Fundamentals of Remote Sensing

PRESENTED BY

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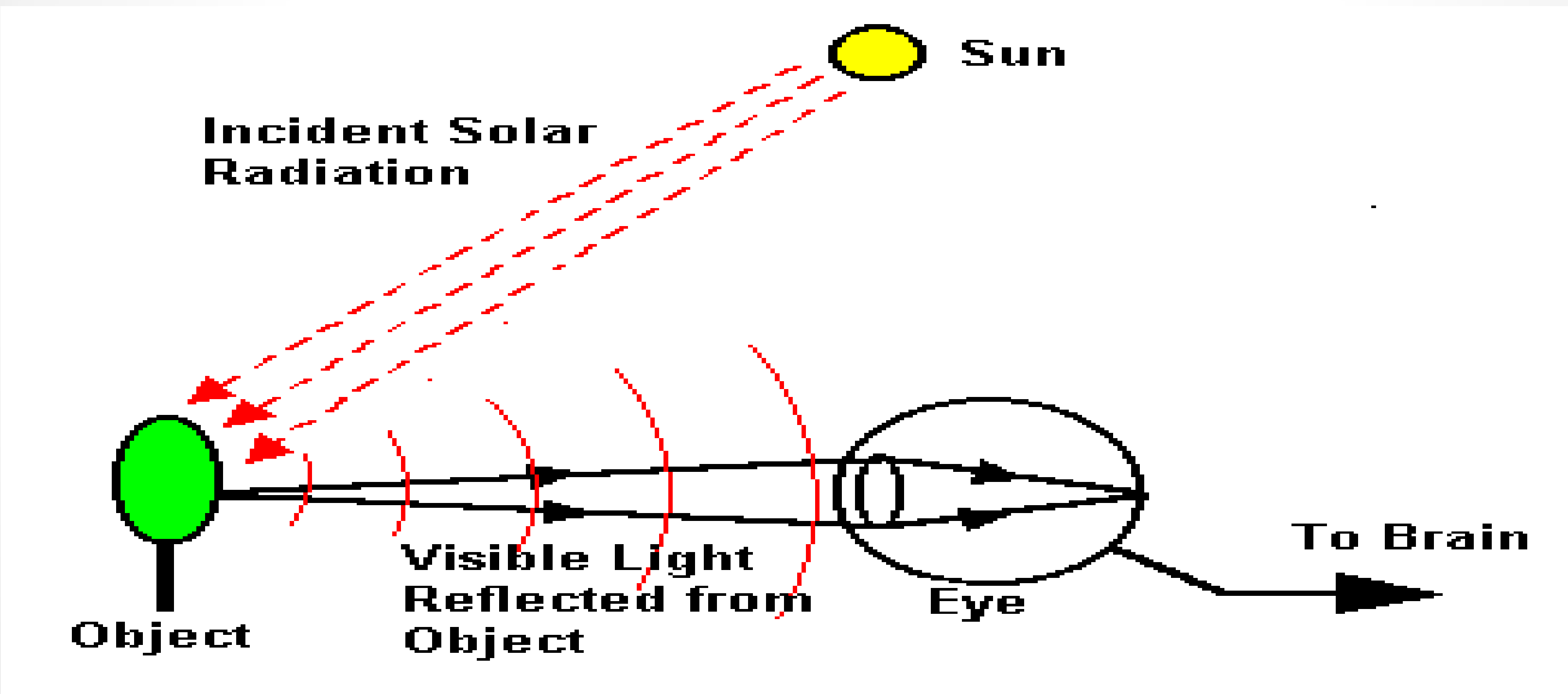
- ***Remote sensing*** **is defined as the science and art of acquiring information about a material object by making measurements, at a distance from it, of the electromagnetic energy it radiates.**

- **Measurements are carried out using sensors e.g. a camera, MSS, Radar.**

Eye sight is a form of remote sensing. When the eye sees an object, the e.m. radiation, which is the reflected light, from the surface of the object, gets registered in the eye and information is sent to the brain.



ESSENTIAL ELEMENTS IN REMOTE SENSING

- 1. **Sensor** - Used for sensing and recording the information about the object e.g. cameras, scanners, radars.
- 2. **Object** - Object under observation -Earth
- 3. **Platform** - Used for supporting the instrument – Planes and satellites

SENSOR SYSTEMS

- **Major instruments for recording e.M. Radiation are the sensors and the carrier of the sensor is the platform**
- **Radiation may originate from:**

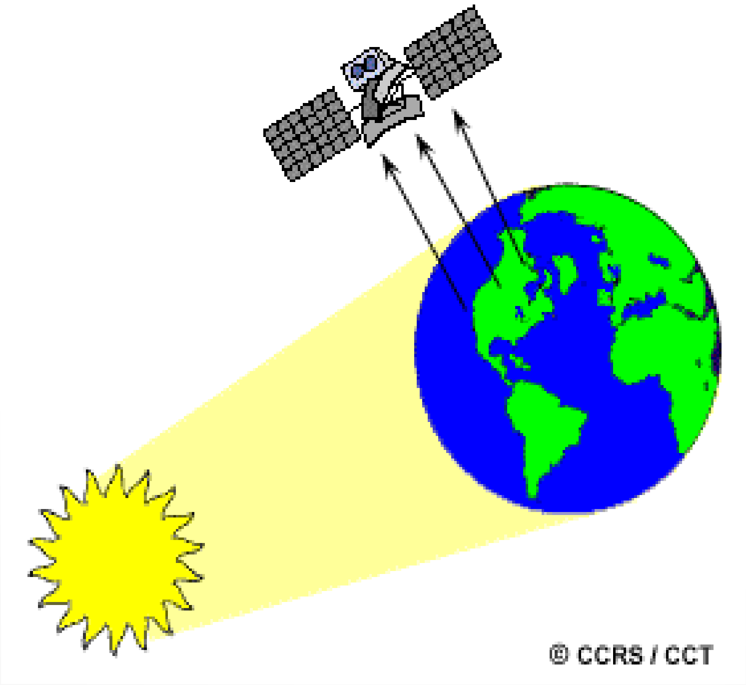
1.Solar energy reflected or

2. Natural microwave energy emitted by the target or

3.Reflection of energy transmitted to the target by the sensor

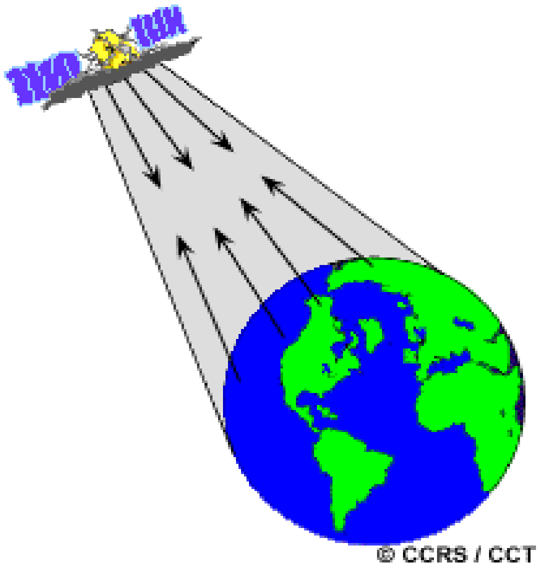
DIFFERENT REMOTE SENSING SYSTEMS

- **PASSIVE SYSTEM** – SENSOR UTILISING NATURALLY OCCURRING SOURCE OF ENERGY



CONTD.

- **ACTIVE SENSOR - SYSTEM UTILISING MAN-MADE SOURCE OF ENERGY**



Types of satellites

- **Natural – Moon is the only natural satellite**
- **Artificial – Landsat, IRS, SPOT**

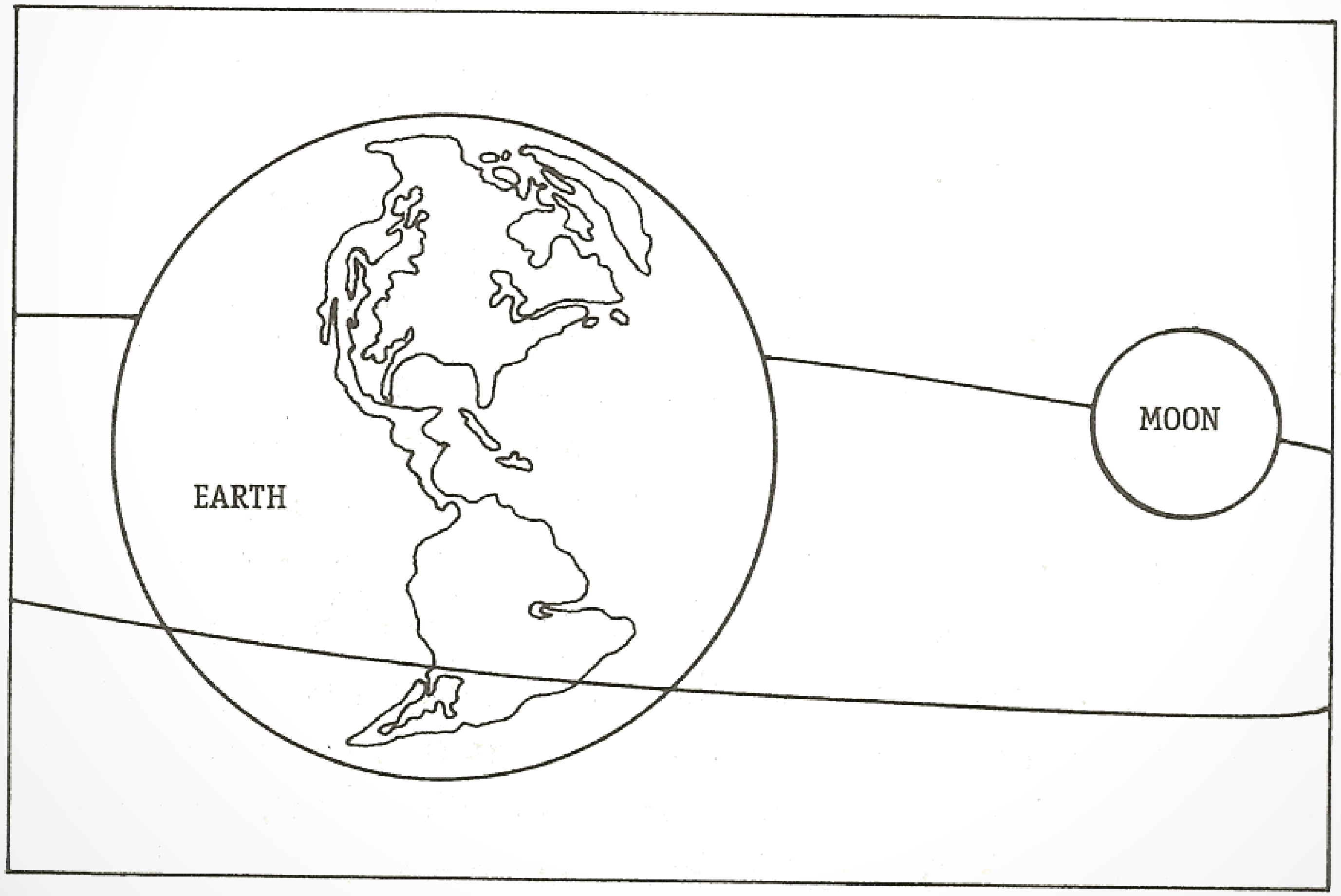


Fig. 4.1 Orbit of natural satellite—moon (after NRSA).

Broad Groups of Artificial Satellites

- **Geostationary Satellites – In general, satellite changes its position in the sky continuously. If a satellite is launched on equatorial plane travels at the same angular velocity at which the earth rotates and in same direction, it remains above the same point on earth at all times. Orbital plane is above 36,000 km**
- **Sun-synchronous satellites – Orbit plane is nearly polar and the orbital plane rotates at the same rate as the mean rotation rate of the earth around sun (0.98°/day). Satellite crosses a given latitude at the same sun time as the local sun time**

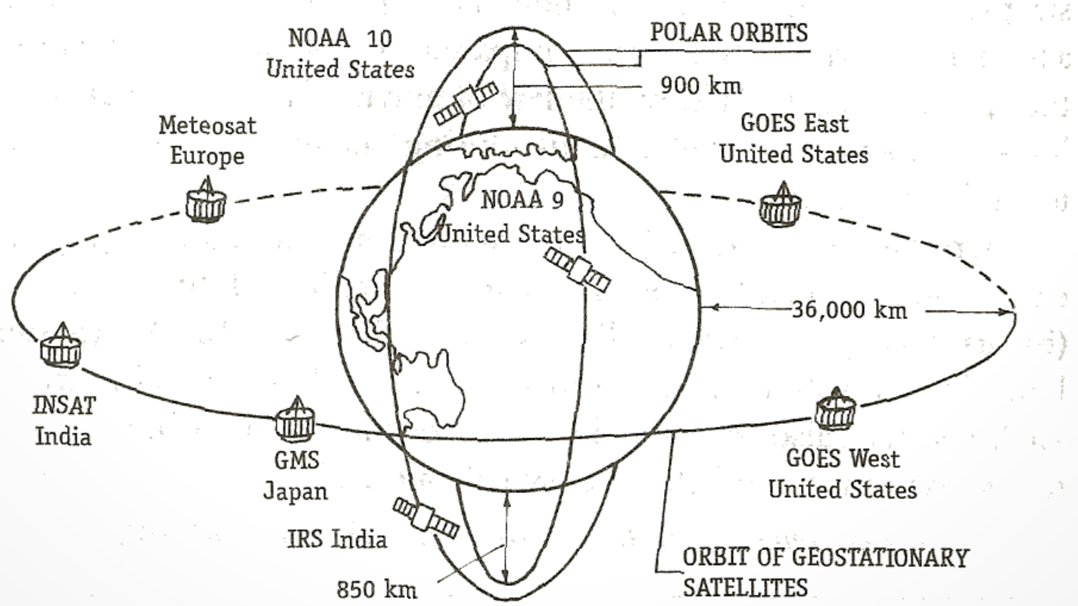


Fig. 4.2 Orbits of geostationary and sun-synchronous satellites (after NRSA).

Remote sensing platforms

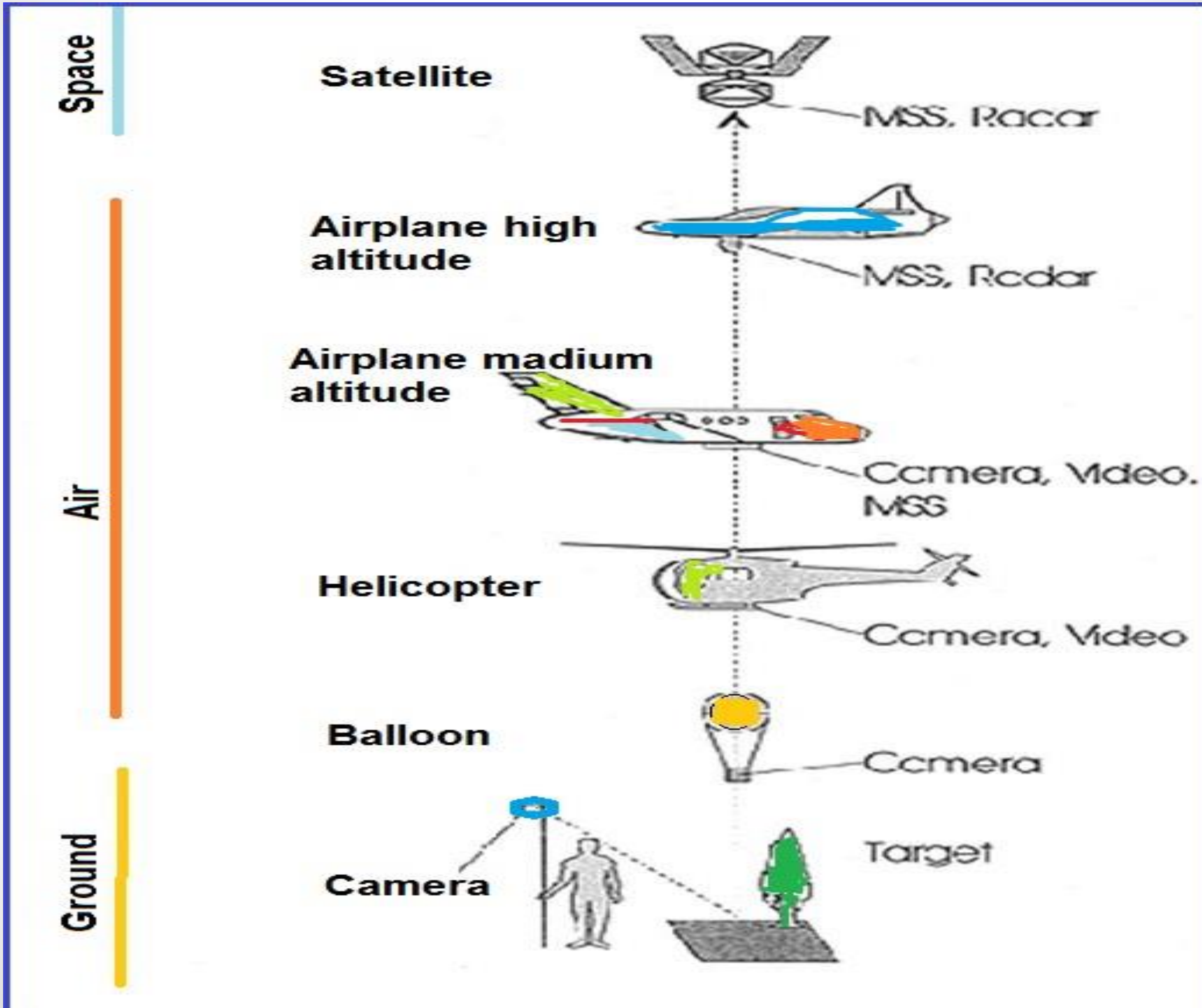
- There are three main categories of remote sensing platforms

Commonest platforms

Spaceborne
- Satellite
- Shuttle

Airborne
- Aeroplane
- Helicopter
- Hot air balloon
- Air ship
- Tethered balloon

Ground-based
- Hand-held
- Raised platform


Space
Air
Ground
Satellite
MSS, Racar
Airplane high altitude
MSS, Rcdar
Airplane madium altitude
Ccmera, Vdeo, MSS
Helicopter
Ccmera, Vdeo
Balloon
Ccmera
Camera
Target

REMOTE SENSING OF THE EARTH

- Information acquired by airborne platforms, such as:
  - Aircraft, Balloons
- Information acquired by space borne platforms, such as:
  - Satellites, Space Shuttle
- Information pertains to all areas of interest, such as: Land, Oceans, Atmosphere

ADVANTAGES OF REMOTE SENSING

- Data collection using remote sensing offers a variety of advantages as compared to other forms of data acquisition.

- Makes it possible to measure energy (e.g. ultraviolet, infrared, microwaves etc.) at wavelengths that can not be reached by human vision.

ADVANTAGES OF REMOTE SENSING (Contd.)

- Data can be used in a variety of disciplines like agriculture, forestry, hydrology, geology, cartography, meteorology.
- Important applications are in the field of oceanography.
- Global monitoring is possible from any site on earth

ADVANTAGES OF SATELLITE REMOTE SENSING

- **Synoptic view** - On account of its vantage point, can obtain information of large areas of the ground under fixed illumination.

- **Repetitive coverage** – At regular intervals allows us to monitor dynamic features like changes (vegetation, water)

ADVANTAGES OF SATELLITE REMOTE SENSING (Contd.)

- **Time and cost saving** – Economical in price. Due to long life span of a satellite, it is possible to amortise initial cost. Data can be utilised in all disciplines
- **Feasibility aspect** – Possible to gather information of area inaccessible to ground survey

LIMITATIONS

- **Difficult to obtain data and information through cloud cover.**
- **Microwave sensors can image the earth through clouds, but the relatively low spatial resolution of many satellite borne microwave sensors may not suite the needs of many projects.**
- Satellite remote sensing creates large quantities of data which needs extensive processing as well as storage and analysis.

EARLY HISTORY

- Collection of information about earth surface started with the invention of camera and later aeroplane.
- During American civil war, photographs taken from balloon were used

EARLY HISTORY (Contd.)

- Use of aerial photographs for peaceful purposes started after First World War
- Collection of information from space started in 1960
- The photographs taken by astronauts of Gemini and Apollo showed potential of such photographs for earth resource survey.

REMOTE SENSING PRACTICE IN INDIA

- **B & W aerial photographs used for survey and geological exploration started in 1920**

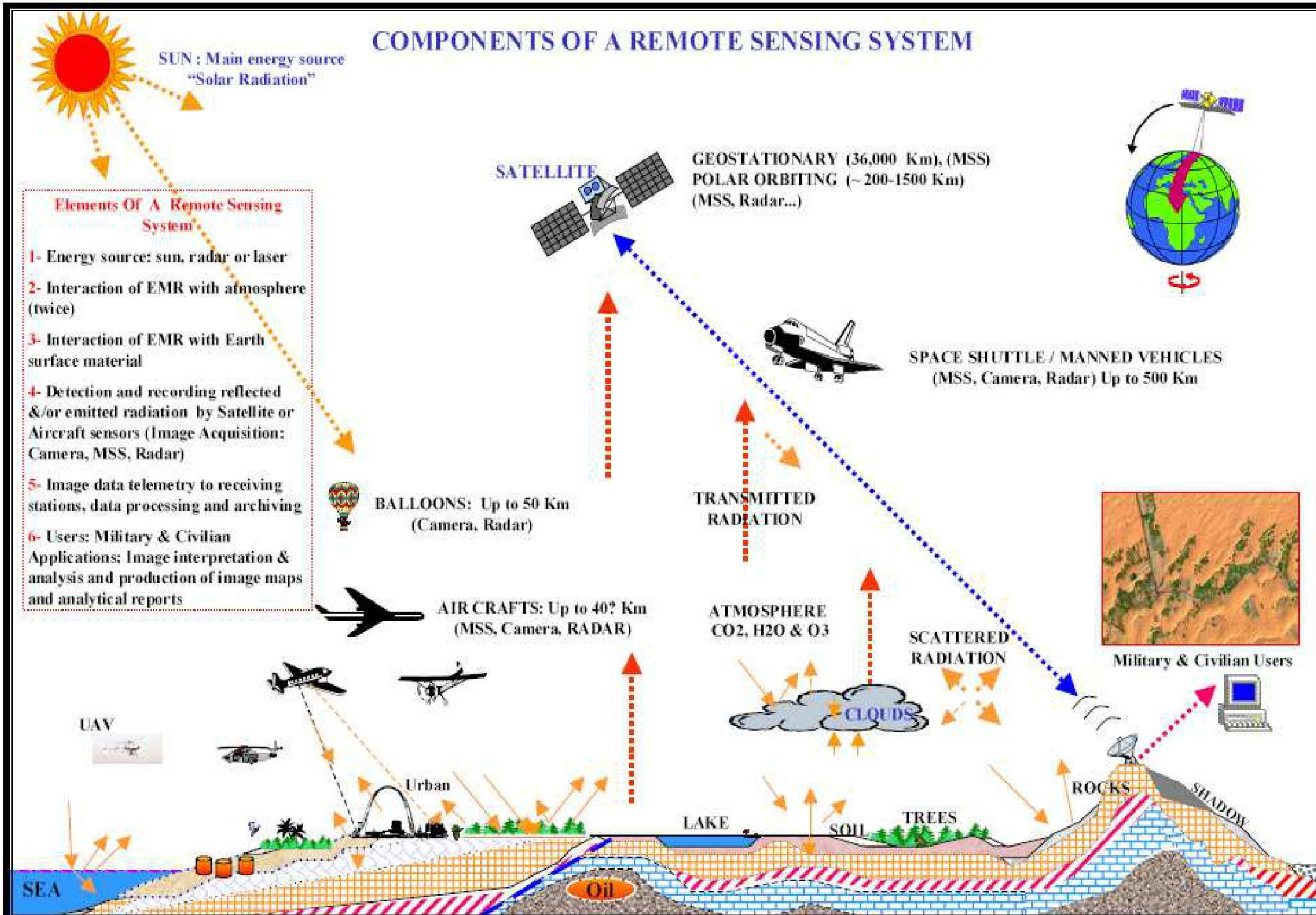
- **Aerial photographs used for flood assessment of Indus river in 1923**

- **Remote sensing using sophisticated sensors was attempted in agriculture in 1970**

REMOTE SENSING PROCESS

- Remote sensing process involves an interaction between incident radiation and the targets of interest.

- In this process a number of elements are involved

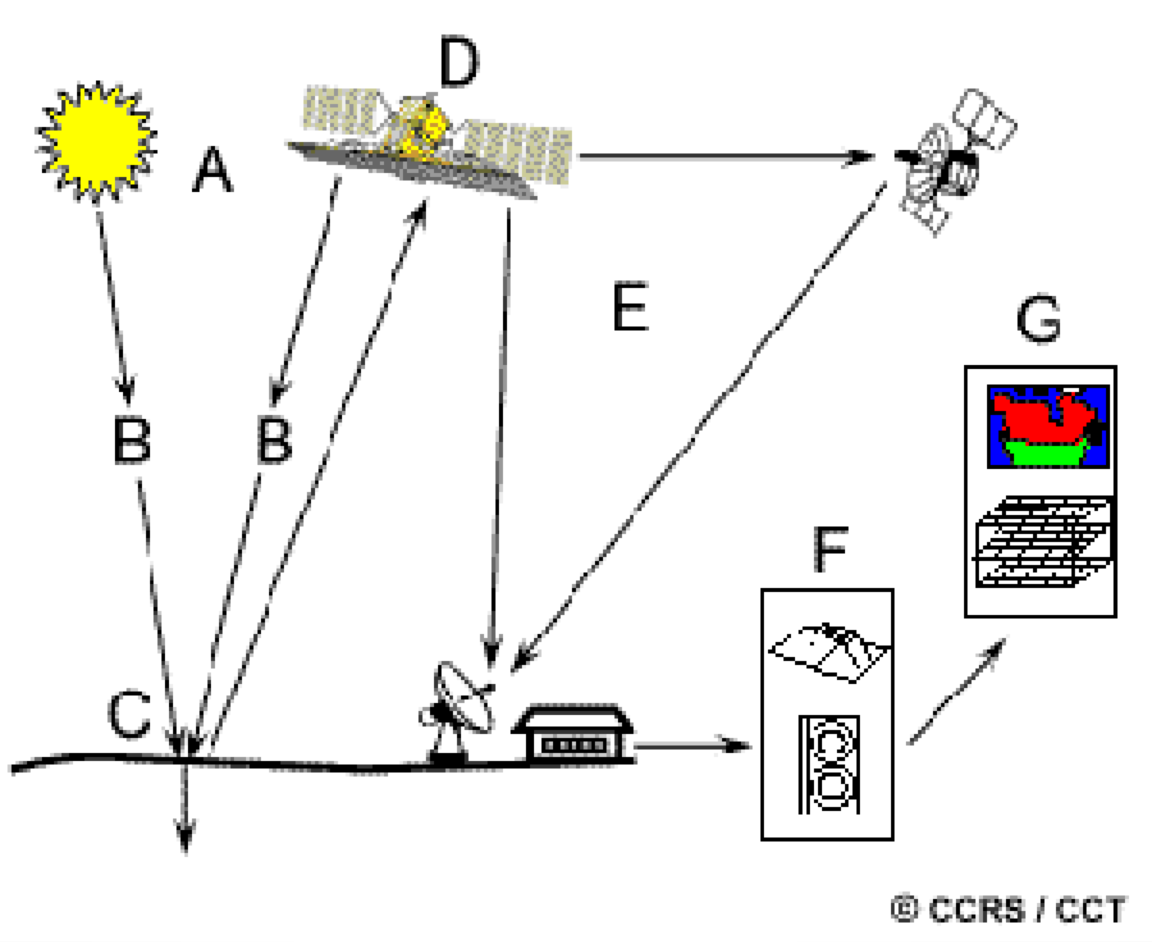


COMPONENTS OF A REMOTE SENSING SYSTEM
SUN : Main energy source
"Solar Radiation"
Elements Of A Remote Sensing System
1- Energy source: sun, radar or laser
2- Interaction of EMR with atmosphere (twice)
3- Interaction of EMR with Earth surface material
4- Detection and recording reflected &/or emitted radiation by Satellite or Aircraft sensors (Image Acquisition: Camera, MSS, Radar)
5- Image data telemetry to receiving stations, data processing and archiving
6- Users: Military & Civilian Applications; Image interpretation & analysis and production of image maps and analytical reports
SATELLITE
GEOSTATIONARY (36,000 Km), (MSS)
POLAR ORBITING (~ 200-1500 Km)
(MSS, Radar...)
SPACE SHUTTLE / MANNED VEHICLES
(MSS, Camera, Radar) Up to 500 Km
BALLOONS: Up to 50 Km
(Camera, Radar)
TRANSMITTED RADIATION
AIR CRAFTS: Up to 40? Km
(MSS, Camera, RADAR)
ATMOSPHERE
CO2, H2O & O3
SCATTERED RADIATION
Military & Civilian Users
CLOUDS
UAV
Urban
LAKE
SOIL
TREES
ROCKS
SHADOW
SEA
Oil

A. ENERGY SOURCE OR ILLUMINATION

- The first requirement of remote sensing is to have an energy source.
- This energy source illuminates and provides EM energy to the target of interest.
- Energy source may be natural or artificial.

REMOTE SENSING PROCESS



B. RADIATION AND THE ATMOSPHERE

- As the energy travels from the source to the target, it will come in contact and interact with the atmosphere it passes through.

- This interaction may take place again as the energy travels from the target to the sensor.

C. INTERACTION WITH THE TARGET

- Once the energy makes its way to the target through the atmosphere, it interacts with the target depending on the properties of both the target and the radiation.

D. RECORDING OF THE ENERGY BY THE SENSOR

- After the energy has been scattered by, or emitted from the target, we require a sensor (remote – not in contact with the target) to collect and record the EM radiation

E. TRANSMISSION, RECEPTION & PROCESSING

- The energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station, where the data are processed into an image (hard copy and/or digital)

F. INTERPRETATION AND ANALYSIS

- The processed image is interpreted visually and/or digitally or electronically to extract information about the target which was illuminated.

G. APPLICATION

- The final element of the remote sensing process is achieved, when we apply the information extracted from the imagery about the target in order to better understand the target.
- This may reveal some new information or assist in solving a particular problem
- These seven elements comprise the remote sensing process from beginning to end.

ELECTROMAGNETIC ENERGY

- Refers to all forms of energy that moves with speed of light i.e.186,000 miles/sec
- This energy can be detected only when it interacts with matter
- During such interaction, this energy behaves as consisting of many particles moving as messenger particles known as photons.
- Remote sensing is based on measurement of varying energy levels of photons

ELECTROMAGNETIC WAVE

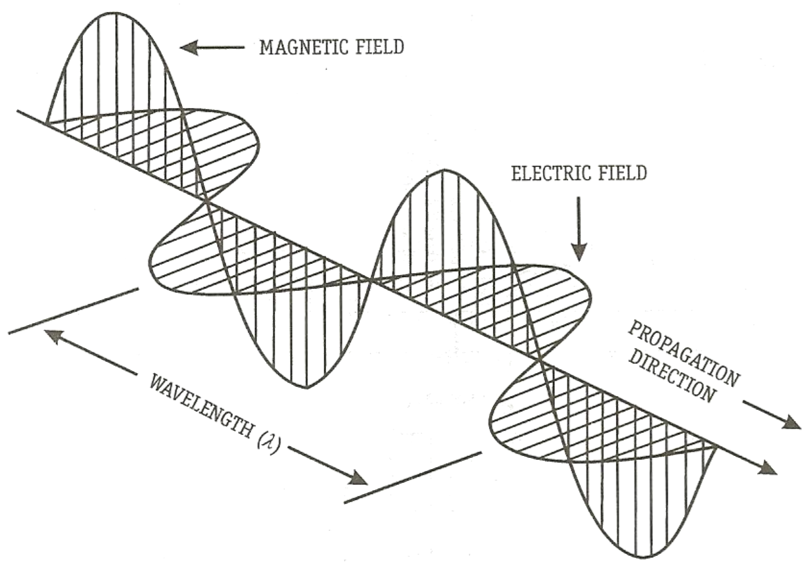


Fig. 1.1 Electromagnetic wave showing its electric and magnetic components, both sinusoidal and perpendicular to its direction of propagation.

ELECTROMAGNETIC ENERGY (CONTD.)

- Photons move in the form of a sine wave which has two components involving electric and magnetic fields

- The wave is usually composite, involving electric and magnetic fields fluctuating at right angles to each other and to the direction of travel

ELECTROMAGNETIC ENERGY (C0NTD.)

- E.M. energy is measured in terms of wavelength, amplitude and frequency

- Sources of this energy are

(a) natural and (b) artificial

MEASUREMENT OF ELECTROMAGNETIC ENERGY

- Can be measured in terms of
- (a) Wavelength - length from the top of one wave to the top of the next,

  (b) Amplitude – which is the height of the wave
- © Frequency – which is the number of waves passing by a specified point in a unit of time

MEASUREMENT OF ELECTROMAGNETIC ENERGY

- Wavelength and frequency are related by the equation

$$c = v\lambda$$

Where

c = velocity of light (3 x 10^8 m per second)

v = frequency (Hz)

λ = wavelength (m)

The velocity of light being constant, wavelength and frequency are inversely related to each other

AMOUNT OF RADIATION FROM A TARGET

- At temperatures above absolute zero all objects radiate electromagnetic energy by virtue of their atomic and molecular oscillations.

- The total amount of emitted radiation increases with the body's absolute temperatures and peaks at progressively shorter wavelengths

SOURCE OF ELECTROMAGNETIC ENERGY

- The Sun is a common source of electromagnetic energy. It radiates solar energy in all directions.
- Earth reflects the energy from the Sun and also absorbs some energy.
- Different earth surface materials have different absorption characteristics. Besides, absorption is wavelength specific; that is more energy is absorbed at some wavelengths than at others.

ABSORPTION AND EMITTANCE

- Electromagnetic radiation that is absorbed is transformed into heat energy, which raises the material's temperature. Some of the heat energy may then be emitted as e.m. radiation at a wavelength dependent on material's temperature.
- The lower the temperature, the longer the wavelength of the emitted temperature
- The portion of the IR spectrum with wavelengths greater than 3μm is commonly called the TIR region

ELECTROMAGNETIC SPECTRUM

- Any object at temperature above absolute zero (0 K, -273°C) continuously emits EM radiation whose wavelength depends on the temperature.

ELECTROMAGNETIC SPECTRUM (CONTD.)

- The total range of wavelengths from a micrometer to metres (ranging from gamma rays, X-rays to ultraviolet (UV), visible and infrared radiation including microwave and television & radio waves)., is commonly referred to as the electromagnetic spectrum

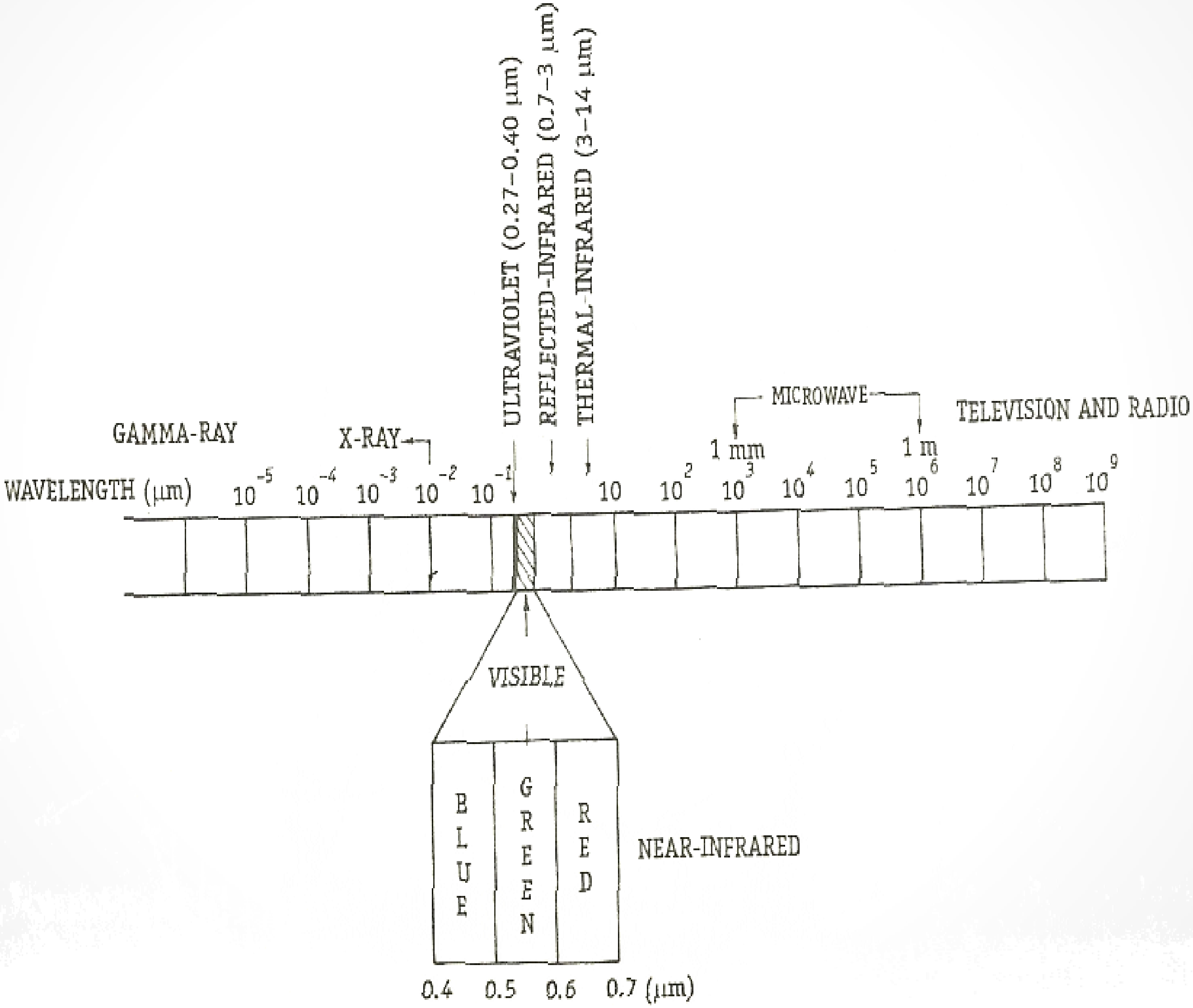
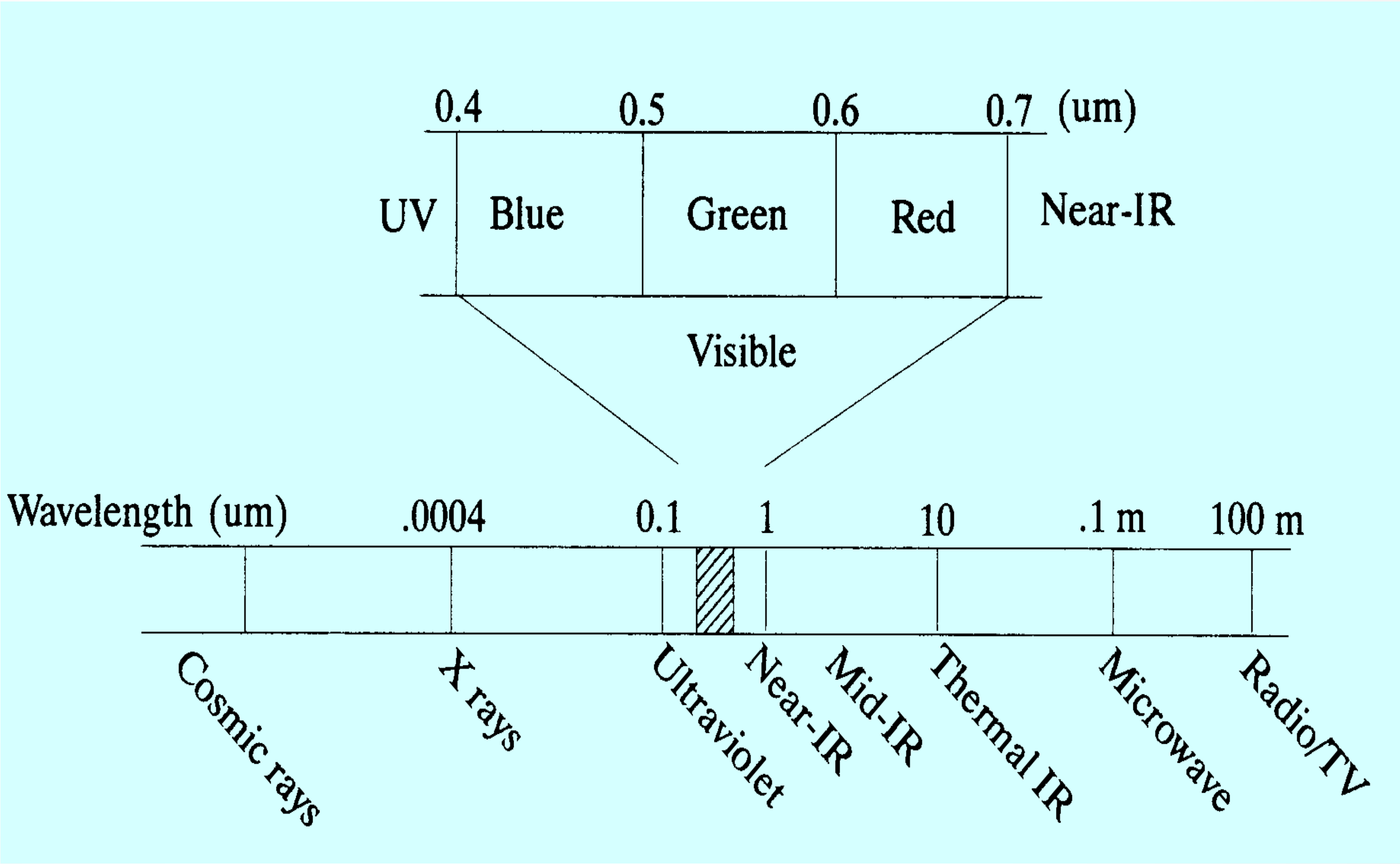


Fig. 1.2 The electromagnetic spectrum.

ELECTROMAGNETIC SPECTRUM



MAJOR REGIONS OF THE EM SPECTRUM

- Region Name Wavelength Comments
- Gamma Ray < 0.03 nm (Entirely absorbed by the Earth's atmosphere and not available for remote sensing).
- X-ray 0.03 to 30 nm Entirely absorbed by the Earth's atmosphere and not available for remote sensing.
- Ultraviolet .03 to 0.4μm Wavelengths from 0.03 to 0.3 mcrometers absorbed by ozone in the earth's atmosphere.

MAJOR REGIONS OF THE EM SPECTRUM

Region Name	Wavelength	Comments
Photographic		
Ultraviolet	0.3 to 0.4 μm	Available for remote sensing of the Earth. Can be imaged with photographic film.
Visible	0.4 to 0.7 μm	Available for remote for sensing of the earth. Can be imaged with photographic film.
Infrared	0.7 to 100 μm	Available for remote sensing of the Earth. Can be imaged with photographic film.

MAJOR REGIONS OF THE EM SPECTRUM

- Region Name Wavelength Comments

Microwave or Radar	0.1 to 100 centimeters	Longer wavelengths of this band can pass throughclouds,fog, and rain. Images using this band can be made with sensors that actively emit microwaves.
Radio	> 100centimeters	Not normally used for remote sensing the Earth.

VISIBLE LIGHT BANDS

- This narrow band of electromagnetic radiation extends from about 400 nm (violet) to about 700 nm (red).
- The various color components of the visible spectrum fall roughly within the following wavelength regions:
    - Red: 610 - 700 nm
    - Orange: 590 - 610 nm
    - Yellow: 570 - 590 nm
    - Green: 500 - 570 nm
    - Blue: 450 - 500 nm
    - Indigo: 430 - 450 nm
    - Violet: 400 - 430 nm

INFRARED BANDS

- **Infrared is from 0.7 to 3µm wavelength.**
- **This region is further divided into the following bands:**
  - **Near Infrared (NIR): 0.7 to 1.5 µm.**
  - **Short Wavelength Infrared (SWIR): 1.5 to 3 µm.**
  - **The NIR and SWIR bands are also known as reflected infrared,**

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INFRARED BANDS

- Mid Wavelength Infrared (MWIR): 3 to 8 μm.
- Long Wavelength Infrared (LWIR): 8 to 15 μm.
- Far Infrared (FIR): longer than 15 μm.

- The MWIR and LWIR are known as thermal infrared

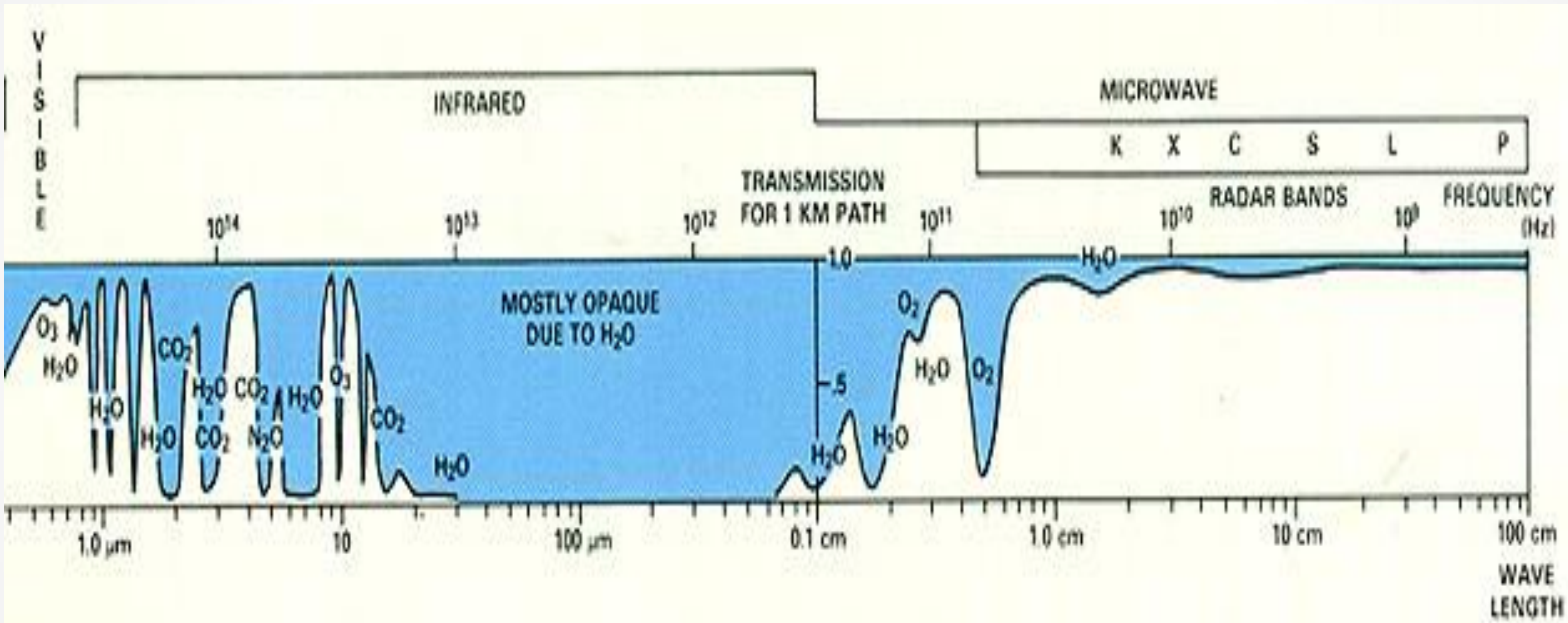
SUMMARY

- Electromagnetic radiation is the energy that is propagated through free space or through a material medium in the form of e.m. waves.
- Characteristics of e.m. radiation vary in the different wavelengths

SUMMARY

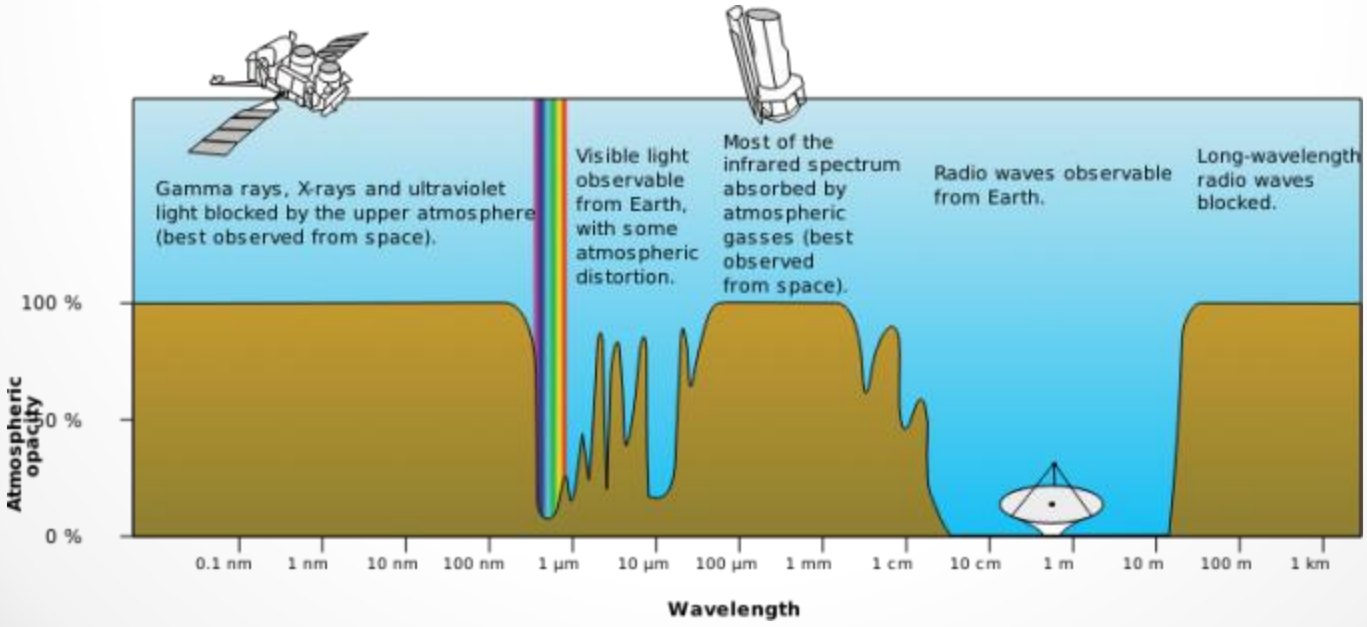
- The whole range of wavelength is called the e.m. spectrum.
- The variation in wavelength of e.m. radiation is so vast that it is usually shown on a logarithmic scale.

ATMOSPHERIC TRANSMITTANCE



ATMOSPHERIC WINDOW

- Gases and water vapours in the atmosphere disturb the recording of EM energy. Atmospheric absorption. is due primarily to water vapour, carbon dioxide and ozone. These gases selectively absorb EMR in specific wavelength bands..
- These generate a succession of absorption and transparency intervals
- RS data acquisition is limited to transparency intervals which are called atmospheric windows



ATMOSPHERIC WINDOW (Contd.)

- Windows in VIS and reflected IR extend from 0.4 to 3µm
- Windows in TIR are between 3 to 5µm and 8 to 14µm
- No transmission of energy between 22µm to 1mm
- Beyond 1 mm is the microwave region

ATMOSPHERIC ABSORPTION IN DIFFERENT WAVELENGTH REGIONS

- Atmospheric absorption has maximum affect on shorter wavelengths (gamma, x-ray, UV)
- Atmospheric absorption has little to no affect on microwave radiation (longer wavelengths)

ATMOSPHERIC WINDOWS IN THE E.M. SPECTRUM

- Atmospheric windows are wavelength ranges in which the atmosphere is particularly transmissive of energy

- Visible region resides within the atmospheric window with wavelengths of about 0.3 to 0.9 μm

ATMOSPHERIC WINDOWS IN THE E.M. SPECTRUM

- Emitted energy from the earth's surface is sensed through the windows at 3–5 μm and 8–14 μm
- Radar and passive microwave systems operate through a window region 1 mm to 1m

applications

Region	Wavelength	Principal applications
Visible (0.4 – 0.7 µm)	0.4 – 0.5µm	Sensitive to sedimentation, discrimination of forest cover
	0.5 – 0.6µm	Green reflectance by healthy vegetation, vegetation vigour, rock-soil discrimination, turbidity and bathymetry in shallow waters
	0.6 – 0.7µm	Sensitive to chlorophyll absorption, plant species discrimination, differentiation of soil and geological boundaries
Infrared (0.7 – 1.0µm)	0.7 – 0.8µm	Sensitive to green biomass and moisture in vegetation, land and water contrast, landform and geomorphic studies.
	0.8 – 1.0µm	Suitable for recognising surface water bodies, particularly land-water boundary delineation and soil crop contrasts
Reflected-infrared (0.7 - 3.0µm)	1.55 – 1.75µm	Can penetrate thin clouds. Good contrast between the vegetation types, discrimination of moisture in the soil and for differentiating snow from clouds.
Thermal infrared (3-5µm and 8-14µm)	3 - 5µm	Detection of hot targets – fire, lava flow, and such other features
	8 - 14µm	Optimum for terrain mapping, vegetation stress analysis and soil moisture discrimination.

principal applications (Contd.)

Region	Wavelength	Principal applications
Microwave/Radar (0.1 – 30 cm)	2 – 6 cm	Suitable for sensing crop canopies and tree leaves. Useful for determining ice types.
	15 – 30 cm	Affords greater depth penetration measured in terms of metres; can penetrate 1 – 2 m into a dry material to reveal underlying bedrock structure. Useful for mapping total extent of ice and for sensing tree trunks.

ENERGY INTERACTIONS IN THE ATMOSPHERE

- Sun is the main source of energy, which illuminates and provides electromagnetic energy to all terrestrial objects.

- Electromagnetic energy recorded by the sensors has to travel through some distance in the atmosphere.

ENERGY INTERACTIONS IN THE ATMOSPHERE (Contd.)

- This path length is highly variable.
- It depends on the source of the EM energy and also on the height of the sensor platform
- In space images, sunlight has to travel a full thickness of earth's atmosphere twice on its journey from source to the sensor.

ENERGY INTERACTIONS IN THE ATMOSPHERE (Contd.)

- In an airborne thermal sensor, the directly emitted energy from the target has to pass through a very short length in the atmosphere to reach the sensor.
- The energy signal which is received by the sensor depends on magnitude of the energy signal, distance travelled through the atmosphere, atmospheric condition and the wavelengths involved.

ENERGY INTERACTIONS IN THE ATMOSPHERE (Contd.)

- The energy signal which is received by the sensor depends on:
- (a) magnitude of the energy signal,
- (b) distance travelled through the atmosphere
- (c) atmospheric condition and
- (d) the wavelengths involved.

ENERGY INTERACTIONS IN THE ATMOSPHERE (Contd.)

- Atmosphere significantly affects the intensity and spectral composition of radiation received by the sensor.
- These effects are caused by the mechanism of scattering and absorption.

SCATTERING

- Scattering occurs when the EM radiation interact with particles present in the atmosphere, which redirect the EM radiation from its original path.

- This scattering takes place in all directions.

SCATTERING (Contd.)

- Scattering depends upon several factors :
- wavelength of radiation
- abundance of particles and gases in the atmosphere
- path length of energy travelling
  through the atmosphere

TYPES OF SCATTERING

- ***Rayleigh scatter***:
- It occurs when the radiation interacts with particles which are very small in diameter as compared to the wavelength of the interacting radiation.
- These particles are - small specks of dust or nitrogen or oxygen molecules

RAYLEIGH SCATTERING (Contd.)

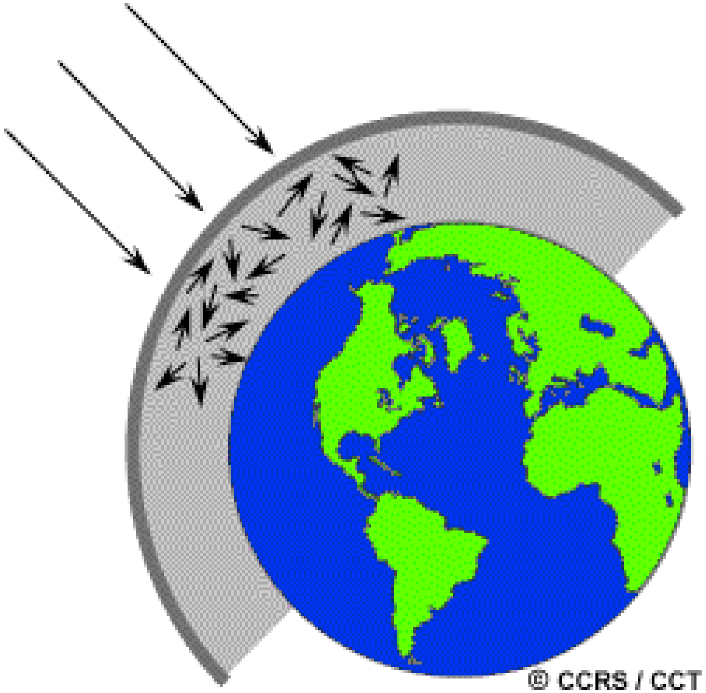
- The shorter wavelengths of energy are much more scattered in comparison to the longer wavelengths of energy.

- We see the daytime sky blue because of highest scattering of shorter wavelengths of visible region i.e. blue in comparison to the other visible wavelengths i.e. green and red.

RAYLEIGH SCATTERING (Contd.)

- Sky would appear black in the absence of scattering.
- Rayleigh scattering is dominant in the upper atmosphere.
- We sometimes see ‘haze’ in images which is caused by Rayleigh scatter.

RAYLEIGH SCATTERING



MIE SCATTERING

- ***Mie scatter***: Mie scatter occurs if the particles present in the atmosphere is just about the same as the wavelength of the radiation.
- This scatter is mainly caused by the dust, pollen, smoke and water vapour in the atmosphere which mainly affects longer wavelengths of radiation.

MIE SCATTERING (Contd.)

- This scatter is common in the lower atmosphere, where larger particles are abundant and dominates particularly when the sky is overcast.

MIE SCATTERING

NON-SELECTIVE SCATTERING

- ***Non-selective scattering:***
- This type of scatter takes place when the diameter of the particles in the atmosphere (e.g., water droplets and large dust particles) are much larger than the wavelength of the radiation.
- All wavelengths of radiation are scattered equally.

NON-SELECTIVE SCATTERING

- Blue, green and red wavelengths are scattered equally to produce white light (blue + green +red = white).
- This is the reason why we see the fog and cloud as white.
- Other effects of non-selective scattering are decrease in contrast and spatial details in an image.

ABSORPTION

- Another mechanism works when the electromagnetic energy interacts with the atmosphere.
- This is known as absorption in which the molecules present in the atmosphere absorb energy in various wavelengths
- It results effective loss of energy to atmospheric constituents.

ABSORPTION (Contd.)

- Ozone, carbon dioxide and water vapour are very effective absorbers of solar radiation.

- Ozone absorbs the harmful ultraviolet radiation and thus helps us in protecting our skin from burning, when exposed to sunlight.

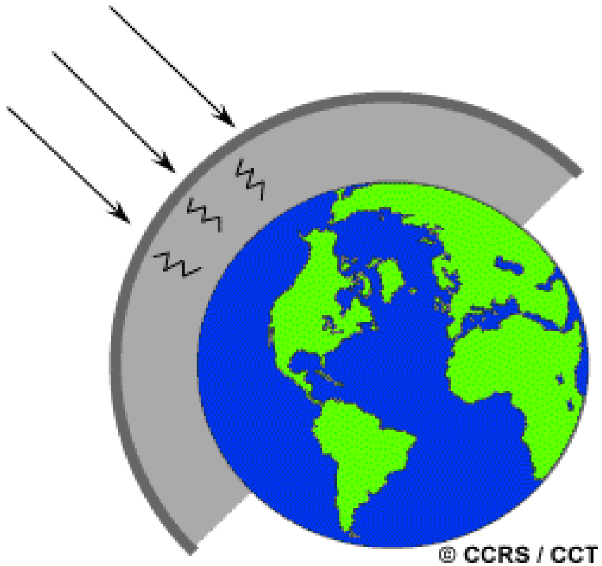
ABSORPTION (Contd.)

- Carbon dioxide present in the atmosphere strongly absorbs radiation in the infrared portion of the spectrum – that is associated with thermal heating.
- This helps in trapping the heat within the atmosphere.

ABSORPTION (Contd.)

- Water vapour in the atmosphere absorbs the incoming long wave infrared & shortwave microwave

ABSORPTION



ENERGY INTERACTIONS WITH EARTH SURFACE FEATURES

- **EM energy incident is reflected, absorbed and transmitted**
- **Variations of the proportion of energy reflected, absorbed and transmitted enable us to distinguish earth surface features**

Energy Balance Relationship

$$EI(L) = ER(L) + EA(L) + ET(L)$$

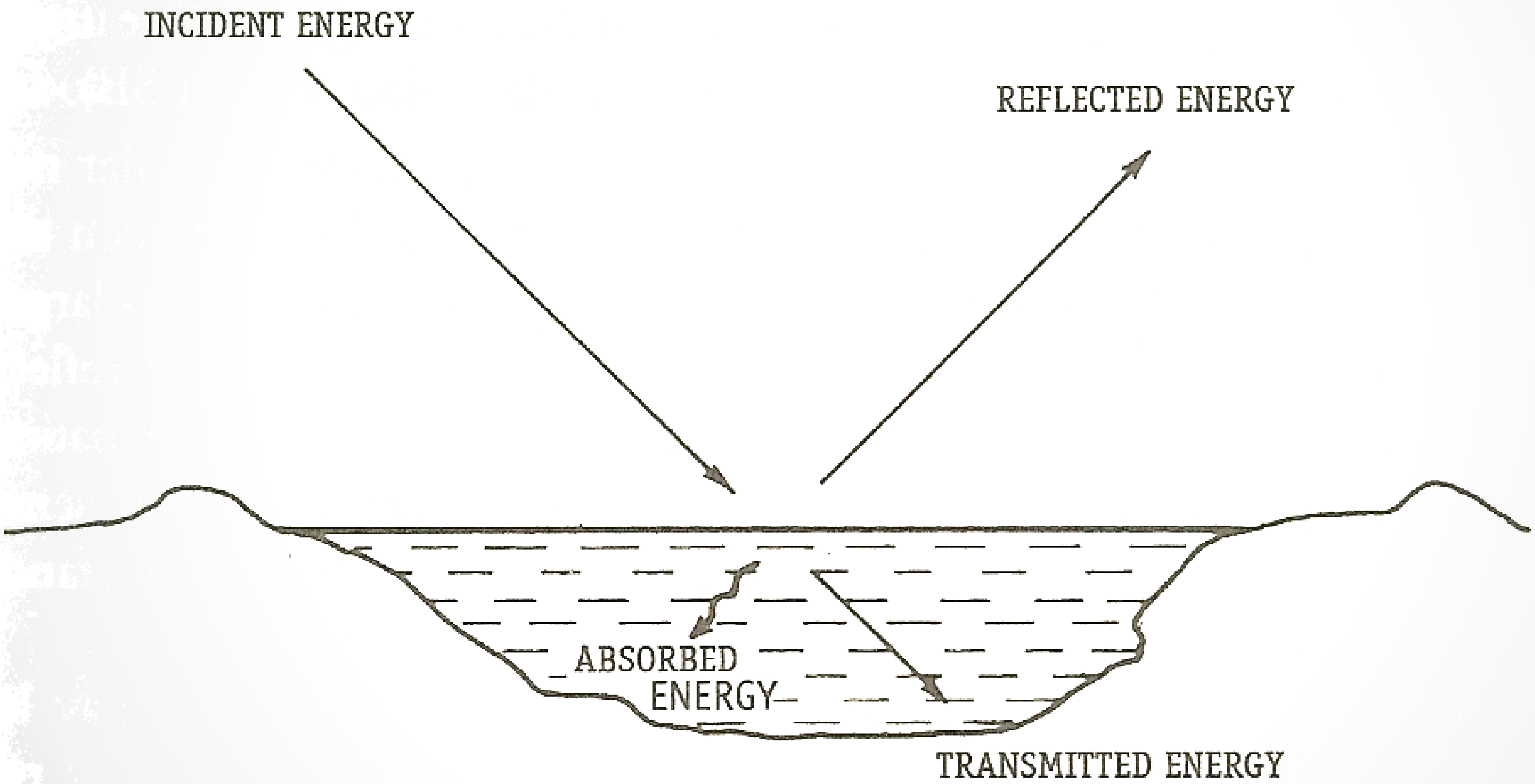


Fig. 1.4 Interactions between electromagnetic energy and a water body.

GEOMETRIC MANNER OF REFLECTION

- Geometric manner in which an object reflects energy is very important.
- This is mainly a function of the roughness of the object's surface.
- There are two main types of reflectors

TYPES OF REFLECTORS

- ***Specular reflector*** – Smooth surface mirror like reflections
- ***Diffuse reflector*** – Rough surface from which uniform reflection in all directions
- ***Near perfect diffuse reflector*** – Reflect some energy in all directions and larger portion in specular direction

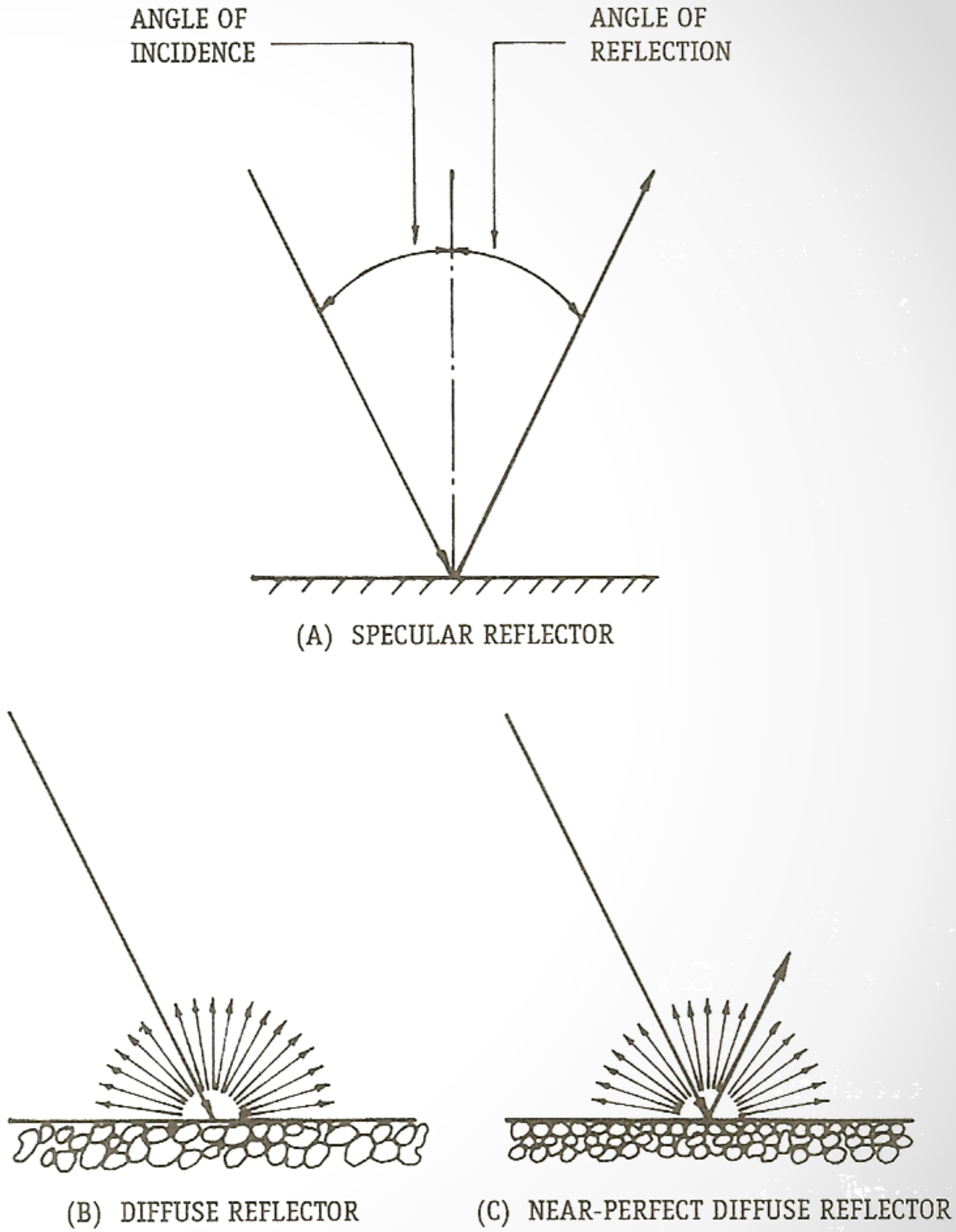


Fig. 1.5 Geometric characters of reflectors.

SPECULAR AND DIFFUSE REFLECTION

- Whether a particular target reflects specularly or diffusely, or somewhat in between depends on surface roughness of the feature in comparison to the wavelengths of the incoming radiation

SPECULAR AND DIFFUSE REFLECTION (Contd.)

- If the wavelengths are much smaller than the surface variations, or particle sizes that make up the surface, diffuse reflection will dominate.
- Example – Fine grain sand would appear fairly smooth to long wavelength microwaves, but would appear quite rough to the visible wavelengths

SPECTRAL INFORMATION

- Specular reflections do not contain spectral information
- Spectral information is obtained in the case of diffused reflections
- Hence, in remote sensing we are mostly interested in measuring the diffused reflectance properties of a feature

SPECTRAL REFLECTANCE

- Reflected energy can be quantified as a function of wavelength which is called *spectral reflectance* (RL)
- Mathematically defined as RL = ER(L)/EI(L)
- It is expressed in percentage
- Spectral reflectance is used to prepare spectral reflectance curve of an object. It is the graph of the spectral reflectance of an object as a function of wavelength

SPECTRAL REFLECTANCE CURVE

- It is a graph of the spectral reflectance of an object as a function of wavelength.

- The configuration of the spectral reflectance curve gives us an insight into the spectral characteristics of the object.

SPECTRAL REFLECTANCE CURVE (Contd.)

- Two different objects may be having the same reflectance in a particular wavelength region, and thereby are not distinguishable
- But, the same two different objects may be having different reflectance in another wavelength region, where it is distinguishable.

SPECTRAL REFLECTANCE CURVE (Contd.)

- Example : Snow and cloud have similar reflectance in the visible and NIR region, but different reflectance in SWIR

Spectral Response of Natural Earth Surface Features

Healthy Vegetation

- **Spectral reflectance curve for healthy green vegetation shows almost a peak and valley configuration**

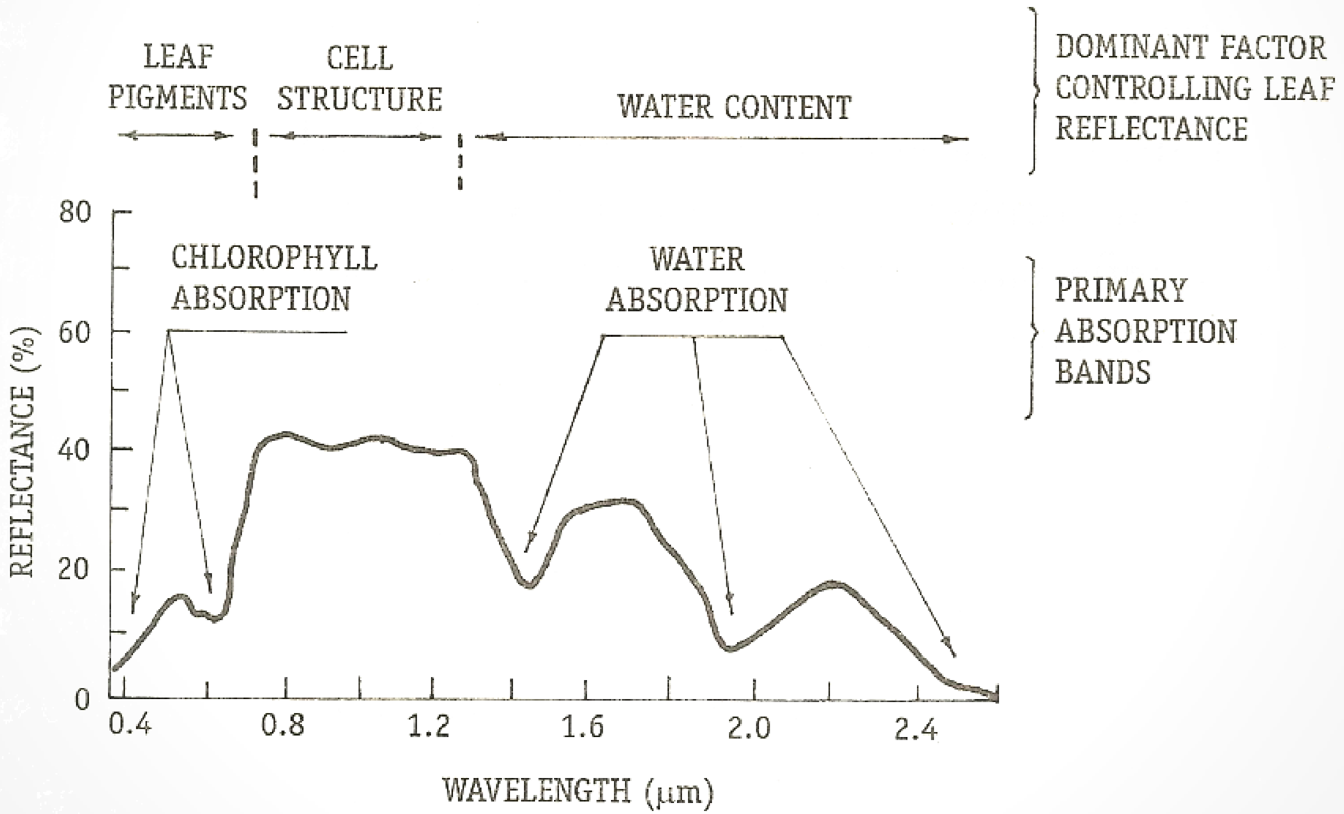
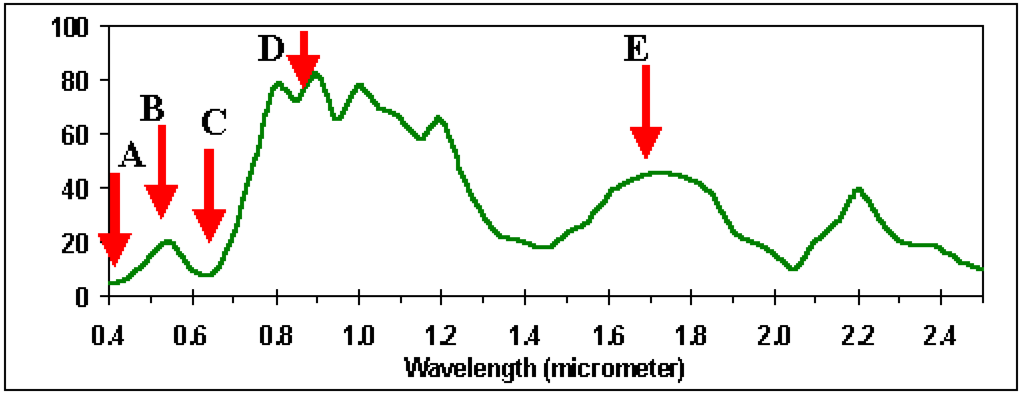


Fig. 1.6 Spectral reflectance curve of healthy green vegetation (after Deekshatulu and Bajpai, 1982).

C: red band; D: near IR band;

E: short-wave IR band



CHARACTERISTICS OF VEGETATION

SPECTRAL REFLECTANCE CURVE (Contd.)

- Valleys in the visible portion are centered at about 0.45 and 0.65μm (blue and red regions are dictated by pigments in the plant leaves)
- Between the above two zones, there is a reflectance peak at 0.54 μm which is the green wavelength region. This is the reason why we perceive a healthy vegetation as green (due to high absorption of the blue and red energy)

VEGETATION SPECTRAL REFLECTANCE CURVE (Contd.)

- As we go from the visible to the reflected infrared region of the spectrum at about 0.7µm, the reflectance of healthy vegetation increases dramatically. Between 0.7 and 1.3µm, a plant leaf reflects about 50% of the energy incident on it.
- Reflectance in this range is due to internal structure of the leaf, which is highly variable in different plant species.

VEGETATION SPECTRAL REFLECTANCE CURVE (Contd.)

- Dips in reflectance occur at 1.4, 1.9 and 2.7 μm which are due to water absorption

STRESS OR DISEASE IN PLANTS

- Chlorophyll production may decrease or cease due to some stress or disease in a plant
- This results in decrease in chlorophyll absorption and an increase in red reflectance.
- This is the reason why we see diseased plant in yellow, a combination of green and red

WATER

- Absorption of almost all energy in infrared region
- Reflectance from the water body may be due to specular reflection, suspended material or bottom reflection
- In NIR water acts as almost like a black body

SPECTRAL REFLECTANCE CURVES

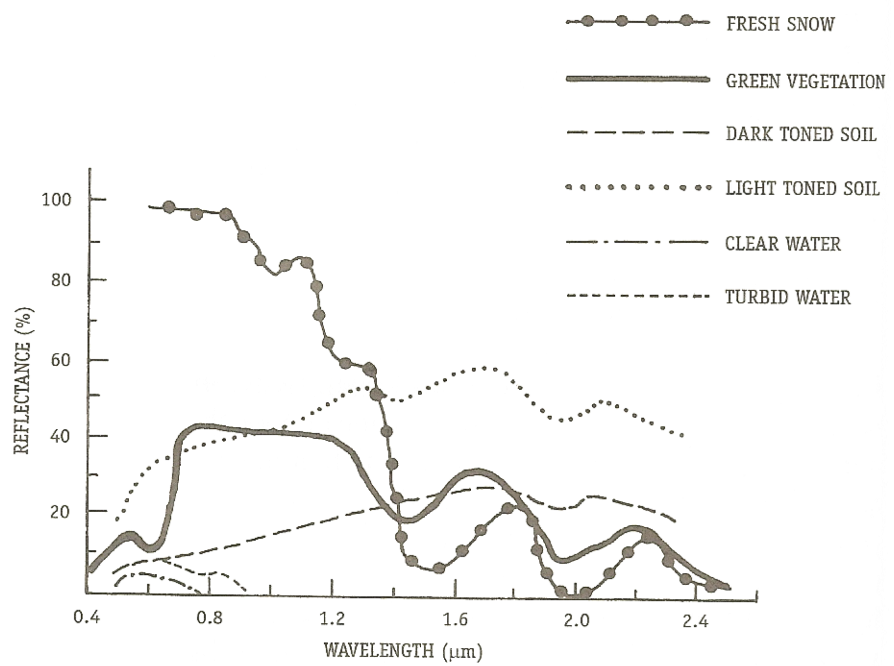
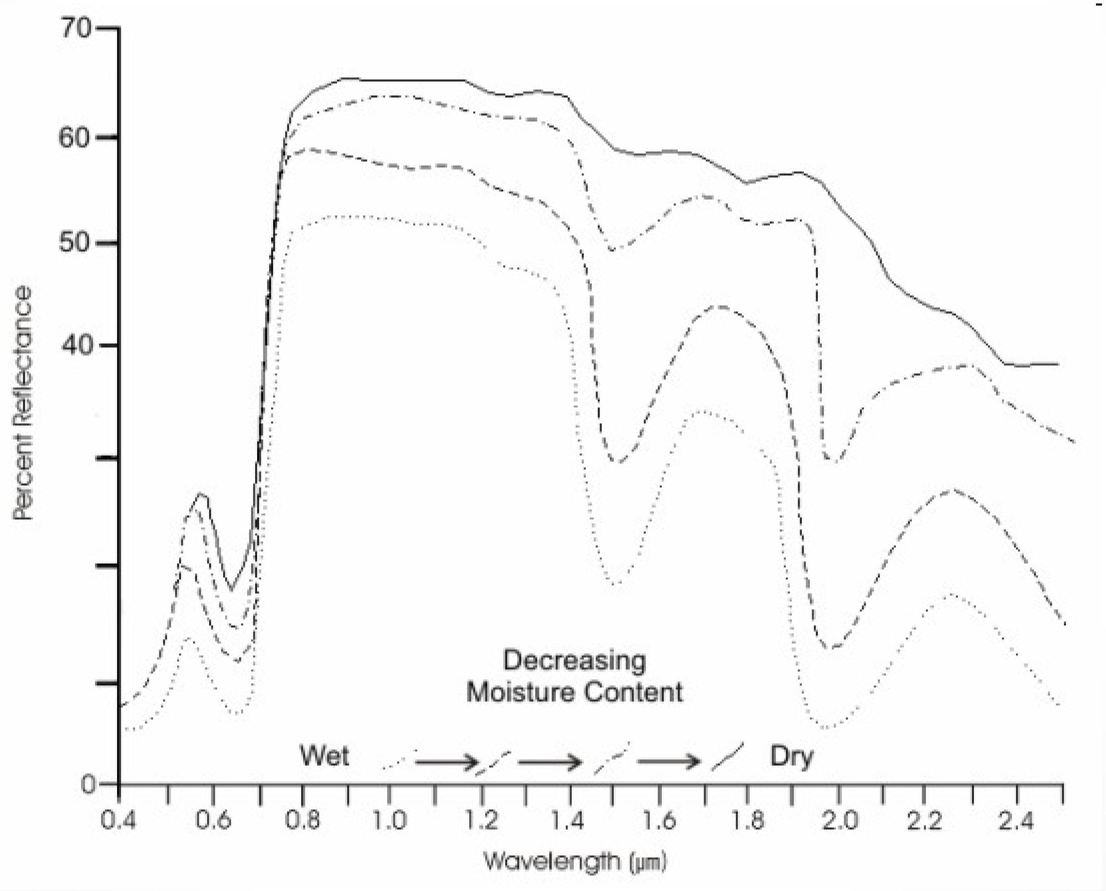


Fig. 1.7 Spectral reflectance curves of vegetation, soil, water, and snow (after Joseph and Navalgund, 1991).

VARIATION IN REFLECTANCE DUE TO LEAF MOISTURE IN VEGETATION



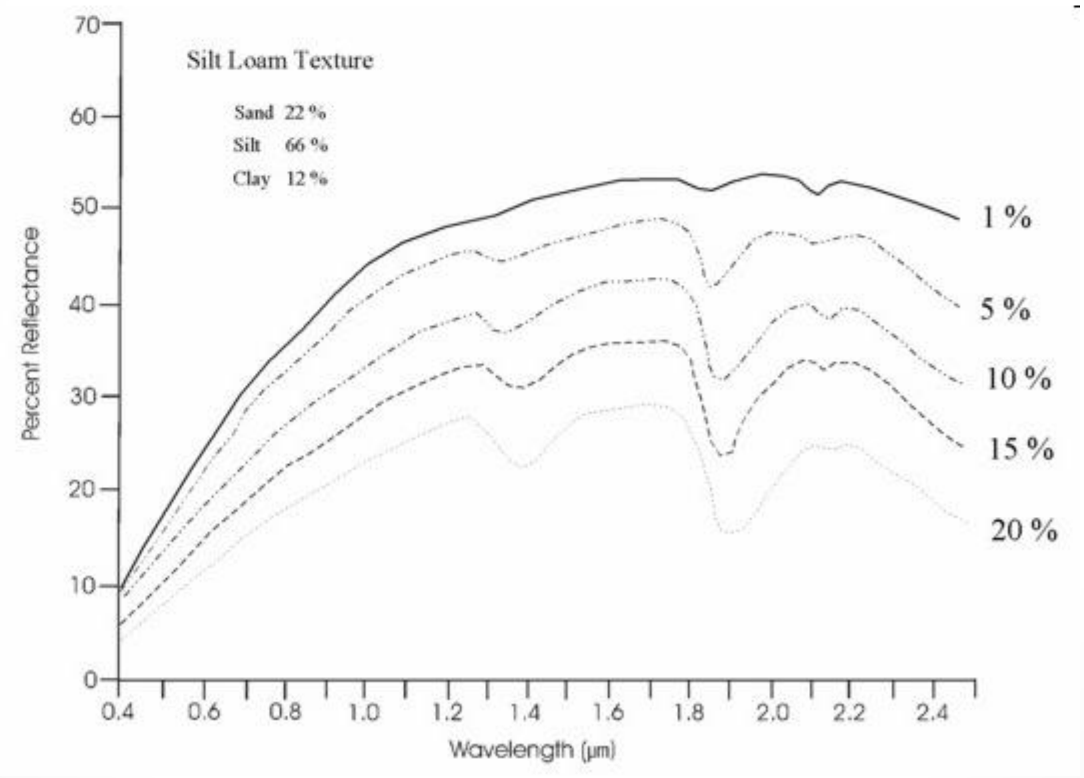
SOIL

- Soil curve shows considerably less peak and valley configuration.
- Factors affecting soil reflectance are – moisture content, soil texture (proportion of sand, silt and clay), surface roughness, presence of iron oxide and organic matter content.
- Presence of moisture in soil will decrease its reflectance.

SOIL (Contd.)

- Soil moisture content is related to the soil texture – coarse sandy soil, usually well drained, resulting in low moisture content will have high reflectance.
- Poorly drained fine textured soil will generally have lower reflectance.
- Presence of iron oxide in soil reduces reflectance at least in the visible wavelengths.

VARIATION IN SOIL REFLECTANCE DUE TO MOISTURE CONTENT



SNOW AND CLOUDS

- Snow has a very high reflectance in the VIS and very NIR (upto 0.8μm) and then decreases rapidly
- Clouds appear uniformly in the range 0.3 to 3.0μm
- Snow and cloud is best discriminated in the MIR around 1.6μm and 2.2μm
- Cloud tops and snow have almost similar temperature and thus very difficult to discriminate even in TIR

AND AN IMAGE :

- (a) An image refers to any pictorial representation, regardless of what wavelength or remote sensing device has been used to detect.
- (b) A photograph refers specifically to images that have been detected as well as recorded on photographic film.
- So, we can say that all photographs are images, but not all images are photographs.