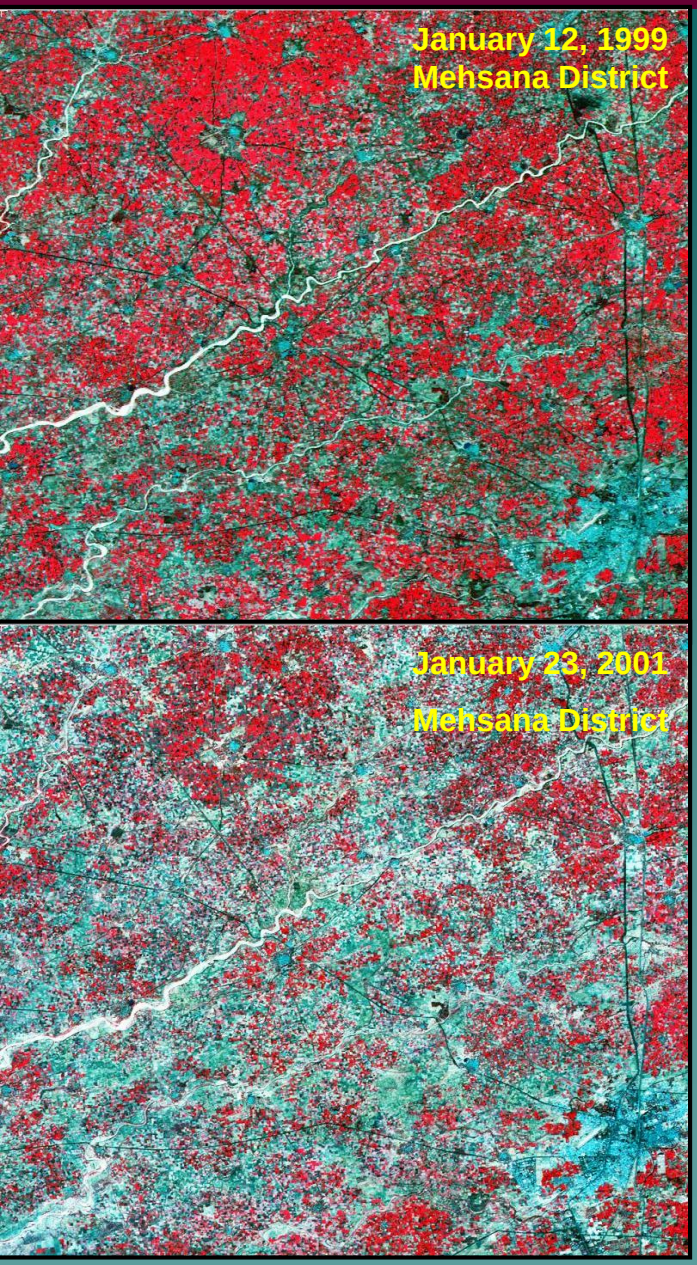
FUNDAMENTALS OF REMOTE SENSING

PRINCIPLES OF REMOTE SENSING



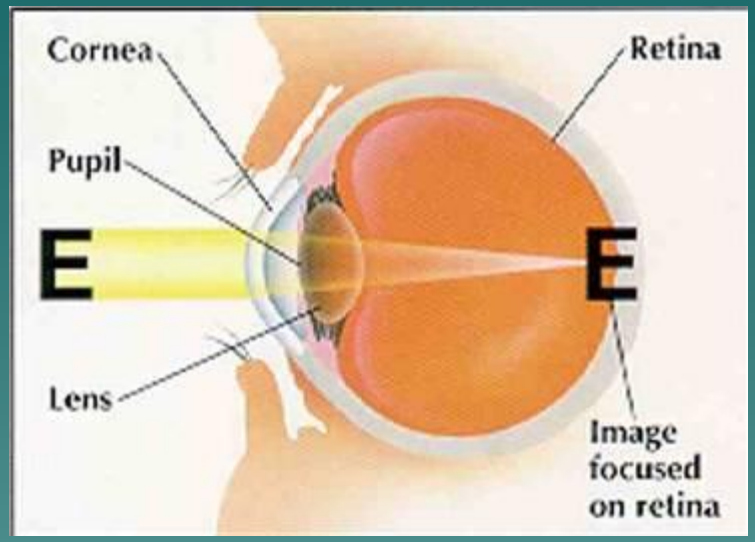
Contents:

- *Remote Sensing – Definitions*
- *Electromagnetic Radiations*
- *Radiometric Quantities (definitions)*
- *Electromagnetic Spectrum*
- *Interaction with earth's surface*
- *Remote Sensing Signatures*
- *Colour Composites*
- *Organisations, Data providers, Books*

Remote Sensing

To sense an object without being in physical contact with it

Some Remote Sensors



What is Remote Sensing

Science of collecting information about an object, area or phenomenon from a distance ie without any physical contact

Remote Sensing

Collection and interpretation of information about an object without being in physical contact with the object.

Aircraft and satellites - common platforms.

It is commonly restricted to methods that employ electromagnetic energy (such as light, heat, sound etc.) as the means of detecting and measuring target characteristics.

What is remote sensing?

The International Society for Photogrammetry and Remote Sensing (ISPRS) defined Remote Sensing (RS) as:

"The art, science, and technology of obtaining reliable information about physical objects and the environment, through the process of recording, measuring, and interpreting imagery and digital representation of energy patterns derived from non contact sensor system " . This definition considered photogrammetry as sub-field of remote sensing

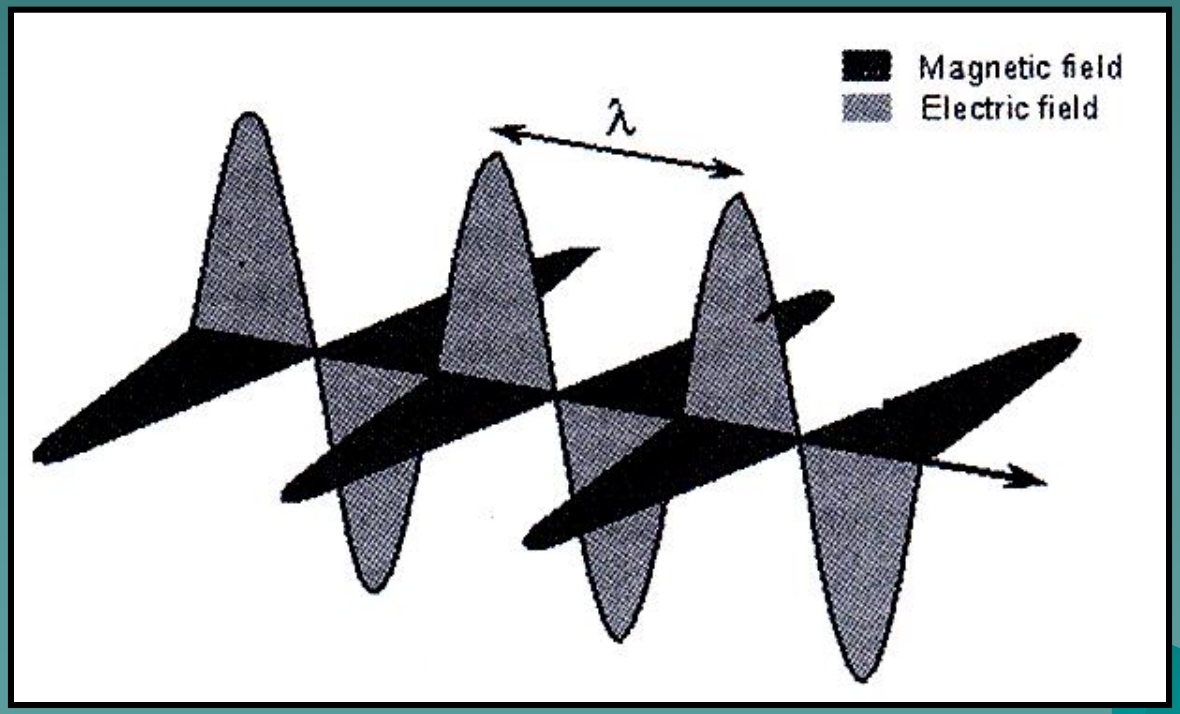
- **via cameras recording on film, which may then be scanned (aerial photos)**
- **via sensors, which directly output digital data (satellite imagery)**

Electromagnetic Radiation

Energy propagated in the form of advancing interaction between electric and magnetic fields. All electromagnetic radiation moves at the speed of light.

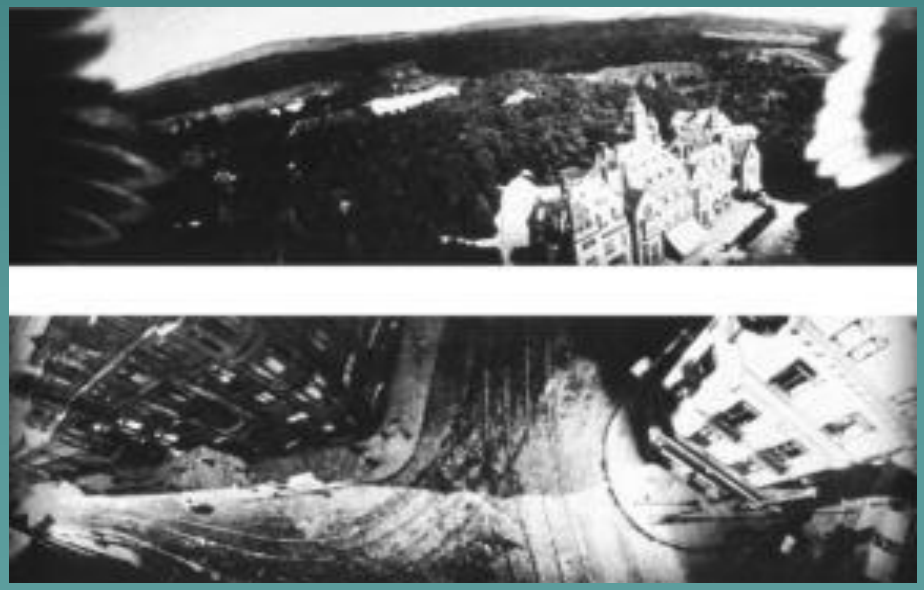
ELECTROMAGNETIC RADIATION (EMR)

- EMR has two components viz. “Electric Field” and “Magnetic Field”
- The two components are mutually perpendicular to each other
- Electromagnetic radiation (EMR) transmits energy



Evolvement of Remote Sensing

- 1903 - The Bavarian Pigeon Corps uses pigeons to transmit messages and take aerial photos.



1914 - WWI provided a boost in the use of aerial photography, but after the war, enthusiasm waned

Evolvement of Remote Sensing

1934 - Photogrammetric Engineering first published. American Society of Photogrammetry founded and renamed ***Photogrammetric Engineering and Remote Sensing***. The Society was again renamed, and is now ***The American Society of Photogrammetry and Remote Sensing.***

Evolvement of Remote Sensing

1946 - First space photographs from V-2 rockets.

1954 - U-2 takes first flight.

Evolvement of Remote Sensing

1957 - Russia launches Sputnik-1, this was unexpected and encouraged US government to make space exploration a priority.

Evolvement of Remote Sensing

- 1972 - Launch of ERTS-1 (the first Earth Resources Technology Satellite ,later renamed Landsat 1).
- 1972 - Photography from Skylab, America's first space station, was used to produce land use maps.
- 1975 - Landsat 2, GOES
- 1977 - Meteosat-1 the first in a long series of European weather satellites
- 1978 - Landsat 3
- 1978 - Seasat, the first civil Synthetic Aperture Radar (SAR) satellite.

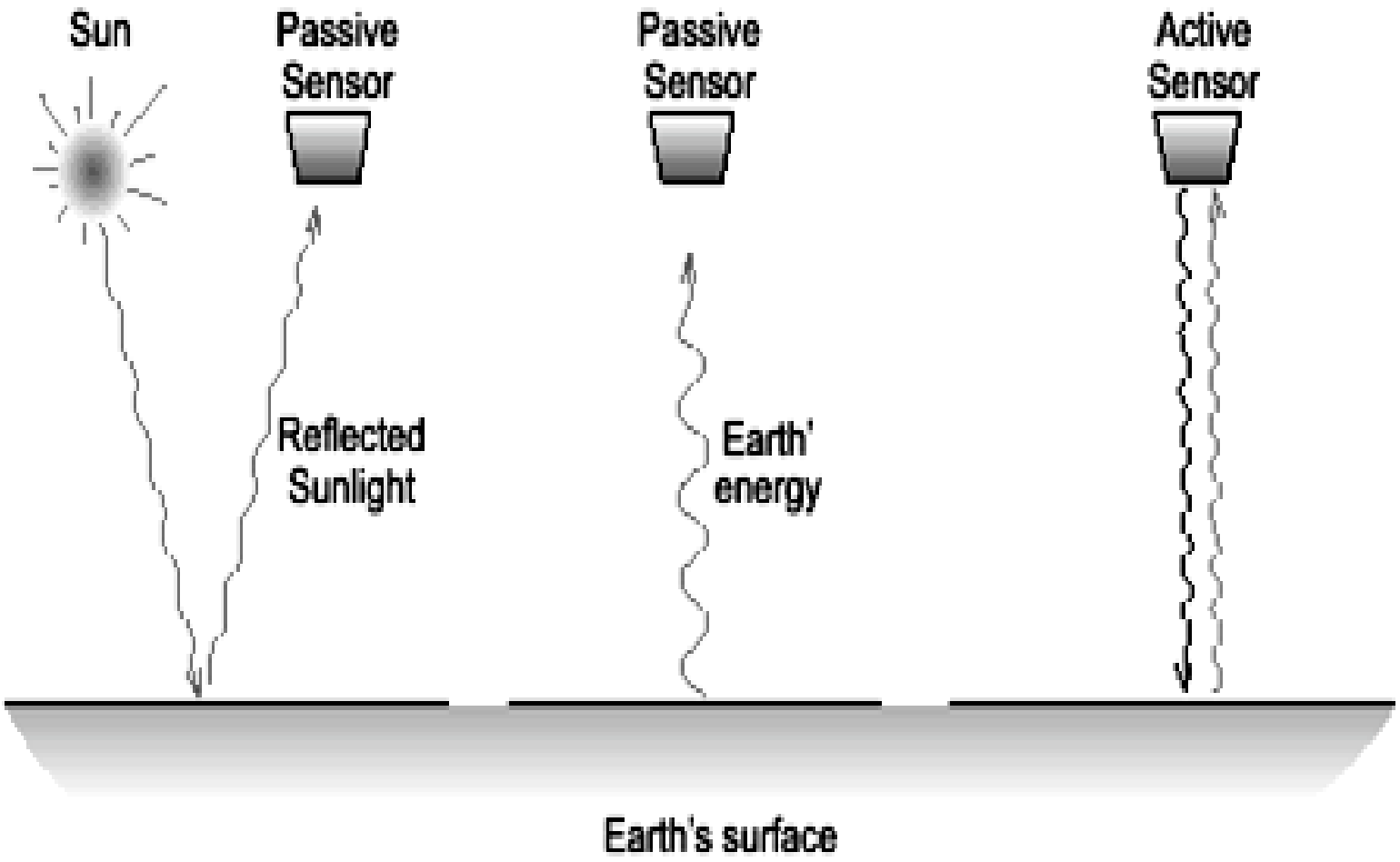
Active Remote Sensing

Remote sensing method that provide their own source of electromagnetic radiation to illuminate the terrain. Radar is one example.

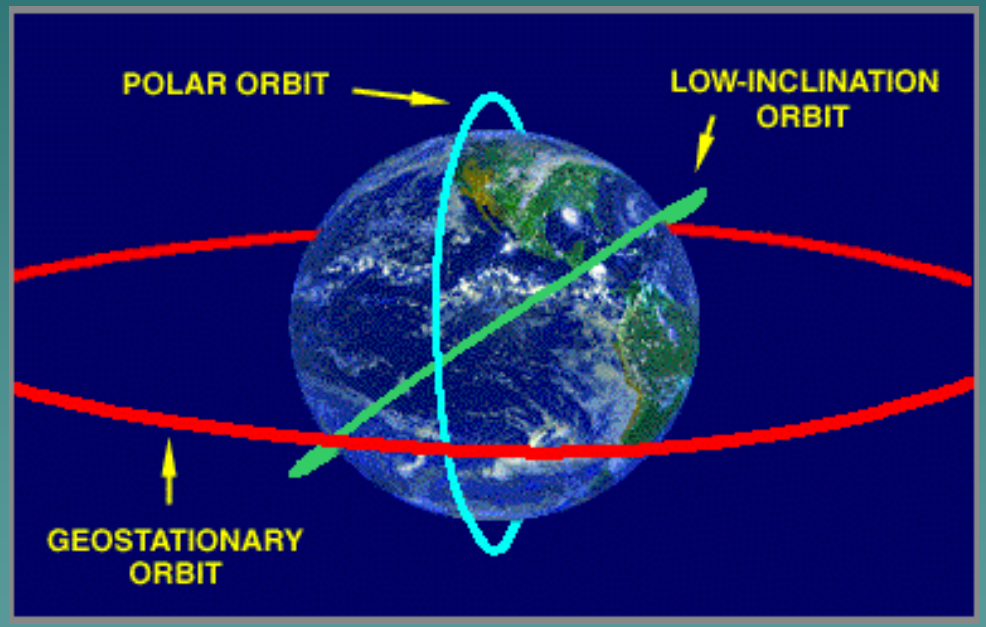
Passive Remote Sensing

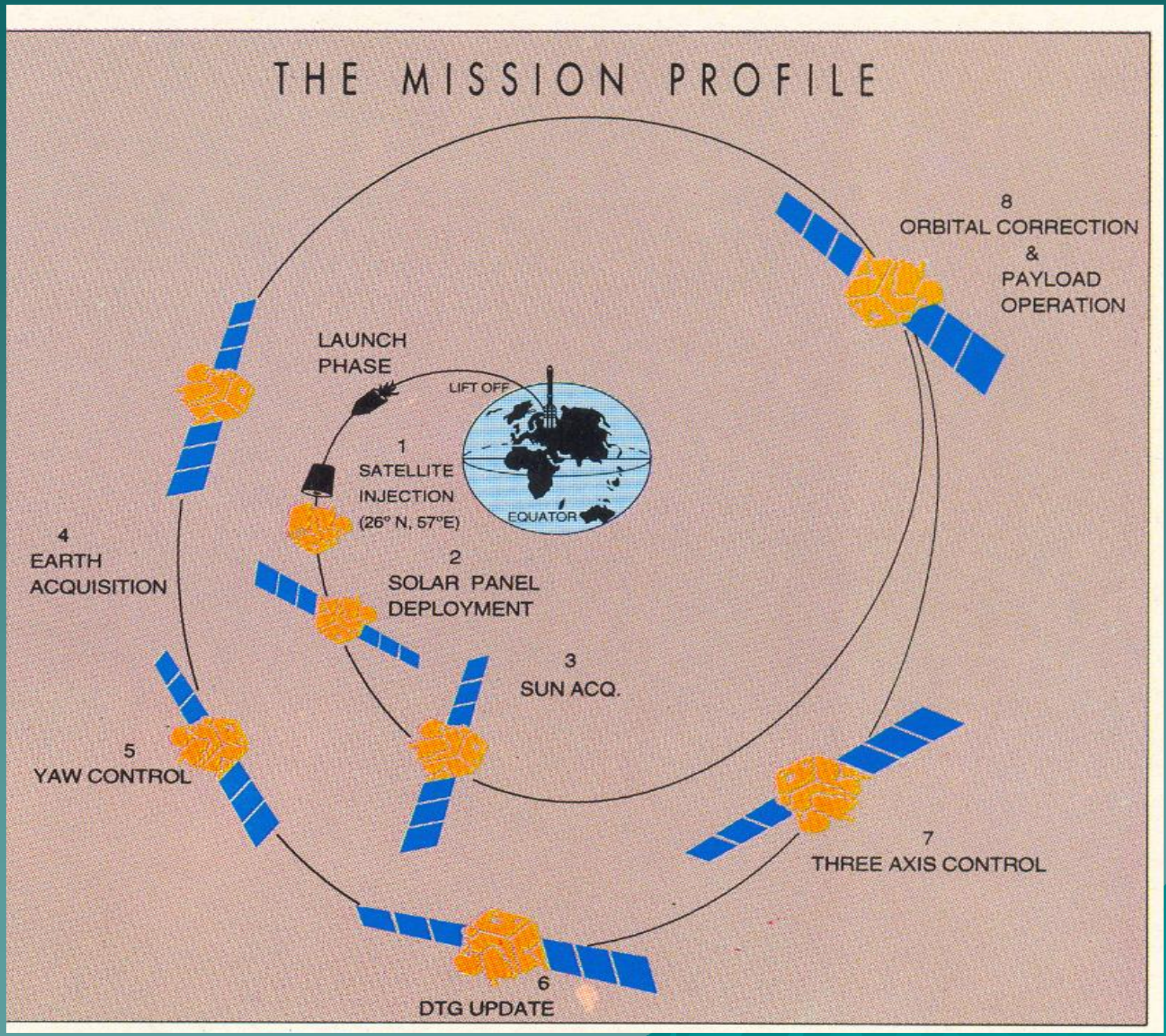
Remote sensing of energy naturally reflected / radiated from the terrain.

ACTIVE & PASSIVE REMOTE SENSING

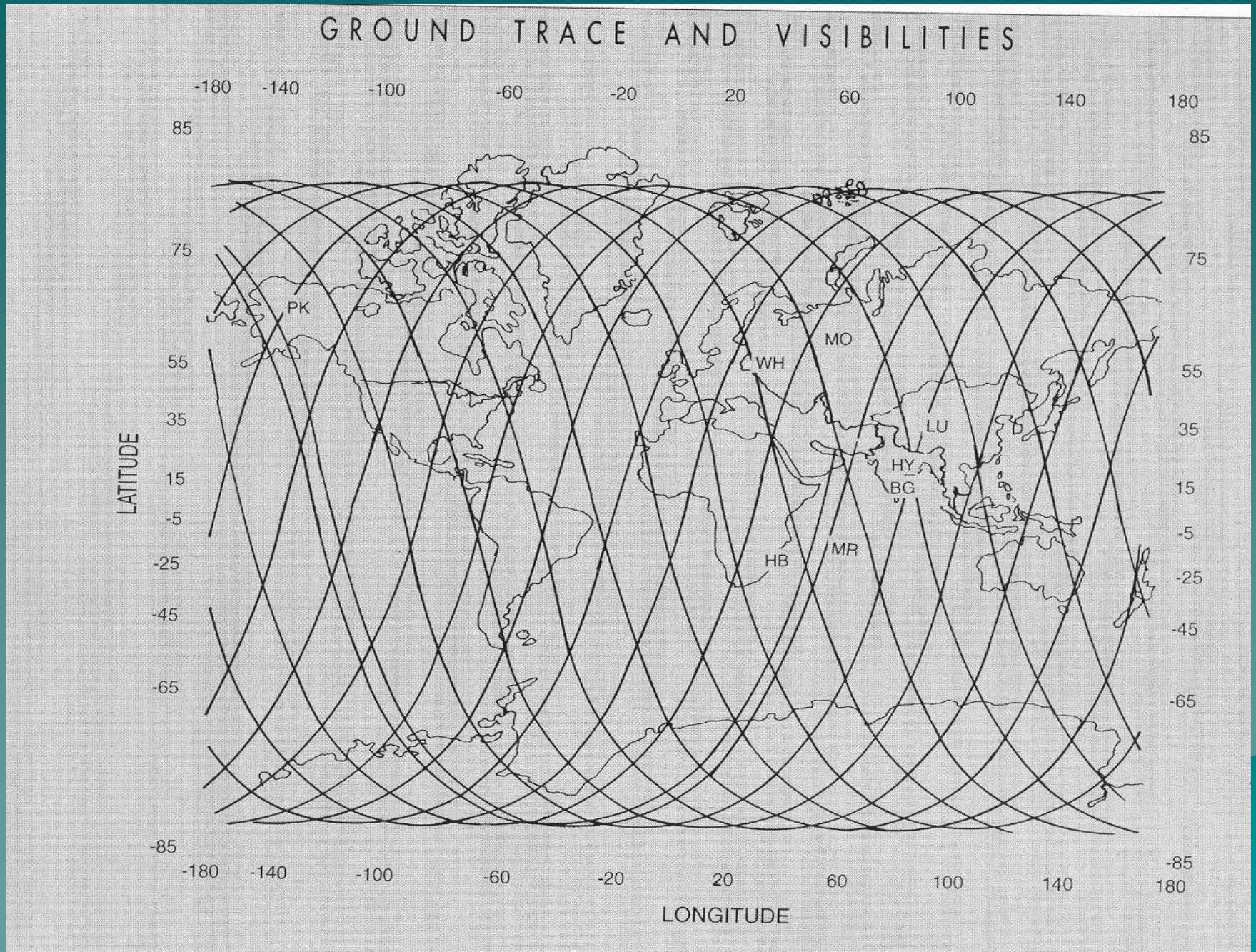


Satellite Remote Sensing

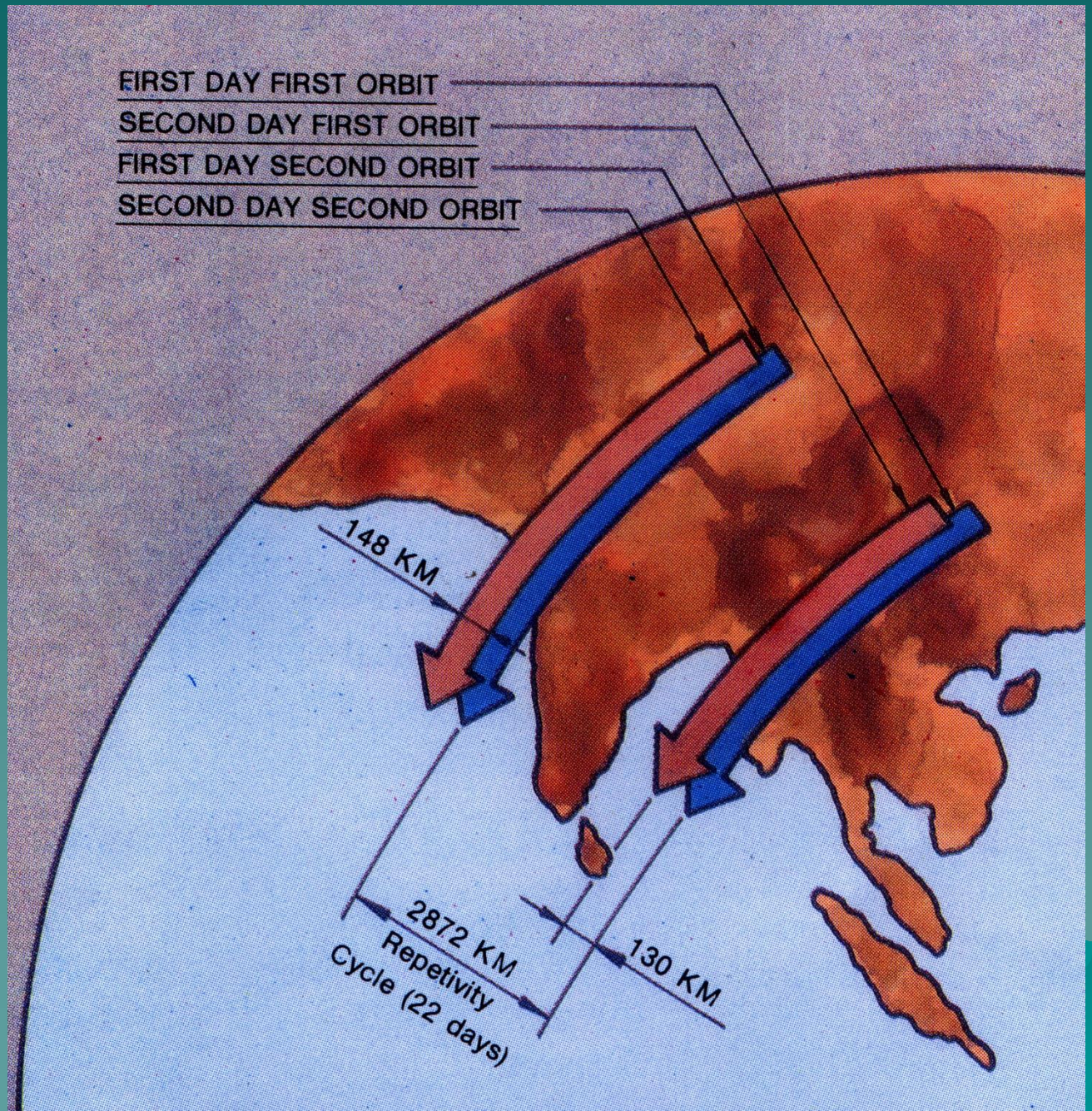


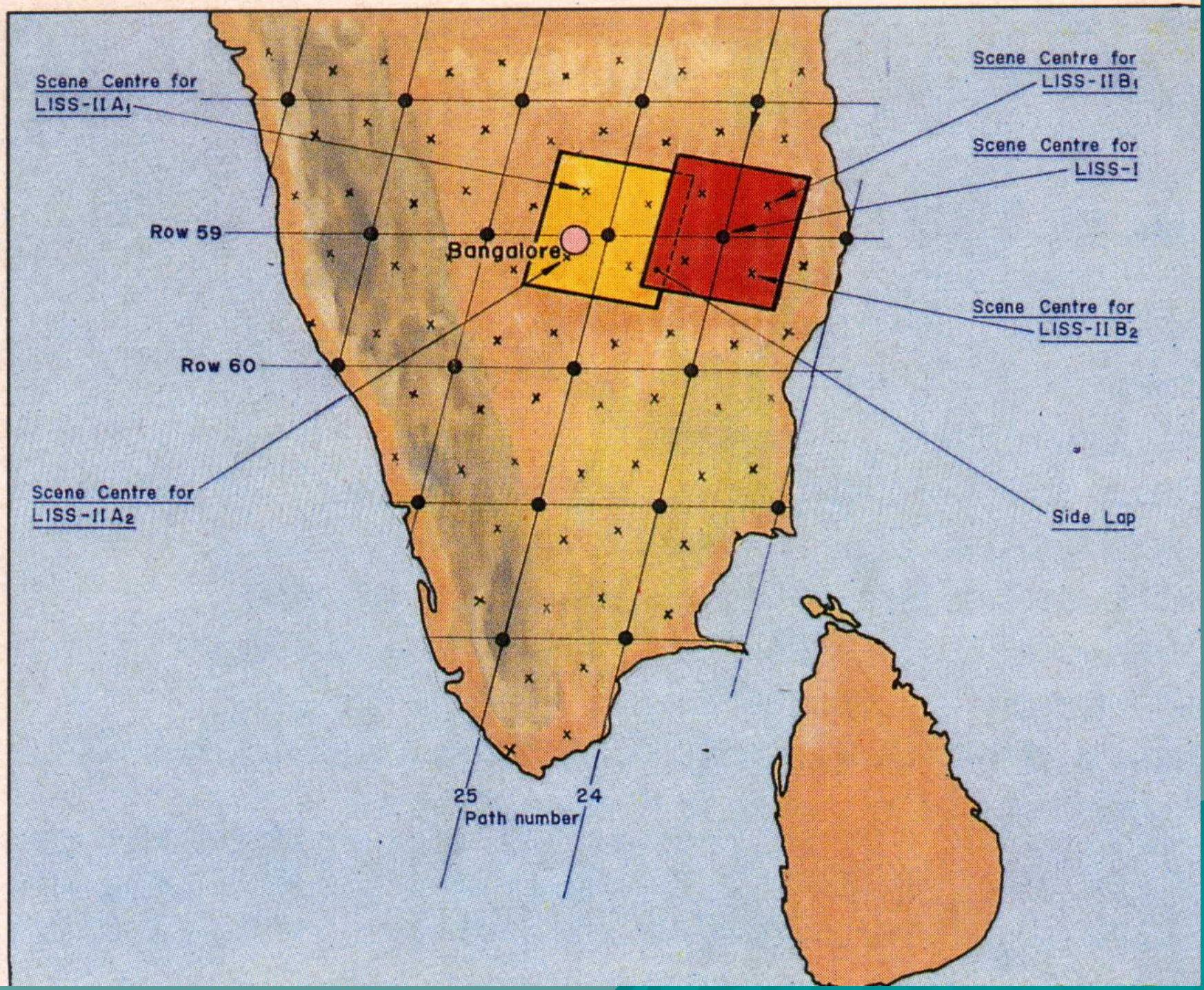

THE MISSION PROFILE
LAUNCH PHASE
LIFT OFF
EQUATOR
1 SATELLITE INJECTION (26° N, 57°E)
2 SOLAR PANEL DEPLOYMENT
3 SUN ACQ.
4 EARTH ACQUISITION
5 YAW CONTROL
6 DTG UPDATE
7 THREE AXIS CONTROL
8 ORBITAL CORRECTION & PAYLOAD OPERATION

ORBITS OF IRS 1C/1D



Orbits of Satellites




Scene Centre for LISS-II A1
Scene Centre for LISS-II B1
Scene Centre for LISS-I
Row 59
Bangalore
Scene Centre for LISS-II B2
Row 60
Scene Centre for LISS-II A2
Side Lap
25
24
Path number

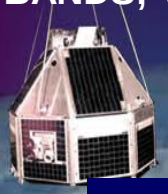
India & Pakistan as seen from Space Shuttle

INDIAN IMAGING SYSTEMS

1979

BHASKARA

1982



RS-D1

1988/91

IRS-1A & 1B LISS-1&2 (72/36M, 4 BANDS; VIS & NIR)

1994

IRS-P2
LISS-2

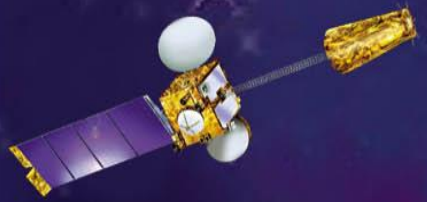
1995/1997

IRS-1C/1D LISS-3 (23/70M, STEERABLE PAN (5.8 M); WiFS (188M)

1996

IRS-P3 (1996)
WiFS MOS
X-Ray,

1999



INSAT-2E CCD
(1KM RESOLUTION; EVERY 30 MNUTESS)

1999

IRS-P4
OCEANSAT OCM, MSMR

2001

TES –1M

RESOURCESAT-1
LISS3 - 23 M; 4 XS
LISS4 - 5.8 M; 3-XS
AWIFS - 70 M; 4-XS

2003

CARTOSAT - 1
PAN - 2.5M, 30 KM, F/A

2004

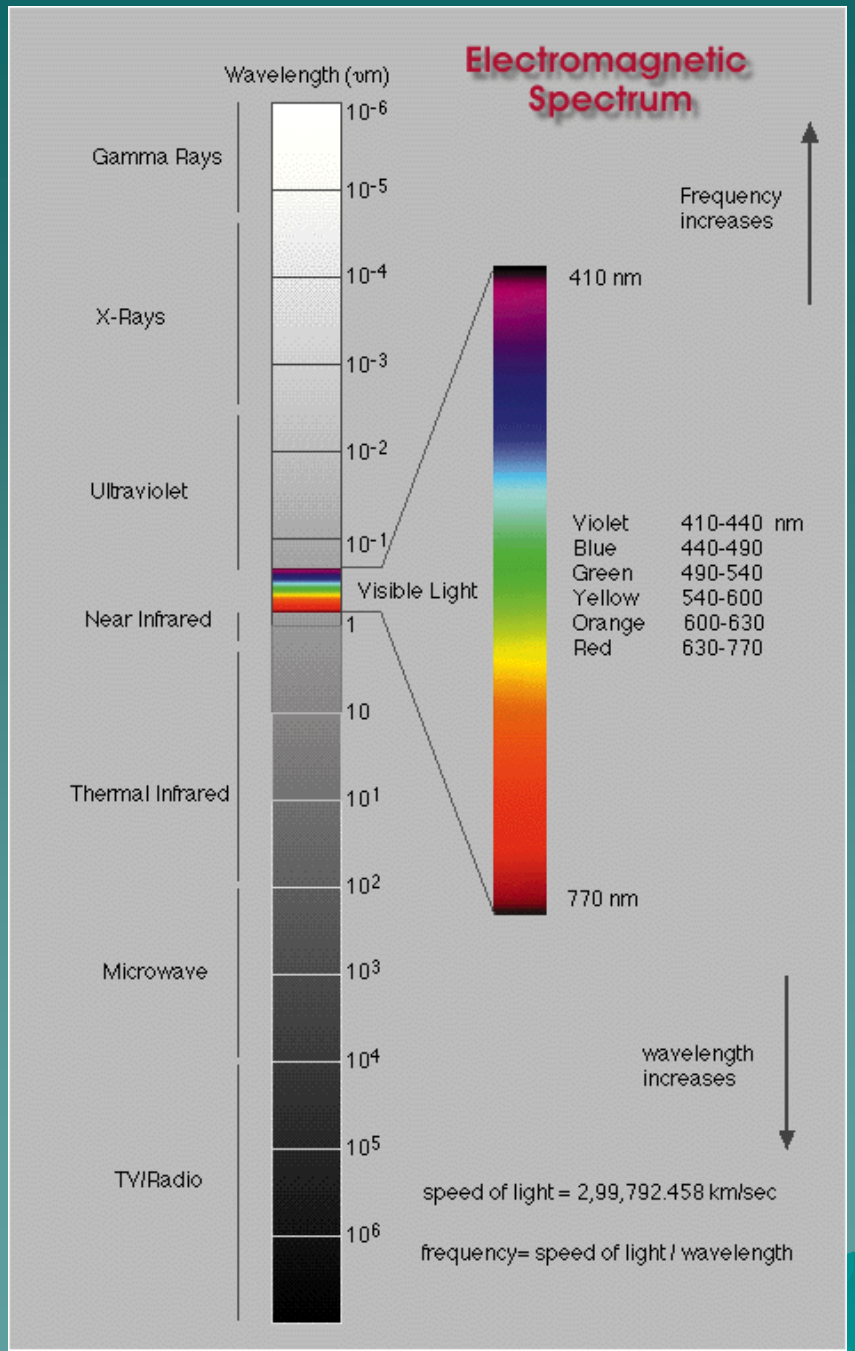
CARTOSAT-2
PAN - 1M

2004 Onwards

CARTOSAT – 2,3..
ResourSAT-2…

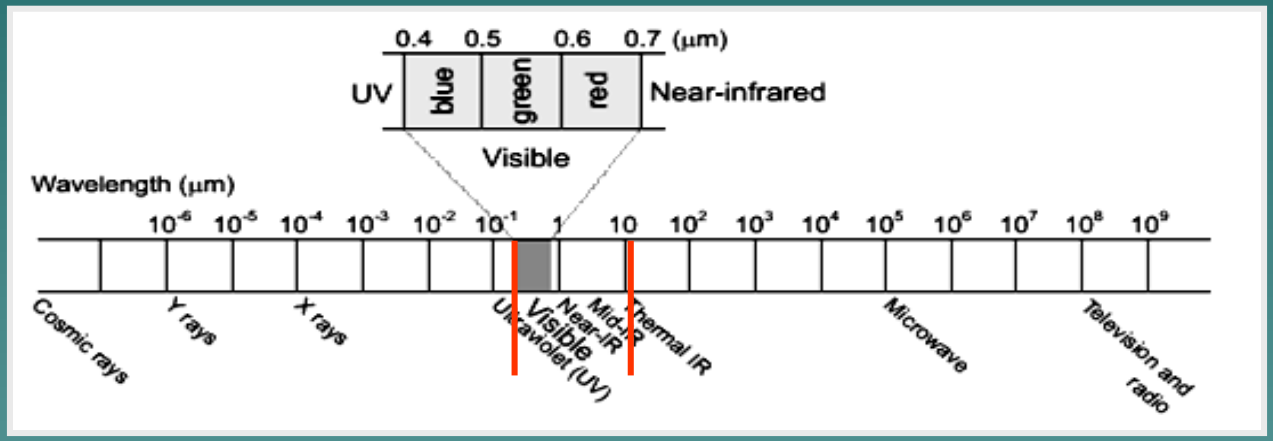
RISAT
C- BAND SAR
& OCEANSAT-2
OCM
SCATTEROMETER

ELECTROMAGNETIC SPECTRUM



ELCTROMAGNETIC SPECTRUM

The set of all electromagnetic waves is called the ***electromagnetic spectrum***, which includes the range from the long radio waves, through the microwave and infrared wavelengths to visible light waves and beyond to the ultraviolet and to the short-wave X and gamma rays



Electromagnetic Spectrum

Visible	:	0.4 – 0.7 μm
Near Infrared (NIR)	:	0.7 – 1.5 μm
Short-wave Infrared (SWIR)	:	1.5 – 3.0 μm
Mid-wave Infrared (MWIR)	:	3.0 – 8.0 μm
Thermal Infrared (TIR)	:	8.0 – 15.0 μm
Far Infrared (FIR)	:	Beyond 15.0 μm

INTERACTION WITH EARTH'S SURFACE

- Electromagnetic radiation reaching the earth's surface from the sun is reflected, transmitted or absorbed.
- Reflected energy travels upwards and interacts with the atmosphere
- The part of reflected radiation which enters the field of view of the sensor is detected and converted into a numerical value that is transmitted to a ground receiving station on earth.

INTERACTION WITH EARTH'S ATMOSPHERE

The interaction is usually described in terms of two processes:

1. ***Scattering:*** deflects the radiation from its path
2. ***Absorption:*** converts the energy present in electromagnetic radiation into the internal energy of the absorbing molecule

☞ "*both Scattering and Absorption vary in their effect from one part of the spectrum to the other*"

INTERACTION WITH EARTH'S ATMOSPHERE

1. ***Rayleigh Scattering:***

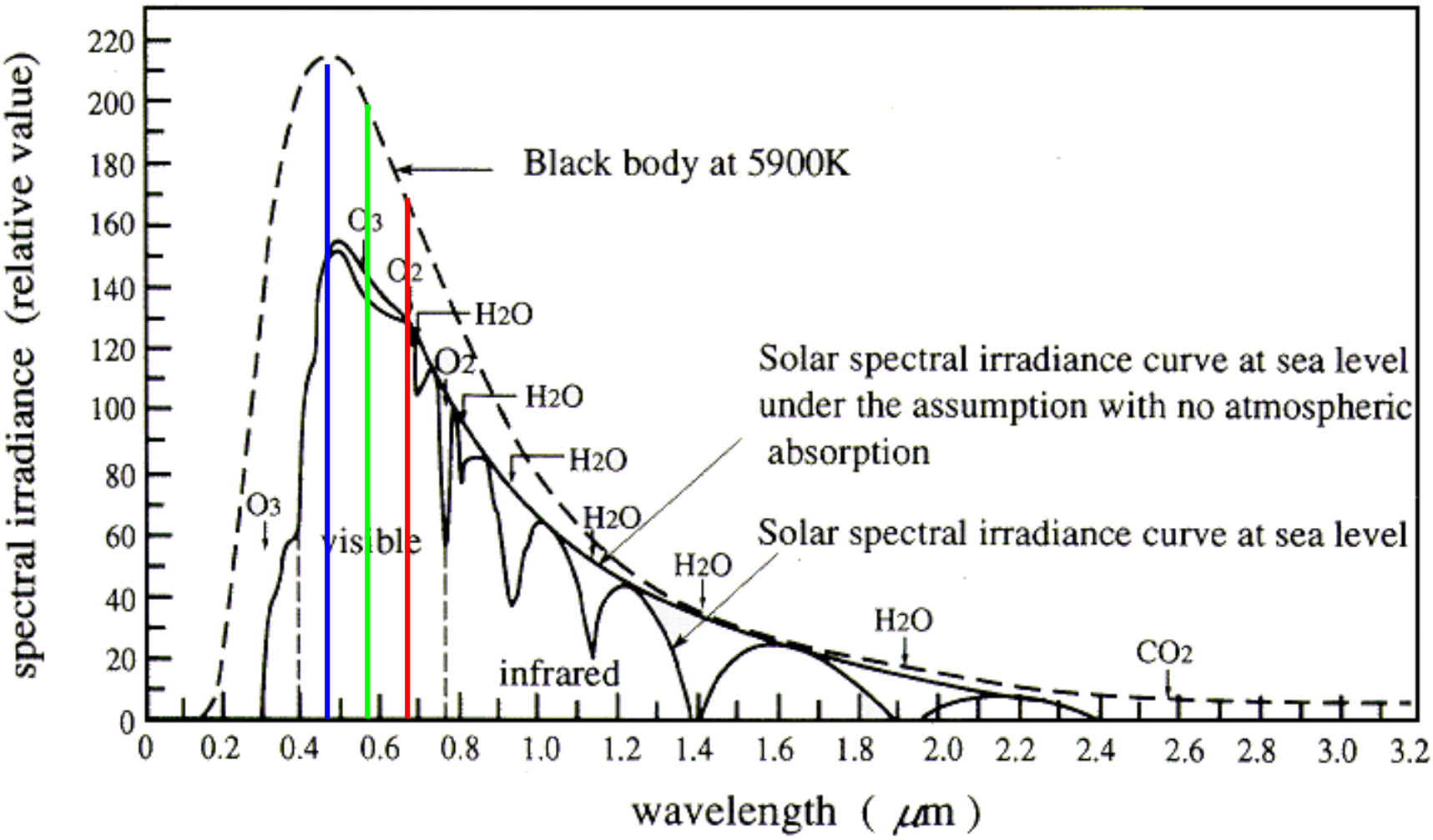
   Very small particles and molecules, with radii far less than the wavelength of the electromagnetic radiation of interest, are responsible for Rayleigh scattering

2. ***Mie Scattering:***

   Mie scattering is caused by the particles that have radii between 0.1 and 10μm i.e. approximately the same magnitude as the wavelengths of EM radiation in the visible, near infrared and thermal infrared regions of the spectrum.

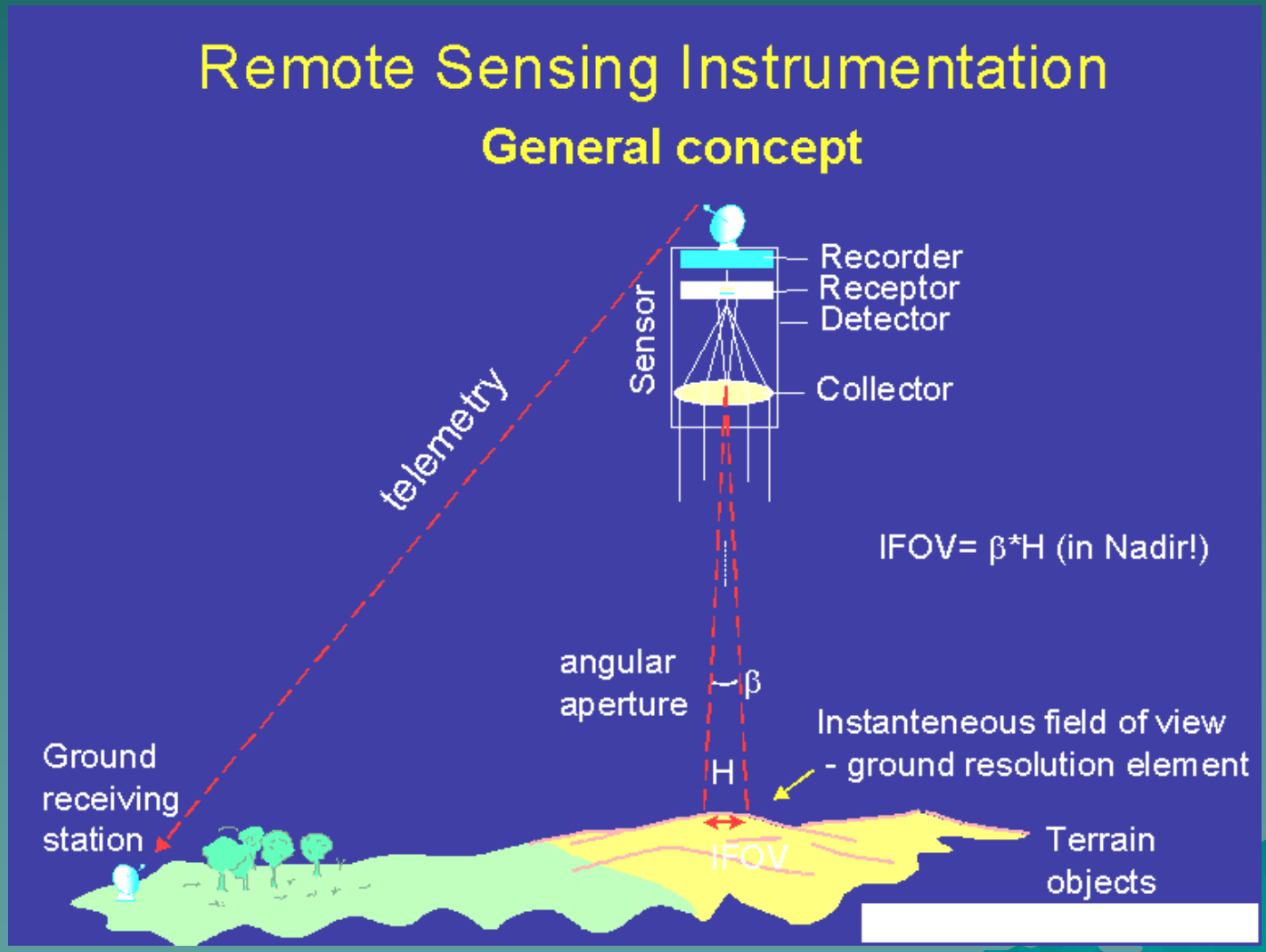
3. ***Non-Selective Scattering:***

   Non-selective scattering is wavelength independent. Produced by particles whose radii exceed 10 μm e.g. water droplets in clouds

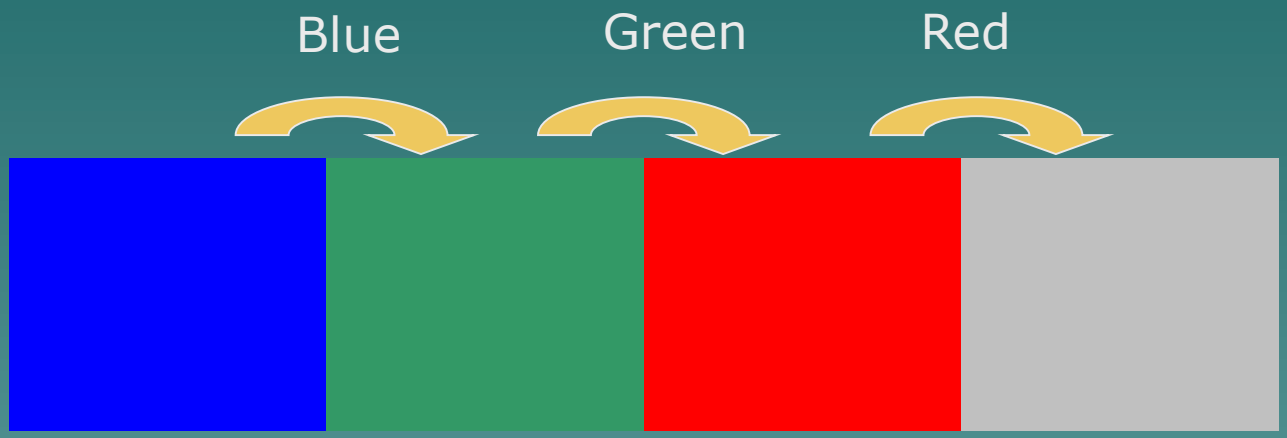


Comparison of spectral irradiance of solar light at sea level with black body radiation

Sensor & Platform



Colour Composite

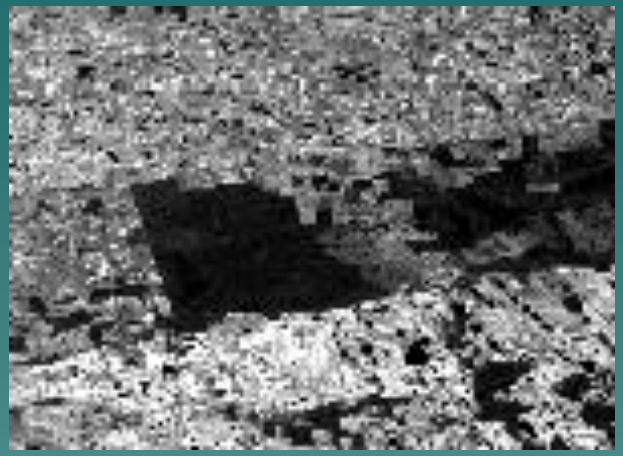


Conventional RGB Combination

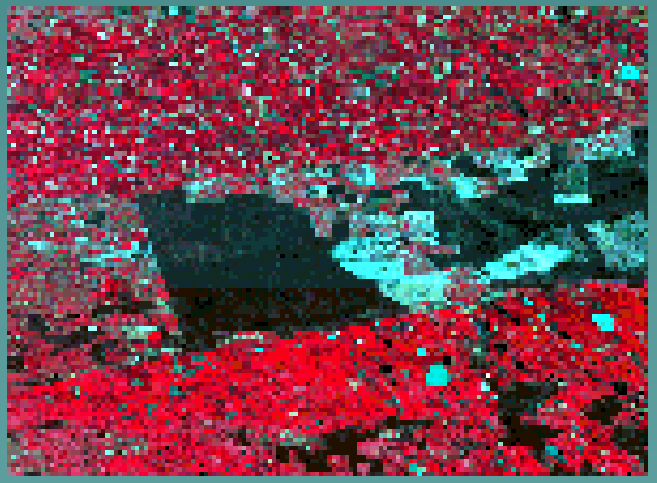
Multispectral Images

Green

Red



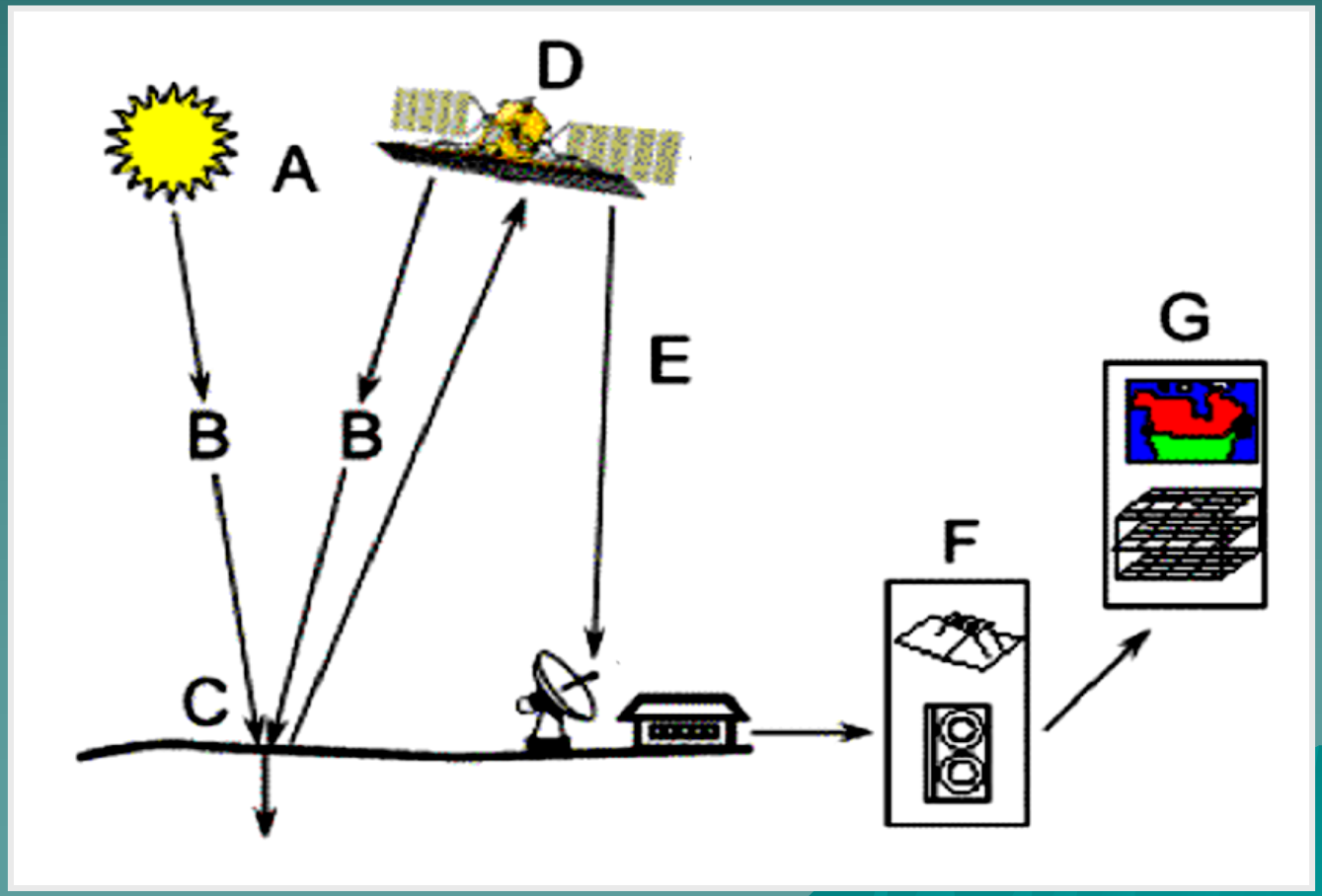
NIR



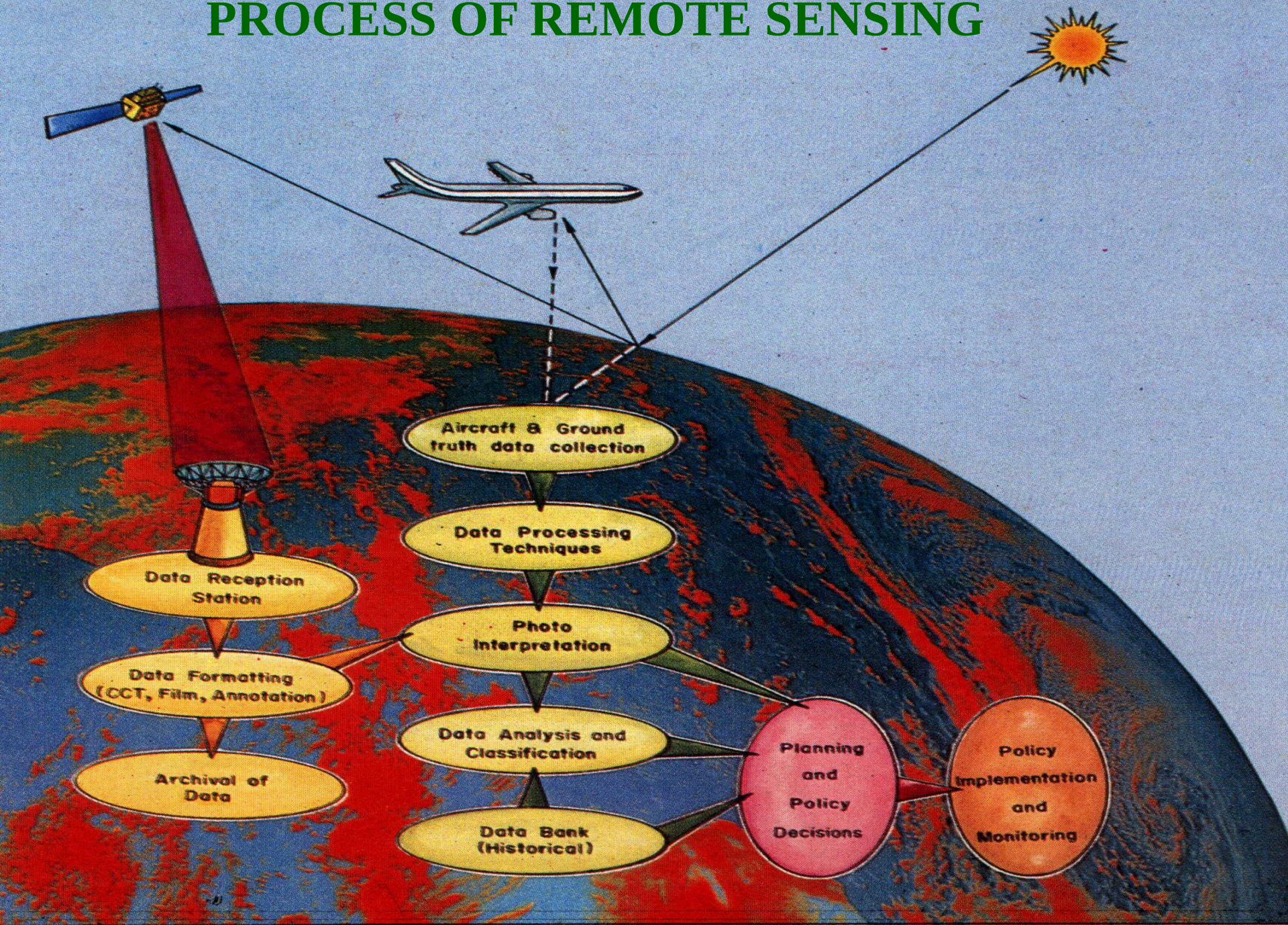
FCC

REMOTE SENSING

Earth Observation (EO) by Remote Sensing is the interpretation and understanding of measurements of EM radiations emitted by the objects on earth's surface



PROCESS OF REMOTE SENSING



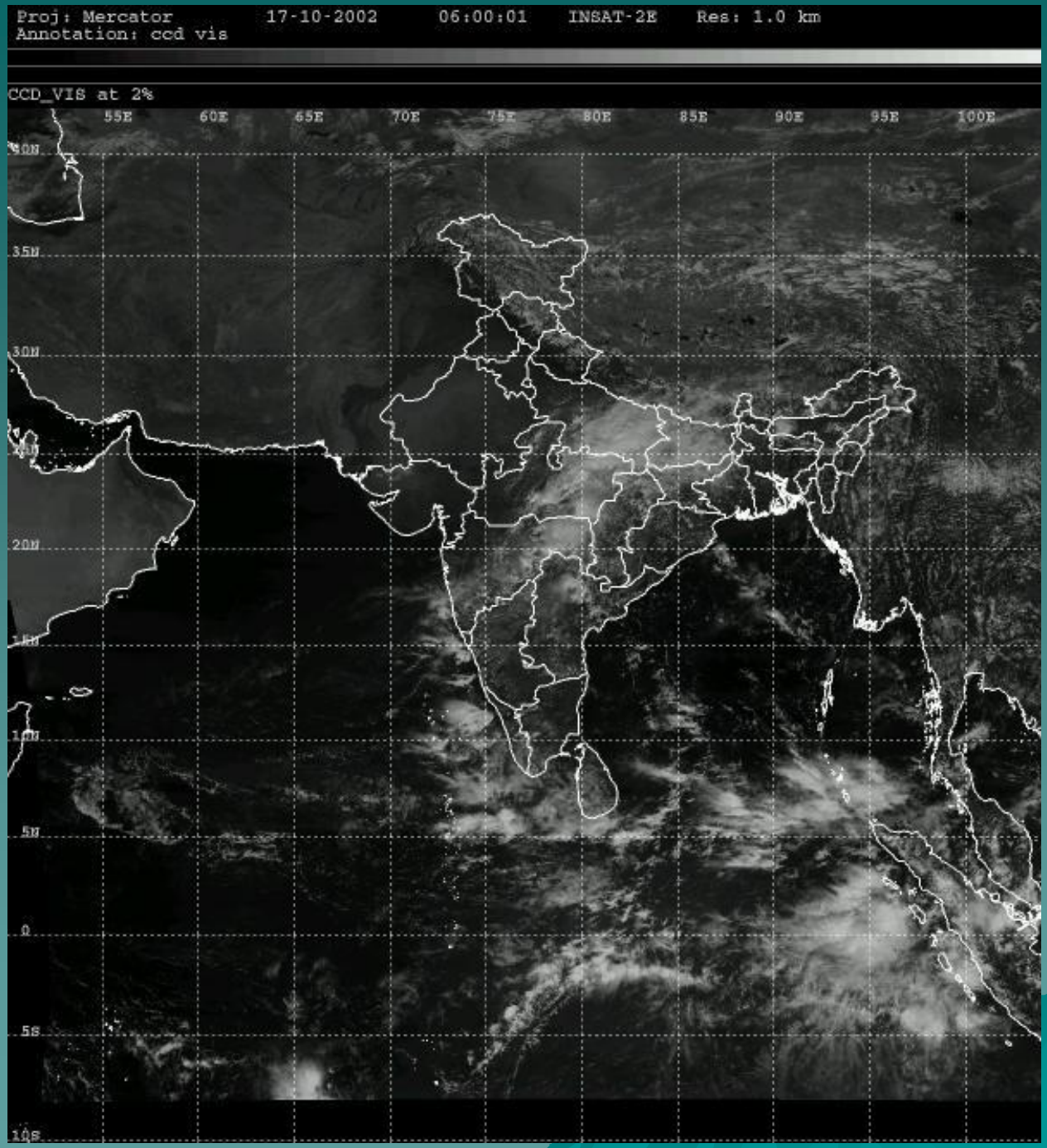
Remote sensing basic processes

- Data acquisition (energy propagation, platforms)
- Processing (conversion of energy pattern to images)
- Analysis (quantitative and qualitative analysis)
- Accuracy assessment (radiometric and geometric correction)
- Information distribution to users (hard copy, CCT, CD-ROM, X-BYTE)

Remote Sensing

Four Fundamental Properties For Design

- **Image depends on the wavelength response of the sensing instrument (radiometric and spectral resolution) and the emission or reflection spectra of the target (the signal).**
  - **Radiometric resolution**
  - **Spectral resolution**
- **Image depends on the size of objects (spatial resolution) that can be discerned**
  - **Spatial resolution**
- **Knowledge of the changes in the target depends on how often (temporal resolution) the target is observed**
  - **Temporal resolution**


Proj: Mercator 17-10-2002 06:00:01 INSAT-2E Res: 1.0 km
Annotation: ccd vis
CCD_VIS at 2%
55E
60E
65E
70E
75E
80E
85E
90E
95E
100E
35N
30N
20N
5N
0
5S

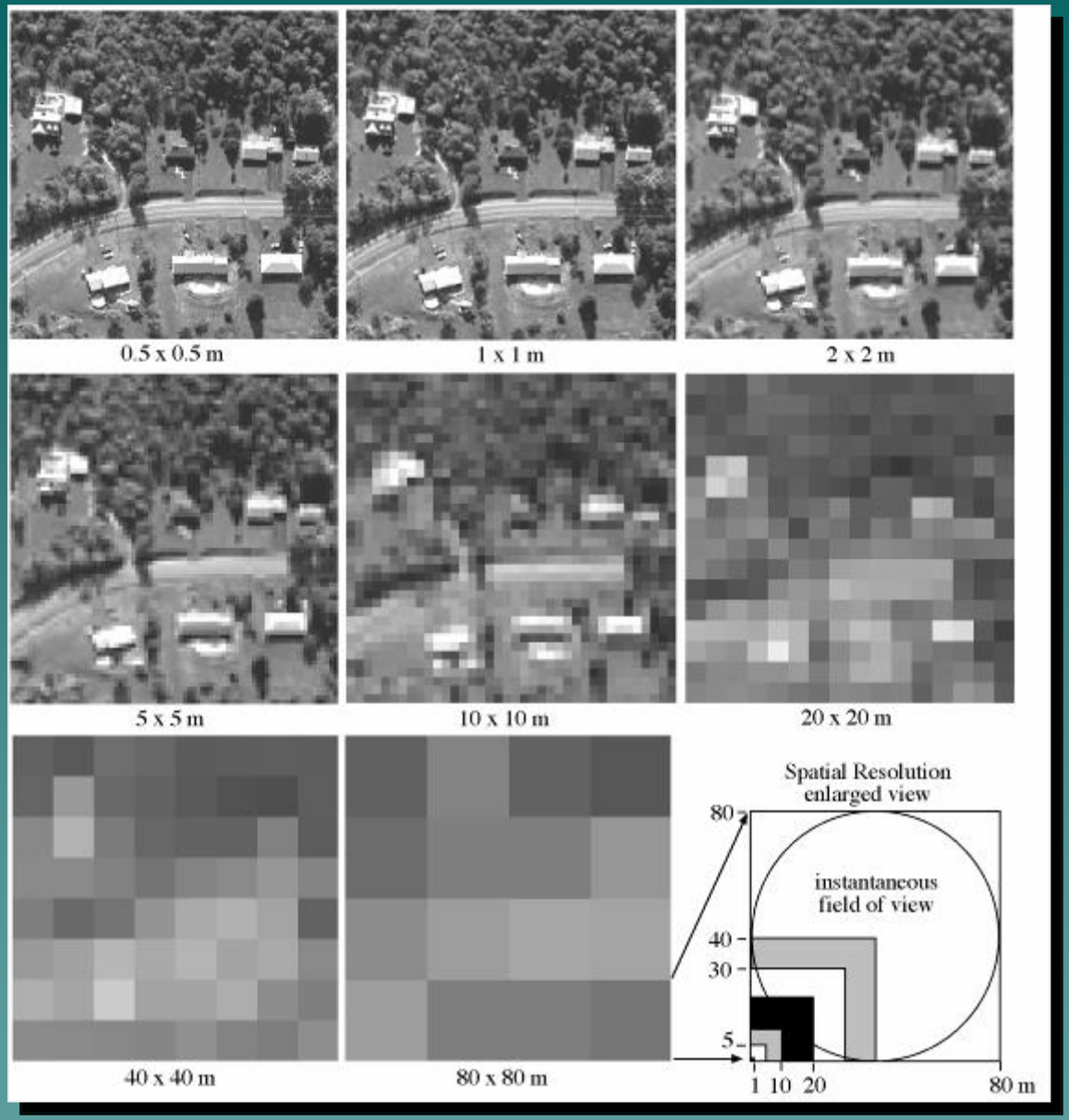
Spatial Resolution

40 x 40

80 x 80

320 x 320

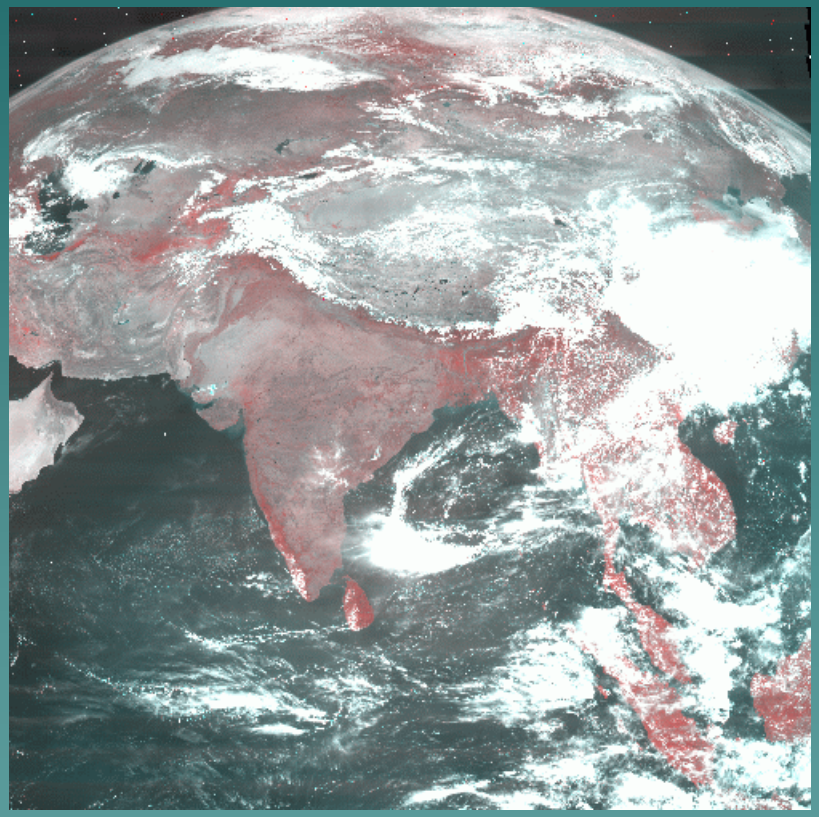
Spatial Resolution



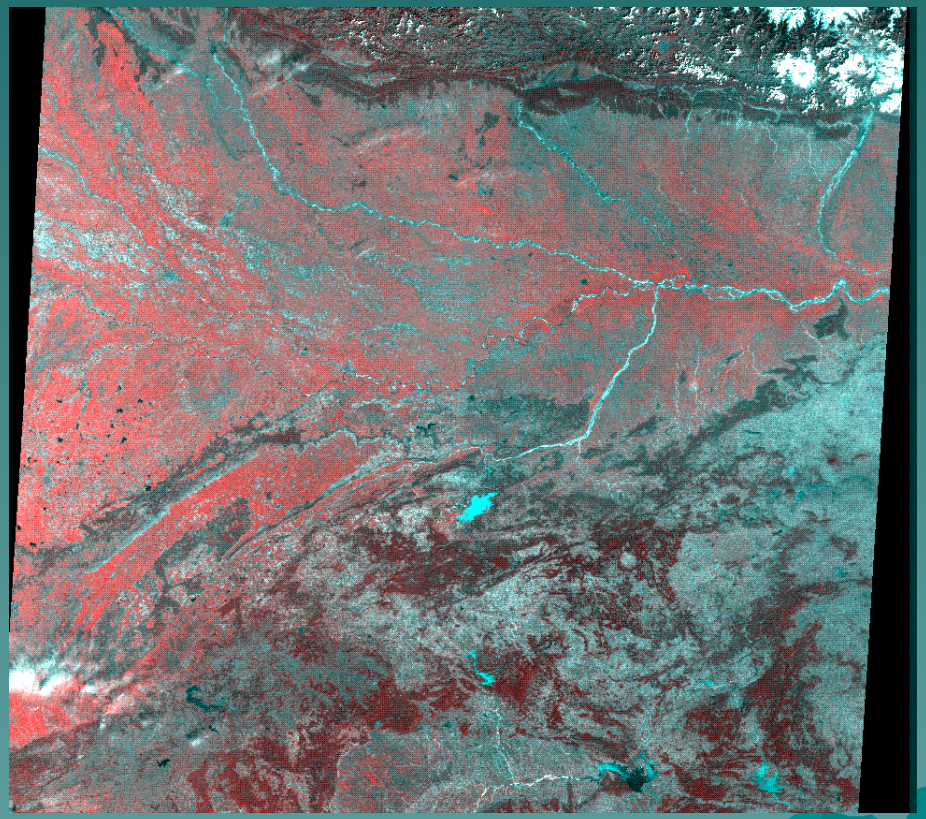
High vs. Low?

Source: Jensen (2000)

Different Resolutions



INSAT-2E, 1 km Resolution



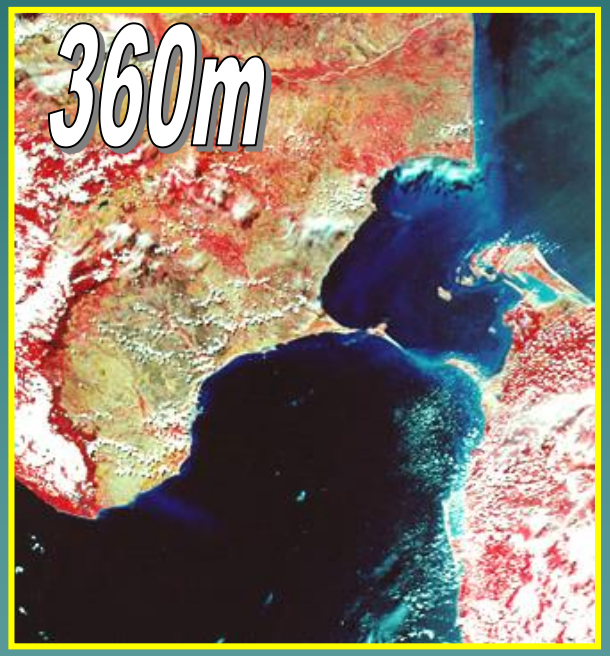
IRS 1C WiFS, 188 m Resolution

Different Resolutions….

EVERY 30 MIN.IMAGING

1M+ SCALES

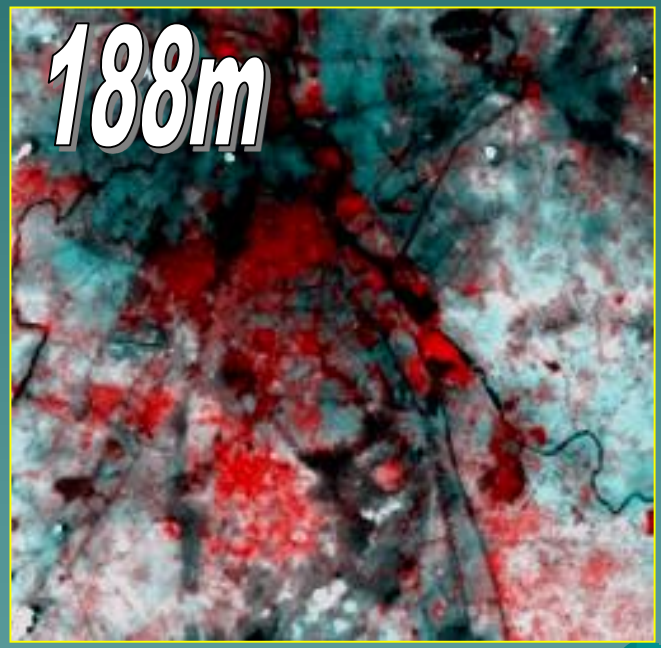
CLIMATE/WEATHER



EVERY 2 DAYS IMAGING

1:250K SCALES

OCEAN APPLICATIONS



EVERY 5 DAYS IMAGING

1:250K SCALES

NATIONAL SURVEYS

Different Resolutions….

- EVERY 22 DAYS IMAGING
- 1:50K SCALES
- DETAILED RESOURCES SURVEY

- EVERY 5 DAYS IMAGING
- 1:12500 SCALES
- LARGE SCALE MAPPING
- STEREO CAPABILITY

Spectral resolution

The spectral bandwidth in which the data is collected.

Spectral Resolution

- **Example: Black and white image**

  - Single sensing device

  - Intensity is sum of intensity of all visible wavelengths

Can you tell the color of the platform top?

How about her sash?

Spectral Resolution (Con't)

- Example: Color image
  - Color images need least three sensing devices, e.g., red, green, and blue; RGB

Using increased spectral resolution (three sensing wavelengths) adds information

In this case by "sensing" RGB can combine to get full color rendition

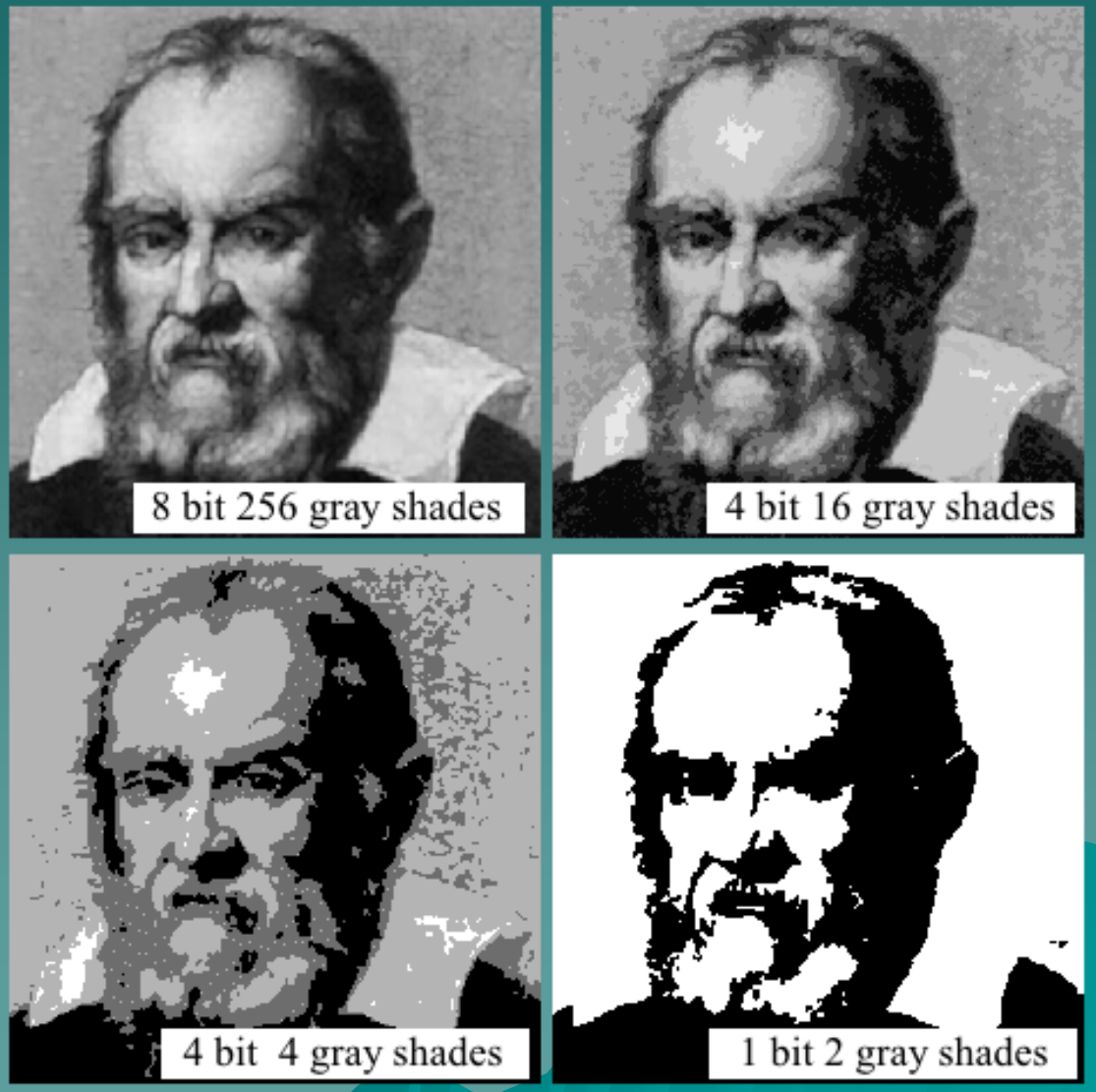
Radiometric resolution

The capability of the sensor to discriminate two targets based on its reflectance/emittance difference; it is measured in terms of the smallest the radiance difference that can be detected between two targets.

Radiometric Resolution

- **Number of Shades or brightness levels at a given wavelength**

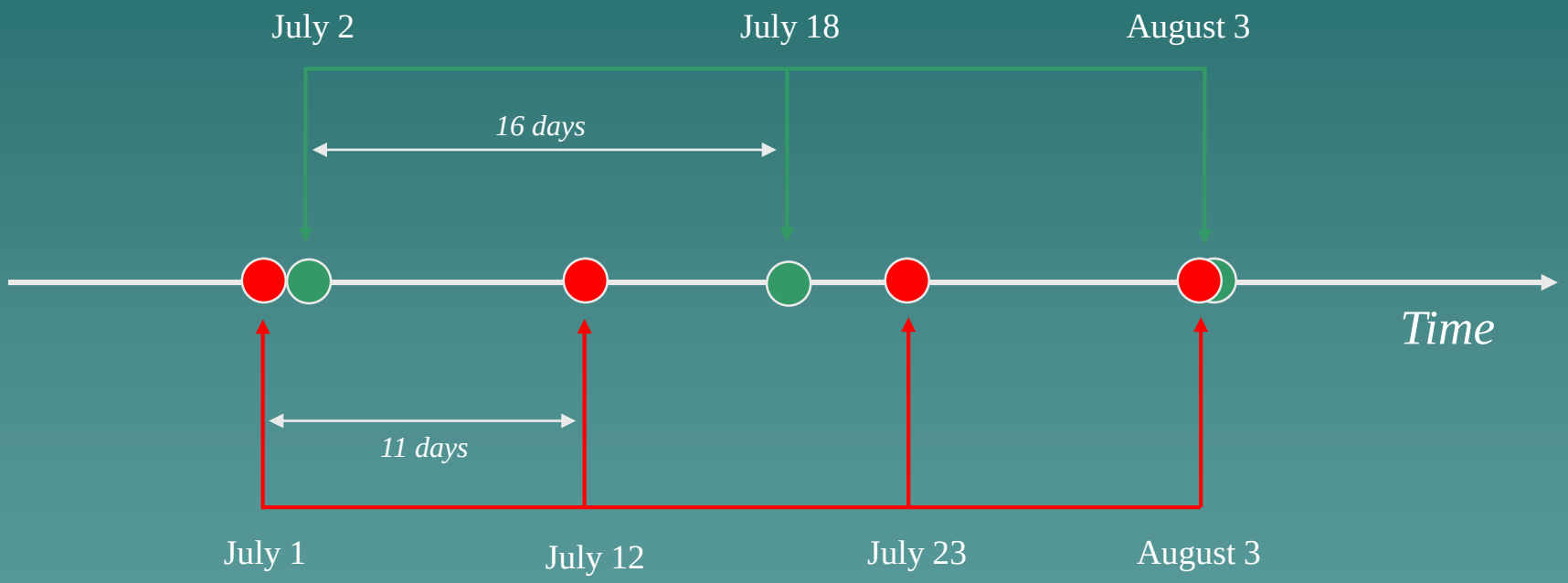
- **Smallest change in intensity level that can be detected by the sensing system**



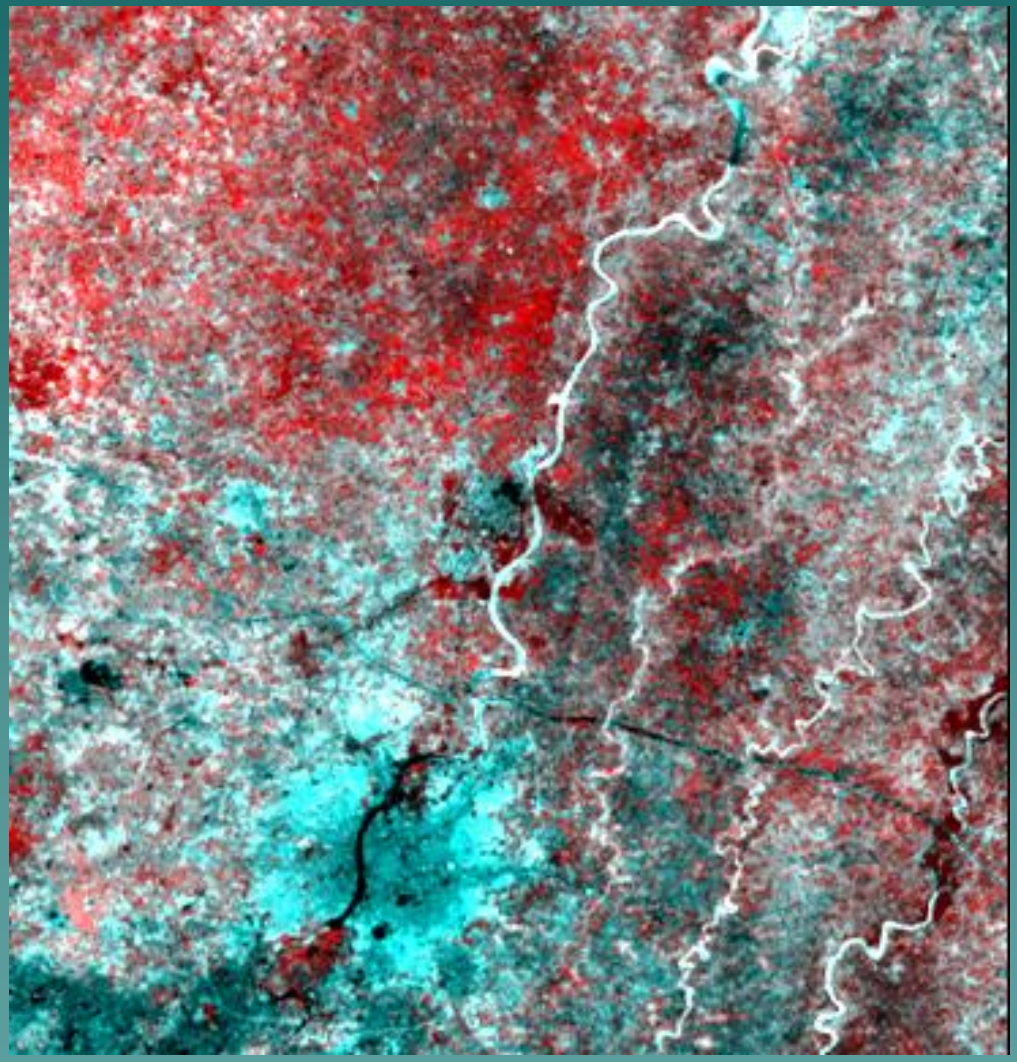
Temporal Resolution

The capability to view the same target, under similar conditions, at regular intervals.

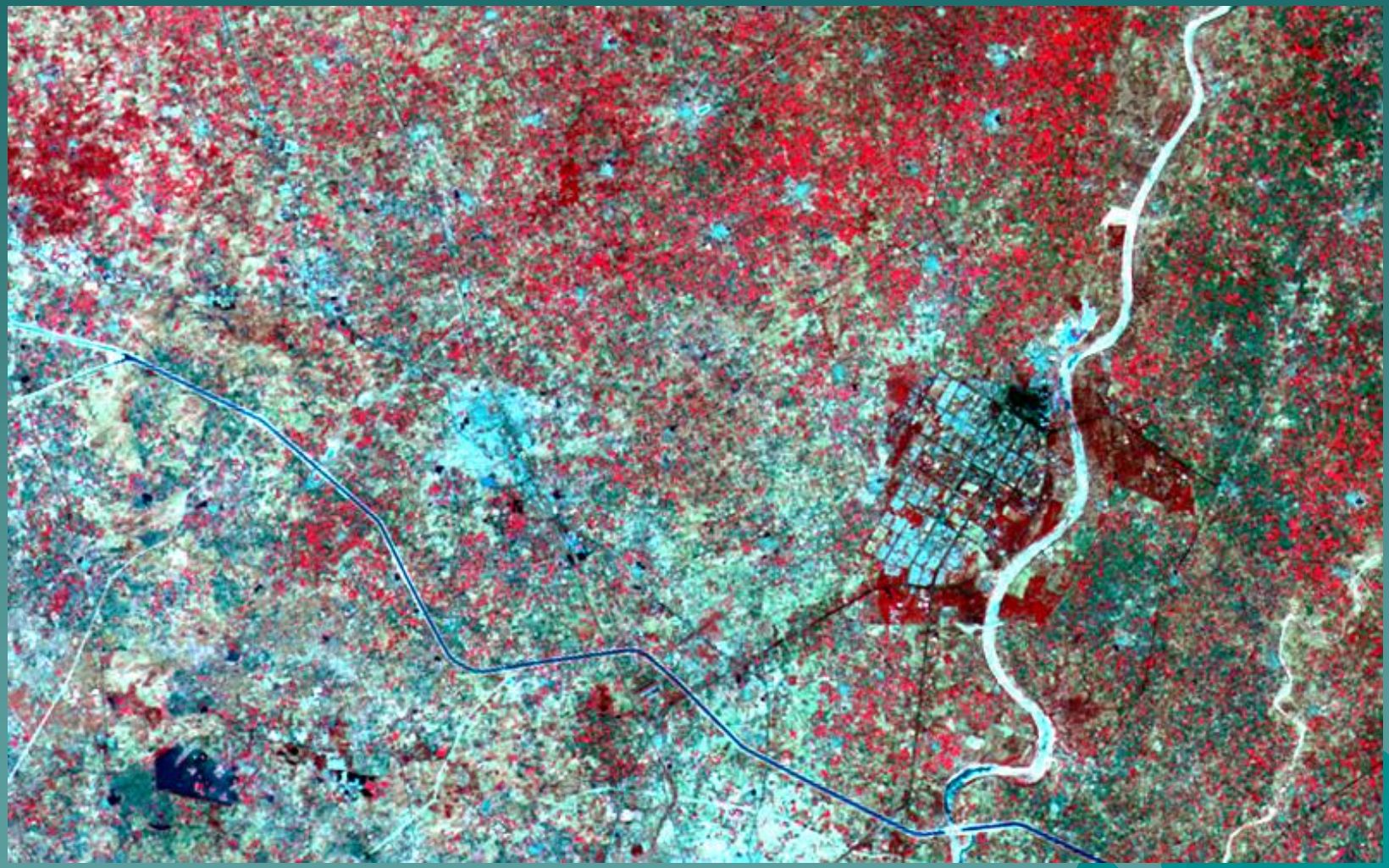
Temporal Resolution



WiFS Image 188m



AWiFS Image 56m



LISS-III Image 24m

LISS-IV Image 6m

Image

Pictorial representation of a scene recorded by a remote sensing system.

Picture Element

In a digitized image, the area on the ground represented by each digital number. Commonly known as *pixel.*

Digital Number (DN)

Value assigned to a pixel in a digital image.

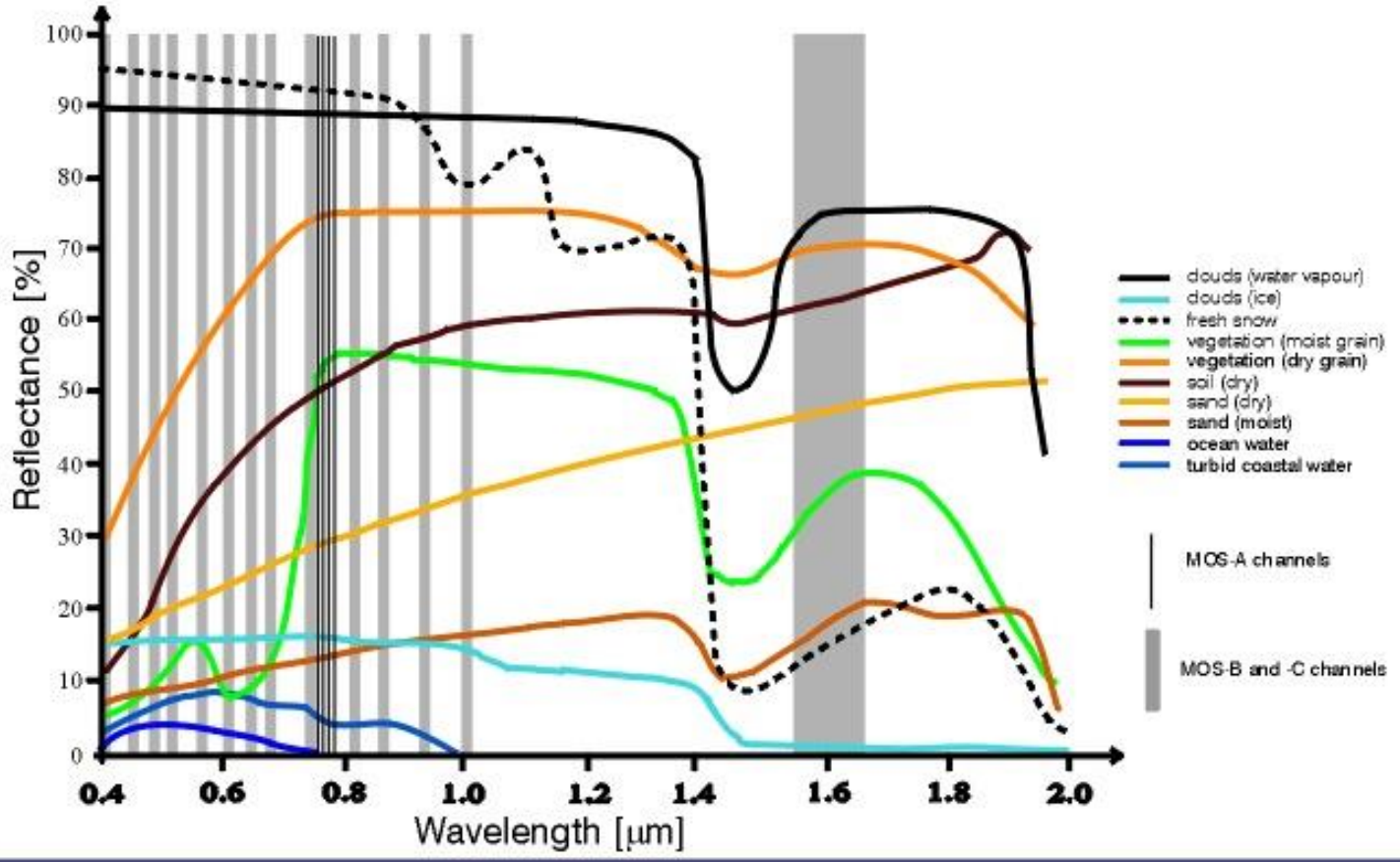
Signature

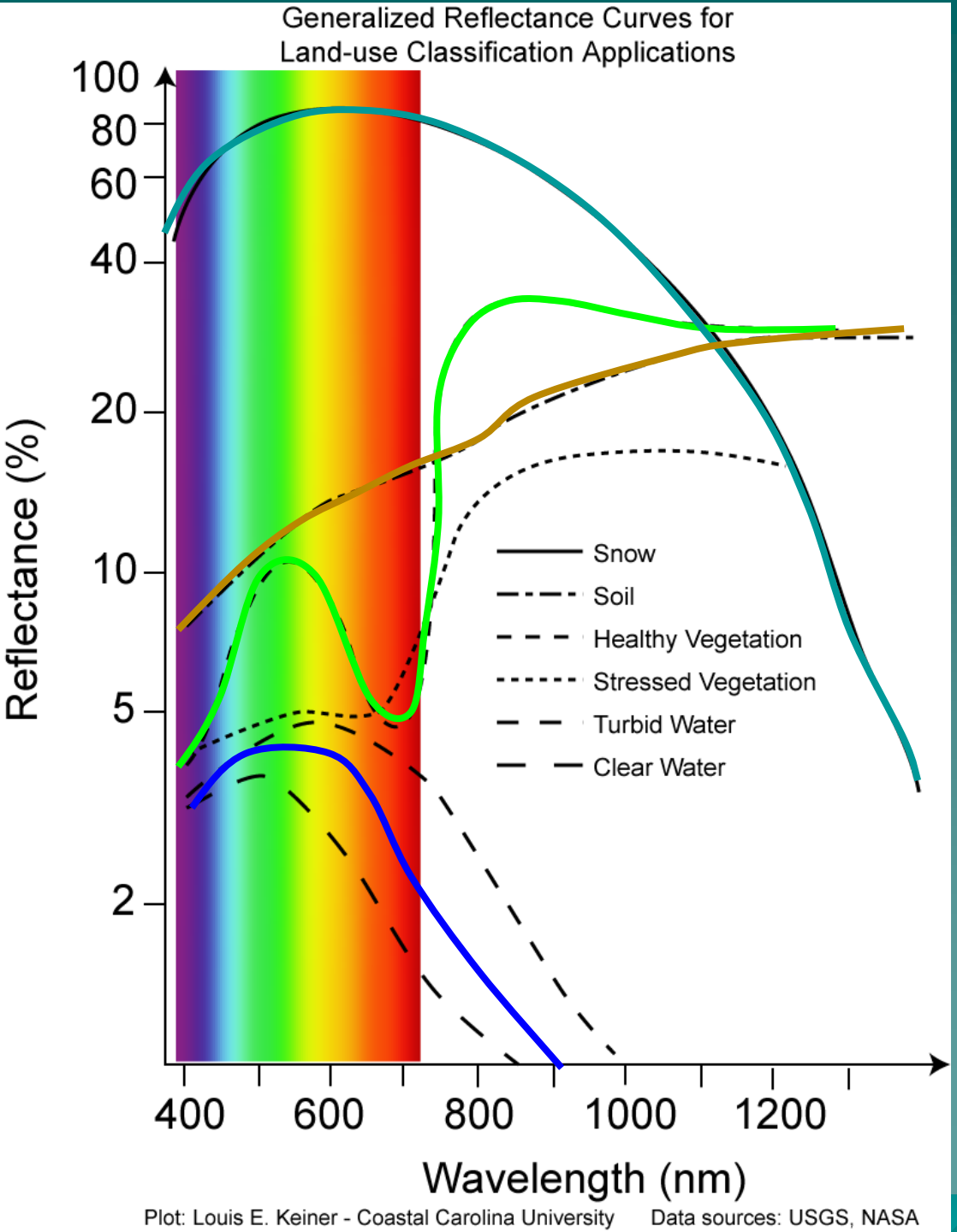
Set of characteristics by which a material or an object may be identified on an image or photograph.

Geometric Correction

Image-processing procedure that corrects spatial distortions in an image.

Spectral reflectance of different remote sensing objects





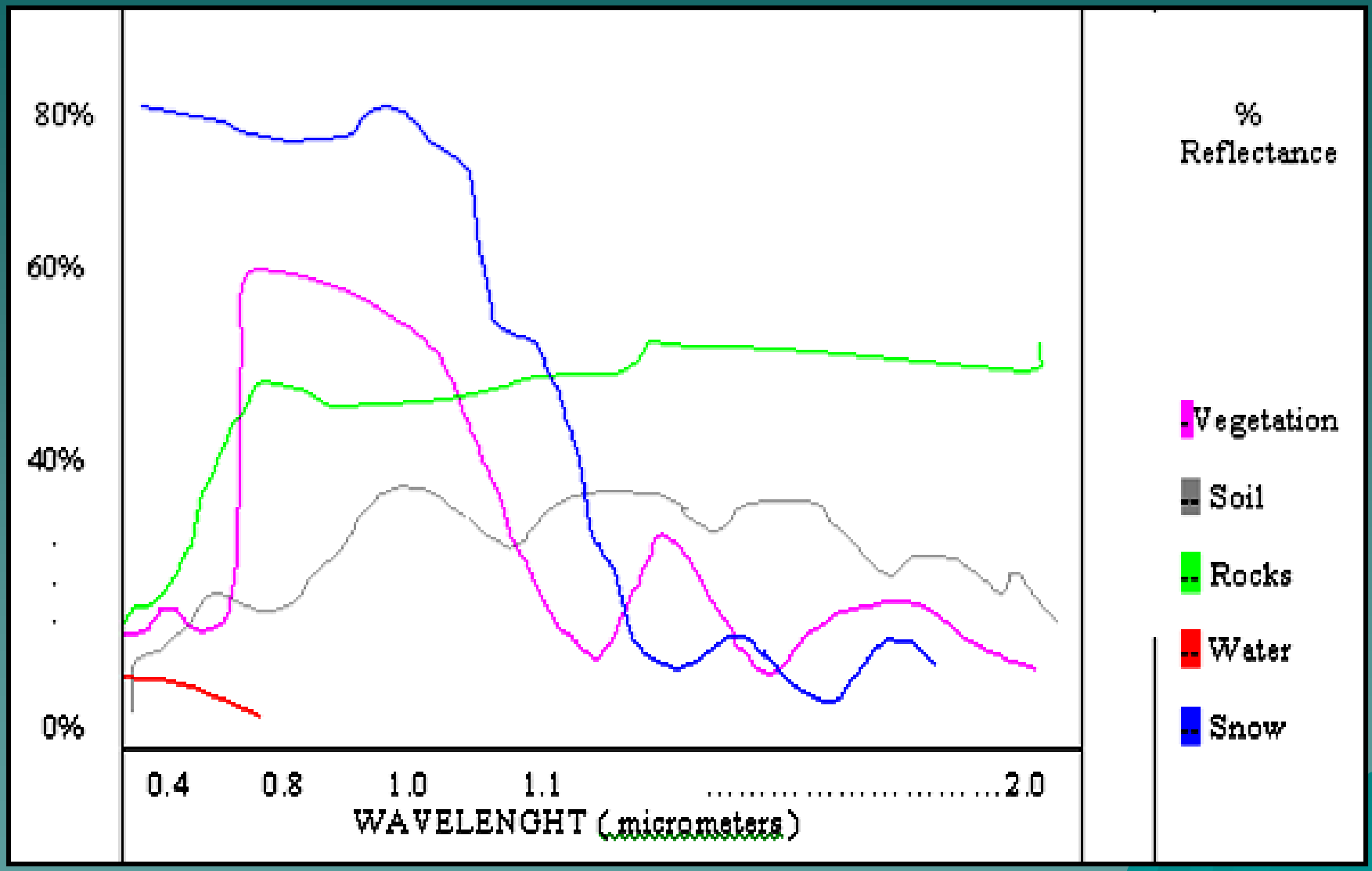
Soil

Vegetation

Snow

Ocean

REFLECTANCE SPECTRA



REFLECTANCE SPECTRA - SOILS

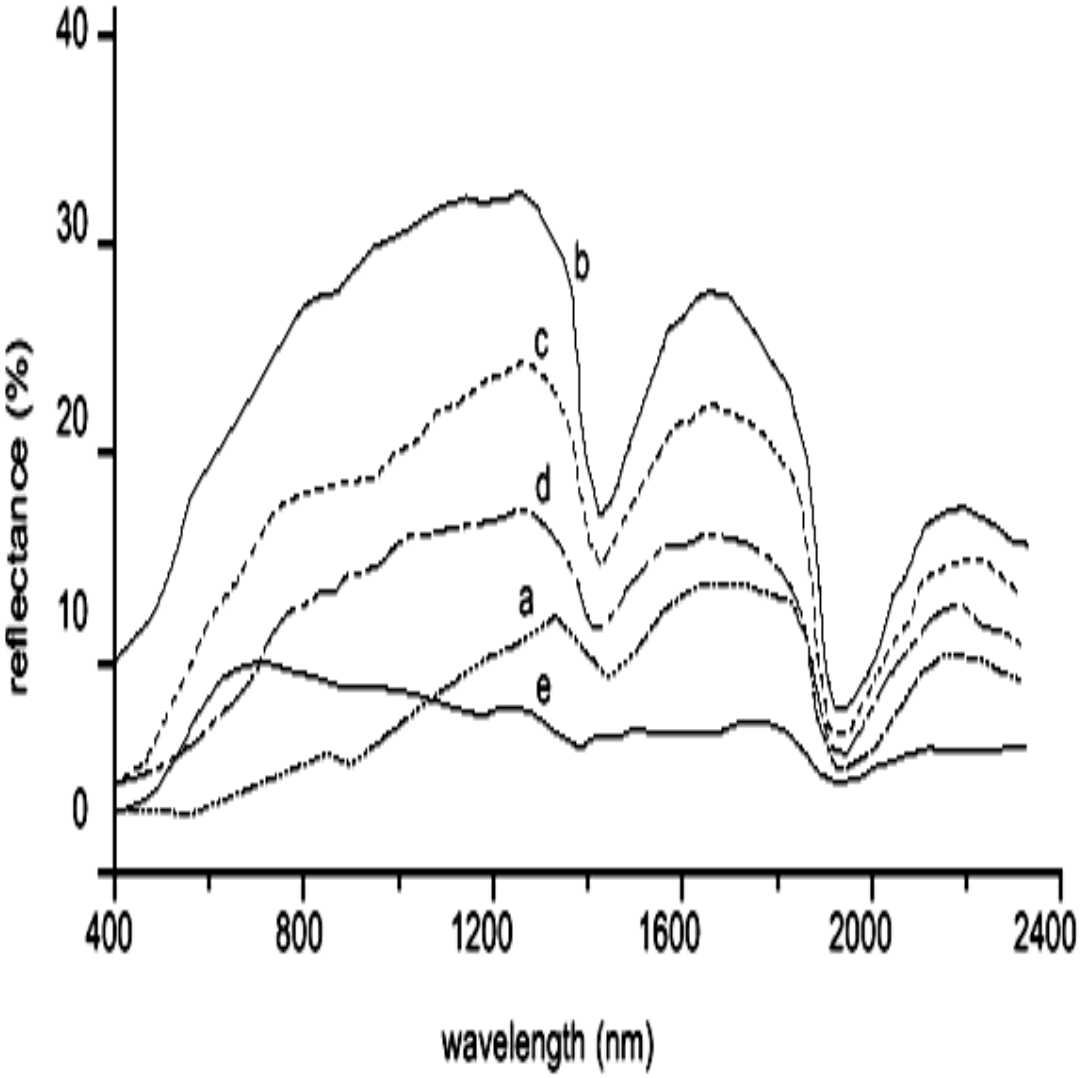


Figure 2.14: Reflectance spectra of surface samples of five mineral soils, (a) organic dominated, (b) minimally altered, (c) iron altered, (d) organic affected and (e) iron dominated (from [17])

REFLECTANCE SPECTRA - WATER

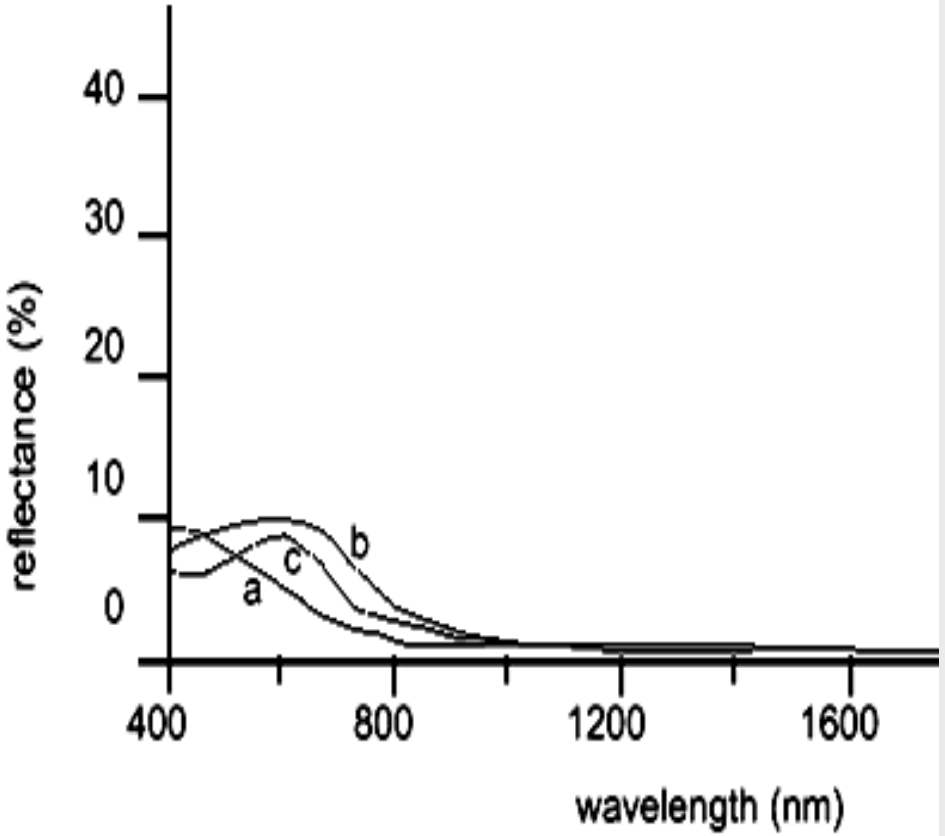
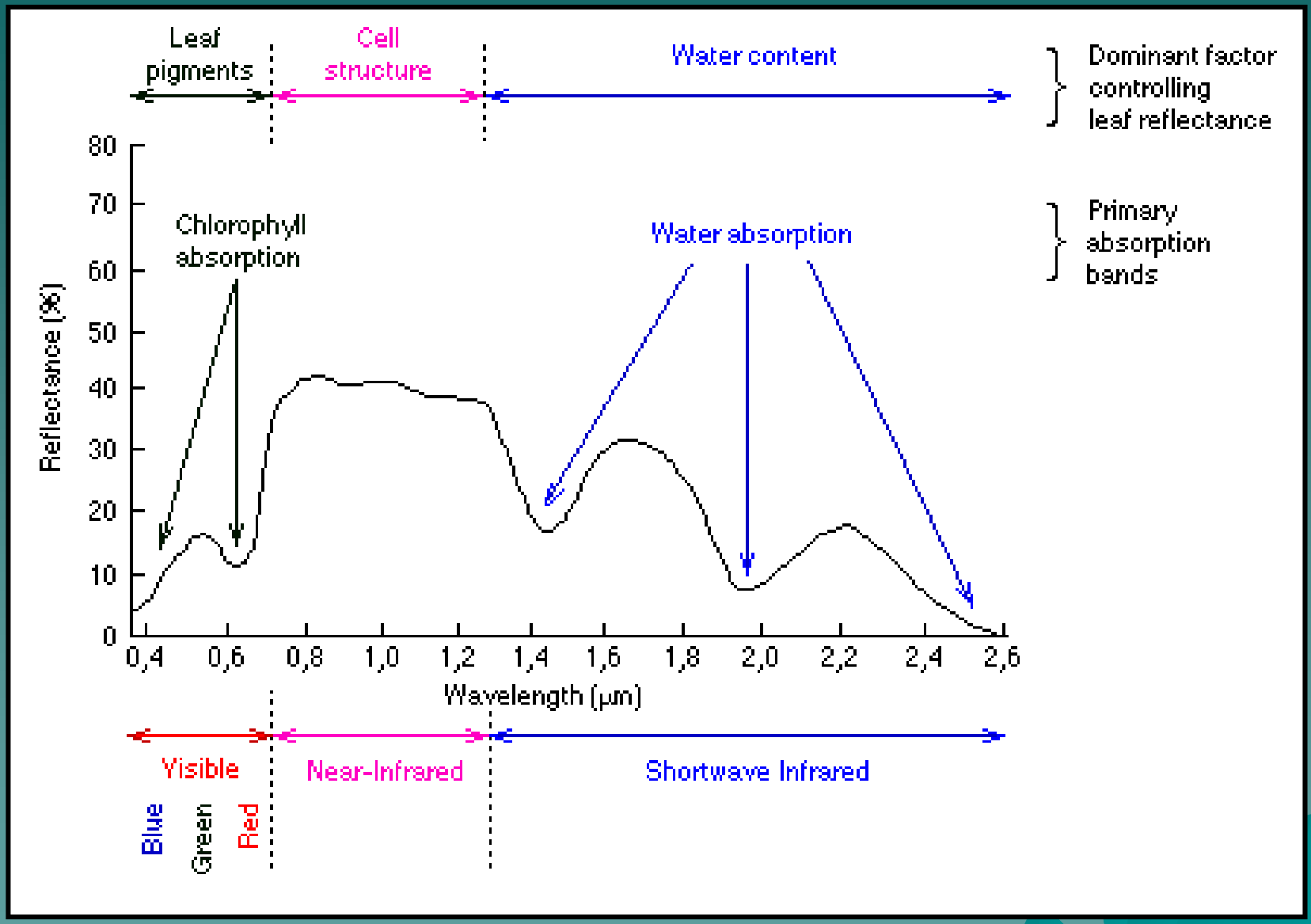


Figure 2.15: Typical effects of chlorophyll and sediments on water reflectance: (a) ocean water, (b) turbid water, (c) water with chlorophyll (from [17])

SPECTRAL RESPONSE OF VEGETATION



MULTI-SPECTRAL DATA

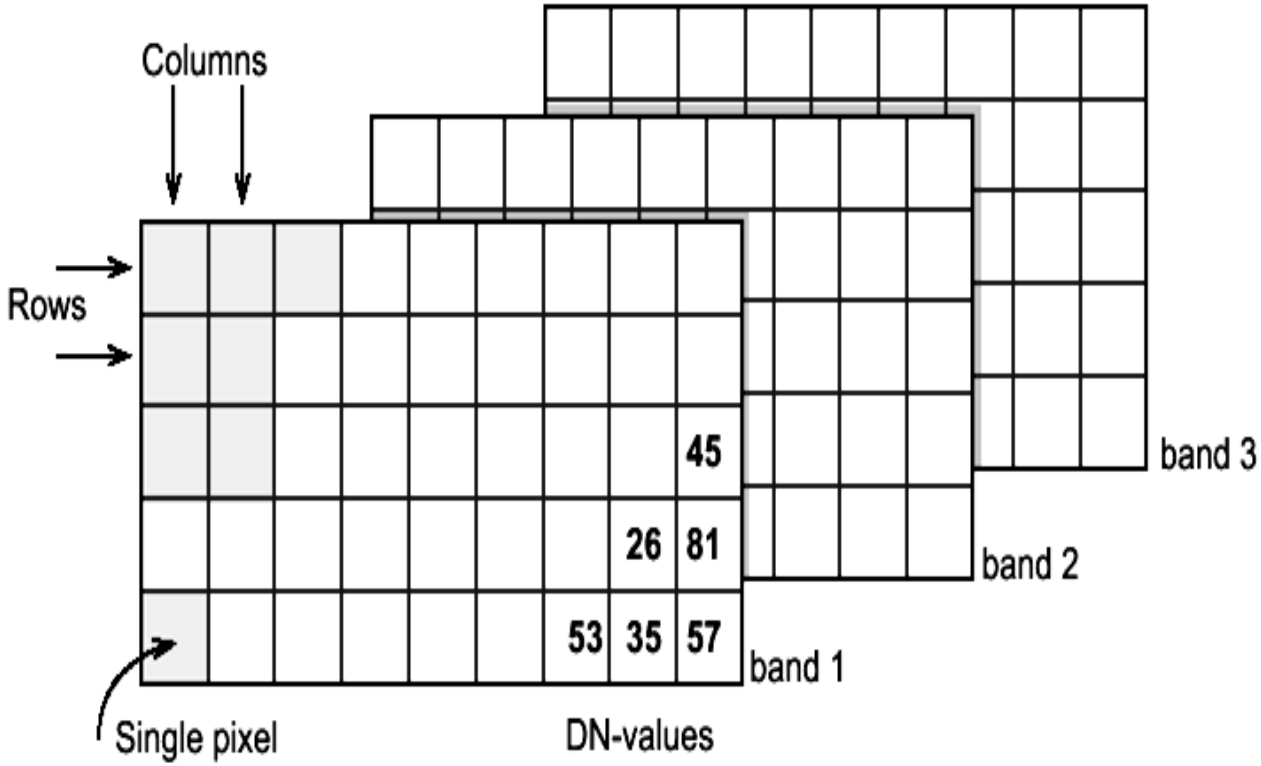
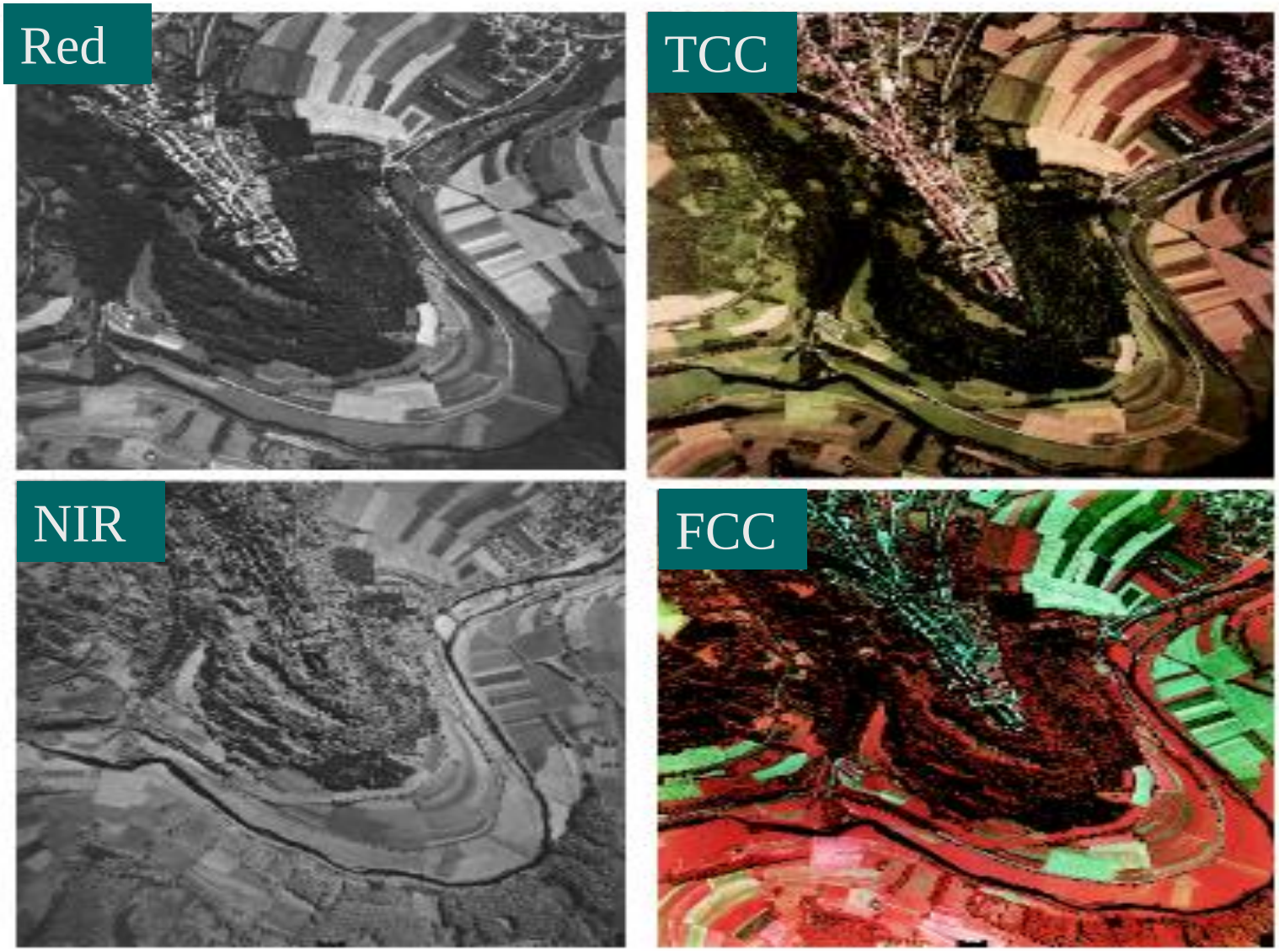


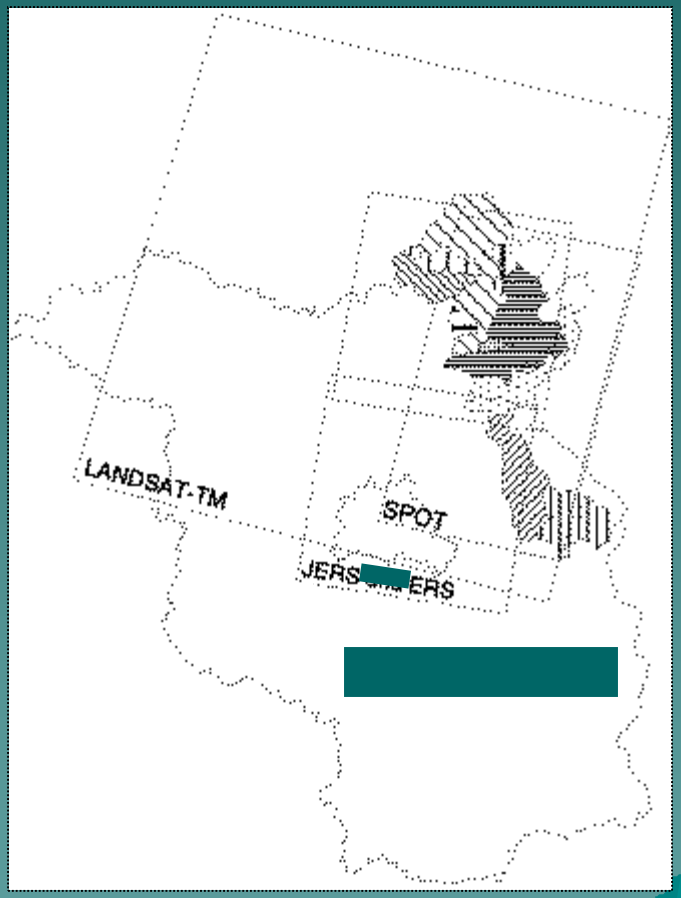
Figure 3.11: An image file comprises a number of bands. For each band the Digital Number (DN) values, corresponding to the measurements, are stored in a row-column system.

COLOUR COMPOSITES



Spatial data resolution problem

- trade-off pixel size vs. spatial coverage
- quantization and data volume
- data merge from different sources
- grid displacement in time
- information content of different resolutions
- raster-vector conversion



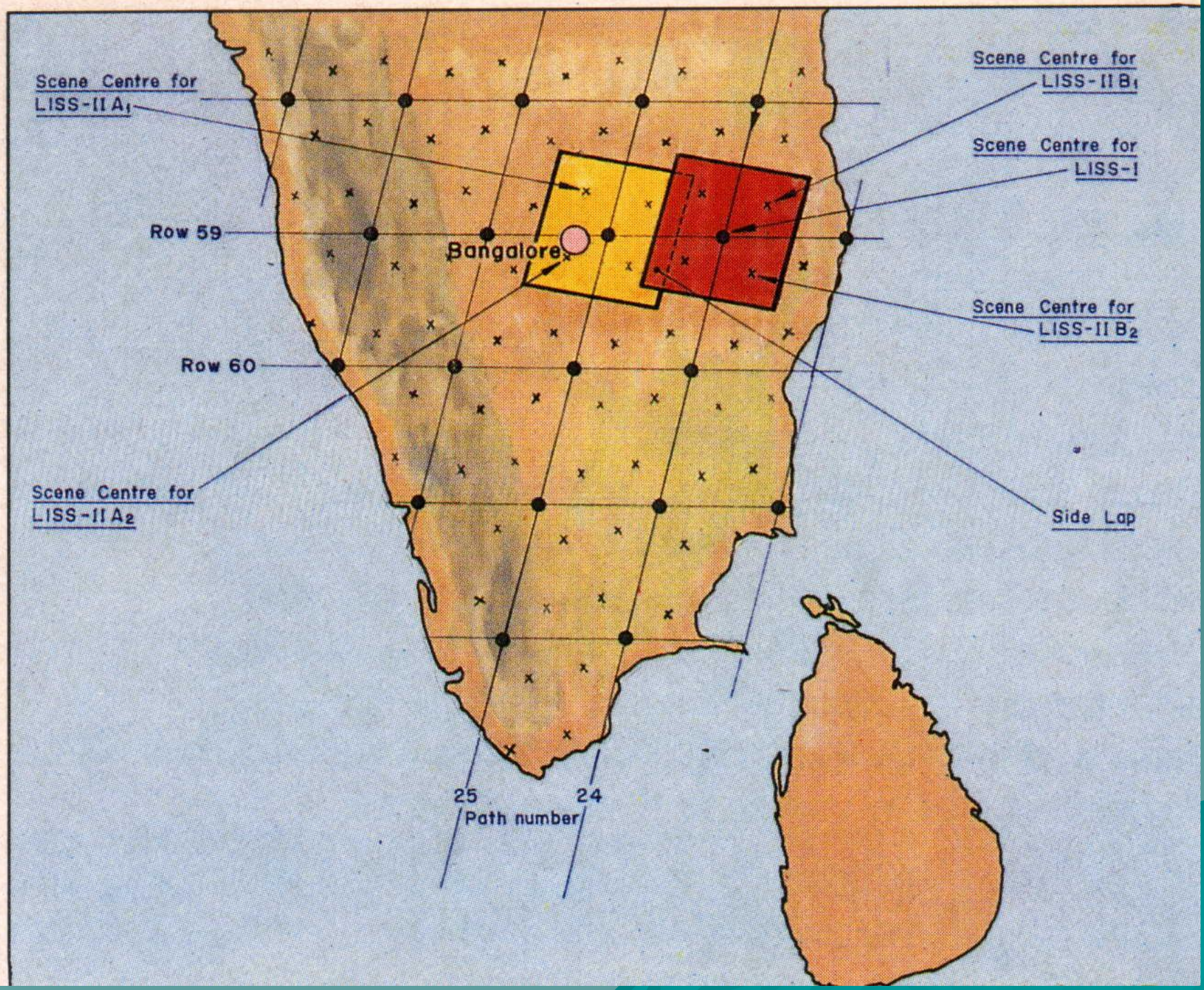

Scene Centre for LISS-II A1
Scene Centre for LISS-II B1
Scene Centre for LISS-I
Row 59
Bangalore
Scene Centre for LISS-II B2
Row 60
Scene Centre for LISS-II A2
Side Lap
25
24
Path number

Image processing steps

- geometric and radiometric correction
- atmospheric correction
- subsetting, mosaic, enhancement
- geo-coding (map projection, spheroid, units)
- parameter extraction (multivariate statistics, regression model, physical model etc.)
- post-processing (filtering, grouping, data reduction)
- Raster GIS: focal or global operations
- hybrid GIS: zonal/region-based operations, spatial statistics

Processing level of remote sensing data

- raw data from the satellite
- system corrected, calibrated, geo-coded, terrain corrected
- atmospheric correction for optical data
- thematic evaluations (land use, NDVI, rainfall etc.)
- CD-DVD/ FTP
- most commercial data formats are read by software
- generic binary format BSQ, BIL,Tiff,

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 a number of bandwidths simultaneously
- Provides geo-referenced, digital, data
- Some remote sensors operate in all seasons, at night, and in bad weather

Scope of Remote Sensing Applications

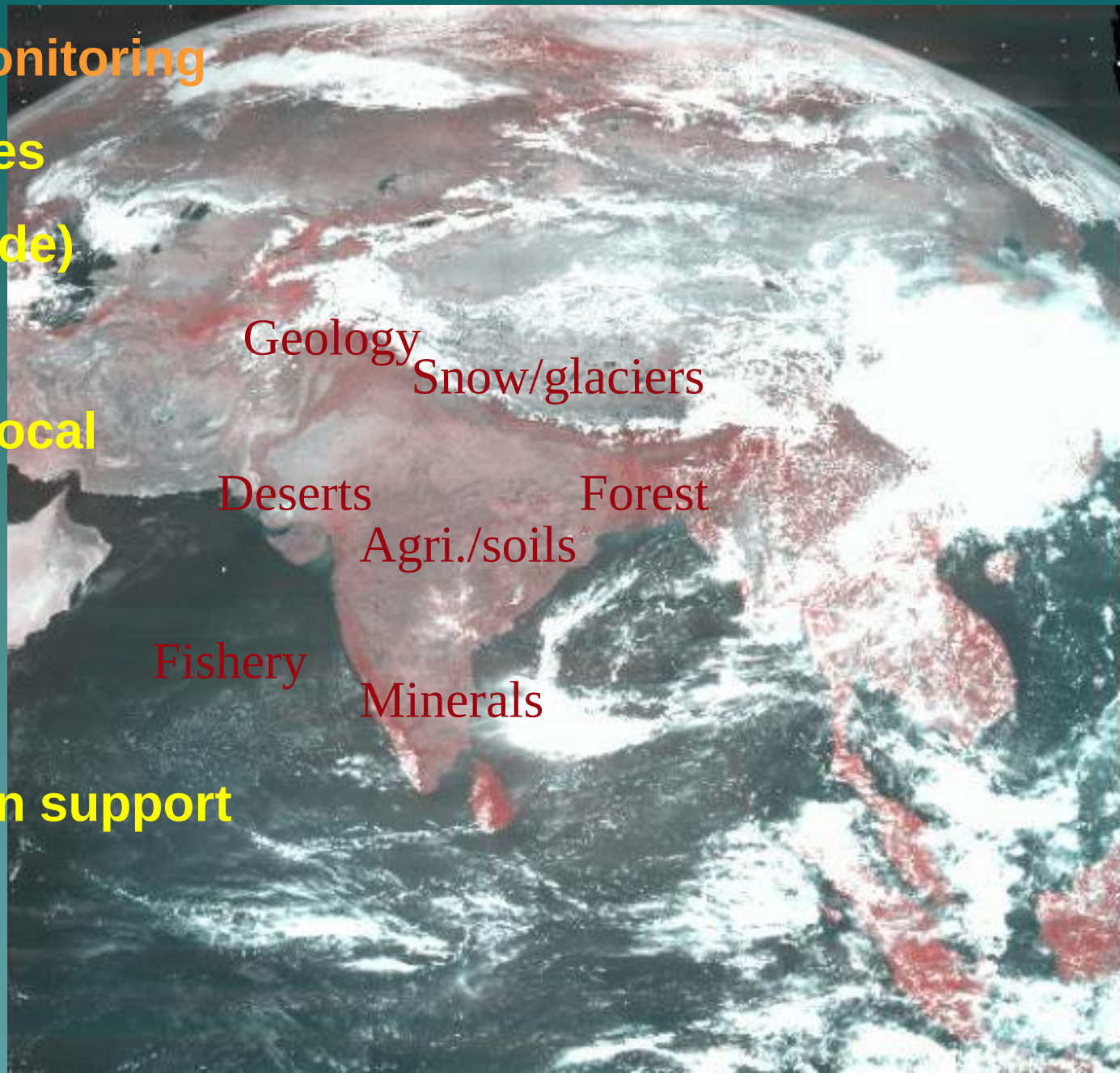
Inventory and monitoring

Theme: Resources

(natural /manmade)

Scale

Global-regional-local

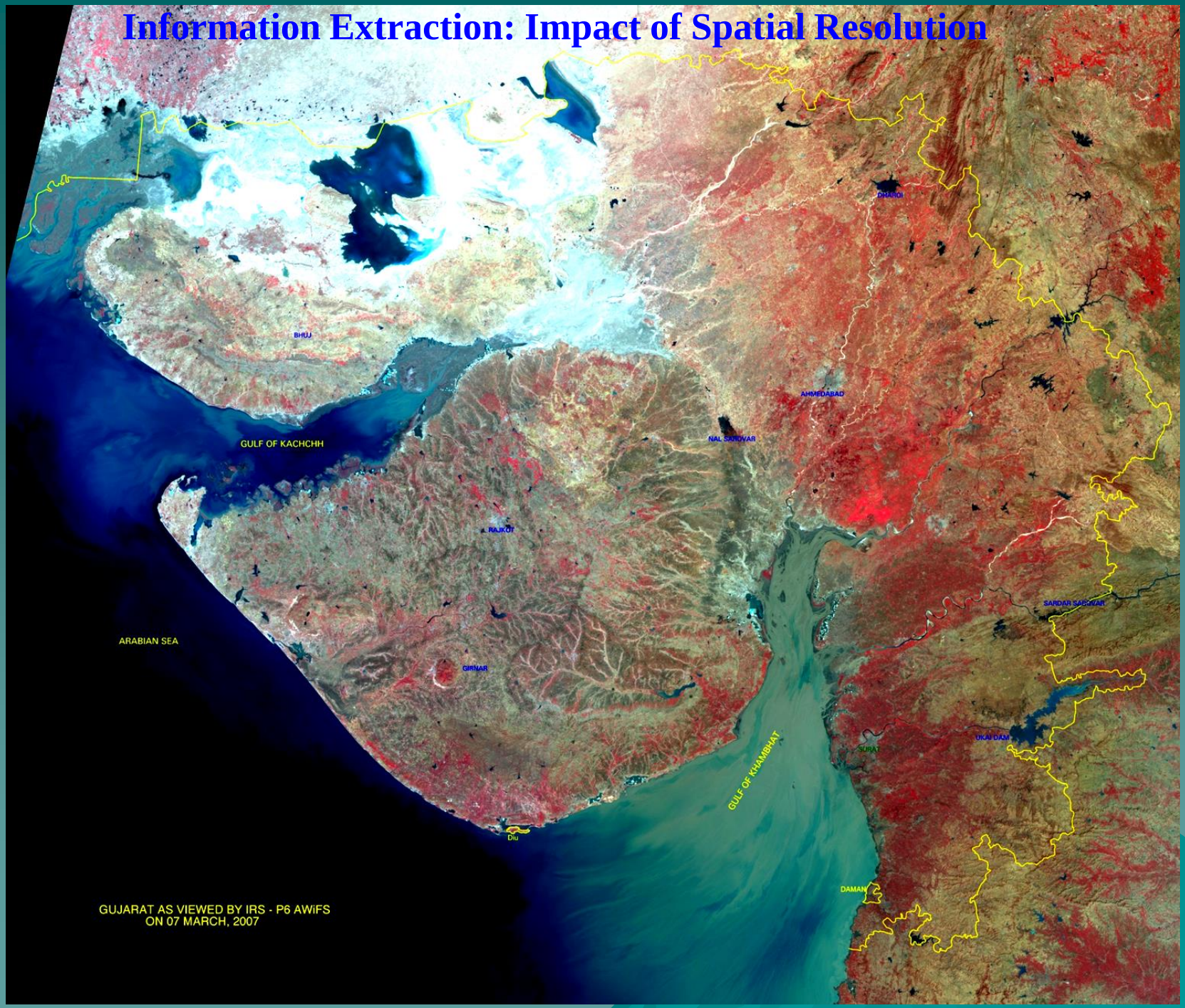


Scope of GIS

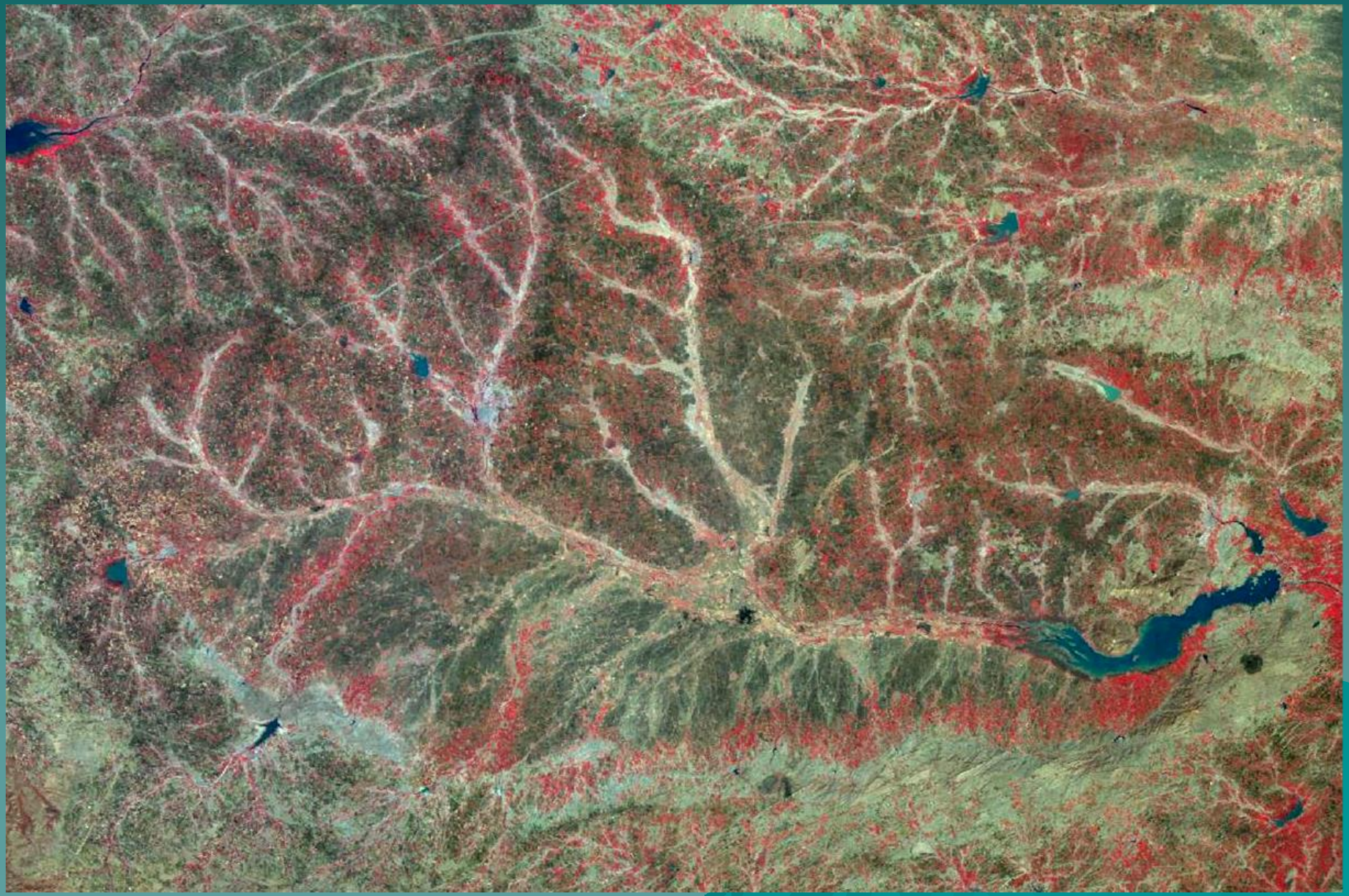
Planning/decision support

A-Z

Information Extraction: Impact of Spatial Resolution



River basin - Shetrunji



Remote sensing applications

- Land-use mapping
- Forest and Agriculture applications
- Environmental Applications
- Hydrology and Coastal Mapping
- Ocean Applications
- Urban planning
- Emergencies and Hazards
- Telecommunication – Gas pipelines planning
- Global change and Meteorology
- …

Remote Sensing Organizations

- **ISPRS-** **I**nternational **S**ociety for **P**hotogrammetry and **R**emote **S**ensing
- IGARSS- **I**nternational **Geosciences A**nd **R**emote **S**ensing **S**ymposium
- **NASA** -National Aeronautic and Space Administration (USA)
- **ESA-** **E**uropean **S**pace **A**gency (Europe)
- **NASDA-** National Space Development Agency (Japan)
- **CNES-** Centre National d'Etudes Spatiales (France)
- **DARA**- German Space Agency
- **CSA** - Canadian Space Agency
- **NRSC**- National Remote Sensing Centre (India)
- …

Data providers

- US-EROS Data Center, www.eros.usgs.gov
- Canada-RADARSAT Int., www.rsi.ca
- France-SPOT,www.spotimage.com
- ESA/ESRIN, www.esrin.esa.it
- EURIMAGE,www.eurimage.com
- Spaceimaging,www.geoeye.com
- India, NRSC, www.nrsc.gov.in
- ...

Remote sensing literature -Books

- Askne, J. (1995). **Sensors and Environmental applications of remote sensing**, Balkema, Rotterdam, NL
- Campbell, J. B. , 1996. **Introduction to Remote Sensing**. 2nd ed.,Taylor and Francis, London
- Dengre, J. (1994). **Thematic Mapping from satellite imagery**: Guide book, Elsevier ltd, Boulevard
- Lillesand, T. M. and R. W. Kiefer, 2000. **Remote Sensing and Image Interpretation.** 4th ed., John Wiley and Sons, Inc. New York
- Simonette, D. S. (ed) (1983) **Manual of remote sensing**, the Sheridan Press, Falls church
- …

Thank You