**Energy-Matter Interaction**

**Radiation-matter interactions**

• EMR that impinges upon matter is called incident radiation.

• When the EMR encounters the atmosphere, land surface, or ocean surface, one of 3 reactions occurs:*reflected* off the object, *absorbed* bythe object, or *transmitted* through the object.

• Proportion of energythat is ***transmitted***, ***reflected*** or ***absorbed*** depends upon:

1) composition and physical properties of medium;

2) wavelength or frequencyof incident radiation;

3) angle at which incident radiation strikes a surface.

• In remote sensing, they are largely concerned with *reflected radiation* of the sun.***Reflected radiation*** causes our eyes to see colors.

**Transmission (Transsmitted Energy)**

• ***Incident*** radiation passes through matter; Radiation penetrates into certain surface media, such as water.

• ***Refraction*** occurs when the media are of different densities and the speed of EMR is different in each.

**Reflection (Reflected Energy)**

There are *two types of reflection*, while there is *no changein velocity* or *wavelength* in those two types:

1. **Specular Reflection**

• Caused by smooth surfaces; The angle of reflection is equal to the angle of incidence. No changein velocityor wavelength.

1. **Scattering (Diffuse Reflection)**

• Occurs when surfaces rough, such as white paper or powders; No changein velocityor wavelength.



**Absorption (Absorped Energy)**

***Incident radiation*** is taken in by the medium through electron or molecular reactions within the medium encountered.

**EMR-Atmosphere Interactions**

***EMR*** travels through vacuum space without modification;***Atmospheric windows***(transmission bands): areas of EMS where specific wavelengths pass relatively unimpeded through the atmosphere. Important atmospheric windows exploited in remote sensing: Visible, Infrared, and Microwave.

**Atmospheric Scattering**

* ***Scattering*** process disperses radiation in all directions. Important scattering agents include; gaseous molecules, suspended particulates (aerosols), and clouds.
* *Three types* of atmospheric scattering are important in remote sensing.
* They are 1- ***Rayleigh (molecular)*** ***Scattering***, 2- ***Mie (nonmolecular) Scattering***, and 3- ***non-selective scattering***.
1. **Rayleigh (Molecular) Scattering**

• Primarily caused by oxygen and nitrogen molecules (diameters at least 0.1times smaller than affected wavelengths); Most influential at altitudes above 4.5km;

• Bluesky-clearsky appears bluein daylight; blue wavelengths reach our eyes;



1. **Mie (nonmolecular) Scattering**

• Occurs when there are sufficient particles in atmosphere with mean diameter 0.1 to 10 times larger than wavelength under consideration; Most pronounced in lower 4.5km of atmosphere;

• Caused bywater vapor, tinyparticles of smoke, dust, volcanic smoke, salt crystals released from evaporation of sea spray;

1. **Nonselective scattering**

• Occurs when lower atmosphere contains sufficient number of suspended aerosols(diameters 10 times larger than wavelengths under consideration);

• Water droplets and ice crystals that compose clouds and fogs;Clouds appear brilliant white because colorless water droplet and ice crystals scatter all wavelengths equallywell.

**EMR - Surface Interactions**

• Natural and man-made (cultural)features of Earth's surface interactwith solar radiation differently. On average, 50% of incident shortwave radiation on top of atmosphere reaches and interacts with Earth's surface features:

50% incident at surface = 4% reflected directly+ 46% absorbed.

**Albedo (Spectral Reflectance):** it is the ratio between the reflected radiation to incident radiation.

*R*(λ)=*ER*(λ)×100

*EI*(λ)

• ***Albedo of Earth's***: Earth made visible from space only by its albedo.

• Earth's brightest features - clouds, snow and ice surfaces; darkest - water bodies.

• Objects with high albedo are good reflectors but poor absorbers. Objects with low albedo are poor reflectors but good absorbers.

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**Energy Conservation Principle**

• Radiation Budget Equation:

*EI*(λ)=*ER*(λ)+*EA*(λ)+*ET*(λ)

*EI*(λ): incident radiation that strikes an object, *ER*(λ): reflected radiation, *EA* (λ): absorbed radiation, *ET*(λ): transmitted radiation



* Transparent materials have little or no absorption and scattering.
* Clear glass - high transmission, low reflection and absorption.
* Fresh snow - high reflectance, low transmission and absorption.