Unit - 1

Syllabus →

Duration (hour)		9
S-1	SLO-1	*Introduction of Remote Sensing*
	SLO-2	*EMR and its characters*
S-2	SLO-1	*Electromagnetic radiation interaction with Atmosphere*
	SLO-2	*Electromagnetic Radiation interaction with Earth surface features*
S-3	SLO-1	*Remote Sensing systems*
	SLO-2	*Platforms and sensors*
S-4	SLO-1	*Scanning mechanisms*
	SLO-2	*Optical and thermal scanners*
S-5	SLO-1	*Microwave remote sensing*
	SLO-2	*Lidar remote sensing*
S-6	SLO-1	*LANDSAT series SPOT series*
	SLO-2	*Indian Remote Sensing satellites*
S-7	SLO-1	*Metrological satellites*
	SLO-2	*High resolution satellites*
S-8	SLO-1	*Resolution*
	SLO-2	*Types of resolutions*
S-9	SLO-1	*Merits*
	SLO-2	*Multi and hyperspectral remote sensing*

CT PYQ's →

EndSem →

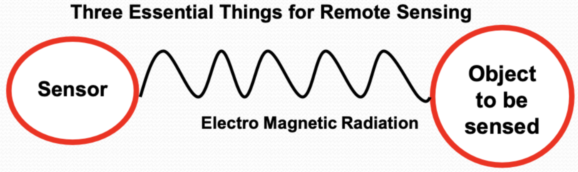
26. a. Illustrate on					
(i)	Electromagnetic spectrum	3	2	1	1
(ii)	Interaction of electro magnetic spectrum with atmosphere	7			
	(OR)				
b. Explain					
(i)	Sensor resolutions	6	2	1	1,2
(ii)	Multispectral and hyper spectral remote sensing	4			

Notes →

REMOTE SENSING

"Remote sensing is the science of acquiring information about an object without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information."

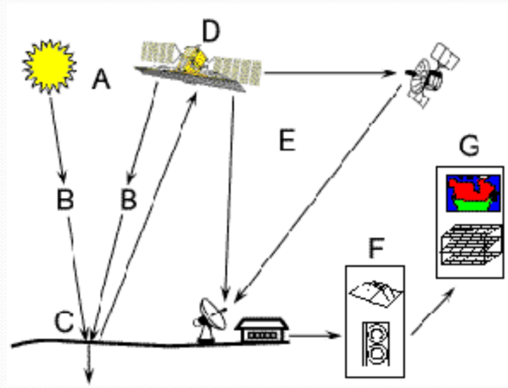
Three Essential Things for Remote Sensing

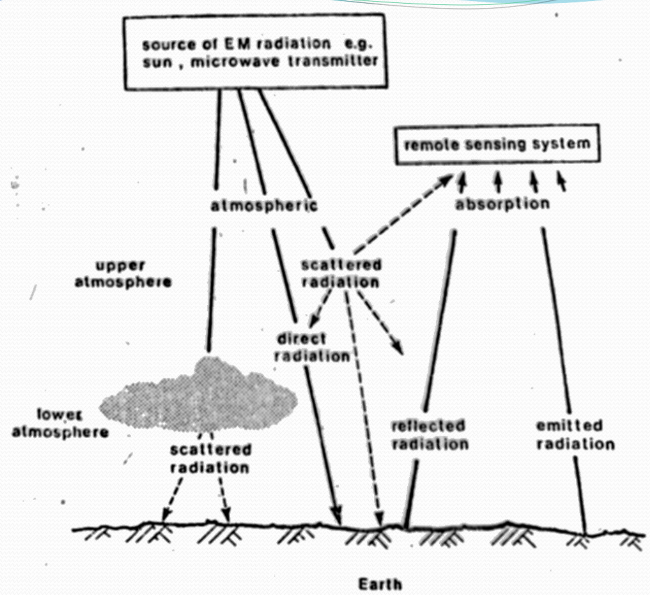


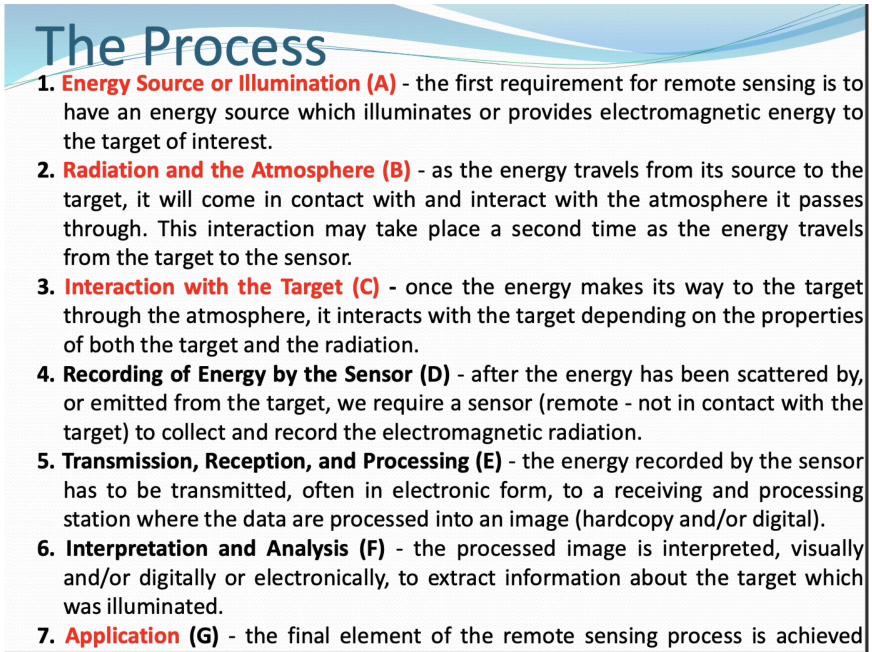
Remote Sensing System andProcesses

The process involves an interaction between incident radiation and the targets of interest.

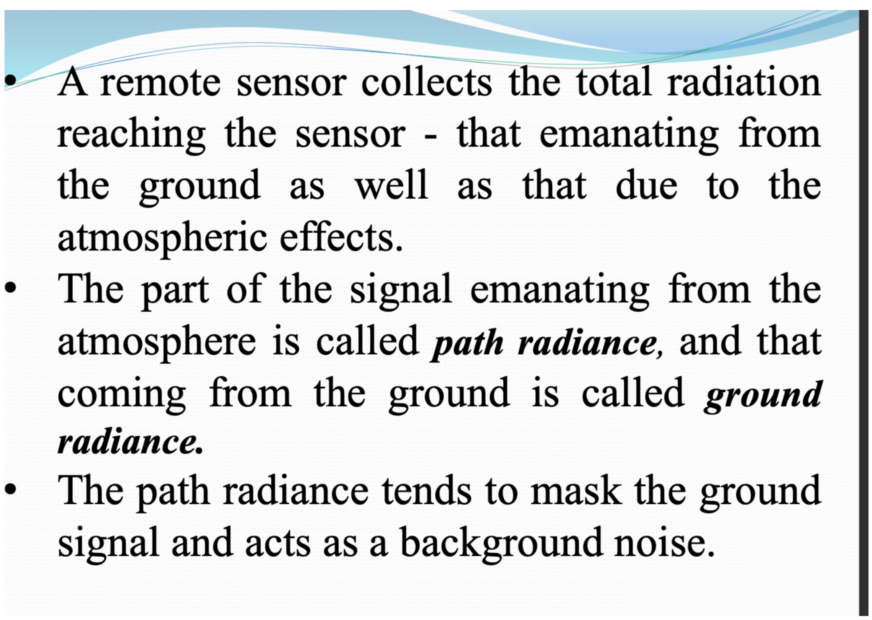
(A) Energy Source or Illumination
(B) Radiation and the Atmosphere
(C) Interaction with the Target
(D) Recording of Energy by the Sensor
(E) Transmission, Reception, and Processing
(F) Interpretation and Analysis
(G) Application



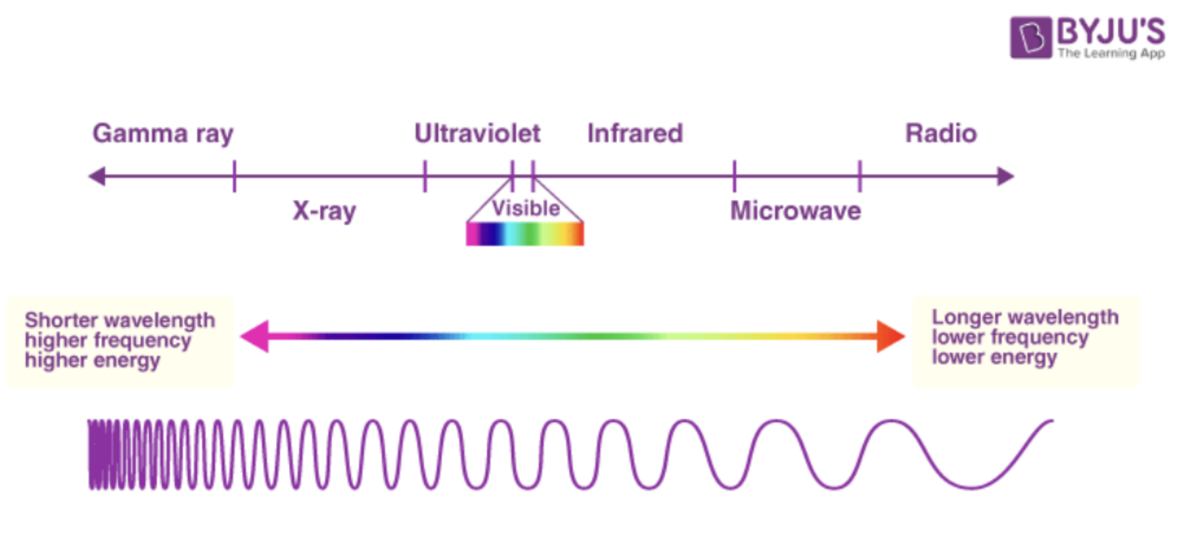




- Path Radiance → information collected by radar from atmosphere
- Ground Radiance → information collected by radar from ground



Electromagnetic Radiation →



Electromagnetic waves can be categorized based on their wavelength or frequency. The electromagnetic spectrum encompasses a wide range of waves, each with distinct properties and applications. Here are the main types of electromagnetic waves, listed in order of increasing frequency (or decreasing wavelength):

short way to memorise RMIVUXG → "Riding my invisible vehicle, under Xtra glow."

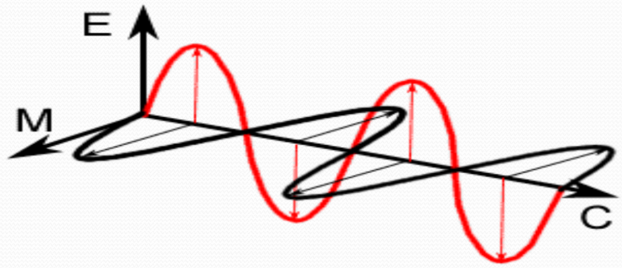
1. Radio Waves:
    - Wavelength Range: From hundreds of meters to about 1 millimeter.
    - Applications: Broadcasting radio and television signals, communication, radar systems.
2. Microwaves:
    - Wavelength Range: From about 1 millimeter to 1 meter.
    - Applications: Microwave ovens, communication, radar, satellite communication.
3. Infrared (IR) Radiation:
    - Wavelength Range: From about 1 millimeter to around 700 nanometers.
    - Applications: Thermal imaging, remote controls, heat lamps, some types of sensors.
4. Visible Light:

- Wavelength Range: From around 700 nanometers (red) to about 400 nanometers (violet).
- Applications: Human vision, photography, illumination, optical communication.

5. Ultraviolet (UV) Radiation:
    - Wavelength Range: From about 400 nanometers to 10 nanometers.
    - Applications: UV sterilization, black lights, some types of medical treatments, detecting counterfeit money.
6. X-rays:
    - Wavelength Range: From about 10 nanometers to 0.01 nanometers (10 picometers).
    - Applications: Medical and dental imaging, security screening, material analysis.
7. Gamma Rays:
    - Wavelength Range: Below 0.01 nanometers (10 picometers).
    - Applications: Cancer treatment (radiation therapy), sterilization, probing the atomic and subatomic world.

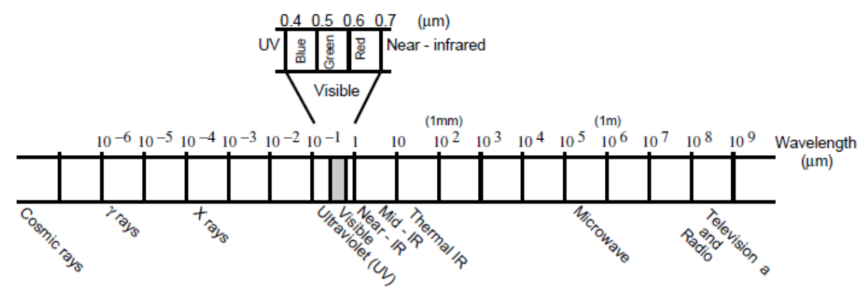
It's important to note that these categories are not rigid, and there can be some overlap between adjacent types of electromagnetic waves. Each type of wave interacts differently with matter and has unique properties that make it suitable for various applications in science, technology, medicine, and everyday life.

AN ELECTROMAGNETIC WAVE



Electromagnetic radiation consists of an electrical field(E) which varies in magnitude in a direction perpendicular to the direction in which the radiation is traveling, and a magnetic field (M) oriented at right angles to the electrical field. Both these fields travel at the speed of light (c).

THE ELECTROMAGNETIC SPECTRUM



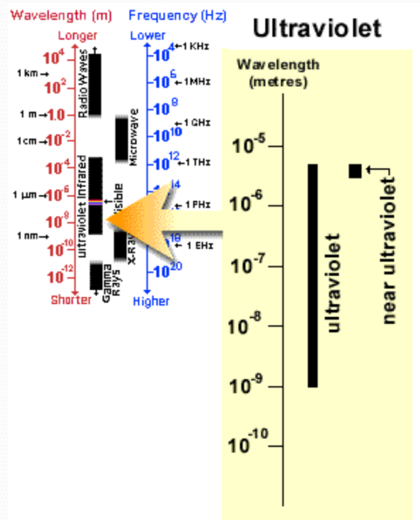
From Lillesand and Kiefer 1987

Ultraviolet Spectrum (UV)

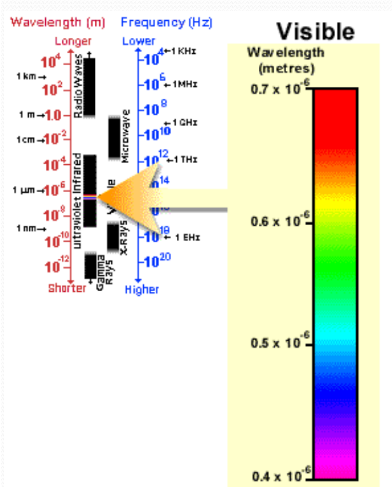
UV portion of the spectrum has the shortest wavelengths which are practical for remote sensing.

This radiation is just beyond the violet portion of the visible wavelengths, hence its name.

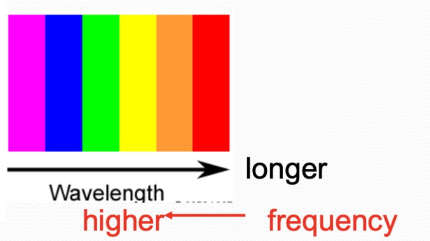
Some Earth surface materials, primarily rocks and minerals, fluoresce or emit visible light when illuminated by UV radiation.



Visible Spectrum



The light which our eyes - our "remote sensors" - can detect is part of the **visible spectrum**.



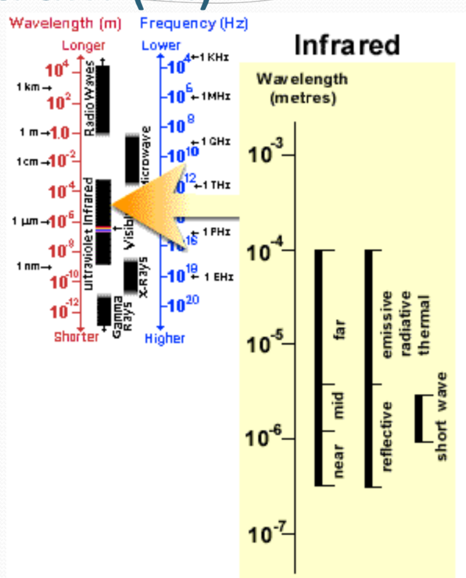
Visible Spectrum

- It is important to recognize how small the visible portion is relative to the rest of the spectrum. There is a lot of radiation around us which is "invisible" to our eyes, but can be detected by other remote sensing instruments and used to our advantage.
- The visible wavelengths cover a range from approximately 0.4 to 0.7 µm. The longest visible wavelength is red and the shortest is violet.
- This is the only portion of the spectrum we can associate with the concept of **colors**.

Infrared Spectrum (IR)

IR region covers the wavelength range from approximately 0.7 µm to 100 µm - more than 100 times as wide as the visible portion!

The IR can be divided into two categories based on their radiation properties - the **reflected IR**, and the emitted or **thermal IR**.

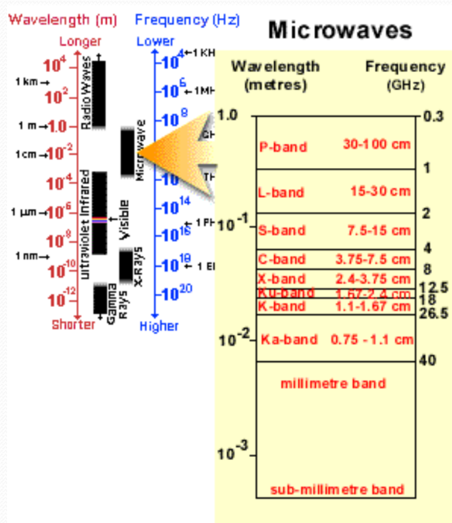


Microwave Spectrum

The portion of the spectrum of more recent interest to remote sensing is the **microwave region** from about 1 mm to 1 m.

This covers the longest wavelengths used for remote sensing.

The shorter wavelengths have properties similar to the thermal infrared region while the longer wavelengths approach the wavelengths used for radio broadcast.



- Infrared light 2 types →

1. reflected IR Region → very similar to visibile light
2. Thermal IR Region → Reflected as heat energy

Infrared Spectrum

- Radiation in the reflected IR region is used for remote sensing purposes in ways very similar to radiation in the visible portion.
- The reflected IR covers wavelengths from approximately ***0.7 µm to 3.0 µm***.
- The thermal IR region is quite different than the visible and reflected IR portions, as this energy is essentially the radiation that is emitted from the Earth's surface in the form of heat.
- The thermal IR covers wavelengths from approximately ***3.0 µm to 100 µm***.

Interaction with Atmosphere →

The electromagnetic spectrum interacts with Earth's atmosphere in various ways, leading to effects such as absorption, scattering, and transmission of different types of electromagnetic waves. These interactions play a crucial role in shaping our environment and influencing the behavior of electromagnetic radiation. Here's a brief overview of how different parts of the electromagnetic spectrum interact with the Earth's atmosphere:

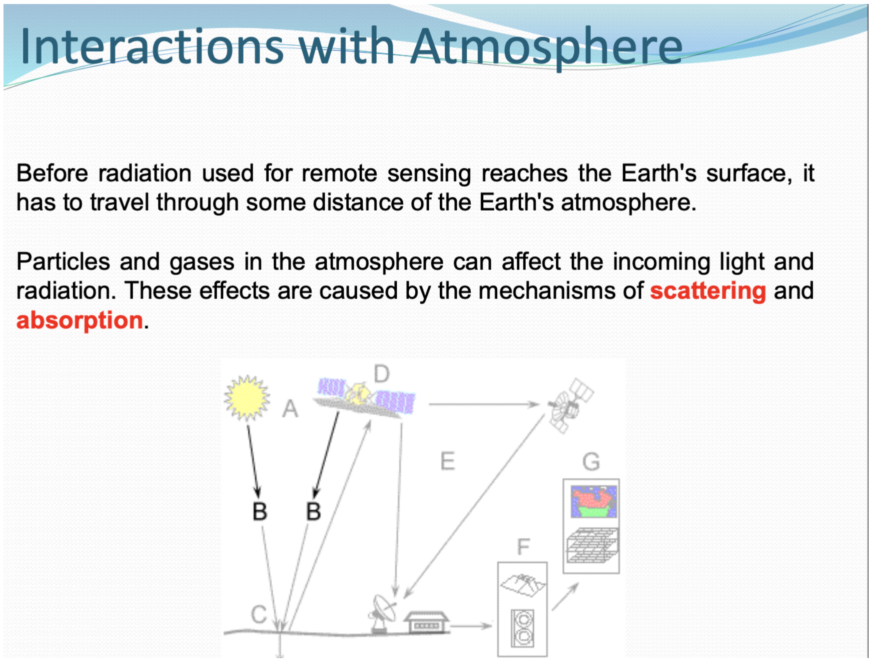
1. Radio Waves:
   - Interaction: Radio waves have relatively long wavelengths, which allow them to pass through the atmosphere with minimal absorption or scattering. They can travel long distances and are commonly used for communication and broadcasting.
2. Microwaves:
   - Interaction: Certain microwave frequencies are absorbed by water vapor and oxygen molecules in the atmosphere. This absorption can impact the quality of microwave communication and weather radar systems.
3. Infrared (IR) Radiation:
   - Interaction: Infrared radiation is partially absorbed by greenhouse gases, such as carbon dioxide and water vapor, in the atmosphere. This absorption leads to the warming of the lower atmosphere and the planet's surface, contributing to the greenhouse effect.
4. Visible Light:
   - Interaction: Visible light from the Sun easily penetrates the Earth's atmosphere and reaches the surface. Some of this light is scattered by particles and molecules in the atmosphere, giving rise to phenomena like Rayleigh scattering, which makes the sky appear blue.
5. Ultraviolet (UV) Radiation:
   - Interaction: The majority of UV-C radiation (shortest wavelengths) is absorbed by the ozone layer in the stratosphere, preventing it from reaching the surface. UV-A and UV-B radiation still reach the surface and can have biological effects, such as causing sunburn and skin damage.
6. X-rays and Gamma Rays:

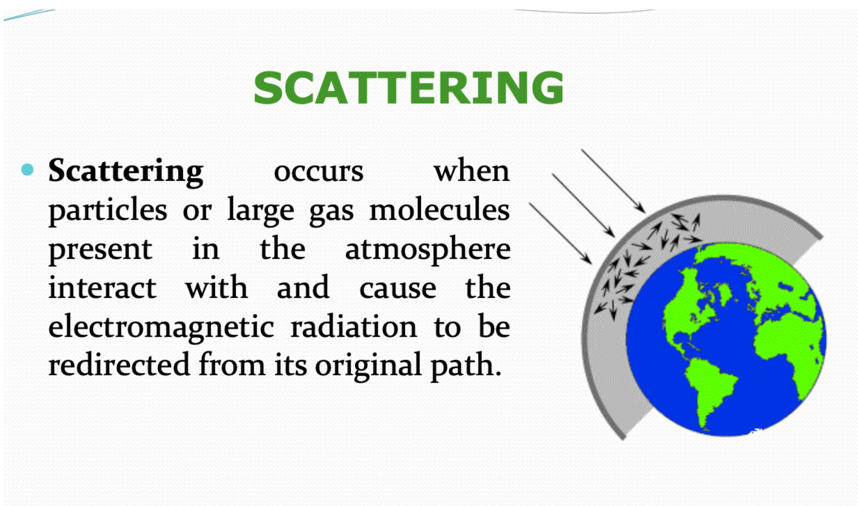
- Interaction: These high-energy waves are typically absorbed by the upper atmosphere, including the ionosphere. As a result, only a small fraction of X-rays and gamma rays from space actually reach the Earth's surface.

The interactions described above have important implications for a wide range of applications and phenomena:

- **Weather and Climate:** Absorption of certain electromagnetic wavelengths by water vapor and greenhouse gases plays a significant role in influencing weather patterns and climate change.
- **Communication:** The behavior of radio waves and microwaves in the atmosphere affects wireless communication, satellite communication, and radar systems.
- **Astronomy:** The absorption and scattering of electromagnetic radiation by the atmosphere limit the wavelengths that can be observed from the ground, leading to the development of space-based telescopes.
- **Medical Imaging and Radiation Therapy:** Understanding how X-rays and gamma rays interact with the atmosphere helps in designing medical imaging techniques and radiation treatments.

In summary, the Earth's atmosphere interacts with different parts of the electromagnetic spectrum in complex ways, shaping our environment, influencing technology, and providing insights into the workings of the universe.





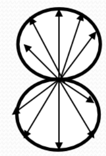
Scattering Types →

1. Rayleigh Scattering → small particles interact with wavelength of radiation (wavelengths scattered 1/**λ^4)**
2. MIE Scattering → particles with same size as wavelength interact with radiation (wavelengths scattered 1/**λ to 1/λ^2)**
3. NonSelective Scattering → large particles interact with wavelength of radiation (all wavelengths scattered)

RAYLEIGH SCATTERING

- **Rayleigh scattering** occurs particles are very small compared to the wavelength of the radiation

- Small specks of dust or nitrogen and oxygen molecules
- The fact that the sky appears "blue" during the day and red sunset is because of this phenomenon.

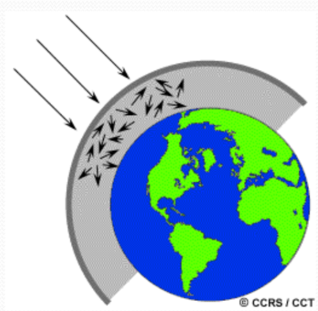


- Rayleigh **Scattering** $\propto$ **$1/\lambda^4$**

Rayleigh Scattering

Rayleigh scattering also called molecular scattering occurs when particles are ***very small compared to the wavelength*** of the radiation, e.g. small specks of dust or nitrogen and oxygen molecules.

Rayleigh scattering causes shorter wavelengths of energy to be scattered much more than longer wavelengths. This is the ***dominant scattering mechanism in the upper atmosphere***.

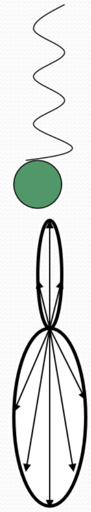


Raleigh scattering is **inversely proportional to the fourth power of the wavelength.**

Shorter wavelengths are scattered more Negligible at wavelengths beyond micro meter.
It leads to haze on images and photographs

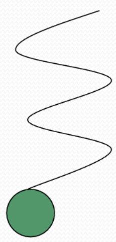
MIE SCATTERING

- **Mie scattering** occurs when the particles are just about the same size as the wavelength of the radiation. e.g., Dust, pollen, smoke and water vapour
- **Mie Scattering ∝ 1/ λ to 1/λ²**



NONSELECTIVE SCATTERING

- This occurs when the particles are much larger than the wavelength of the radiation. Water droplets and large dust particles can cause this type of scattering.
- Nonselective scattering gets its name from the fact that all wavelengths are scattered in all directions without following any law.



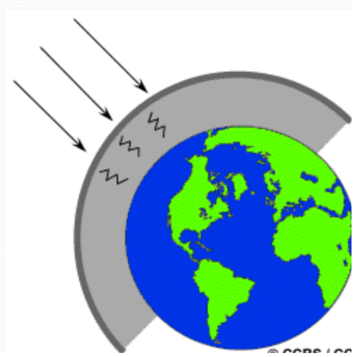
Types of Atmospheric Scatter in order of importance (Curran. 1988)

Type of Scatter of particles	Size of effective atmospheric particles	Type of effective atmospheric particles	Scatter of particles	Effect of scatter on visible and near visible wavelength
Rayleigh	Smaller than the wavelength of radiation.	Gas molecules	Molecule absorbs high energy radiation and re-emits. skylight scatter is inversely proportional to fourth power of wave length.	Affects short visible wave lengths,resulting in haze in photography, and blue skies.
Mie	Same size as the wavelength of radiation.	Spherical particles, fumes and dust	Physical scattering under overcast skies.	Affects all visible wave lengths
Non-selective	Larger than the wavelength of radiation.	Water droplets and dust.	Physical scattering by fog and clouds.	After all visible wave lengths equally, resulting white fog and clouds
Raman	Any	Any	Photon has elastic collision with molecule resulting in a loss or a gain in energy; this can decrease or increase wave length.	Variable

Interactions with Atmosphere - Absorption

Absorption is the other main mechanism at work when electromagnetic radiation interacts with the atmosphere.

In contrast to scattering, this phenomenon causes molecules in the atmosphere to absorb energy at various wavelengths.



Ozone, carbon dioxide, and water vapor are the three main atmospheric constituents which absorb radiation.

Absorbers of the Atmosphere

- **Ozone** serves to absorb the harmful (to most living things) ***ultraviolet*** radiation from the sun.
- **Carbon dioxide** tends to absorb radiation strongly in the ***far infrared*** portion of the spectrum - that area associated with thermal heating - which serves to trap this heat inside the atmosphere.
- **Water vapor** in the atmosphere absorbs much of the incoming ***longwave infrared and shortwave microwave radiation (between 22μm and 1m).***

Atmospheric Window

- One important practical consequence of the interaction of electromagnetic radiation with matter and of the detailed composition of our atmosphere is that ***only light in certain wavelength regions can penetrate the atmosphere well.***
- Those areas of the frequency spectrum which are not severely influenced by atmospheric absorption and thus, are useful to remote sensors, are called **atmospheric windows**.

Interaction with target →

RADIATION - TARGET INTERACTIONS

- Radiation that is not absorbed or scattered in the atmosphere can reach and interact with the Earth's surface

Three forms of interaction are

Absorption (A)

Transmission (T)

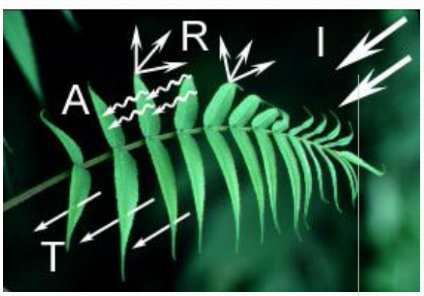
Reflection (R).

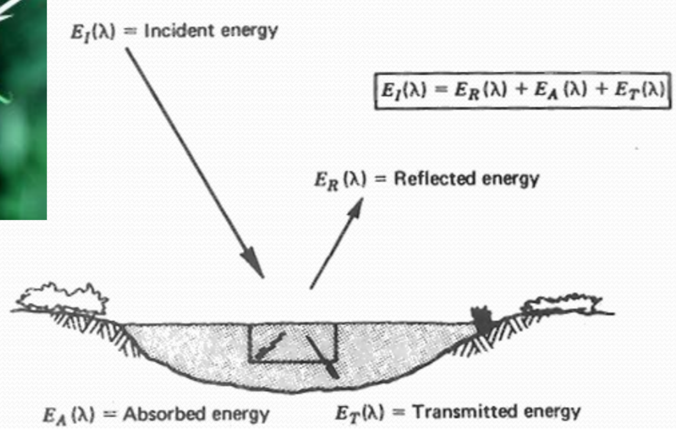
Incident energy (I) from the source

Absorption (A) occurs when radiation (energy) is absorbed into the target

Transmission (T) occurs when radiation passes through a target

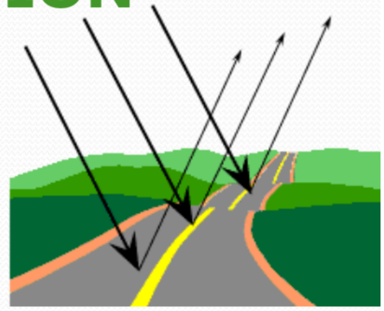
Reflection (R) occurs when radiation "bounces" off the target and is redirected.





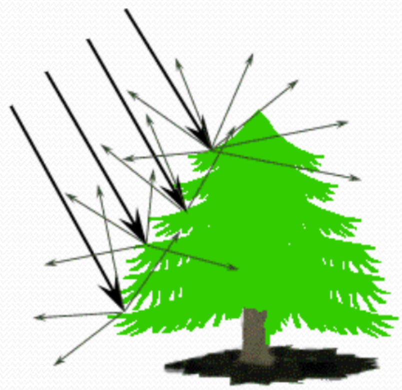
SPECULAR REFLECTION

When a surface is smooth we get **specular** or mirror-like reflection where all (or almost all) of the energy is directed away from the surface in a single direction.



DIFFUSE REFLECTION

When the surface is rough and the energy is reflected almost uniformly in all directions.

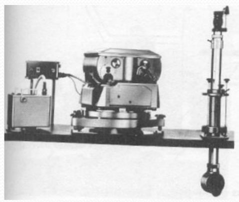


SPECTRAL REFLECTANCE OF VEGETATION,SOIL AND WATER

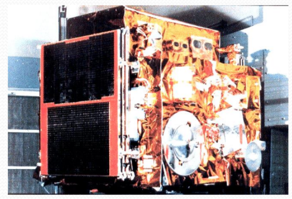
Key to feature identification from space imagery depends on the characteristic changes in the properties of the EM spectrum reflected/emitted from the target surface – **referred 'signature'**

Sensors →

SENSORS



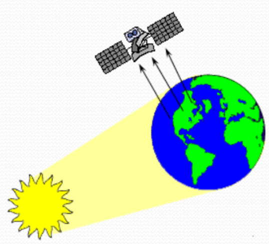
Camera



Scanner

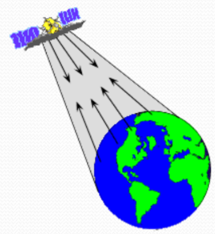
PASSIVE SENSORS

- Remote sensing systems which measure energy that is naturally available are called **passive sensors**.
- Passive sensors can only be used to detect energy when the naturally occurring energy is available.



ACTIVE SENSORS

- **Active sensors**, on the other hand, provide their own energy source for illumination.
- The sensor emits radiation which is directed toward the target to be investigated. Eg: RADAR



- **IMAGING SENSORS**
  - Sensors which provide output to create an image
  - Eg : LISS I,LISS II, LISS III etc.
- **NON IMAGING SENSORS**
  - Sensors which provide numerical output with respect to the quantum of radiation
  - Eg: Radiometer, Scatterometer etc.

- Imaging Sensor → Device that converts an optical image into an electronic signal

COMMON SENSORS USED IN REMOTE SENSING

- Cameras
- Scanners
- Radar

CHARACTERISTICS OF CAMERA

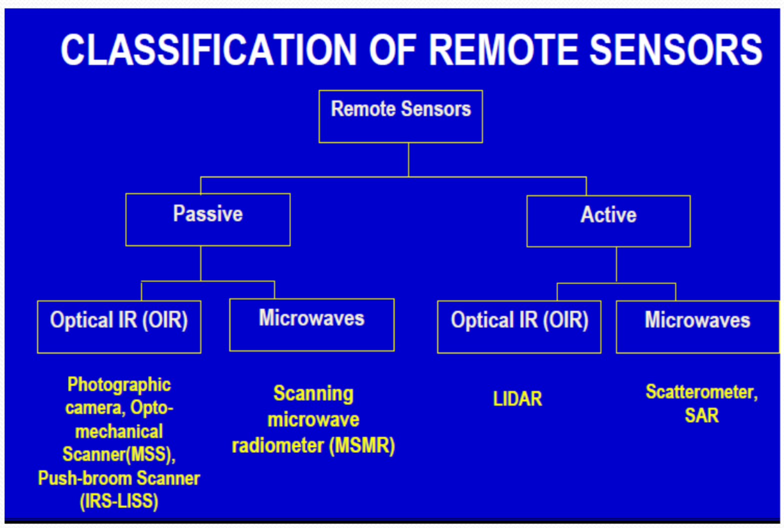
- Passive Remote Sensing
- Very high resolution imagery
- Stereo-capability
- Films - black & white, Colour, Colour Infrared
- Central perspective
- Well-defined geometry.

CHARACTERISTICS OF SCANNER

- Output in digital form
- Highly amenable for computer processing
- No consumables
- Flexible w.r.t. radiometric and spectral resolutions

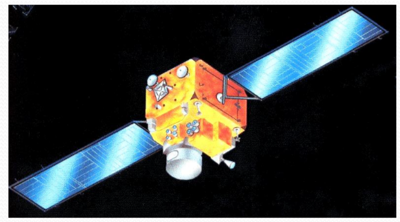
CHARACTERISTICS OF RADAR

- All weather capability, day and night observing capability
- Sensitive to moisture
- Soil depth penetration to certain extent



•**Photographic Cameras** – Conventional Camera System.
•**Return Beam Videocon** – Image formed over semi transparent film as charge or potential. Similar to Television Cameras.
•**Thermal System** – Measures the emitted radiation from an object.
•**Optical Mechanical Scanners** – Employs filters and Detector combinations.
•**RADAR and Microwave Sensors** (SLAR/SAR)

PLATFORM CHARACTERISTICS



USUAL PLATFORMS

- Aircraft
  - Helicopters
  - Microlites
  - Low altitude aircrafts
  - High altitude aircraft
- Satellites
  - Orbiting satellites
  - Geostationary satellites

CHARACTERISTICS OF PLATFORMS

AIRCRAFT /Airborne Platform

- Defence permission needed
- Imagery can be obtained at the time and place of our choice
- Expensive
- Usually used for cameras
- Narrow limited view
- Platform less stable
- Large scales
- Flexible repeat coverage
- High spatial resolution
- Less cost effective

Satellite/Spaceborne platform

- Global coverage
- No fuel needed(for 3 years operation)
- Defence permission not needed
- Wide, synoptic view
- Very stable platform
- Limited repeat coverage
- Highly cost effective

ORBIT

The path followed by a satellite

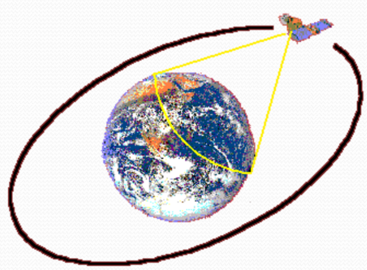
Two types of Orbits are

1) Geostationary Orbits

2) Near Polar Orbits

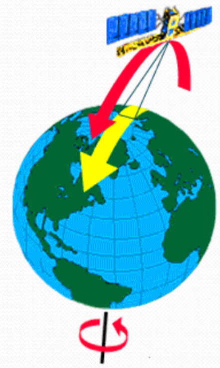
GEOSTATIONARY ORBITS

- At altitudes of approximately 36,000 kilometres
- Revolve at speeds which match the rotation of the Earth so that they seem stationary, relative to the Earth's surface
- This allows the satellites to observe and collect information continuously over specific areas

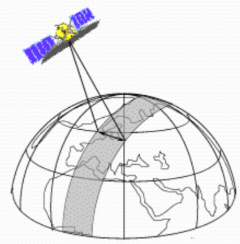


NEAR-POLAR ORBITS

- The inclination of the orbit relative to polar axis.
- Some of these satellites' orbits are also **sun-synchronous.** This means that they cover each area of the world at a constant local time of day called **local sun time**.

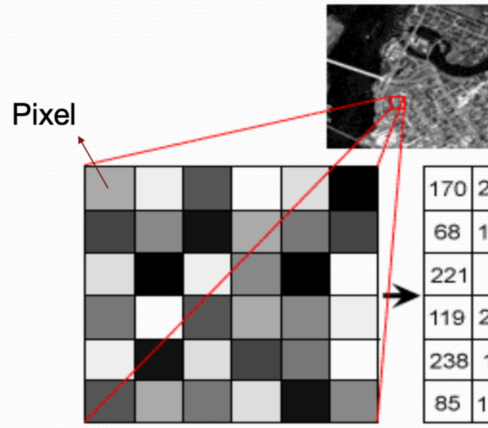


SWATH



- As the satellite revolves around the Earth, the sensor "sees" a certain portion of the Earth's surface.
- The width of the strip imaged is referred to as the **swath width.**

PIXELS (Picture + elements)

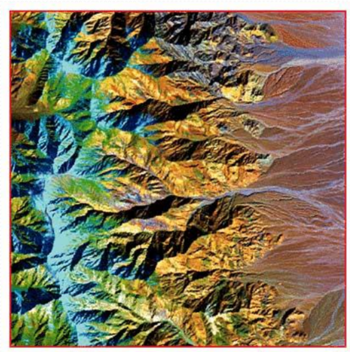


Black - 0
White - 255
Grey values

170	238	85	255	221	0
68	136	17	170	119	68
221	0	238	136	0	255
119	255	85	170	136	238
238	17	221	68	119	255
85	170	119	221	17	136

FOUR TYPES OF RESOLUTION

- Spatial Resolution
- Spectral Resolution
- **Radiometric Resolution**
- Temporal Resolution



Spatial Resolution

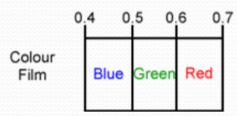
- Refers to the size of the smallest possible feature that can be sensed

IRS 1C/D – 5.8m (PAN)

IKONOS – 1m (PAN)

RESOURCESAT – 5.8m MULTISPECTRAL

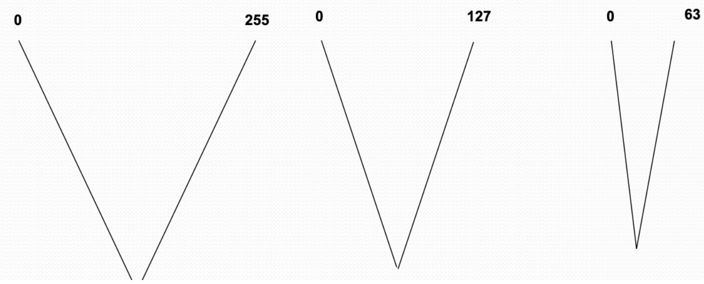
Spectral Resolution



- Ability of a sensor to define fine wavelength intervals.
- The finer the spectral resolution, the narrower is the wavelength range for a particular channel or band.

Radiometric Resolution

- Ability of the sensor to discriminate very slight differences in energy.
- The finer the radiometric resolution of a sensor, the more sensitive it is to detecting small differences in reflected or emitted energy.



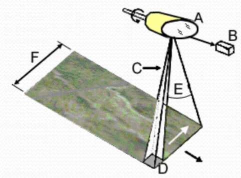
Temporal Resolution

- Time interval between two successive visits of the satellite for the same place.
- Spectral characteristics of features may change over time and these changes can be detected by collecting and comparing **multi-temporal** imagery.

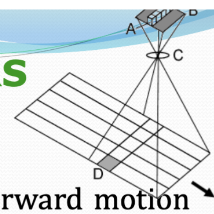
SCANNERS

ACROSS-TRACK SCANNERS

- Scan the Earth in a series of lines.
- The lines are oriented perpendicular to the direction of motion of the sensor platform (i.e. across the swath).
- Each line is scanned from one side of the sensor to the other, using a **rotating mirror (A), also called whiskbroom**.



ALONG-TRACK SCANNERS



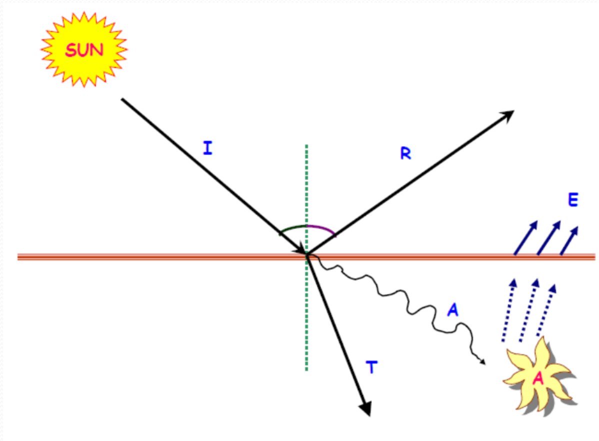
Along-track scanners also use the forward motion of the platform to record successive scan lines and build up a two-dimensional image, perpendicular to the flight direction.

Instead of a scanning mirror, they use a linear array of detectors (A) located at the focal plane of the image (B) formed by lens systems (C), which are "pushed" along in the flight track direction (i.e. along track).

Also referred to as **pushbroom scanners**

Thermal remote sensing →

Thermal remote sensing



- Sensors that measure emitted radiation in the thermal region (infrared region) of the spectrum can produce very informative data about earth features.
- *Thermal Remote Sensing* can be defined as 'detection of remote objects by recording amount of thermal radiation emitted from various surfaces'.
- All materials having a temperature above absolute zero (0 K or –273°C) emit thermal energy both day and night.

BAND BAND

- Thermal IR radiation is absorbed by glass lenses of conventional cameras and can't be detected by photographic films.
- Special optical-mechanical or electronic scanners are used to detect and record images in thermal IR region.

THERMAL PROPERTIES OF MATERIALS

The primary objective of temperature measurements and related thermal response is to infer something about the nature, composition and other physical attributes of materials at the earth's surface and in its atmosphere.

Emissivity (ε)

Thermal Inertia (P)

Heat capacity (C)

Thermal Conductivity (K)

Thermal Diffusivity (Γ)

Microwave remote sensing

Introduction

Analyzing the information collected by the sensors that operate in the *microwave portion* of the electromagnetic spectrum is called as Microwave Remote Sensing.

1mm to 1m

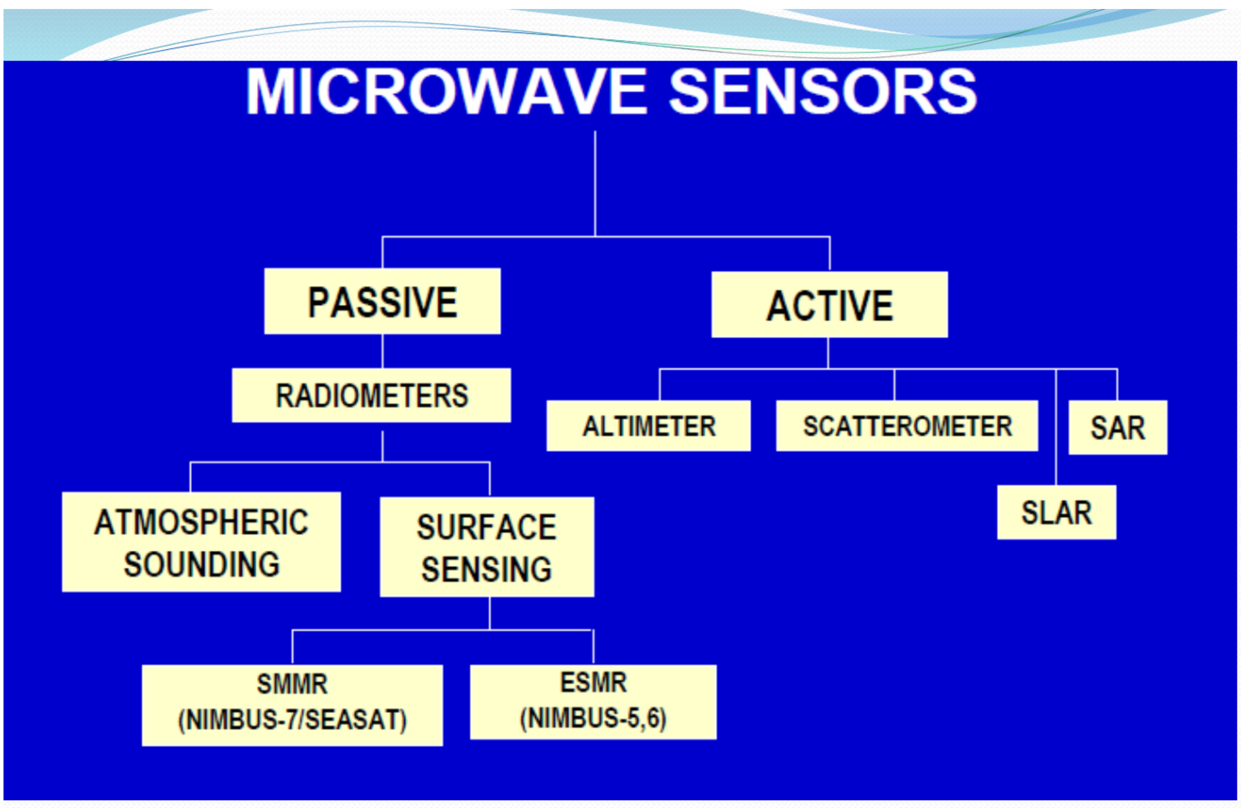
These longer waves have capability of penetrating through the clouds thus overcoming the atmospheric effects

Microwave reflection (backscattering) - in active mode
emission - in passive mode,

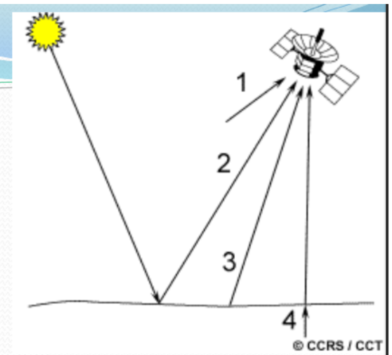
The amount and nature of backscattered electromagnetic radiation can provide information about the size, shape, configuration and electrical properties, etc of the surfaces and objects irradiated.

Advantages over remote sensing in the other regions of EMR.

1. Time independent.
2. Weather independent.
3. Sensitive to moisture in soil, vegetation and snow.
4. Enhancement of surface roughness / relief.
5. Penetration of soil and vegetation cover.
6. Ability to collect data which are far away from flight path.

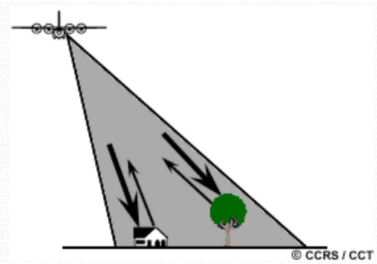


Passive microwave sensor detects the naturally emitted microwave energy within its field of view. This emitted energy is related to the temperature and moisture properties of the emitting object or surface. Passive microwave sensors are typically radiometers or scanners and operate in much the same manner as systems discussed previously except that an antenna is used to detect and record the microwave energy .



Active microwave sensors provide their own source of microwave radiation to illuminate the target. Active microwave sensors are generally divided into two distinct categories: **imaging and non-imaging**.

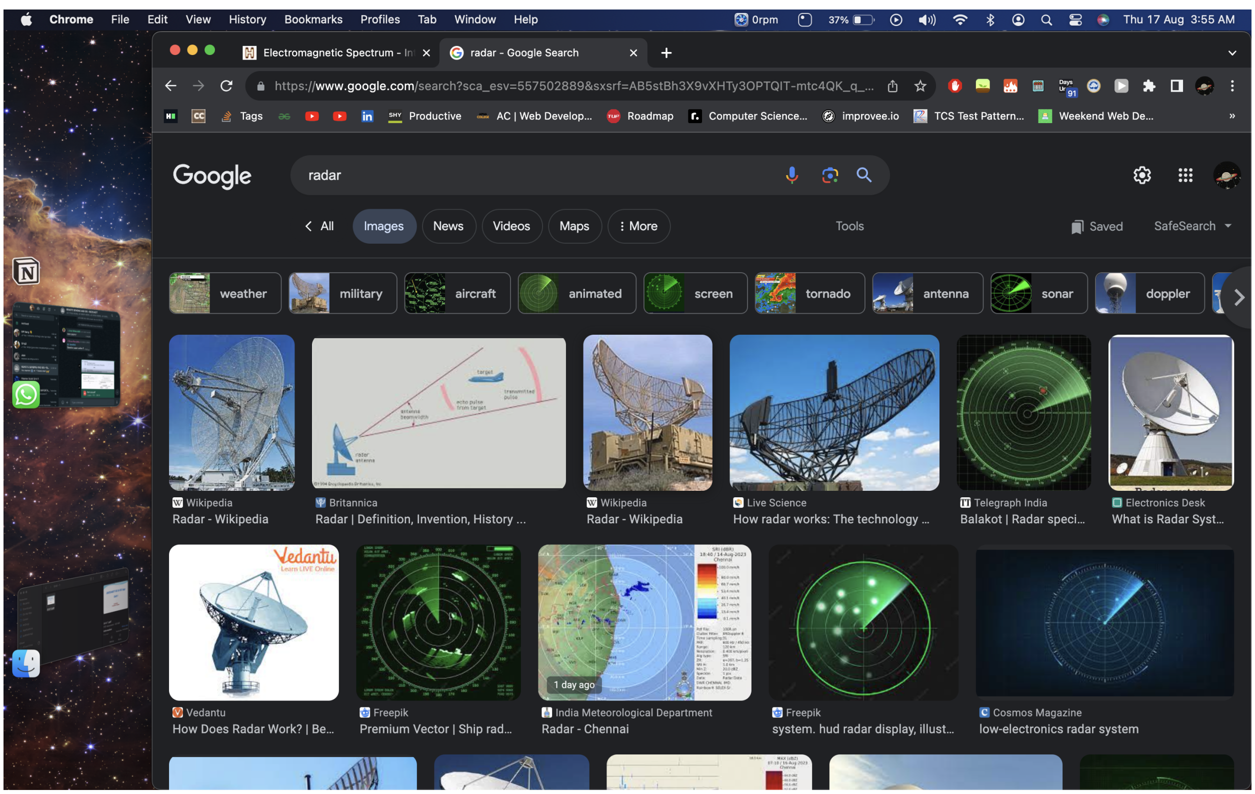
The most common form of imaging active microwave sensors is RADAR.
RADAR is an acronym for **RA**dio **D**etection **A**nd **R**anging, which essentially characterizes the function and operation of a radar sensor.



Non-imaging microwave sensors include **altimeters** and **scatterometers**.

RADAR acronym **Radar Detection and Ranging Active** is an active microwave remote sensing system.

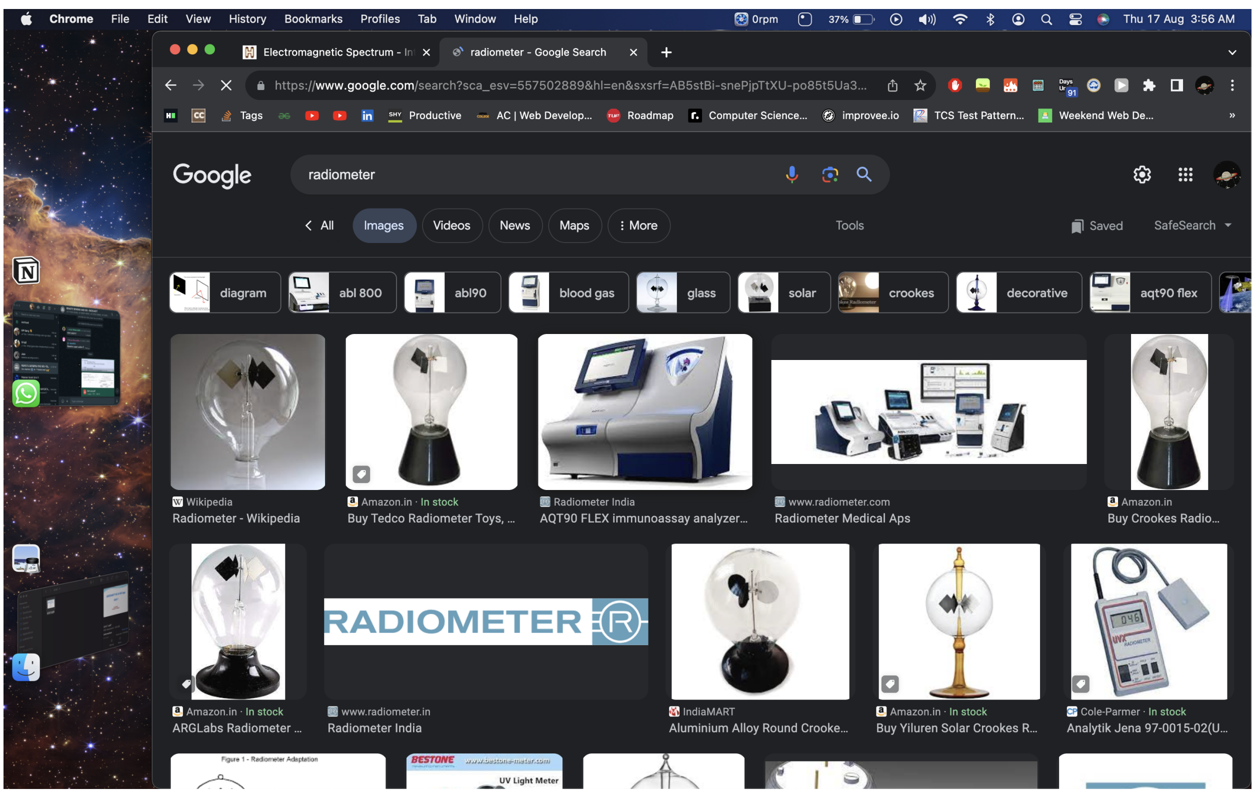
Various systems used to describe imaging radar are Side Looking Radar (SLAR) or Real Aperture Radar (RAR), Synthetic Aperture Radar (SAR), Active Microwave Imager (AMI). Scatterometer, Altimeter and Rain Mapping Radar etc. also fall under active microwave sensors



Radiometer is a device used **to measure the intensity of radiant energy**.

Radiometers

Radiometers are basically high sensitive receivers operating in different frequencies depending on the application. Radiometers receive the natural electromagnetic radiation emitted by the target in the desired frequency and process it to provide the geophysical information. The data is used for studying the soil moisture and snow cover on land, salinity and surface wind speeds in oceans and water vapour and liquid water content in atmosphere. Radiometers also can be used for generating imageries of the target/terrain of interest.



Scatterometers are **active remote sensing instruments for deriving wind direction and speed from the roughness of the sea**.

An altimeter is **a device that measures altitude, the distance of a point above sea level**.

Scatterometer is also a Side Looking Radar, but configured to measure the Radar cross section/scattering co-efficient of the target accurately rather than mapping it. Ground based scatterometers are used to collect the Radar cross section of various targets of interest as a function of the sensor and target parameters. From spaceborne platforms, the scatterometer is mainly used to measure the ocean surface wind speed and direction. This can generate this wind data over a wide area (500 - 800 Km.) with good accuracy.

Altimeter

It measures the ocean surface topography, significant wave height and surface wind speed. It can also be configured to measure the terrain evaluation on land. It operates in nadir looking mode.

Rain mapping Radar

It is meant for measuring the rainfall in the tropical region. The Radar transmits coherent high energy pulses at microwave frequencies and receives the back-scattered power from rain drop and processes to provide information on the rain rate, vertical distribution etc. It can measure rainfall rate upto 0.5 mm/hr.

Side Looking Radar

Real Aperture Radars are less complex. But the resolution is directly linked to the physical length of the antenna and distance to the target. This is overcome by the Synthetic Aperture Radar, though a complex system, using signal processing techniques.

Radar Return Strength →

RADAR Return and Image Signatures

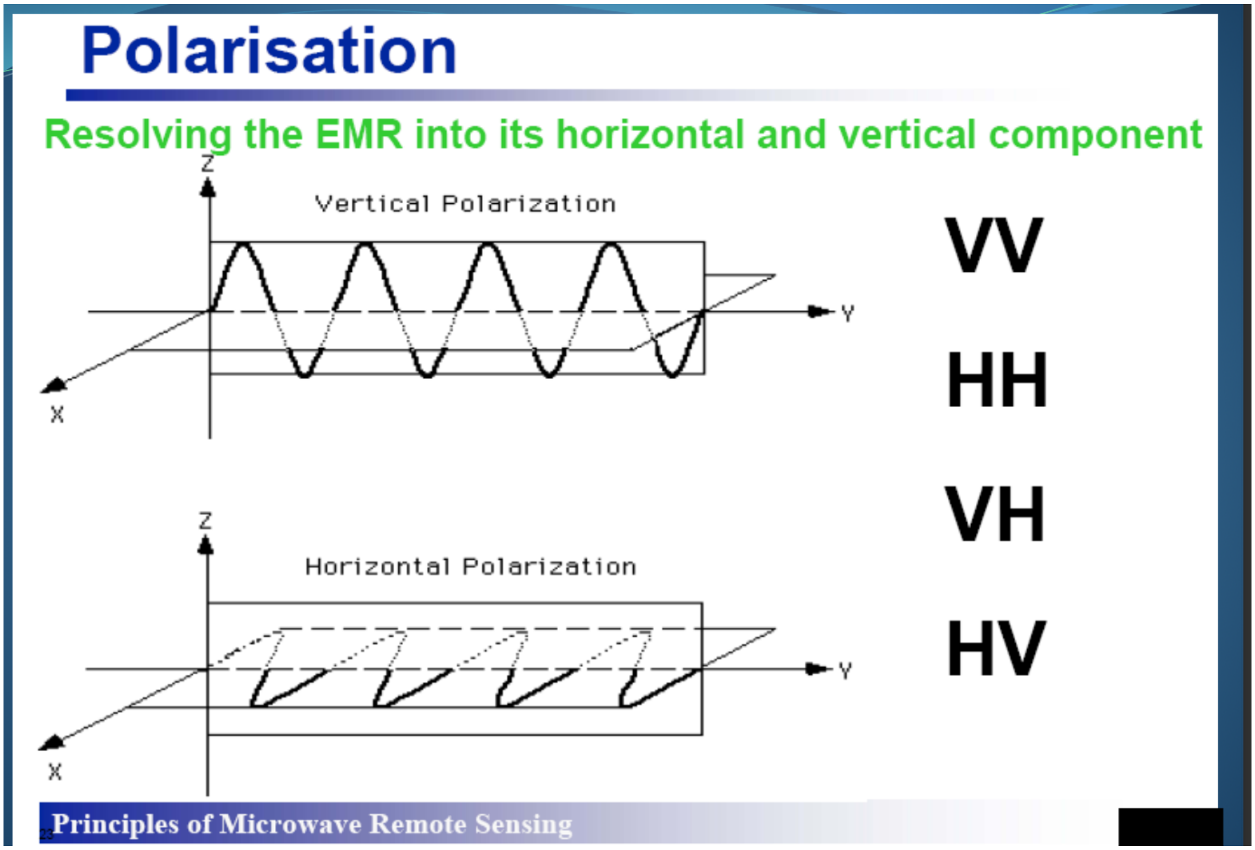
Energy reflected from the terrain to the radar antenna is called radar return. The following parameters strongly affect the radar return.

a) System properties

- i) Wavelength / frequency
- ii) Polarization
- iii) Incidence angle

b) Terrain properties

- i) Dielectric constant
- ii) Surface roughness
- ii) Feature orientation


Polarisation
Resolving the EMR into its horizontal and vertical component
Vertical Polarization
Z
Y
X
Horizontal Polarization
Z
Y
X
VV
HH
VH
HV
Principles of Microwave Remote Sensing

Polarization

HH image and VV image - like polarized images

VH image and HV image - cross-polarized images

Radar system containing single antenna can receive only one image type i.e. either of the *like polarized* or either of the *cross polarized*. If Radar system contains two antenna it can receive two image types simultaneously i.e. either both *like polarized* or both *cross polarized* or one *like polarized* and one *cross polarized*.

A comparison of like and cross-polarized returns might reveal differences leading to terrain identification.

Water and trees appear same in like and cross-polarized images while swamps appear brighter in like polarized and darker in cross-polarized imagery. Grasslands appear darker in like polarized image and brighter in cross-polarized image.

Principles of Microwave Remote Sensing

Surface Roughness

Surfaces can be either smooth or rough or intermediate.

Smooth surfaces reflect all the energy away from the antenna and will be resulted in dark tone.

Rough surfaces diffusely scatter the energy equally in all directions irrespective of the angle of incidence.

Intermediate surfaces scatter the energy diffusely but not equally since a portion of energy is specularly reflected and the rest diffusely scattered.

Multispectral vs Hyperspectral →

Multispectral and hyperspectral are two terms used in remote sensing and imaging to describe different types of data acquisition and analysis techniques. They both involve the capture of information from multiple wavelengths of light, but they differ in the number and narrowness of the spectral bands used.

1. **Multispectral Imaging:**
   Multispectral imaging involves capturing data from a few distinct, broad wavelength bands. Typically, multispectral sensors capture data in a limited number of specific bands, often ranging from 3 to 10 bands. These bands are usually chosen to target specific features or characteristics of the objects being observed. Common applications of multispectral imaging include vegetation analysis, land cover classification, and mineral exploration.

2. **Hyperspectral Imaging:**
   Hyperspectral imaging, on the other hand, captures data from a large number of very narrow and closely spaced wavelength bands across the electromagnetic spectrum. This results in a much finer level of spectral detail compared to multispectral imaging. Hyperspectral sensors can capture tens to hundreds of contiguous spectral bands, allowing for more precise identification and analysis of materials and objects. Hyperspectral imaging is used in a variety of applications, including environmental monitoring, agriculture, mineralogy, forestry, and military surveillance.

In summary, the main differences between multispectral and hyperspectral imaging are the number of spectral bands and their width:

- Multispectral imaging uses a small number of broader wavelength bands.
- Hyperspectral imaging uses a large number of very narrow and closely spaced wavelength bands.

Both techniques have their own advantages and applications, and the choice between them depends on the specific requirements of a given task or study. Hyperspectral imaging offers greater spectral detail and discrimination, making it suitable for tasks that require precise material identification, while multispectral imaging is often used for more general analysis and classification purposes.

Multispectral	Hyperspectral
Multispectral instruments can *discriminate* materials.	Hyperspectral imaging is required to actually *identify* materials
Multispectral data are used to detect the existence of various materials	Hyperspectral data allows the identification of many materials even in mixed materials
Greater accessibility due to the larger number of space-based mulltispectral sensors	Most current hyperspectral sensors are airborne, hence inaccessible (in the Indian context).

Merits of remote sensing →

Merits of remote sensing

- Remote sensing has many advantages over ground-based survey in that ***large tracts of land can be surveyed at any one time***, and ***areas of land (or sea) that are otherwise inaccessible can be monitored.***
- The advent of satellite technology and multispectral sensors has further enhanced this capability, with the ability to ***capture images of very large areas of land in one pass***, and by collecting data about an environment that would normally not be visible to the human eye.

THANK YOU