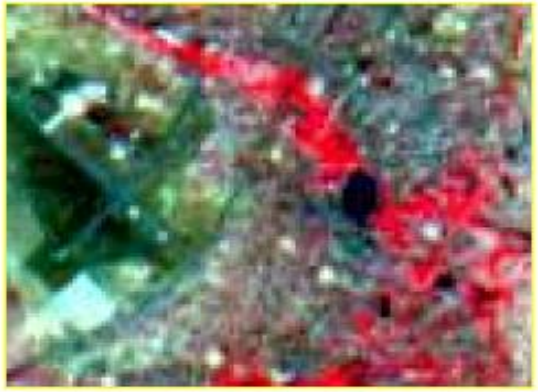


A) OCM (360m)

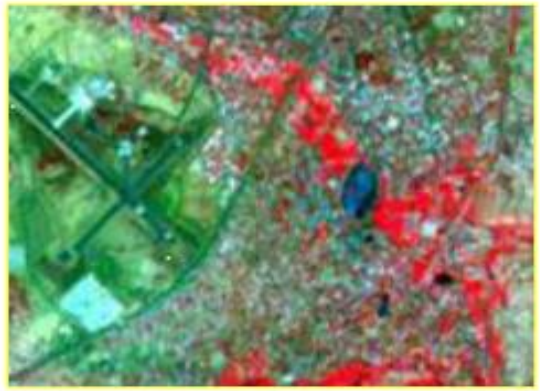
B) 360m (OCM)

C) 188m (WiFS)

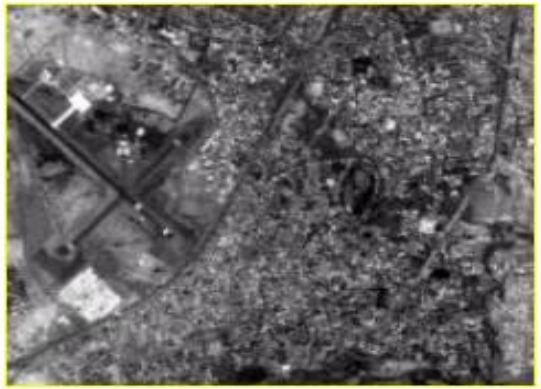
D) 72m (LISS-I)



E) 36m (LISS-II)

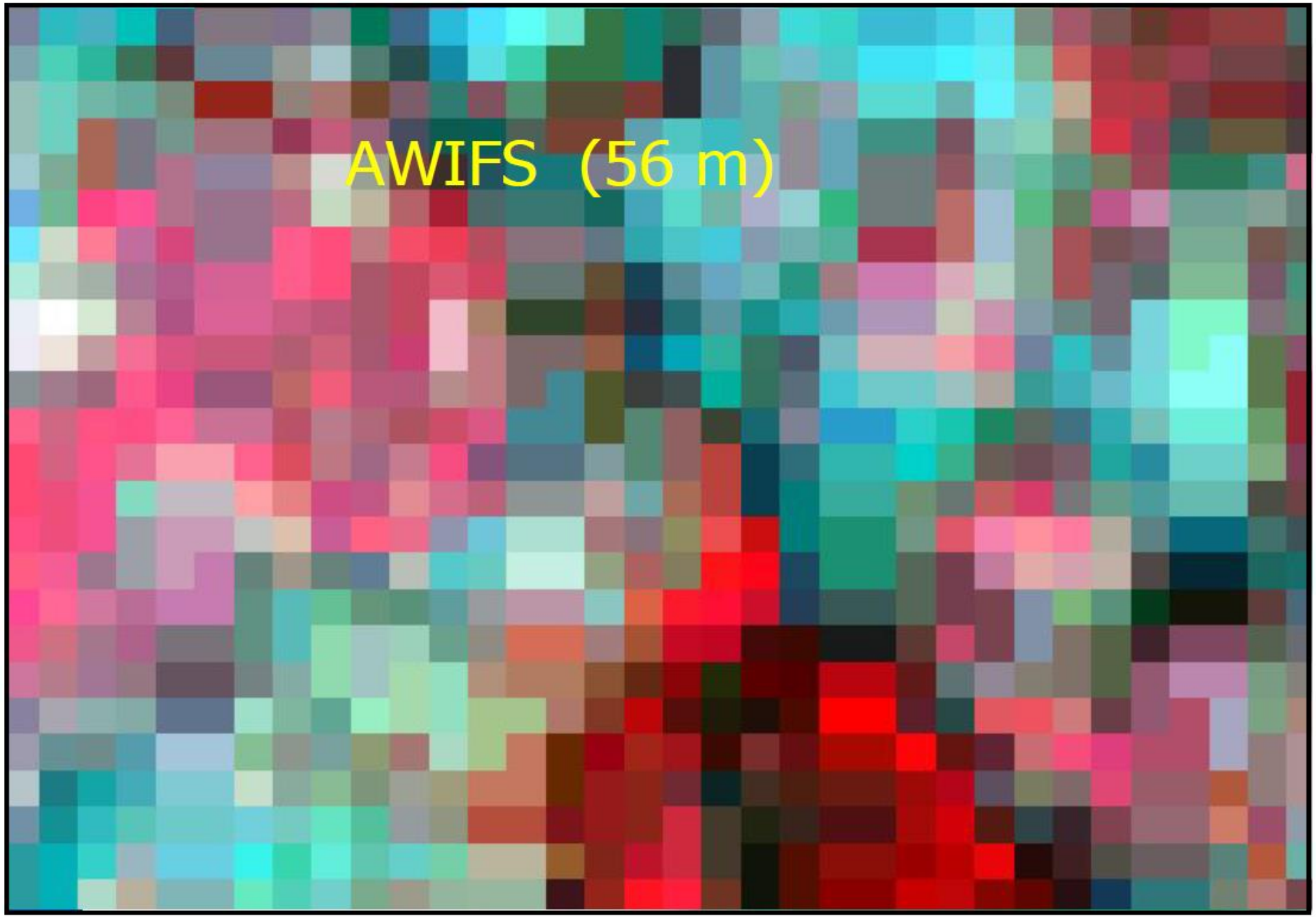


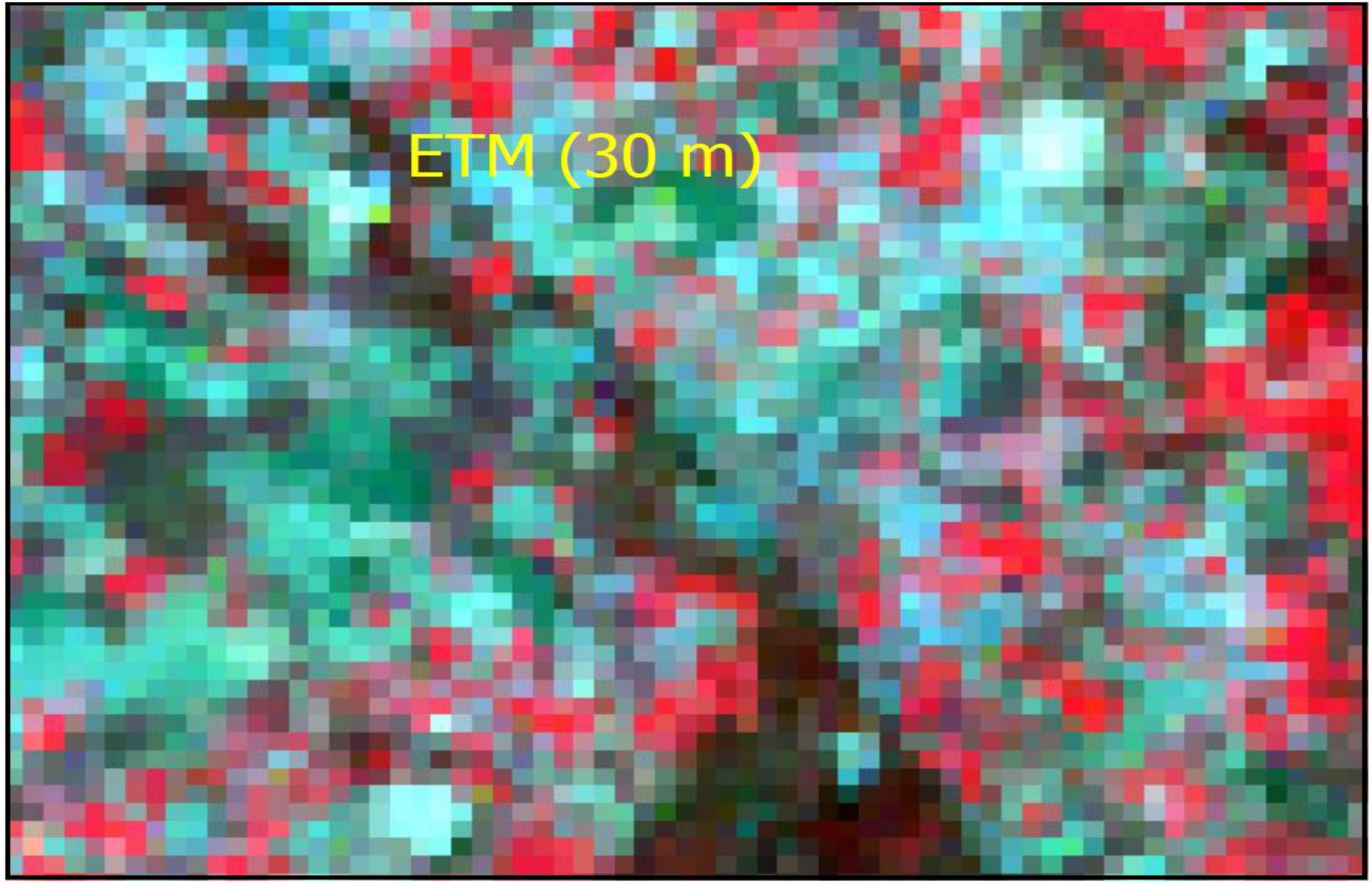
F) 23m (LISS-III)



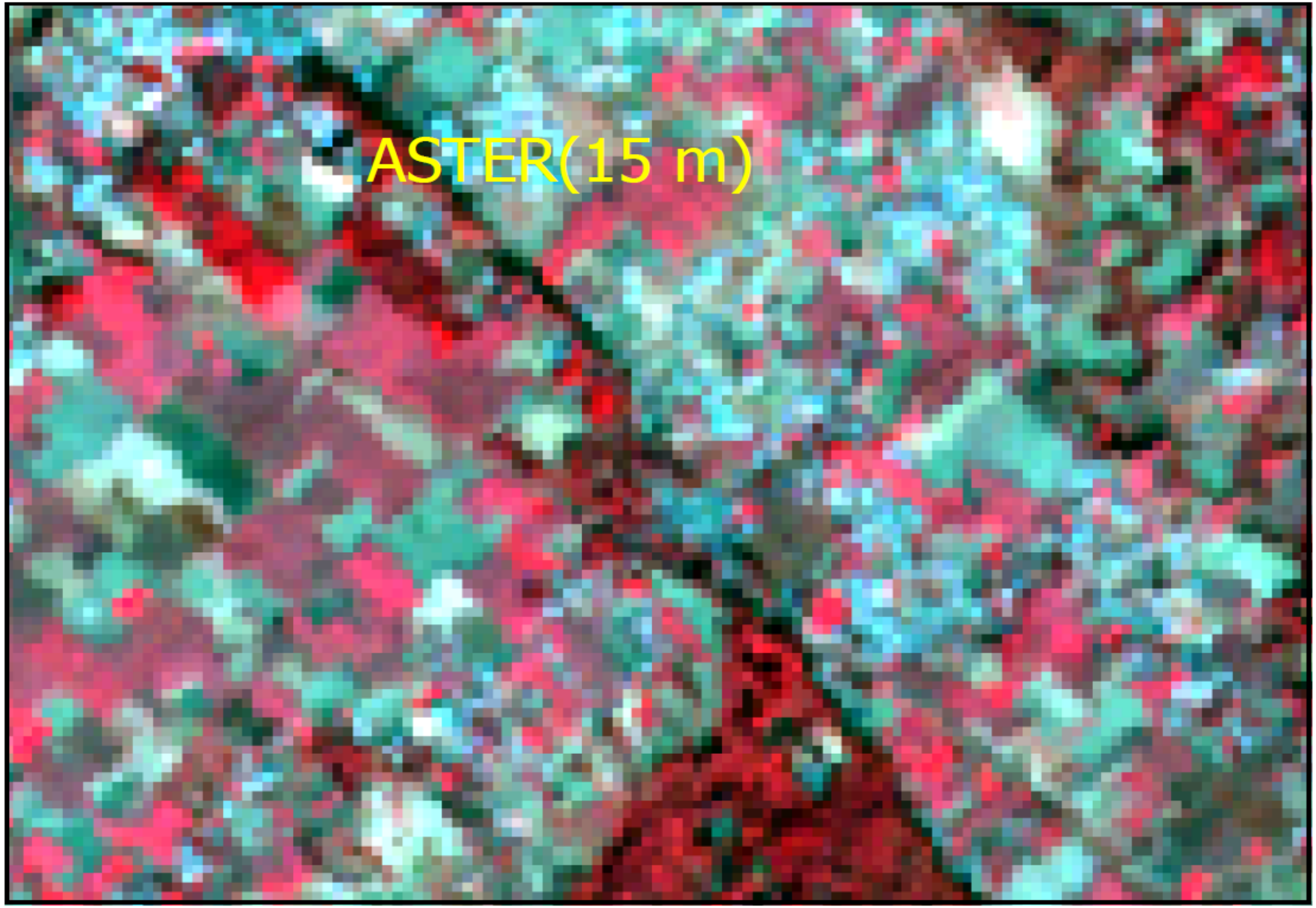
G) 5.8m (IRS 1C PAN)

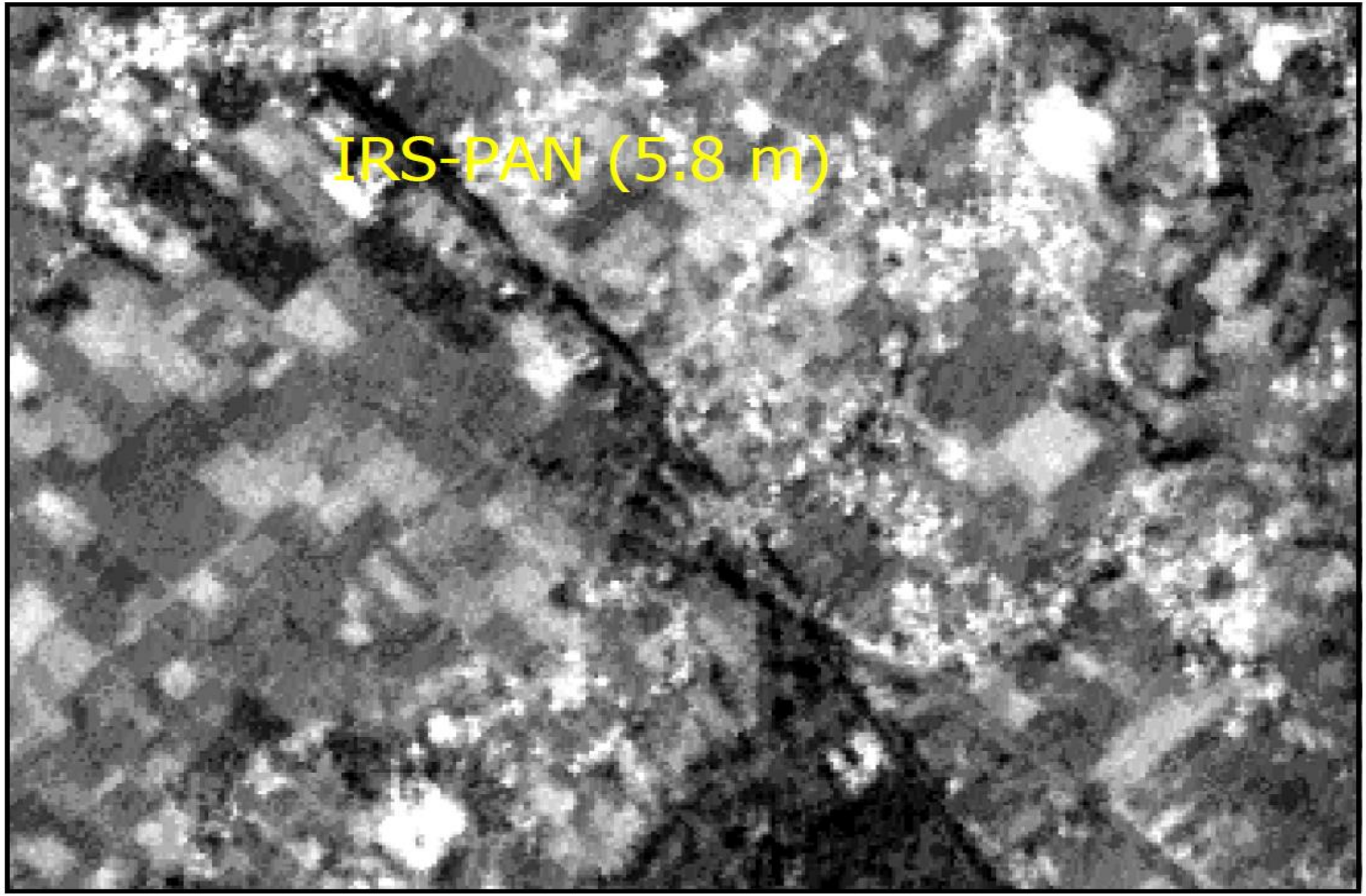
'A' is from a scene from IRS Ocean Colour Monitor (OCM). The area in the small square marked (≈ 4km x 4km) is shown in various resolutions from B to G..

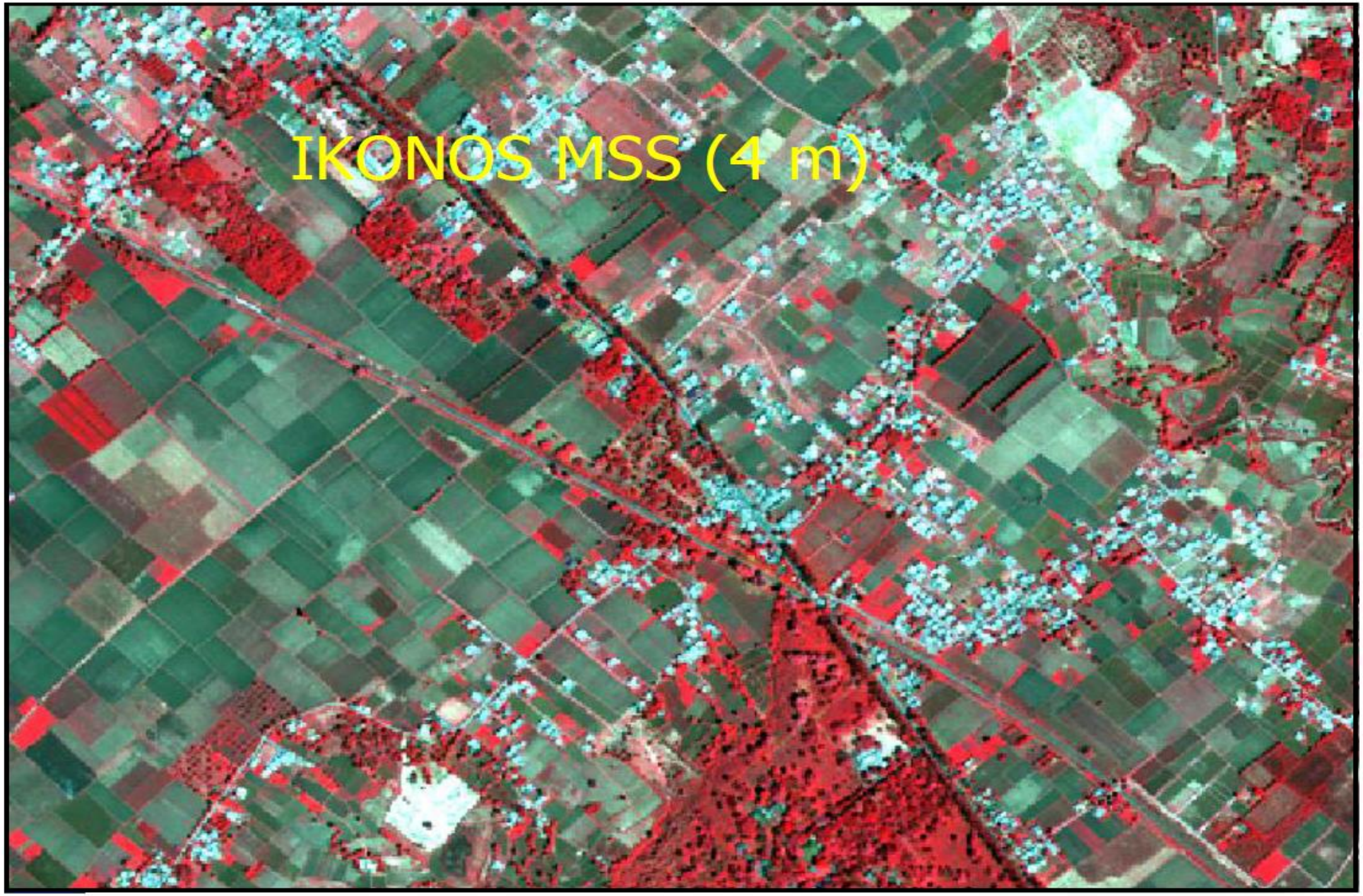

AWIFS (56 m)


ETM (30 m)


IRS-LISS III (23.5 m)


ASTER(15 m)


IRS-PAN (5.8 m)


IKONOS MSS (4 m)


IKONOS PAN (1 m)

Contd..

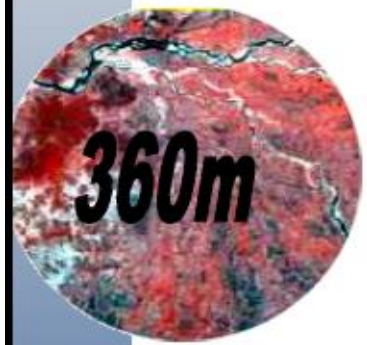
10 m resolution

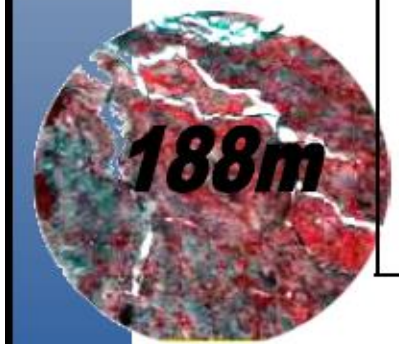
30 m resolution

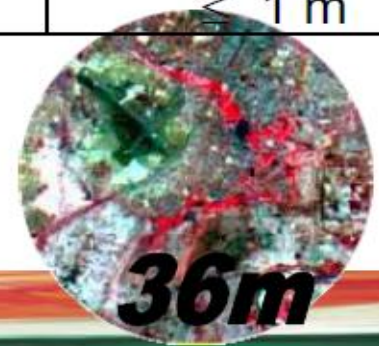
80 m resolution

A "High Resolution" image refers to one with a small resolution size. Fine details can be seen in a high resolution image.
A "Low Resolution" image is one with a large resolution size, i.e. only coarse features can be observed in the image.

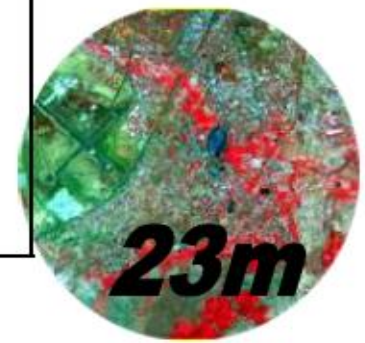
Desirable Spatial Resolution







Meteorology	Cloud patterns, movement Water vapor Analysis	1-2 Kms. 8 Kms.
Oceanography	Ocean Color Monitoring (Chlorophyll, Sediment Map, Yellow Substance, Sea Surface Temp. Mapping)	300-1100 m
Land use	Crop monitoring, Forest Mapping, Hydrology etc.	20-30 m
	Cartography, Urban Planning	2-6 m
	Military Surveillance	< 1 m

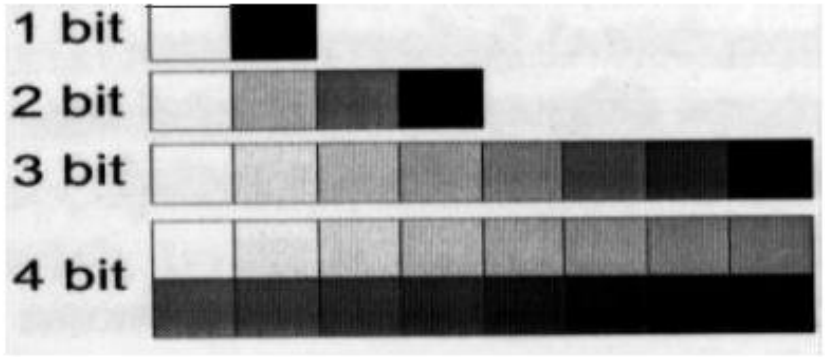


Radiometric Resolution

- It describes the actual information content in an image.
- Sensitivity to the magnitude of the electromagnetic energy determines the **radiometric resolution.**
- **The radiometric resolution of an imaging system** describes its ability to discriminate very slight differences in energy.
- The finer the radiometric resolution of a sensor, the more sensitive it is to detecting small differences in reflected or emitted energy.

Radiometric Resolution

$2^{(\text{number of bits})}$ = number of grey levels



1	2	0-1
2	4	0-3
3	8	0-7
4	16	0-15
5	32	0-31
6	64	0-63
7	128	0-127
8	256	0-255
9	512	0-511
10	1024	0-1203

256 colors

Radiometric Resolution

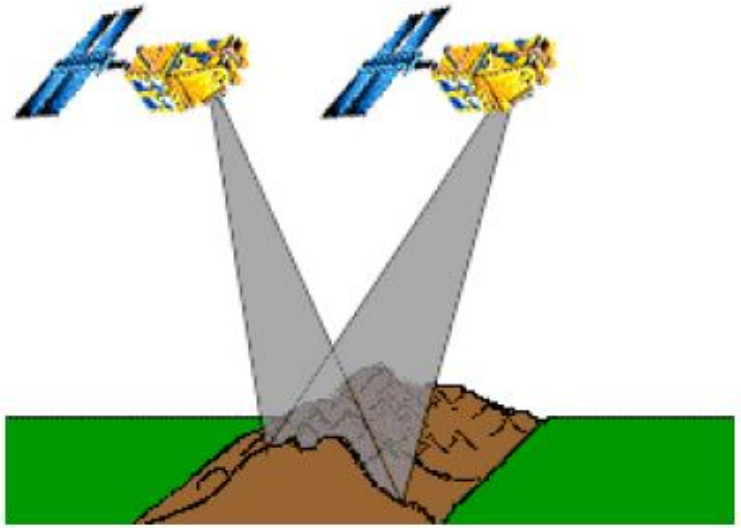
(a) (b)

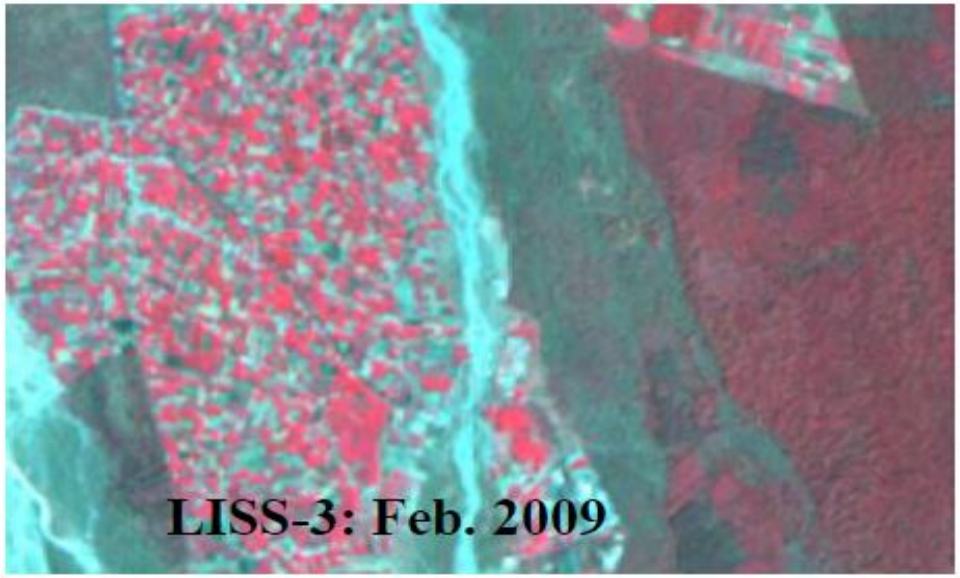
IKONOS 11-bit data enables detail to be captured in areas within the cloud shadow. In the 8-bit image (a) there is no detail in the black cloud shadow area. Image (b) shows improved shadow details after enhancement using full 11 bits of data

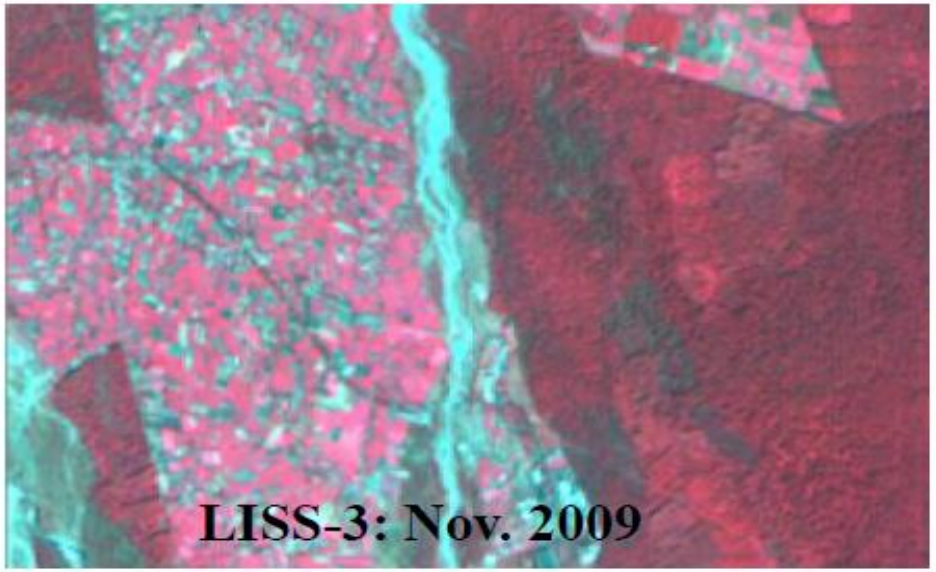
Temporal Resolution

- Represents the frequency with which a satellite can re-visit an area of interest and acquire a new image.

- Depends on the instrument's field of vision, and the satellite's orbit







Resolution Vs Revisit time