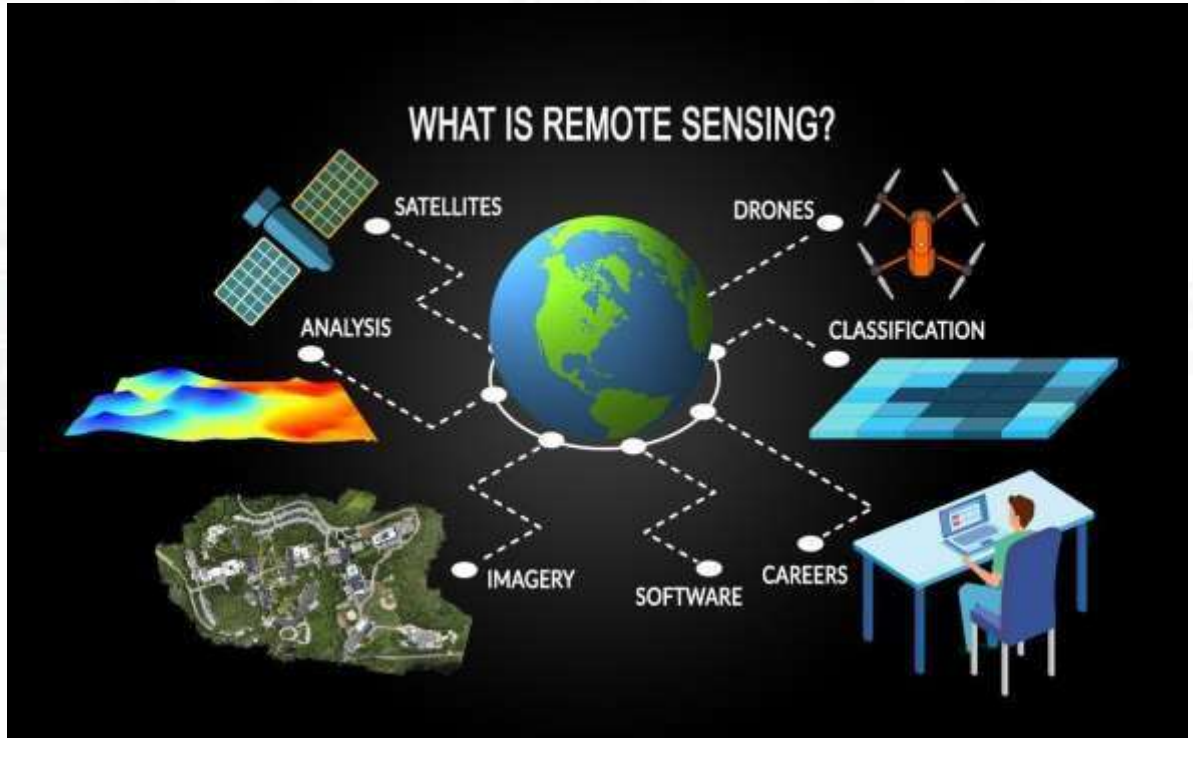
Basic concepts of Remote sensing

- BASIC CONCEPTS: Remote sensing (An EYE in the SKY) is the common methods used to collect data at a distance from the object by recording devices. The use of remote sensing techniques is increasing rapidly.
- The human eye collects information from only a part of the electromagnetic radiation (visible light) reflected from the external objects. The information collected on the retina is transmitted to the mind, which physiologically processes these signals to form a complete picture.

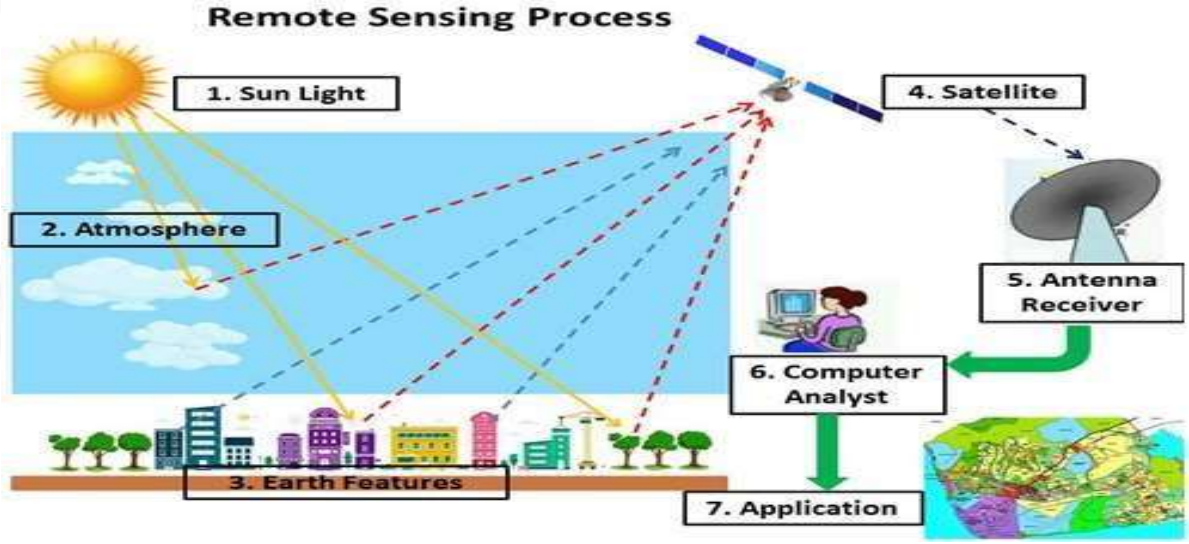
INDIAN REMOTE SENSING SATELLITES

Basic concepts of Remote sensing



- i. RS is an observation tool to identify objects or measure and analyze their characteristics without directly contacting the targets.
- ii. RS utilizes electromagnetic radiations as a medium for the identification, measurement and monitoring of the earth surface features.
- iii. It is based on the fact that all matters reflects, observes, transmits and emits the EMR in a unique way with respect to wavelength.
- iv. This unique property of EMR is called as spectral characters/ signatures.
- v. Camera or scanners are mounted on the satellite sensors, aircrafts and ground drones used in the data collection process.

- **REMOTE SENSING:** "The Art and Science of obtaining information of earth's object without any physical contact". This records the data, the energy interaction and target in electromagnetic radiation.
- **HISTORY OF REMOTE SENSING:**
- 1839 - First photograph
- 1858 - First photo from a balloon
- 1903 - First plane
- 1909 - First photo from a plane



- 1960 – Space Satellite Sensor.
- India began development of an indigenous IRS (Indian Remote Sensing Satellite) program to support the national economy in the areas of Agriculture, Water resources, Forestry, Ecology, Geology, Water sheds, Marine fisheries and Coastal management. With the advent of high resolution satellites new applications in the areas of Urban sprawl, Infrastructure planning and large scale applications for mapping have been initiated.

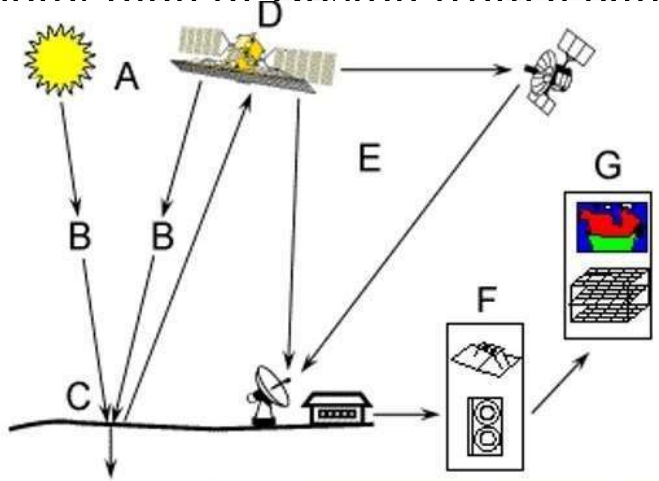
DATA & INFORMATION:

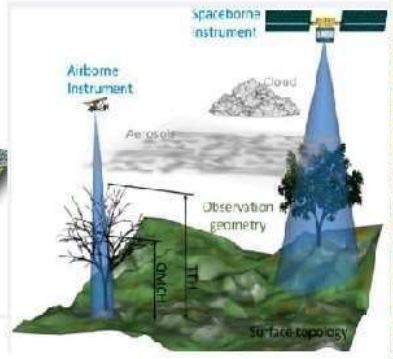
- Remotely gathered data is available from a range of sources and data collection techniques and is not always easily found within the public domain.
- This is largely due to the fact that most of this data is acquired by equipment that is expensive to build and maintain. However, there are many types of basic imagery of high-quality that are readily available at largely subsidized costs
- Remote sensing satellites are characterized by their *altitude, orbit and sensors.*
- i. The main purpose of the Geosynchronous
- Meteorological Satellite (GMS) with an altitude of 36,000 km is meteorological observations.
- ii. Landsat with an altitude of about 700 km, in a polar orbit, is mainly for land area observation.
- iii. Satellite with an altitude of 850 km in a polar orbit is mainly designed for meteorological observation but is also successfully used for vegetation monitoring

- Remote Sensing is being used to collect the information about agriculture, forestry, geography, archeology, weather & climate (meteorology), marine environment, hydrogeology, water resource management & assessment, civil engineering and so on.
- It provides meaningful and valuable information in various fields such as natural disaster such as floods, volcanoes, earthquakes, landslides, tsunami etc.

REMOTE SENSING DATA COLLECTION

- This has started in 1860 with James Wallace Black's photograph of Boston from a balloon.
- Most of the remotely sensed data used for mapping a electromagnetic radiation, which is then processed in objects on the Earth's land surface, atmosphere and o
- a. **Satellites:** Satellites have been used for capturing mainly for weather forecasting, mapping, environme
- b. **Aerial Photography:** It is one of the earliest form widely used and cost-effective methods of remote se
- c. **LIDAR** (LIGHT DETECTION AND RANGING) the form





REMOTE SENSING DATA COLLECTION

- c. **LIDAR** (LIGHT DETECTION AND RANGING): It is a Remote Sensing method that uses light in the form of pulsed laser to measure variable distances to the earth.
- d. **RADAR** (Radio Detection and Ranging): It's also a Remote Sensing method that detects the speed, distance and direction of an aircraft, ships and other objects.
- e. **UAV** (Unmanned Aerial Vehicle): Drone is an aircraft without human that can be controlled by an operator from the ground. They are originated mostly in military applications, but are rapidly utilized for commercial, scientific, recreational, agricultural, traffic monitoring, disasters monitoring and others.

REMOTE SENSING ADVANTAGES

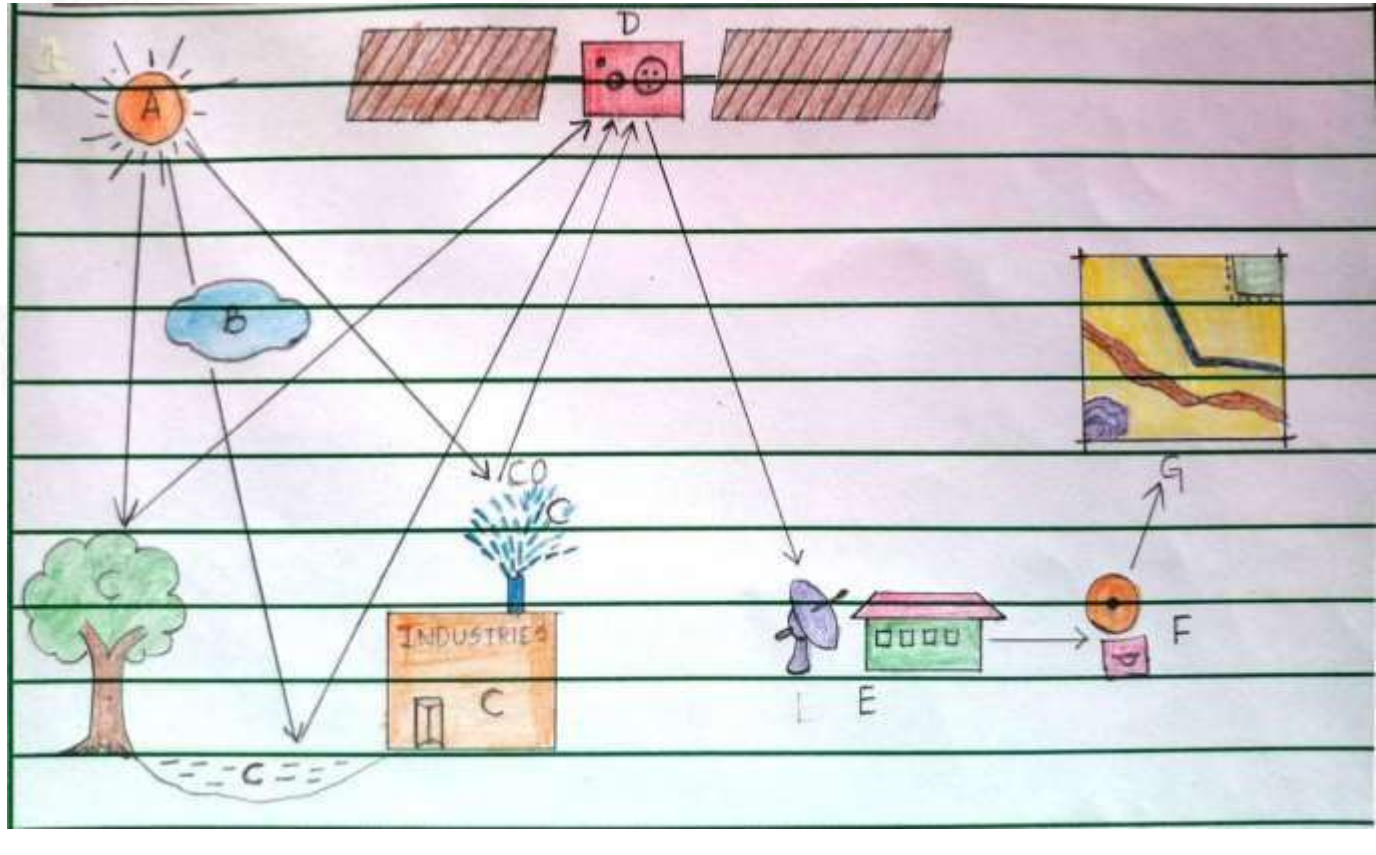
- i. Geology: Geological and structural mapping.
- ii. Hydrology: Mapping of surface water bodies, monitoring wetlands, snow covers and glaciers.
- iii. Agriculture: Crop type, crop rotation & its condition analysis and soil moisture measurements.
- iv. Forestry: Mapping of exact forest boundaries, biomass estimation, species identification and fire scar mapping.
- v. Oceanography: Sea ice identification, coastal wind field and wave slope measurements.
- vi. Shipping: Navigation of types of ship, its detection and classification.
- vii. Coastal Zone: Shoreline detection, sea-fresh water intrusions and general vegetation cover.
- viii. Military/ Security Applications: Detecting the exact location and speed of the war planes.

LIMITATIONS OF REMOTE SENSING

- a. Remote sensing is a fairly expensive method of analysis especially when measuring smaller areas.
- b. Requires a special kind of training for effective interpretation of Remote Sensing technology.
- c. It is expensive to analyze repetitive photographs.
- d. Instrumental error may lead to un-calibrated Remote Sensing data.
- e. The information provided by Remote Sensing data may not be complete and may be temporary.
- f. Large scale engineering maps cannot be prepared from satellite data which makes Remote Sensing data collection incomplete.

Elements/Components of RS

- A=Natural light source (Sun); B= Atmospheric elements (clouds; CO emission); C= Surface features;
- D= Satellite sensor; E= Observation station; F= Disk/ floppy; G= Processed Images

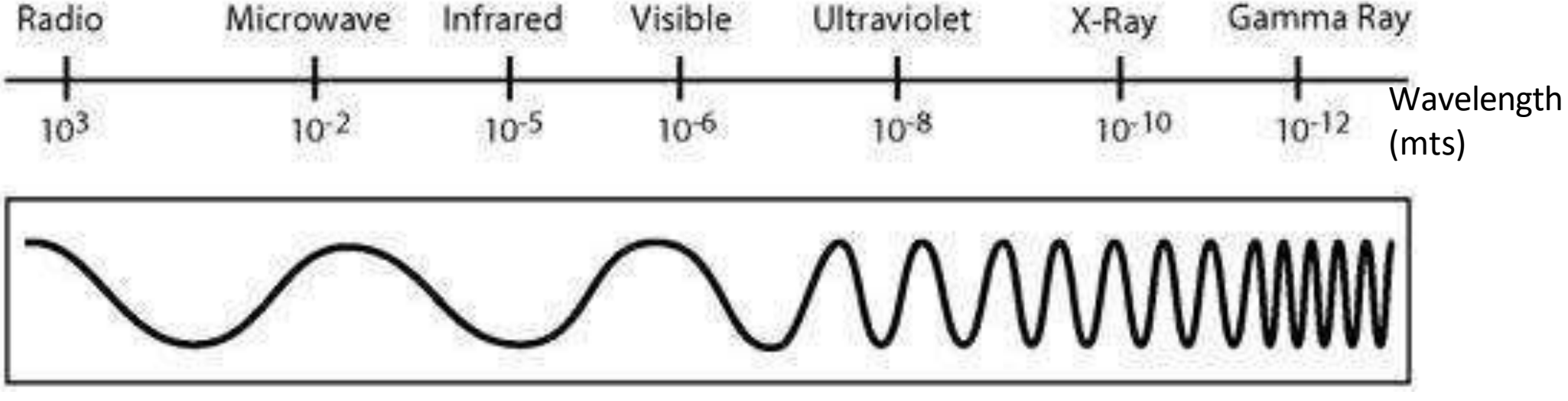


- 1. Energy Source (A):- Sun is the main source of light energy which strikes the earth surface features through Electro-Magnetic Radiation (EMR).
- 2. Radiation and Atmosphere (B):- EMR interacts with the atmospheric elements while traveling from its source to the target. This may obstruct the accuracy of the data collection.
- 3. Interaction with the Target (C):- Radiation that is not absorbed or scattered in the atmosphere can reach and interact with the Earth's surface. Different objects return different amount of energy depending on the physical, chemical & optical properties.

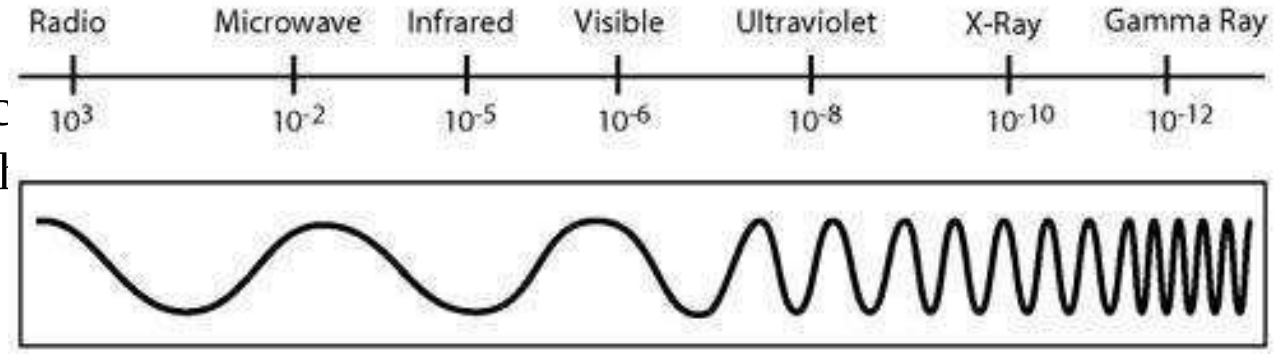
- 4. Recording of Energy by the Sensor (D):- After the energy has been emitted from the target, the reflected wavelength will be collected and recorded by the sensors. Error may occur during the data collection due to difference in surface roughness, angle of incidence, intensity, and wavelength of radiant energy.
- 5. Transmission, Reception, and Processing (E):- The energy recorded by the sensor will transmit the data in electronic form to the nearest observation station. Then the detection and discrimination of earth's feature will be done to form final image.
- 6. Interpretation and Analysis (F):- Later the processed image will be interpreted visually and digitally to extract specific information of the particular features.

ELECTROMAGNETIC SPECTRUM

Electromagnetic Radiation (Waves): Electromagnetic Radiation is the combination of electric and magnetic fields that propagate together at the speed of light.



- 1. The electromagnetic spectrum is the range of all possible frequencies of electromagnetic waves.
- 2. The main components of the electromagnetic spectrum are
- *a. Gamma-rays b. X-rays c. Ultra-violet rays d. Visible light*
- *e. Infra-Red rays f. Microwaves g. Radio waves*
- 3. Lowest frequencies are recorded at the one end of radio waves, while highest frequencies are recorded on the other end of gamma rays.
- 4. Wavelength and frequencies are inversely proportional to each other as the frequencies increases on the EM spectrum wavelength decreases.
- 5. Visible region of the spectrum lies in the spec reflected by the earth and other objects during tl region which is visible to human eye.



6. Reflected Infrared radiation ranges from 0.7 – 3 μm wavelength. These are recorded by infrared sensor systems.
7. Thermal Infrared radiation ranges from 3 – 5 μm and 8 - 14 μm representing greater intensity.
8. Micro-wave region ranges from 1 – 300 mm which can penetrate through rain, fog and clouds. Both active and passive sensors are capable of taking images using this sensors.
9. Gamma rays ranges less than 10 pictometer.
10. X-rays ranges from 10-5 – 10-3 (0.000001 nm).
11. Radio-waves have longest wavelength greater than 106 used for Remote Sensing in some radars.

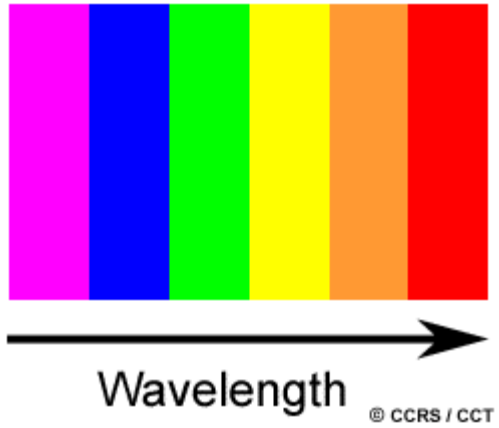
WAVELENGTH REGIONS IMPORTANT TO REMOTE SENSING

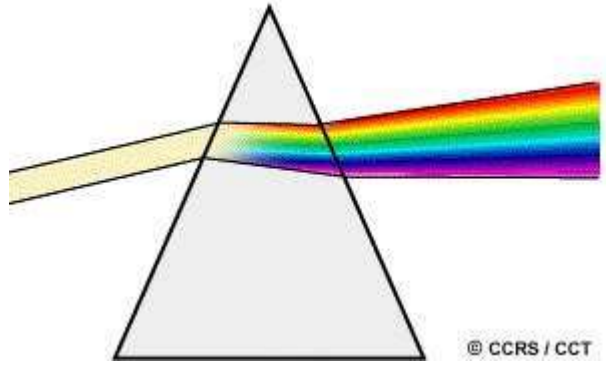
- **Ultraviolet or UV:** Ultraviolet (UV) light has wavelengths of approximately 1 – 380 nm.
- Near and middle UV wavelengths have information about ozone, sulfur dioxide, and trace gases in the troposphere and stratosphere (0–50 km) of interest to the atmospheric and volcanic sciences.

- **Infrared (IR):** This covers the wavelength range from approximately 0.7 μm to 100 μm (750 nm - 10,000 nm) more than 100 times as wide as the visible portion.

- **Visible Spectrums**: The visible wavelengths cover a range from approximately 400 – 750 nm or 0.4 to 0.7 μm.
- The longest visible wavelength is red and the shortest is violet. The visible portion of the spectrum is used extensively in remote sensing and energy is recorded using photography.
- Red, Green and Blue are the primary colors in which all other colors can be formed in various proportions.

Color	Wavelength
violet	380–450 nm
blue	450–495 nm
green	495–570 nm
yellow	570–590 nm
orange	590–620 nm
red	620–750 nm



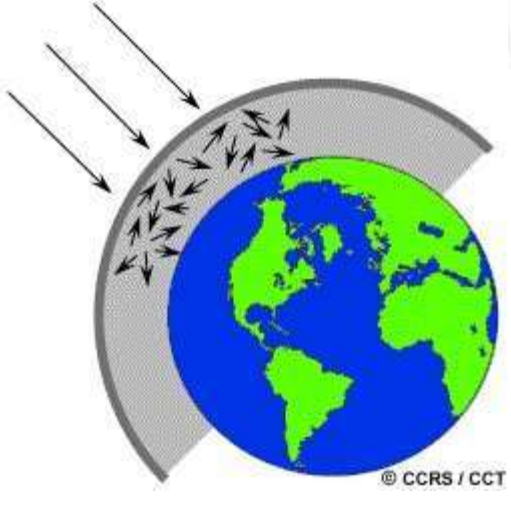


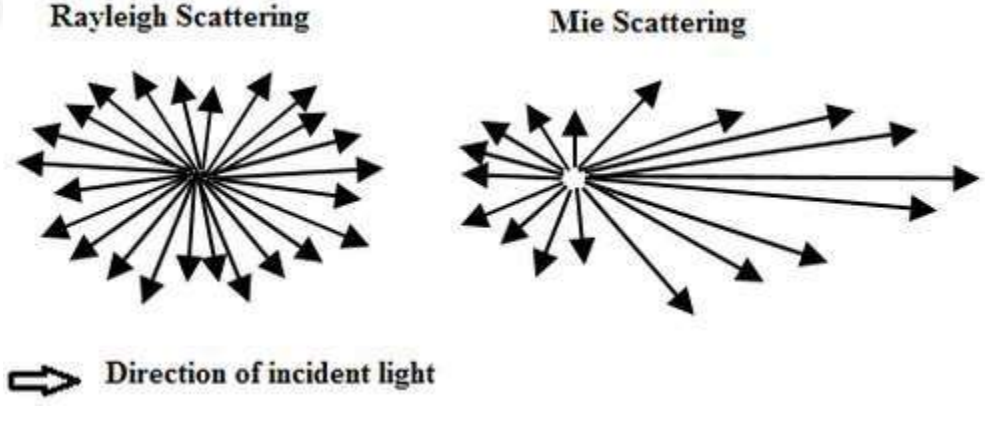
Sl No	Region	Wavelength	Remarks
1.	Gamma ray	<0.03 nm	Incoming radiation is completely absorbed by the upper atmosphere and is not available for RS
2.	X-ray	0.03 to 3.0 nm	Completely absorbed by atmosphere. Not employed in RS
3.	Ultraviolet	0.3 to 0.4 μm	Incoming wavelengths less than 0.3 μm are completely absorbed by ozone in the upper atmosphere.
4.	Photographic UV band	0.3 to 0.4 μm	Transmitted through atmosphere. Detectable with film and photodetectors, but atmospheric scattering is severe
5.	Visible	0.4 to 0.7 μm	Imaged with film and photodetectors. Includes reflected energy peak of earth at 0.5 μm
6.	Infrared	0.7 to 1.00 μm	Interaction with matter varies with wavelength. Atmospheric transmission windows are separated.
7.	Reflected IR band	0.7 to 3.0 μm	Reflected solar radiation that contains information about thermal properties of materials. The band from 0.7 to 0.9 μm is detectable with film and is called the photographic IR band.
8.	Thermal IR	3 to 5 μm	Principal atmospheric windows in the 8 to 14 μm thermal region. Images at these wavelengths are acquired by optical mechanical scanners and special vidicon systems but not by film. Microwave 0.1 to 30 cm longer wavelengths can penetrate clouds, fog and rain. Images may be acquired in the active or passive mode.
9.	Radar	0.1 to 30 cm	Active form of microwave RS Radar images are acquired at various wavelength bands.
10.	Radio	>30cm	Longest wavelength portion of electromagnetic spectrum. Some classified radars with very long wavelengths operate in this region.

ENERGY INTERACTIONS WITH THE ATMOSPHERE

- The constituents of the atmosphere can be divided into two group's viz. (a) pure gases and (b) particulates. Pure gases in the atmosphere comprise nitrogen (78 %), oxygen (21%) and traces of argon, CO, water vapor and ozone. The particulates in the atmosphere include particles of various sizes originating from smoke, dust and rock debris.
- Atmospheric gases and particles may affect the incoming light and radiation caused by the mechanism of **absorption and scattering.**
- **1. ABSORPTION: Ozone, carbon dioxide, and water vapor are the three main atmospheric constituents which absorb radiation.**
- Water vapor in the atmosphere absorbs much of the incoming long wave infrared and shortwave microwave radiation (between 1.4, 1.9 and 2.1 μm). The presence of water vapor in the lower atmosphere varies greatly from location to location and at different times of the year.

- 2. SCATTERING: The atmospheric elements such as gas molecules of 10-4 μm in size and haze (water droplets) vary in size from 10-2 μm to 102 μm may affect the frequency, intensity, spectral distribution and changes the radiation path.
- It reduces the image contrast, and reflectance characteristics of ground objects as seen by the sensor.
- This depends upon the relative size of atmospheric particles.

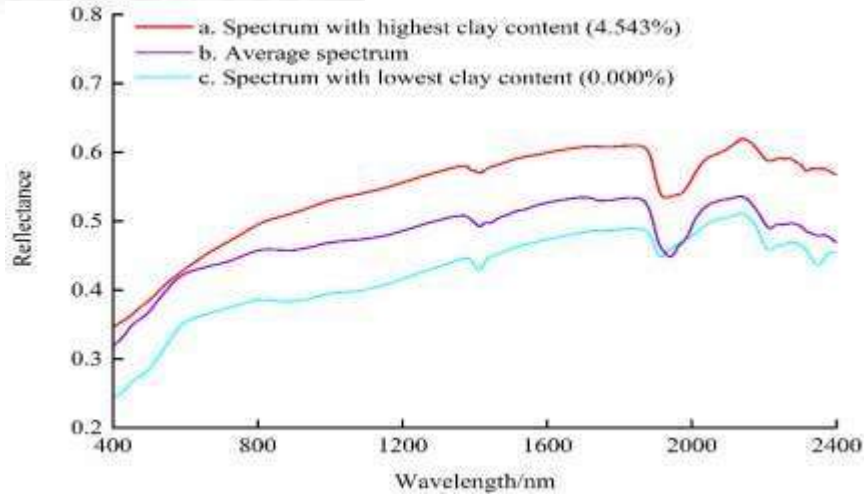




SPECTRAL SIGNATURE CONCEPTS - TYPICAL SPECTRAL REFLECTANCE CHARACTERISTICS OF SOIL, WATER AND VEGETATION

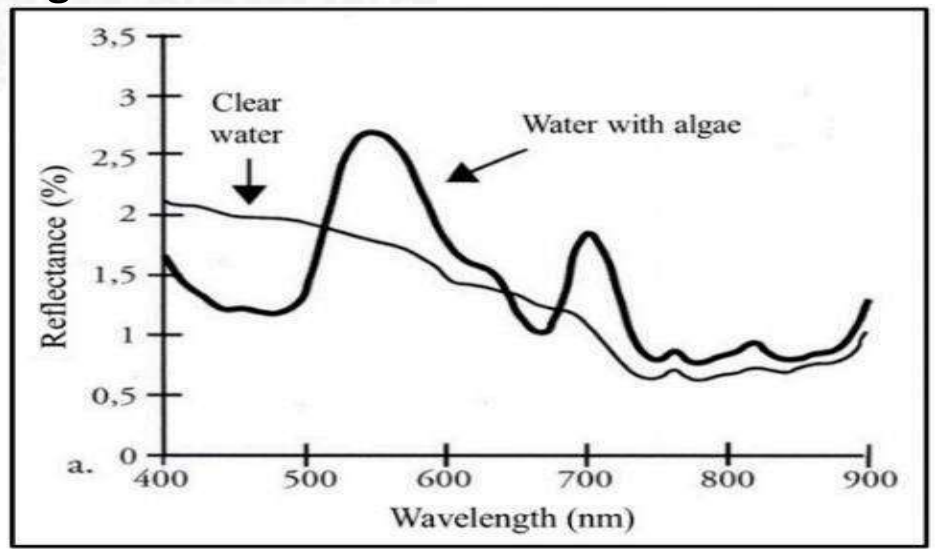
i. Spectral reflectance of Soil

- The factors that influence soil reflectance act over less specified spectral bands.
- 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.
- The presence of moisture in soil will decrease its reflectance -this effect is greatest in the water absorption bands at about 1.4, 1.9, 2.2 and 2.7 μm.
- Bare soil generally has an increasing reflectance, with greater reflectance in near-infrared and shortwave infrared.



ii. Spectral reflectance of Water

- Water (in soil, vegetation or water bodies) absorbs radiation at near-IR wavelengths and beyond (strong absorption bands at about 1.4, 1.9 and 2.7 µm).
- Reflectance from a water body can stem from an interaction with the water's surface (specular reflection), with material suspended in the water, or with the bottom of the water body.
- Water has relatively low reflectance, with clear water having the greatest reflectance in the blue portion of the visible part of the spectrum.

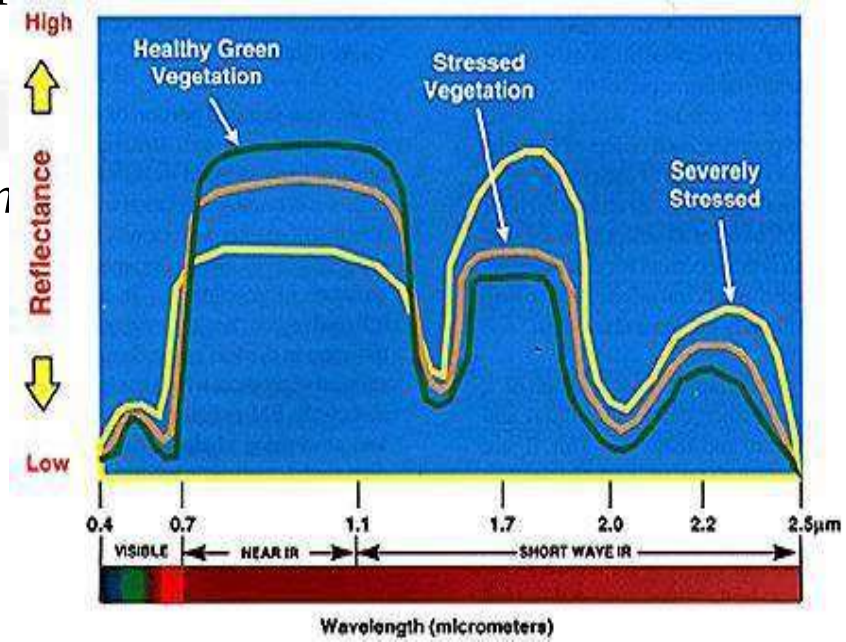


- **Spectral reflectance of Vegetation**
- In the range of 0.7 to 1.3 μm a plant leaf typically reflects 40 - 50% of the energy incident upon it primarily due to the internal structure of plant leaves.
- This helps in discriminating different plants and trees in various fields.
- Beyond 1.3 μm energy incident upon vegetation is essentially absorbed or
- reflected with little to no transmittance of energy.
- Dips in reflectance occur at 1.4, 1.9 and 2.7 μm due to strong

absorption of water by leaves at these wavelengths (*water absorption ban*

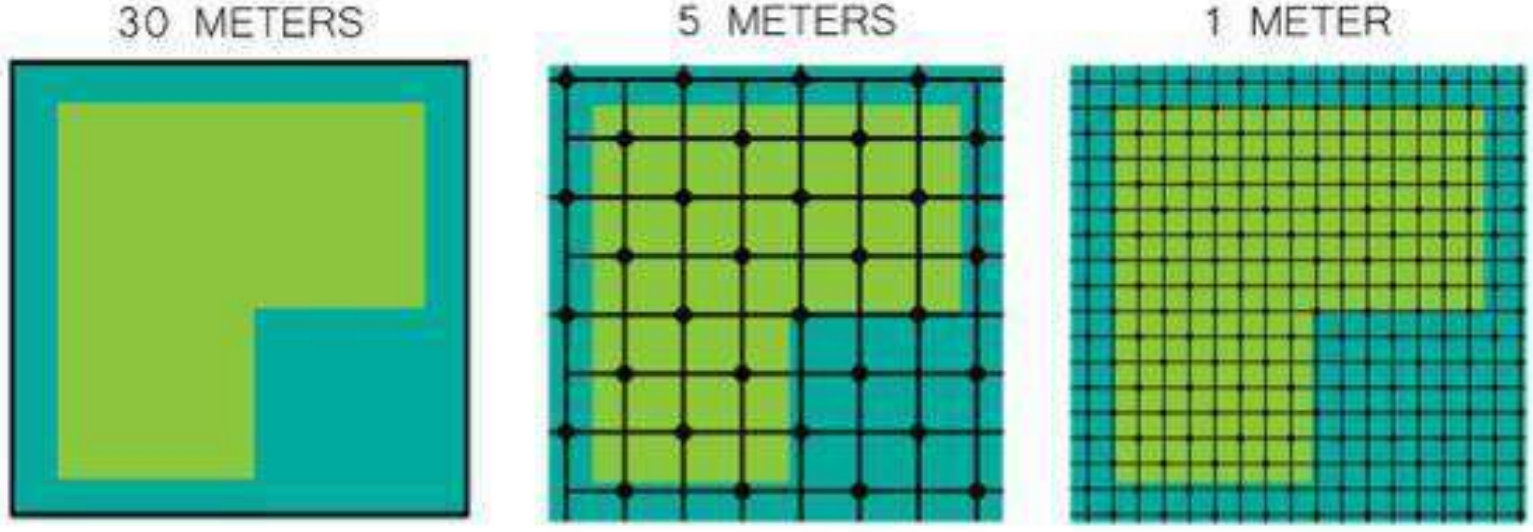
- Reflectance peaks occur at about 1.6μm and 2.2 μm between

the absorption bands throughout the range beyond 1.3 μm, leaf reflectance is approximately inversely related to the total water present in a leaf which is a function of both the moisture content and the thickness of a leaf.



RESOLUTION

- Resolution refers to the smallest size an object or detail can be represented in an image.
- Higher resolution means that pixel sizes are smaller, providing more detail.
- Imagery satellites provide different types of resolutions, revisit rates and carry different information.
- Some have lower resolutions but cover large areas with daily revisits while other offer very high-resolution resolution images from specific locations.



RESOLUTION

- The data can also be full RGB bands as well as black and white images or non-visible bands.
- Very high-resolution satellites usually cover less than 1m per pixel.
- Their level of detail makes them suitable to apply algorithms to monitor changes, detect objects, or spot trends.
- They are very useful to track human activities as well as remote natural areas.
- 30m resolution satellite imagery can capture details on the ground that are greater than or equal to 30m by 30m.
- Anything on the ground that is less than that size will be blended with the surrounding area to make a 30m by 30m square.

IMAGE REGISTRATION

- It is the process of transforming the different set of data into one coordinate system.
- This process helps in overlying two or more images of same place taken at different times, from different viewpoints or from different sensors.
- Image registration is the first step towards using remote sensed images for any purpose.
- Toposheet of 1:50,000 scale from Survey of India will be considered as base map for any satellite image registration.
- These images are geo-rectified by considering permanent features such as temples, major roads (NH/SH), drainages, power-lines, railways, settlements, co-ordinates, forests and village boundaries.

FALSE COLOUR COMPOSITE

- FCC allow us to visualize the wavelengths the human eye does not see (Near infrared range).
- The use of bands, such as near infrared, increases spectral separation and can enhance the interpretability of data.
- False color images are a representation of a multispectral image created using ranges other than visible red, green, and blue, such as red, green and blue image components.
- There are many different false colored composites that can be used to highlight different features.

FALSE COLOUR COMPOSITE

- Band combinations are selected for a number of reasons and it is helpful to understand the spectral reflectance profiles of features.
- For example in the NIR false color composite shown above healthy vegetation appears bright red as they reflect more near infrared than green. In this type of FCC images vegetation appears in different shapes of red depending on the types and conditions of the vegetation.
- Clear water appears as dark blue (higher green band reflectance), while turbid water appear cyan it means higher reflectance of red compared to clear water.
- Bare soils, roads and buildings may appear in various shapes of blue yellowish to white depending on their compositions.

ELEMENTS OF VISUAL INTERPRETATION TECHNIQUES

- 1**. Tone:-** Tone refers to the relative brightness or color of objects in an image. Each sensor records a specific color or range of colors that reveal particular features. Variations or shades of these tone/ colors provide better interpretation techniques. This becomes fundamental element to distinguishing between similar features.
- 2. **Shape:-** Shape refers to the structure or outline boundary of individual objects. Shape can be a very distinctive clue for interpretation. Distinct patterns appears due to human activities such as roads, railway tracks, power lines (line or linear)
- The shape of forest boundaries are more irregular in shape, except where man has created a road are clear cuts. Coconut plantation shows regular shape with shadow due to its height.
- 3. **Size:-** Size of the objects in an image is a function of scale. Recognition of familiar objects allows size estimation of other features; size is an important aspect of association.

- 4. **Pattern:-** refers to the spatial arrangement of objects of discrimination. Typically an orderly repetitive object is a recognizable pattern.
- 5. **Texture**:- Areas of an image with varying degrees of ‘smoothness’ or ‘roughness’. Water appears as smooth while forest canopy results in a rough textured appearance.
- 6. **Shadow**:- Shadow effects change throughout the day and throughout the year. It helps to interpret relative heights and size of an object.
- 7. **Association**:- It identifies the relationship between 2 or more recognizable objects. Commercial properties may be associated with major transportation routes, whereas residential areas would be associated with schools, hospitals, parks and sports fields. Agricultural and irrigation activities will be associated with nearby perennial rivers and streams.
- 8. **Site**:- It refers to the characteristics of an object such as topography, soil, vegetation and cultural features.

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