Remote Sensing - Basics

Drawbacks (Traditional methods)

- Data collection throughout the year – difficult – unfavorable weather
- Inaccessible areas – not possible
- Time consuming
- Gap between data collection and utilization

Advantages (Remote sensing)

- ✓ Synoptic view of large area
- ✓ Data recorded on permanent basis
- ✓ Unbiased recording of data
- ✓ Multidisciplinary use – forestry, soil science, hydrology and geology
- ✓ Data acquisition & analysis faster
- ✓ Periodical data acquisition – updating, monitoring changes in short intervals
- ✓ Unique capability of visible & invisible parts of electrospectrum

  (Ultra violet, reflected infrared, thermal infrared, microwave etc.)

Remote Sensing

Science and art that permits us to obtain information about an object or phenomenon or area through the analysis of data acquired by a sensing device without its being in contact with that object or phenomenon or area.

Basic processes

- Data acquisition
- Data analysis

Elements of data acquisition

- ✓ Energy sources
- ✓ Propagation of energy through atmosphere
- ✓ Energy interaction with earth surface features
- ✓ Retransmission of energy through atmosphere
- ✓ Air borne / space borne sensors
- ✓ Generation of sensor data pictorial / digital

• Use of sensors to record variations in the way earth surface features reflect and emit electromagnetic energy.

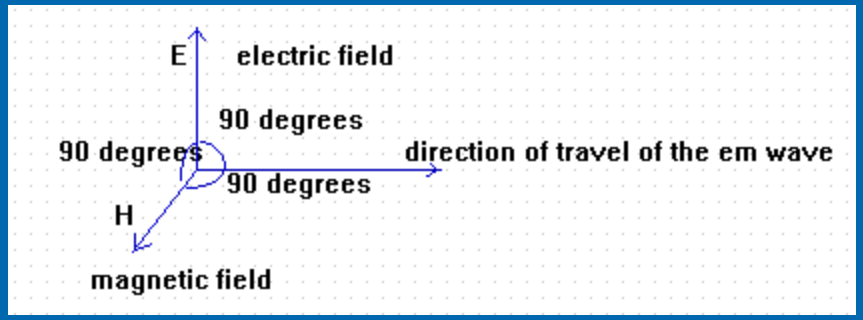
Elements of data analysis

- ✓ Examination of the data using various viewing and interpretation devices
- ✓ Reference data about the resources being studied (such as soil maps, crop statistics, field check data)
- ✓ Extracts information about type, extent, location & condition of various resources
- ✓ Compiling information

  Eg: Hard copy maps
  Tables
  Computer files
  Merged with GIS

- ✓ Data presented to users

An Electromagnetic wave



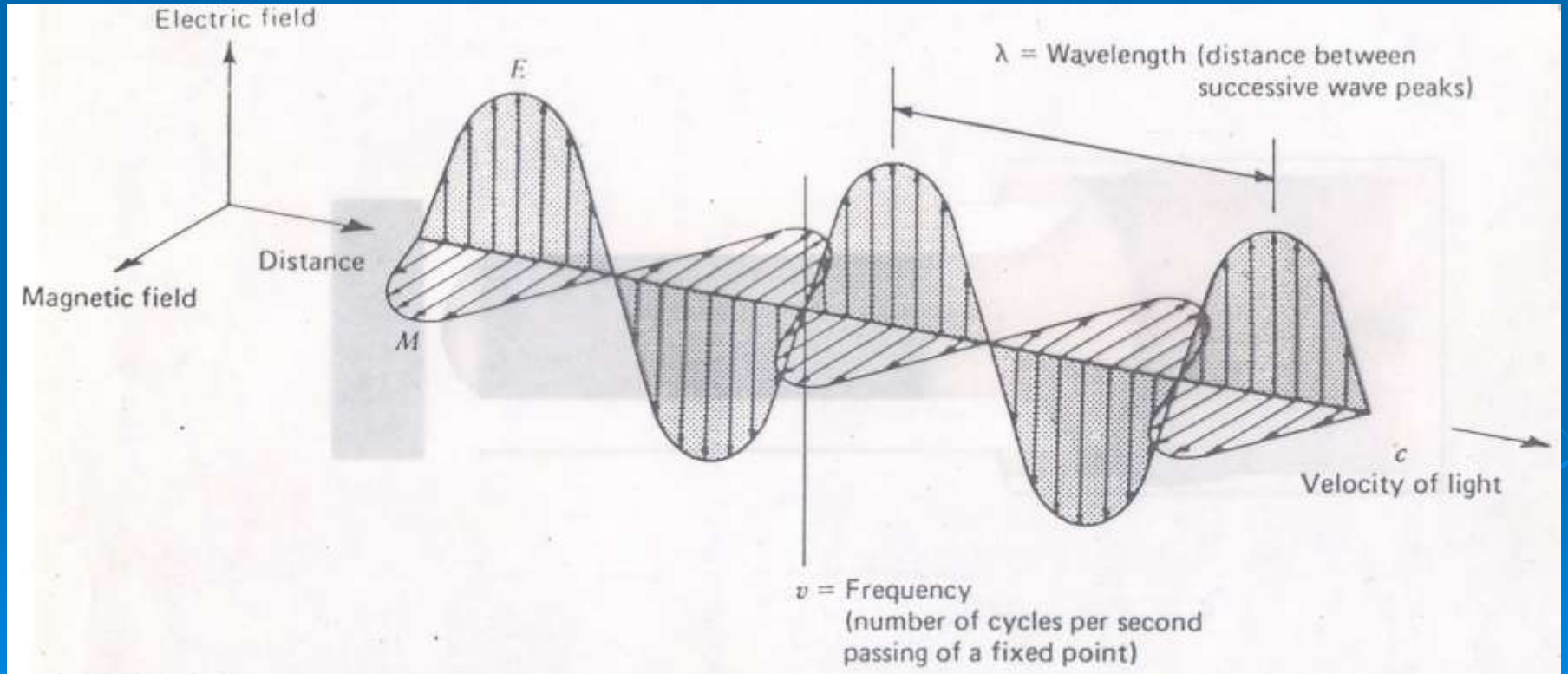


FIGURE 1.2 An electromagnetic wave. Components include a sinusoidal electric wave *(E)* and a similar magnetic wave *(M)* at right angles, both being perpendicular to the direction of propagation.

All forms of electromagnetic spectrum follows basic wave theory

$$C = v\lambda$$

C is essentially constant (3×10^8 m sec^{-1}) (Velocity of light)

v is frequency (Number of peaks passing through a fixed point in space per unit time)

λ is wave length (Distance between one wave peak to the next)

Particle theory

Explains electromagnetic energy interactions with matter.

- **EMR composed of many discrete units called photons or quanta**

Energy of quantum is given by

$$Q = hv$$

Q - Energy of a quantum in Joules (J)

h - Planck's constant 6.626×10^{-34} J sec

v - Frequency ($C = v\lambda$; $v = C / \lambda$)

$$Q = hc / \lambda$$

- **Quantum is inversely proportional to wave length**
- **Microwaves (energy low) difficult to sense than IR (energy high); short wave**
- **Energy radiated by the objects is a function of surface temperature of the object.**

(Stefan-Boltzmann Law - $M = \sigma T^4$)

M – Total radiant exitance from the surface of a material watts (w) m^{-2}

σ – Stefan – Boltzmann constant 5.6697 x 10^{-8} ($wm^{-2}\ {}^{o}K^{-4}$)

T – Absolute temperature (^{o}K) of the emitting material.

Wien's Displacement Law

The dominant wavelength or wave length at which a blackbody radiation curve reaches a maximum is related to it's temperature

$$\lambda m = A / T$$

λm – wave length of maximum spectral radiant exitance μm
A – 2898 μm K
T – Temperature, K

Sun emits as blackbody of 6000 K – peak at visible (0.5μm)
Earth ambient temp 300 K – peak at thermal IR (9.7μm)
Thermal IR neither seen nor photographed but can be sensed

< 3μm – reflection dominates
> 3μm – emitted energy prevails

Energy interaction in the atmosphere

All radiation passes some distance which is "path length"

Space photography – path length more

Air borne thermal sensors – path length less

Atmospheric effect varies with
- Path length,
- Magnitude of energy signal sensed
- Atmospheric condition
- Wave length involved

Atmospheric effects - scattering and absorption

Absorption : Absorption result in effective loss of energy
Water vapour, CO_2, ozone (absorbers of SR)

Reyleigh scatter :

Interaction of radiation with tiny particles that are smaller in diameter than the wave length

Reyleigh scatter is inversely proportional to fourth power of wave length.

Short wave length to be scattered than the longer wave length (Blue sky - reyleigh scatter)

Reyleigh scatter causes 'haze' that diminishes 'crispness' or 'contrast' (bluish gray image)

Mie scatter :

Particles diameter equals the wave length. Water vapour and dust are major causes. Influence longer wave length than smaller wave length

Non selective scatter :

Particle size much larger than wave length – water droplets Scatter all visible and near to mid IR (whitish fog cloud)

Interactions between electromagnetic energy and earth surface

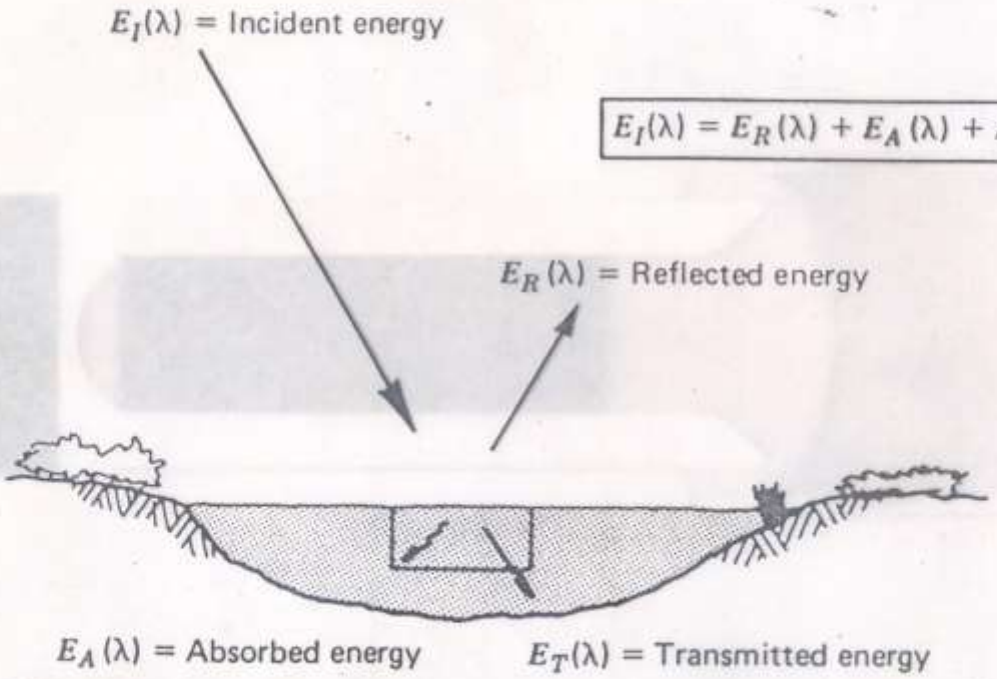
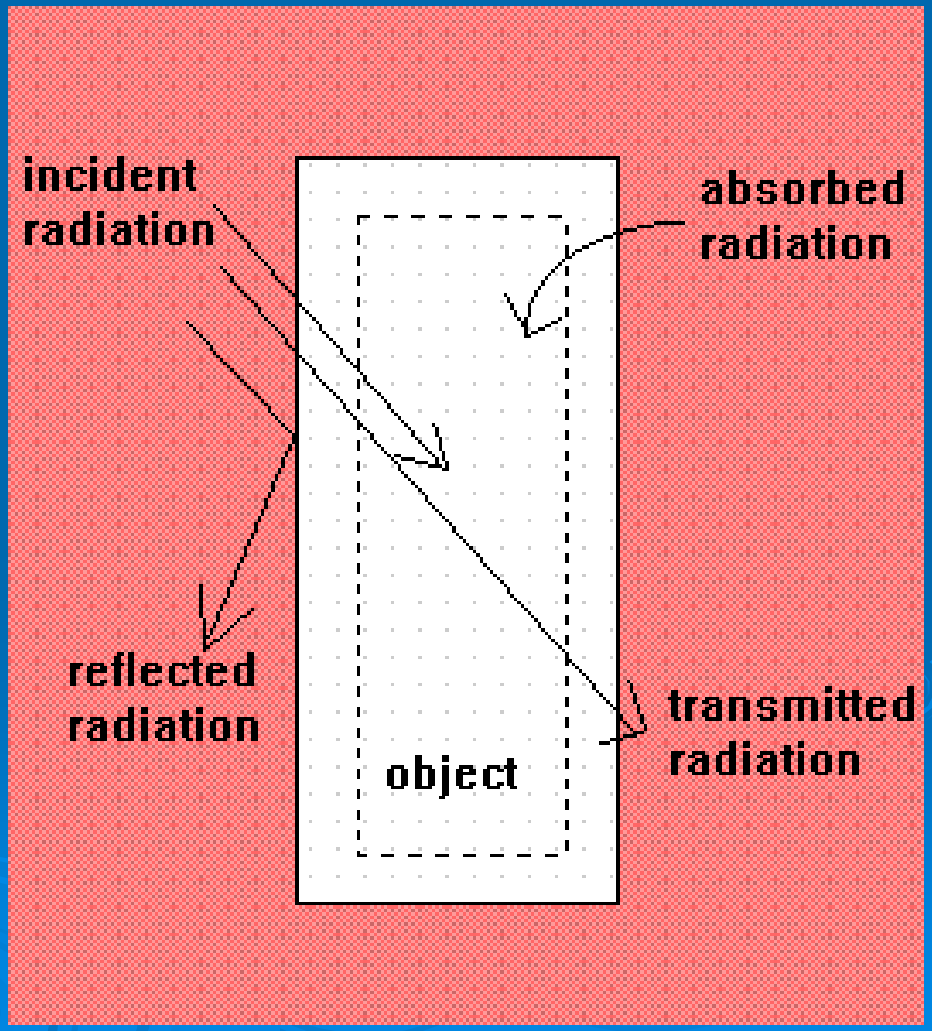


FIGURE 1.6 Basic interactions between electromagnetic energy and an earth surface feature.

Electromagnetic energy and fundamental energy interactions

- Reflection
- Absorption
- Transmission



- ✓ Proportion of energy reflected, absorbed and transmitted vary with earth features.
- ✓ Depends on physical and chemical characteristics of features.
- ✓ Permits on to distinguish different features on an image
- ✓ Proportion of ER, EA and ET vary at different wave lengths of EMR for a given feature

Concepts and principles

- Electromagnetic energy used
- Forms

		Wavelength
Television and radio waves	:	> 30 cm
Microwaves	:	0.1 – 30 cm
Far infrared	:	7.0 – 15 µm
Thermal infrared	:	3.0 – 14.0 µm
Mid infrared	:	1.3 – 3.0 µm
Near infrared	:	0.7 – 1.3 µm
Visible	:	0.4 – 0.7 µm
Ultra violet rays	:	0.03 – 0.4 µm
x-rays	:	Upto 0.03 µm
ɣ-rays		
Cosmic rays		

Most common sensing system operate in one or several of the visible, IR or microwaveS

- Microwaves : RADAR, microwave radiometer, Scateriometer, Altimeter
- IR range : Spectrometers, radiometers, polarimeters, Laser based active sensing system
- Visible : Mostly used for natural resource mapping

Platforms

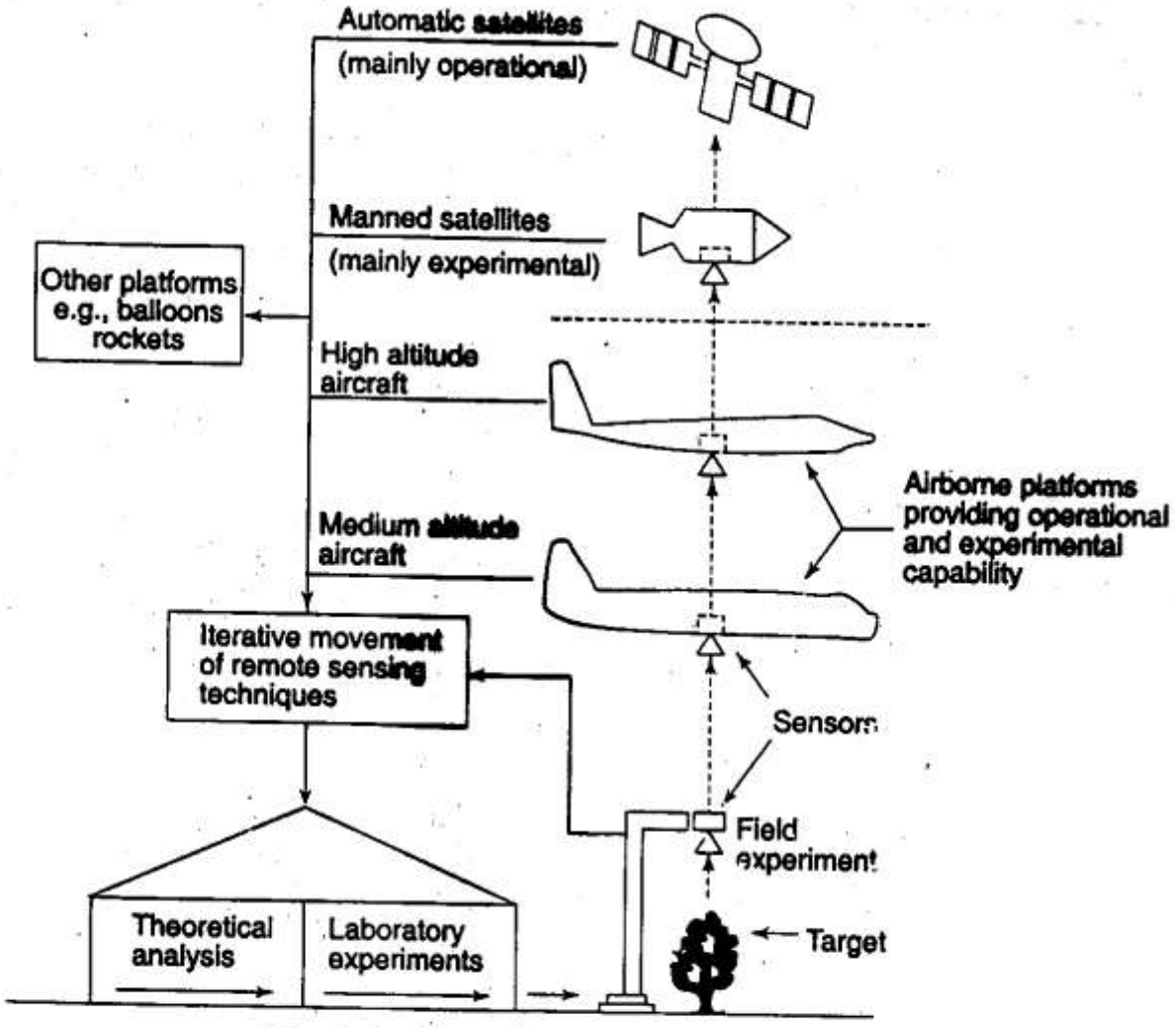


Fig. 2.4 Common remote sensing platforms

Sensors

A device that receives EMR, converts it into a signal and presents it in a form suitable for obtaining information about the land / earth resource as used by an information gathering system.

Based on energy source

- Active sensor

Operates by emitting it's own energy which is needed to detect the various phenomena. (eg. RADAR, Camera with flash gun)

- Passive sensor

Operates on existing sources of energy like sun. (eg. Photography systems and multispectral scanners

Resolution

In general resolution is defined as the ability of an entire remote-sensing system, including lens antennae, display, exposure, processing, and other factors, to render a sharply defined image. Resolution of a remote-sensing is of different types.

Specific parameters of sensors

1. Spatial resolution : Minimum detectable area by a detector placed on a sensor.

2. Spectral resolution : Smallest amount of spectral change that can be detected.

3. Radiometric resolution : The number of grey levels / values which a sensor can distinguish between complete black and white.

4. Temporal resolution : Is characterized by the smallest period of repetitive coverage

Types of sensors

- Photographic cameras
- Return Beam Vidicon (RBV)
- Thermal system
- Optical – Mechanical scanners
- RADAR and microwave sensors
- Advanced remote sensor
    - Linear Imaging and Self Scanning (LISS)
    - Panchromatic camera (PAN)
    - Wide Field Sensor (WiFS)

LANDSAT MSS & TM	(USA)
SPOT HRV	(French)
IRS LISS I, II & III	(India)

Photographic cameras

Conventional camera (Black & white)

Oldest, widely used on ground objects

Employed in aircraft, balloons, space craft

Information limited to size and shape

Operates in visible spectrum (0.4 - 0.7 μm)

Upto 0.9 μm (infrared)

Frame cameras most commonly used

Mid IR and thermal IR not covered

Return Beam Vidicon (RBV)

Similar to television camera

First electronic system - images of earth

Meteorological observations (earlier)

Single / multi wave band systems

Registering in all bands difficult

Limited spectral response / low resolution / poor dynamic range / poor radiometric accuracy / geometric distortions

RBV not employed currently.

Thermal system

- Operates in infrared and part of microwave
- Based on Stefen - Boltzman law of radiation
- Scanning method for recording EMR
- Usually have large distortions

Optical - Mechanical scanners

Not much developed as visible & IR

More complex system

Unaffected by atmospheric conditions

Penetrates smoke / clouds / haze / snow

Images brightness depends EC (SLAR)

Eg. - Plan position indicator (PPI) - terrain mapping

- Side looking air borne radar (SLAR)

- Synthetic aperture radar (SAR)

(Temperature, Tropical, Rainfall real time)

Advanced Remote sensors

Linear imaging and self scanning (LISS)

- Most advanced / two dimensional pictures
- Solid state devices (photo diodes / transistors / charged couple device)
- IRS series carry solid state scanner (push broom scanner)
- IRS 1C advance satellite carry

LISS III camera

Panchromatic camera

Wide field sensor (WiFS)

PLATFORMS

Airborne platforms

Space borne platforms

AIR BORNE PLATFORMS

Balloons

Aircraft

Rockets

Balloons : Designed & used for specific purposes / projects

Air craft : Arial photographs

Regional coverage

Large scale mapping

Flexibility in altitude

Air crafts should have

Maximum stability

Free from vibrations & oscillations

Capable of flying with a uniform speed

In India four types of air crafts used

Air craft	Minimum speed (km hr^{-1})	Height ceiling (m)	Flying agency
Dakota	240	6000 - 7000	IAF / NRSA
Avro	600	8000	IAF
Cessna	350	9000	IAF
Canberra	560	5000	IAF / NRSA

Non conventional aircrafts

Helicopters

Drones

Sail planes

Low altitude photography

Television photography

Space borne platforms

✓ Satellites

Natural resource mapping

Meteorological & communication applications

Free flying orbiting vehicles

motion is governed by gravity

Entire earth / designated portions covered at specific intervals

Least affected by atmosphere disturbances

Helps in extraterrestrial bodies

✓ Based on type of orbits

- Geostationary satellites
- Sun - synchronous satellites

Satellites

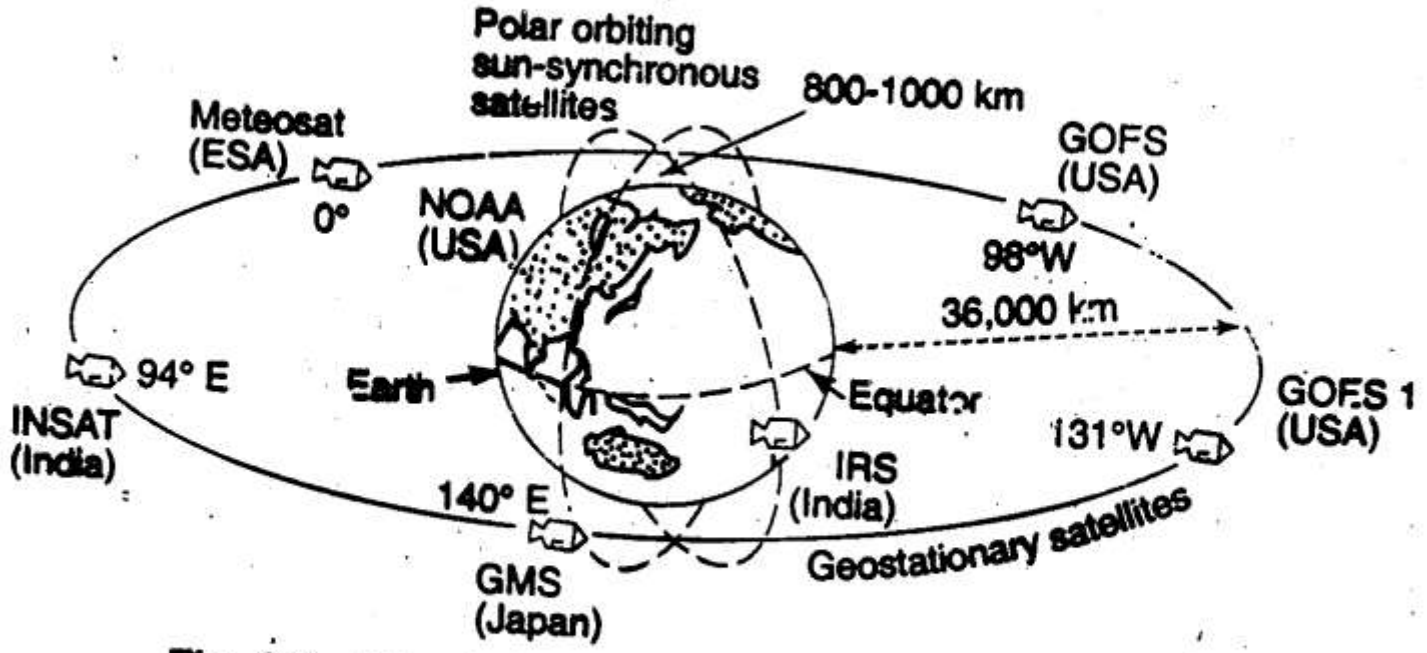


Fig. 2.5 Geostationary and sun-synchronous satellites

Geostationary / Earth - synchronous satellites

Orbit of satellites - Geosynchronus / Geostationary orbit

Placed at distance of 36,000km above equator

Speed same as earth’s rotation

Covers continuously same area

Response of information transmission is rapid

Spatial resolution is poor (1 km or more)

Weather / communication purposes

GOES & INSAT

Sun synchronous / polar / natural resource satellites

- ★ Provides global coverage - high resolution
- ★ Resource survey & monitoring uses
- ★ Move in low earth orbit (800 - 1000 km) altitude over or near north & south poles
- ★ Orbit polar / sun synchronous
- ★ Repetitive coverage
- ★ LANDSAT, SPOT & IRS.

Kinds / Forms of satellite data

- ✓ Space photographs
  - Metric and Non-metric
  - Black and white
  - Colour
  - Infrared
  - Mosaics
  - Orthophotos

Satellite images

- Films
- Paper prints
- False Colour Composite (FCC)
- Computer Compatible Tape (CCT)
- Compact Disks (CD)
- Floppies