Remote Sensing and DIP
(Module-1)

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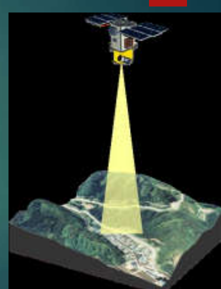
Introduction

What is Remote Sensing?

- Remote sensing is the science and art of obtaining information about an object, area, or phenomenon through the analysis of data acquired by a device that is not in contact with the object, area, or phenomenon under investigation.



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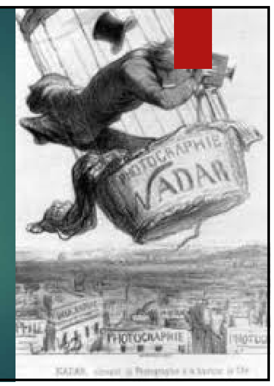
History of Remote Sensing

- Remote sensing starts with the invention of camera more than 150 years ago.
- The idea and practice looking down the Earth surface emerged in 1840s cameras secured to tethered ballon.



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The Bavarian Pigeon Corps:1903

- Attach a very light camera to a carrier pigeon.
- Cameras took a picture every thirty seconds as the pigeon winged its way.

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Photos from an Aeroplane: 1909

- Wilbur Wright was the pilot for two notable events in remote sensing history.
- The first photographs from an aircraft were taken by Wilbur's passenger, L. P. Bonvillain, on a demonstration flight in France in 1908.
- The first aerial motion pictures were taken in Italy when another photographer accompanied Wright.

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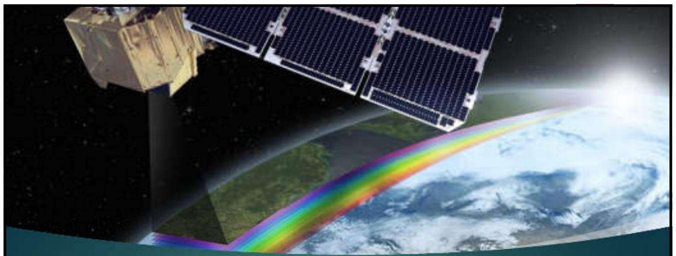

Remote Sensing from Satellite

In 1960s and 1970s Primary Platform Changed to Satellites.

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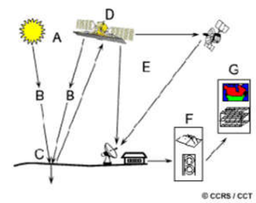
Elements of Remote Sensing

- (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



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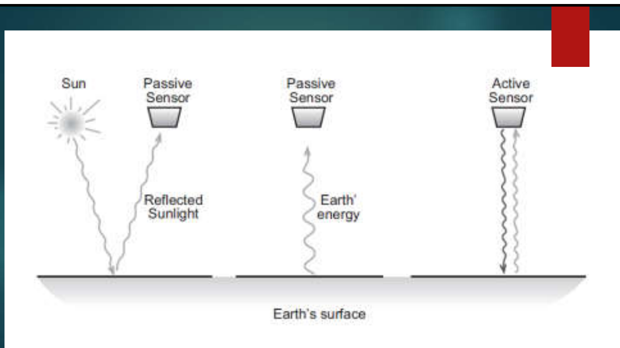

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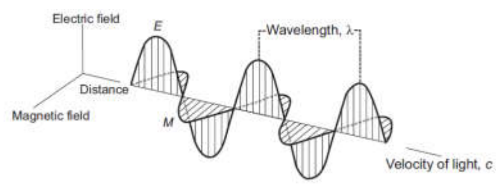

Electromagnetic (EM) Energy

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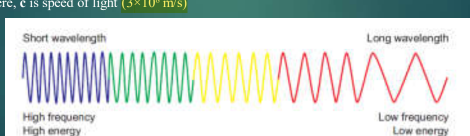
Wave Model

- **Frequency**, υ, is the number of cycles of a wave passing a fixed point over a specific period of time. Units: Hertz (Hz).
- **Wavelength**, λ, is the distance from one crest to another, or from one trough to another, of a wave. Units: meters (m)

$$c = \lambda \times \upsilon$$

Where, **c** is speed of light (3×10^8 m/s)



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Photon Model

- For some purposes, EM energy is more conveniently modelled by the particle theory, in which EM energy is composed of discrete units called 'photons'.
- The amount of energy held by a photon of a specific wavelength is given by:

$$Q = h \times \upsilon = h \times \frac{c}{\lambda}$$

Where, Q is the energy of a photon (J), h is Plank's constant (6.6262×10-34 J s), and υ the frequency (Hz).

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Sources of EM Energy

- All matter with a temperature above absolute zero (0K, where n°C = n + 273 K) radiates EM energy due to molecular agitation.
- This means that the Sun, and also the Earth, radiate energy in the form of waves.
- Blackbody is capable of absorbing and re-emitting all EM energy.
- For blackbodies both the emissivity, ϵ, and the absorptance, α, are equal to (the maximum value of) 1.

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Stefan-Boltzmann's Law

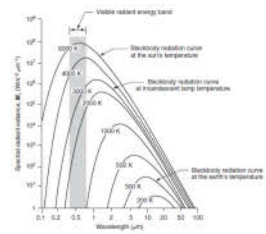
- All matter with a temperature above absolute zero (0K, where n °C = n + 273 K) radiates EM energy due to molecular agitation.

$$M = \sigma T^4$$

Where, M = total radiant existence from the surface of a material, watts (W) m-2

σ = Stefan-Boltzman constant, 5.6697 × 10^{-8} W m^{-2} K^{-4}

T = absolute temperature (K) of the emitting material



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Wien's displacement Law

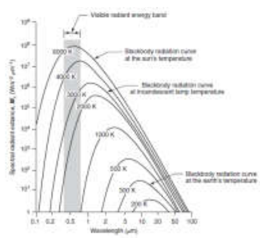
- The *dominant wavelength*, or wavelength at which a blackbody radiation curve reaches a maximum, is related to its temperature by *Wien's displacement law*,

$$\lambda_m = \frac{A}{T}$$

Where, λ_m = wavelength of maximum spectral radiant exitance, µm

A = 2898 µm K

T = temperature, K



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Summary of Radiometric Terms

- **Radiant flux (W):** the amount of radiant energy emitted, transmitted, or received per unit time.
- **Radiant flux density (W/m²):** radiant flux per unit area.
- **Irradiance (W/m²):** radiant flux density incident on a surface.
- **Radiant spectral flux density (W $m^{-2}mm^{-1}$):** radiant flux density per unit of wavelength interval.
- **Radiant intensity (W/sr):** flux emanating from a surface per unit solid angle.
- **Radiance (W $m^{-2}sr^{-1}$):** radiant flux density emanating from a surface per unit solid angle.
- **Spectral radiance (W $m^{-2}sr^{-1}mm^{-1}$):** radiance per unit wavelength interval.
- **Radiant emittance (W/m²):** radiant flux density emitted by a surface.

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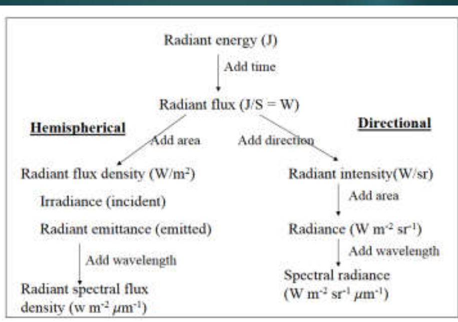

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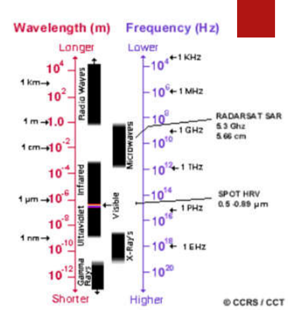
Electromagnetic Spectrum

- The electromagnetic spectrum ranges from the shorter wavelengths (including gamma and x-rays) to the longer wavelengths (including microwaves and broadcast radio waves).



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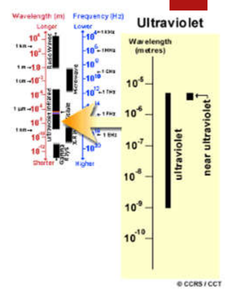
Ultraviolet or UV

- Wavelength Range: 0.03 – 0.4 µm
- Wavelength less than 0.3 µm are absorbed by the ozone layer in the upper atmosphere.
- Wavelengths between 0.3 – 0.4 µm are transmitted and termed as “Photographic UV band”.



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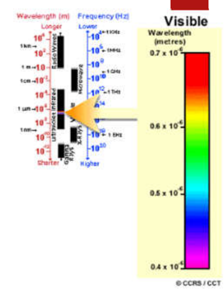
Visible Spectrum

- Wavelength Range: 0.4 – 0.7 µm
- Detectable with film and photodetectors.



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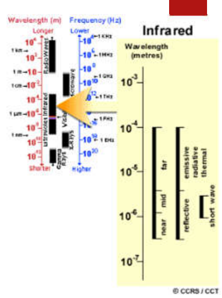
Infrared Region

- Wavelength Range: 0.7 – 100 µm
- Atmospheric windows exist which allows maximum transmission.
- Portion between 0.7 and 0.9 µm is called photographic IR band, since it is detectable with film.
- Two principal atmospheric windows exist in the thermal IR region (3 – 5 µm and 8 – 14 µm)



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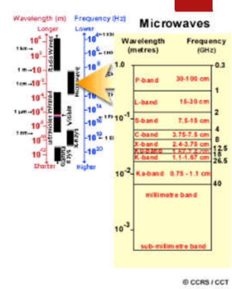
Microwave Region

- Wavelength range: 1 mm to 1 m
- Almost all-weather capability.
- Both active and passive remote sensing is possible.
- Radar uses wavelength in this range.
- Sensitive towards structural, geometrical and dielectric properties of target.



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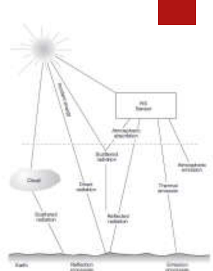
Energy Interaction in the Atmosphere

- Before the Sun’s energy reaches the Earth’s surface, three fundamental interactions in the atmosphere are possible:
  - Absorption
  - Transmission
  - Scattering



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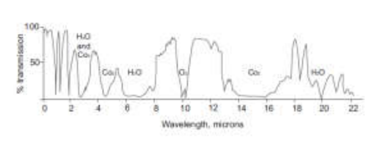
Absorption and Transmission

- The most efficient absorbers of solar radiation in the atmosphere are ozone (O_3), water vapour (H_2O) and carbon dioxide (CO_2)



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- An **atmospheric window** is the portion of the electromagnetic spectrum that can be transmitted through the atmosphere.
- A window in the visible and reflected infrared region, between 0.4-2 µm. This is the window where the (optical) remote sensing operate.
- Three windows in the thermal infrared region, namely two narrow windows around 3 and 5 µm, and a third, relatively broad, window extending from approximately 8 to 14 µm.

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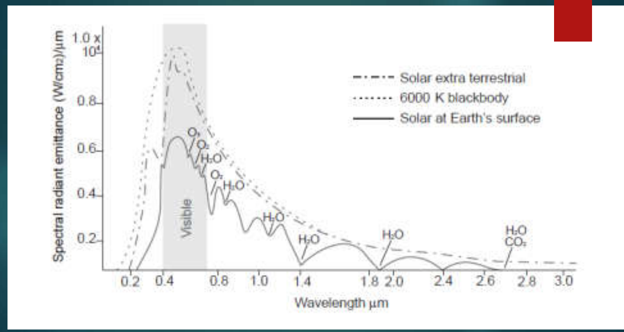

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Atmospheric Scattering

- Atmospheric scattering occurs when the particles or gaseous molecules present in the atmosphere cause the EM waves to be redirected from their original path.
- The amount of scattering depends on several factors including the wavelength of the radiation, the amount of particles and gases, and the distance the radiation through the atmosphere.
- Types of Scattering:
  - Rayleigh scattering
  - Mie scattering
  - Non-selective scattering

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Rayleigh scattering

- Rayleigh scattering predominates where EM radiation interacts with particles that are smaller than the wavelength of the incoming light.
- Examples of these particles are tiny specks of dust and nitrogen (NO_2) and oxygen (O_2) molecules.

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Mie scattering

- Mie scattering occurs when the wavelength of the incoming radiation is similar in size to the atmospheric particles.
- The most important cause of Mie scattering are the aerosols: a mixture of gases, water vapour and dust.
- Mie scattering is generally restricted to the lower atmosphere where larger particles are more abundant, and dominates under overcast cloud conditions.

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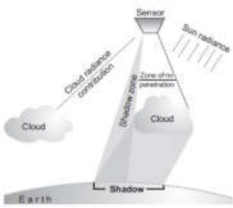
Non-selective scattering

- This occurs when the particle size is much larger than the radiation wavelength.
- Typical particles responsible for this effect are water droplets and larger dust particles.



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Energy interactions with the Earth's surface

- Types of interaction
  - Absorption
  - Transmission
  - Reflection
    - Specular reflection
    - Diffuse reflection
- The total incident energy will interact with the surface in one or more of these three ways.
- The proportions of each will depend on the wavelength of the energy and the material and condition of the feature.

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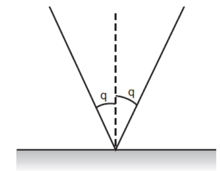
Specular reflection

- Typically occurs when a surface is smooth and all (or most all) of the energy is directed away from the surface in a single direction.
- It can be caused, for example, by a water surface or a glasshouse roof.



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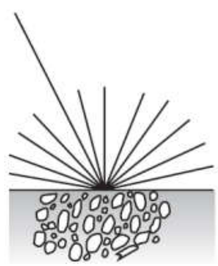
Diffuse reflection

- This occurs in situations where the surface is rough and the energy is reflected almost uniformly in all directions.
- Whether a particular target reflects specularly or diffusely, or somewhere in between, depends on the surface roughness of the feature in comparison to the wavelength of the incoming radiation.



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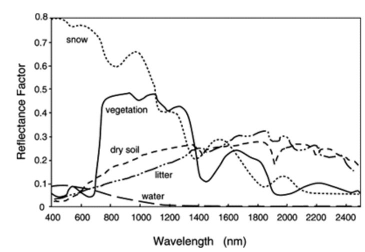

Spectral Reflectance Curve

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Any Questions?

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