UNIT II

EMR INTERACTION WITH ATMOSPHERE AND EARTH MATERIALS

1. ENERGY INTERACTIONS WITH THE ATMOSPHERE

- Before radiation used for remote sensing reaches the Earth's surface it has to travel through some distance of the Earth's atmosphere.
- Particles and gases in the atmosphere can affect the incoming light and radiation. These effects are caused by the mechanisms of scattering and absorption.

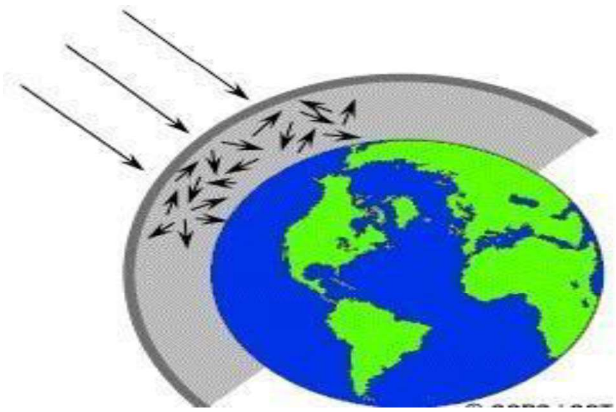


Fig 2.1 Energy Interaction with Atmosphere

1.1 SCATTERING

- Scattering occurs when particles or large gas molecules present in the atmosphere interact with and cause the electromagnetic radiation to be redirected from its original path.
- The amount of scattering that takes place depends on several factors including the wavelength of the radiation, the abundance of particles or gases, and the distance of the radiation travels through the atmosphere.
- There are three (3) types ofscattering which take place.

1.1.1 RAYLEIGH SCATTERING

- Rayleigh scattering occurs when particles are very small compared to the wavelength of the radiation.
- These could be particles such as small specks of dust or nitrogen and oxygen molecules.
- Rayleigh scattering causes shorter wavelengths of energy to be scattered much more than longer wavelengths.
- Rayleigh scattering is the dominant scattering mechanism in the upper atmosphere.

- The fact that the sky appears "blue" during the day is because of this phenomenon.
- As sunlight passes through the atmosphere, the shorter wavelengths (i.e. blue) of the visible spectrum are scattered more than the other (longer) visible wavelengths.
- At **sunrise and sunset** light has to travel farther through the atmosphere than at midday and the scattering of the shorter wavelengths is more complete; this leaves a greater proportion of the longer wavelengths to penetrate the atmosphere.

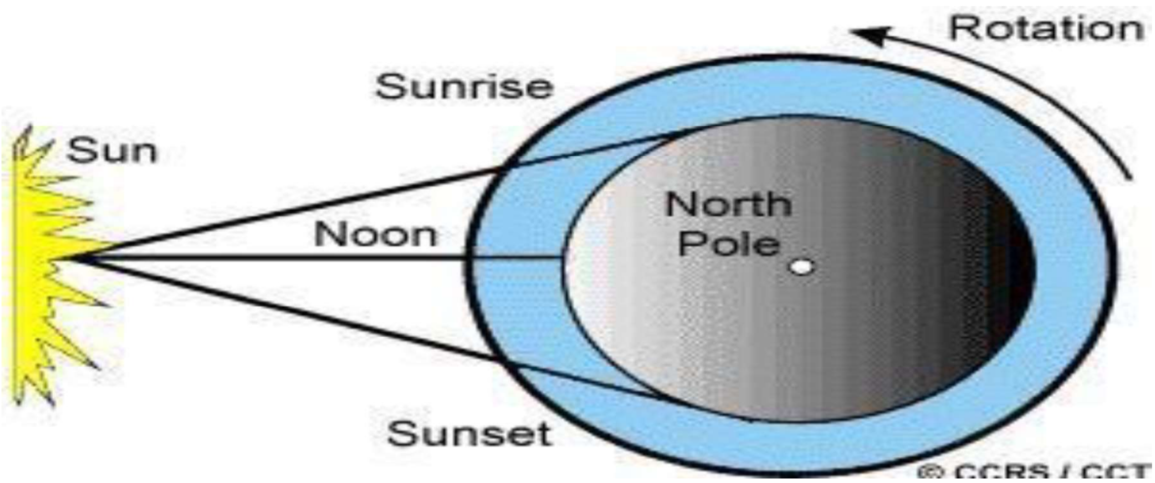


Fig 2.2 Raleigh Scattering

1.1.2 MIE SCATTERING

- Mie scattering occurs when the particles are just about the same size as the wavelength of the radiation.
- Dust, pollen, smoke and water vapour are common causes of Mie scattering which tends to affect longer wavelengths than those affected by Rayleigh scattering.
- Mie scattering occurs mostly in the lower portions of the atmosphere where larger particles are more abundant and dominates when cloud conditions are overcast.

1.1.3 NON-SELECTIVE SCATTERING

- The final scattering mechanism of importance is called **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 about equally.
- This type of scattering causes fog and clouds to appear white to our eyes because blue, green, and red lightare all scattered in approximately equal quantities (blue+green+red light = white light).

1.2 ABSORPTION

- Absorption is the other main mechanism at work when electromagnetic radiation interacts withthe atmosphere.
- In contrast to scattering, this phenomenon causes molecules in the atmospherето absorb energy at various wavelengths.
- Ozone, carbon dioxide, and water vapor are the threemain atmospheric constituents which absorb radiation.
  - ✓ **Ozone** serves to absorb the harmful (to most living things) ultraviolet radiation for the sun. Without this protective layer in the atmosphere our skin would burn when exposed to sunlight.
  - ✓ **Carbon dioxide** is referred to as a greenhouse gas. This is because it tends to absorb radiation strongly in the far infrared portionof the spectrum - that area associated with thermal heating - which serves to trap this heat insidethe atmosphere.
  - ✓ **Water vapour** in the atmosphere absorbs much of the incoming longwave infrared and shortwave microwave radiation (between 22μm and 1m). The presence of water vapour in the lower atmosphere varies greatly from location to location and at different times of the year.

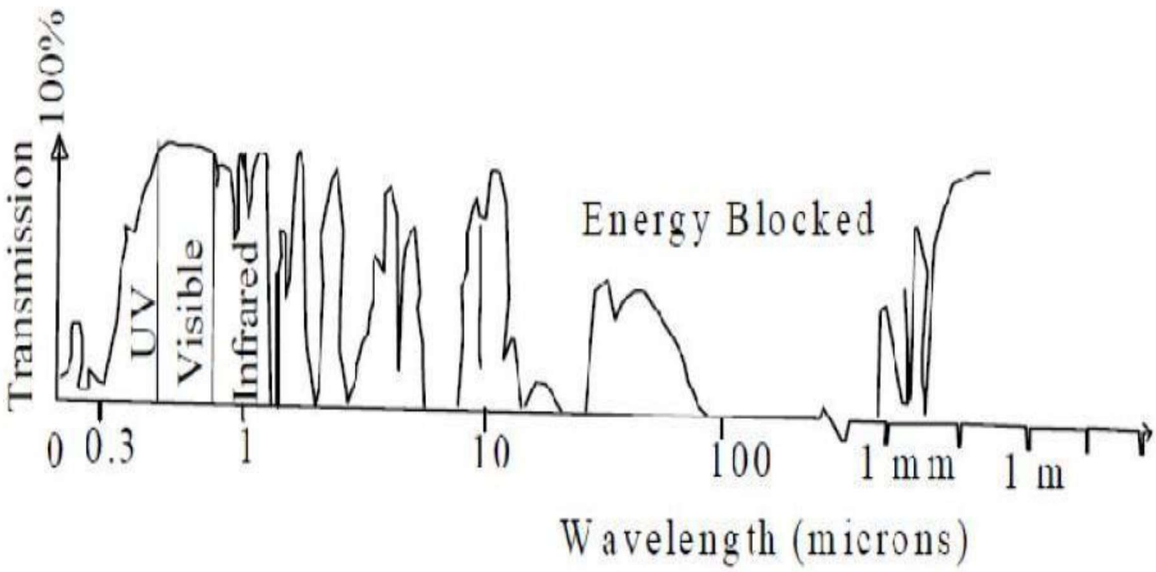
1.3 REFRACTION

- Refraction is a phenomenon that occurs when radiation, such as light or other electromagnetic waves, interacts with the Earth's atmosphere.
- It involves the bending of the path of the radiation as it passes from one medium (e.g., air) into another medium (e.g., glass or water) with a different refractive index.
- In the case of the atmosphere, refraction primarily affects the path of visible light and radio waves. The factors of refraction are,

  - ✓ **Refractive Index:** Every material has a property known as the refractive index (or optical density), which measures how much the speed of light is reduced when it passes through that material compared to a vacuum. The refractive index of air is slightly greater than 1, meaning that light travels slightly slower in air than in a vacuum.
  - ✓ **Change in Speed:** When light or electromagnetic waves enter the Earth's atmosphere from space (which is close to a vacuum), they slow down due to the refractive index of air.
  - ✓ **Bending of Light:** According to Snell's Law, which describes the behavior of light at the boundary between two different media, the change in speed causes the radiation to change direction. The degree of bending depends on the angle of incidence and the refractive indices of the two media.
  - ✓ **Atmospheric Layers:** The degree of refraction in the atmosphere can vary with altitude and atmospheric conditions. Different layers of the atmosphere have different refractive properties, which can lead to complex bending effects, especially during sunrise and sunset.

2. ATMOSPHERIC WINDOWS

- While EMR is transmitted from the sun to the surface of the earth, it passes through the atmosphere.
- Here, electromagnetic radiation is scattered and absorbed by gases and dust particles.
- Besides the major atmospheric gaseous components like molecular nitrogen and oxygen, other constituents like water vapour, methane, hydrogen, helium and nitrogen compounds play important role in modifying electromagnetic radiation.
- This affects image quality.
- Regions of the electromagnetic spectrum in which the atmosphere is transparent are called atmospheric windows.
- The atmosphere is practically transparent in the visible region of the electromagnetic spectrum and therefore, many of the satellite based remote sensing sensors are designed to collect data in this region.
- Some of the commonly used atmospheric windows are shown in thefigure.



3. SPECTRAL SIGNATURE CONCEPTS-TYPICAL SPECTRAL REFLECTANCE - CHARACTRISTICS OF WATER, VEGETATION AND SOIL:

- A basic assumption made in remote sensing is that a specific target has an individual and characteristic manner of interacting with incident radiation.
- The manner of interaction is described by the spectral response of the target.
- The spectral reflectance curves describe the spectral response of a target in a particular wavelength region of electromagnetic spectrum.
- The spectral reflectance curve depends upon certain factors, namely, orientation of the sun (solar azimuth), the height of the Sun in the sky (solar elevation angle), the direction in which the sensor is pointing relative to nadir (the look angle) and nature of the target.