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2nd Stage

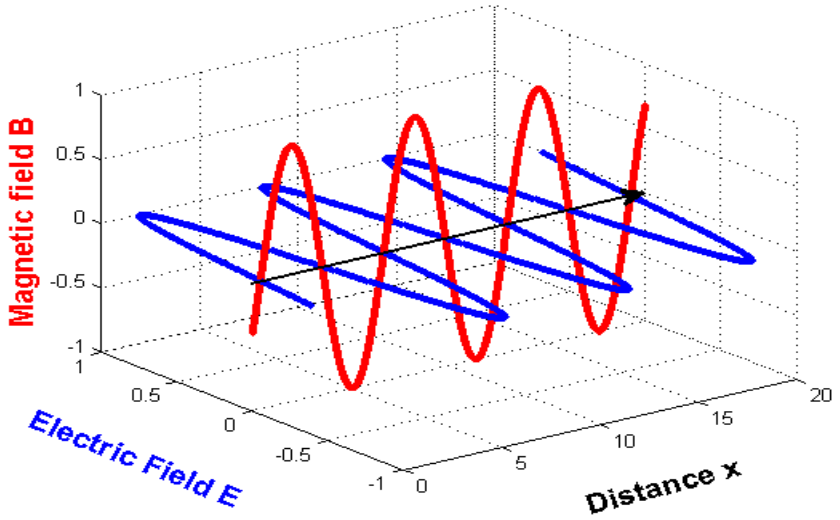
Remote Sensing

Lecture 3 : Physics of Electromagnetic waves

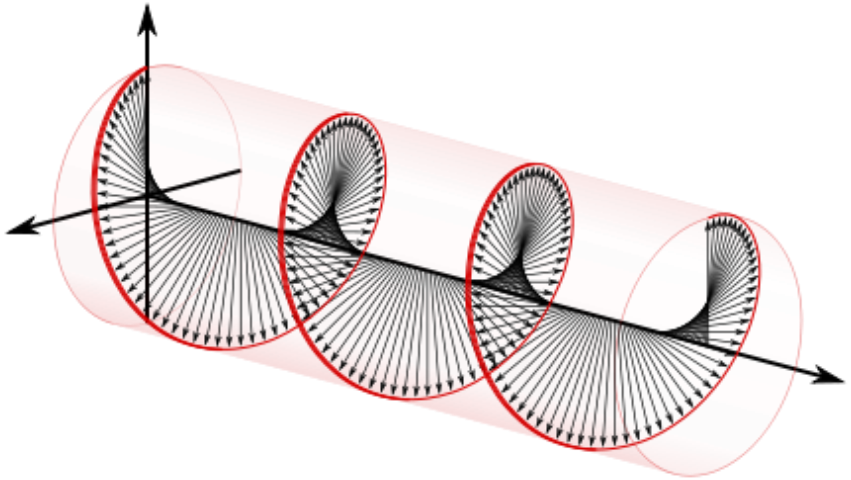
Physics of waves

There are many physical effects and can change the properties of waves

1 – Polarization : The nature of waves can show as tow perpendicular frequencies (Electric and magnetic) transfer and moving by same direction of the general wave . But with different polarization planes ,, Some sources of energy like sun not have constant direction of polarization , such the polarization of electric field can be at any directions that called **Random polarization** . In some cases like Laser ray or radio waves or Radar waves has fix and stable polarized phases



Normal Polarization



Random Polarization

2- Scattering

Scatter differs from reflection in that : the direction of scattering is unpredictable, whereas the direction of reflection is predictable. There are three types of scattering:

1 - Rayleigh

2 - Mie

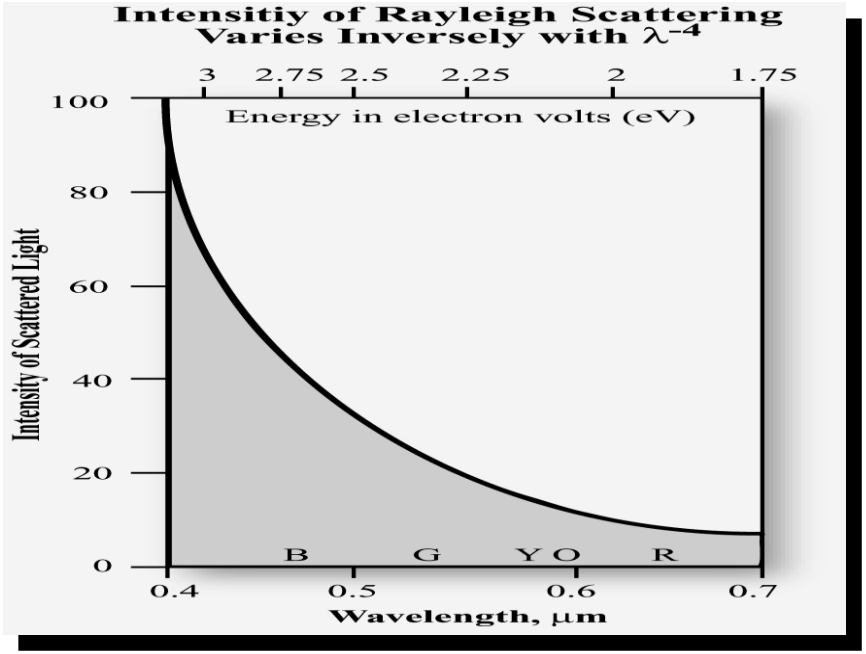
3 - Non-selective.

1 - Rayleigh scattering: occurs when the diameter of the matter (usually air molecules) are many times smaller than the wavelength of the incident electromagnetic radiation. Less than 0.1 micron

The energy required to active an atom is associated with short-wavelength, high frequency radiation. **The amount of scattering is inversely related to the fourth power of the radiation's wavelength.**

For example, blue light (0.4 ζm) is scattered 16 times more than near-infrared light (0.8 ζ m).

is responsible for the **blue sky**. The short **violet and blue** wavelengths are more scattered than the longer orange and red wavelengths.



2 - Mie scattering : takes place when there are spherical particles present in the atmosphere with diameters approximately equal to the wavelength of radiation. For visible light, water vapor, dust, and other particles ranging from a few tenths of a micrometer to several micrometers in diameter are the main scattering agents.

The amount of scatter is greater than Rayleigh scatter and the wavelengths scattered are longer.

Pollution : The greater amount of smoke and dust particles in the atmospheric column, the more violet and blue light will be scattered away and only the longer **orange and red** wavelength light will reach our eyes.

3 - Non-selective scattering : is produced when there are particles in the atmosphere several times bigger than diameter of the wavelength radiation being transmitted. This type of scattering is non-selective, i.e. all wavelengths of light are scattered, not just blue, green, or red. Thus, water droplets, which make up clouds and fog, scatter all wavelengths of visible light equally well, causing the cloud to appear white (a mixture of all colors of light in approximately equal quantities produces white).

Scattering can severely reduce the information content of remotely sensed data to the point that the imagery looses contrast and it is difficult to know one object from another.

3- Transmission

When an electromagnetic energy incident on the media there are 3 types of reactions can happen:

1- Reflection: The return of energy to the same media comes from

2 - passing : energy passes through the media to the original one

3- absorption : the media absorb the electromagnetic pass through .

these 3 cases different by their rates depending on type of media and the wave length of electromagnetic energy

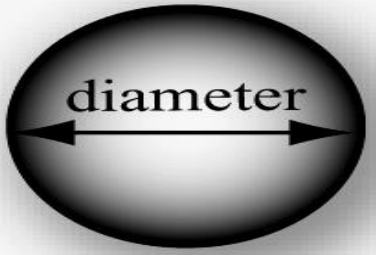
In certain parts of the spectrum such as the visible region (0.4 - 0.7 ζm), the atmosphere does not absorb all of the incident energy but transmits it effectively. Parts of the spectrum that transmit energy effectively are called (Atmospheric Windows)

Atmospheric Scattering

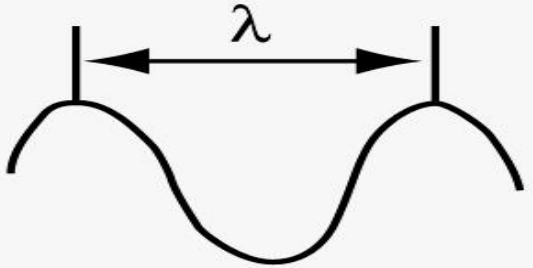
Rayleigh Scattering

a. Gas molecule

Mie Scattering

b. 

Smoke, dust



Photon of electromagnetic energy modeled as a wave

Nonselective Scattering

c. 

4- Absorption

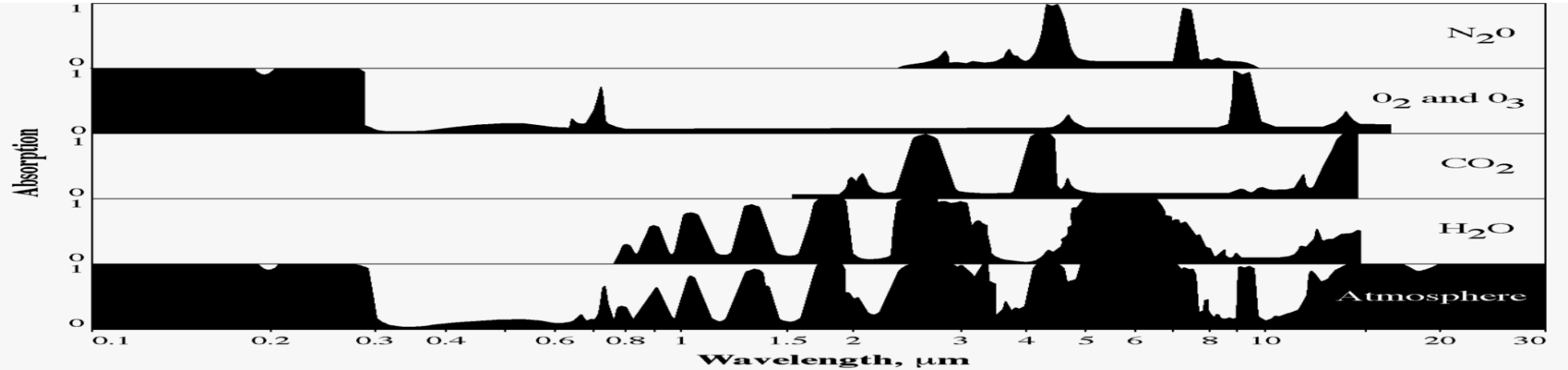
is the process by which radiant energy is absorbed and converted into other forms of energy. An absorption band is a range of wavelengths (or frequencies) in the electromagnetic spectrum within which energy absorbed by material such as water (H2O), carbon dioxide (CO2), oxygen (O2), ozone (O3), and nitrous oxide (N2O).

The cumulative effect of the absorption by the various materials can cause the atmosphere to close down in some regions of the spectrum. This is bad for remote sensing because no energy is available to be sensed.

Atmospheric windows

when the spectral energy come from the sun and pass within the atmospheric layers some changes happen by the effects of absorption and diffusion and refraction , all these effects give some regions of electromagnetic energy would not reached the earth surface then we can not record them by Remote sensing sensors .

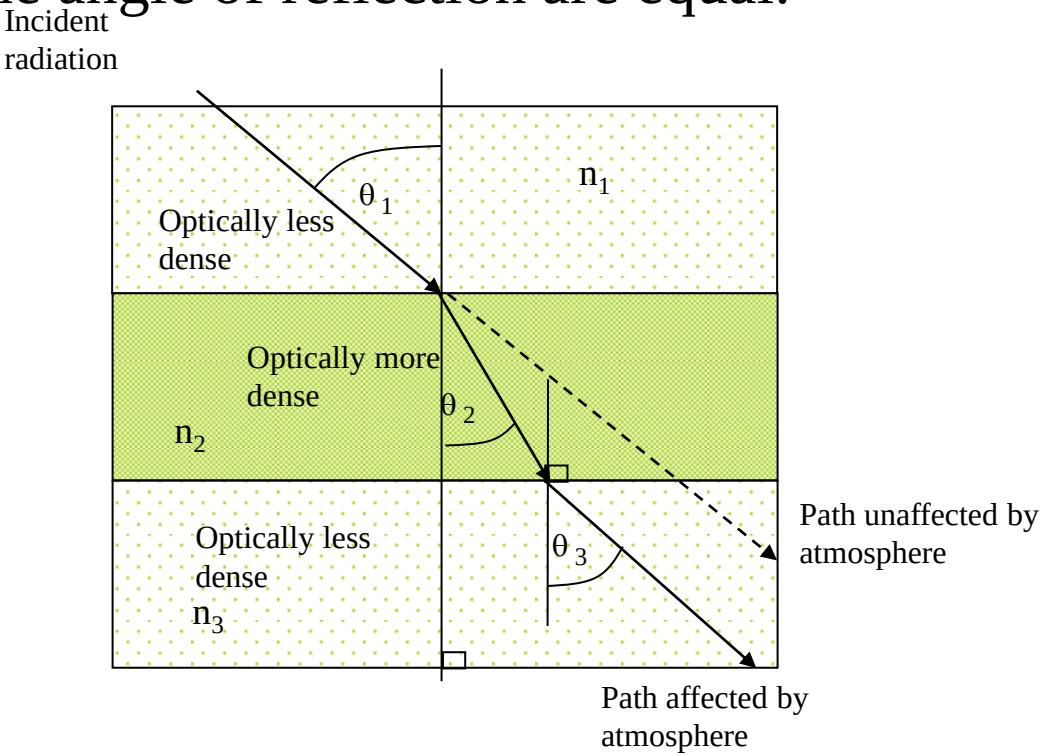
For that when we need to design sensors we must make then work at the open regions . is inversely related to the extinction coefficient times the thickness of the layer. Certain wavelengths of radiation are affected far more by absorption than by scattering. This is particularly true of infrared and wavelengths shorter than visible light.



5- Reflectance

is the process radiation an object like a cloud or the terrain. Actually, the process is more complicated, involving re-radiation of photons by atoms or molecules in a layer one-half wavelength deep.

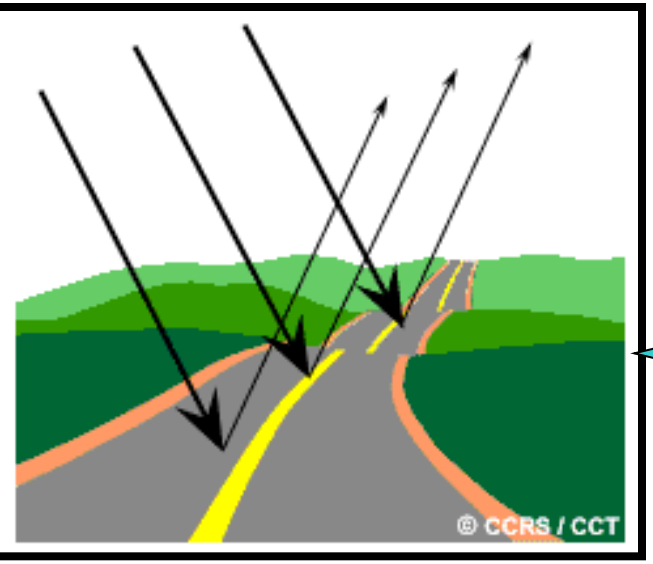
Reflection exhibits fundamental characteristics that are important in remote sensing. First, the incident radiation, the reflected radiation, and a vertical to the surface from which the angles of incidence and reflection are measured all lie in the same plane. Second, the angle of incidence and the angle of reflection are equal.



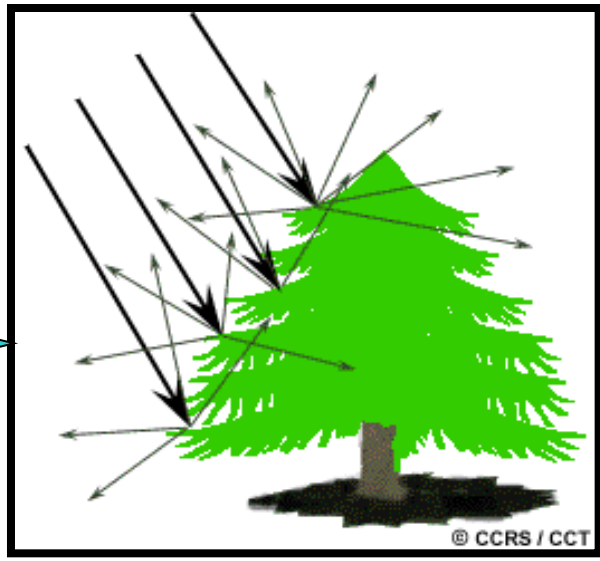
When EMR hits target (surface) Range of surface reflectance behavior

– perfect specular (mirror-like) - incidence angle = existence angle

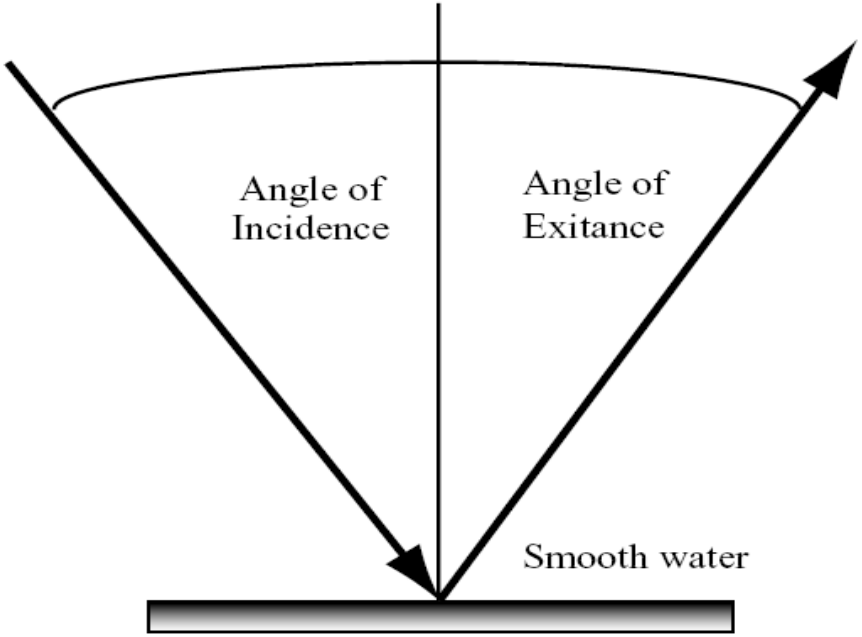
perfectly diffuse (Lambertian) - same reflectance in all directions independent of illumination angle)



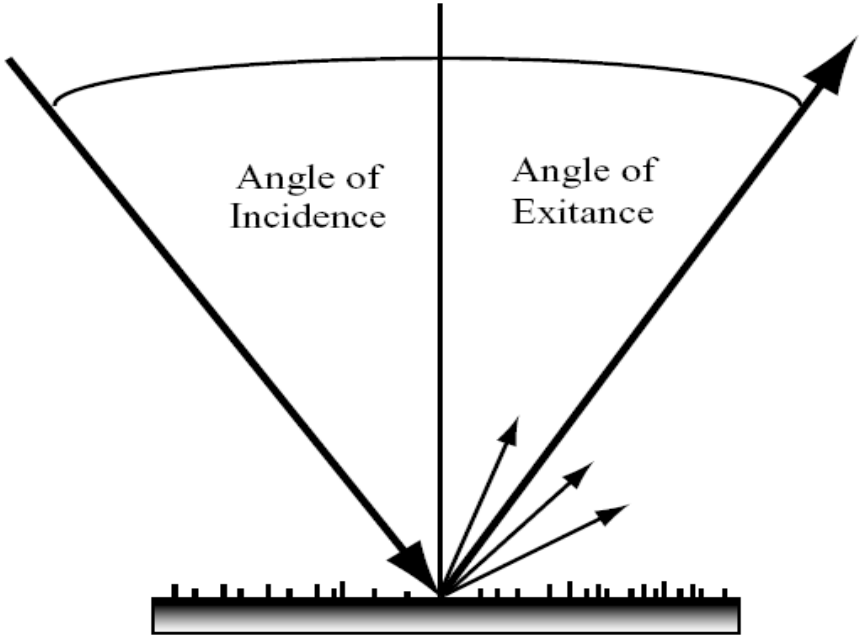
Natural surfaces somewhere in between



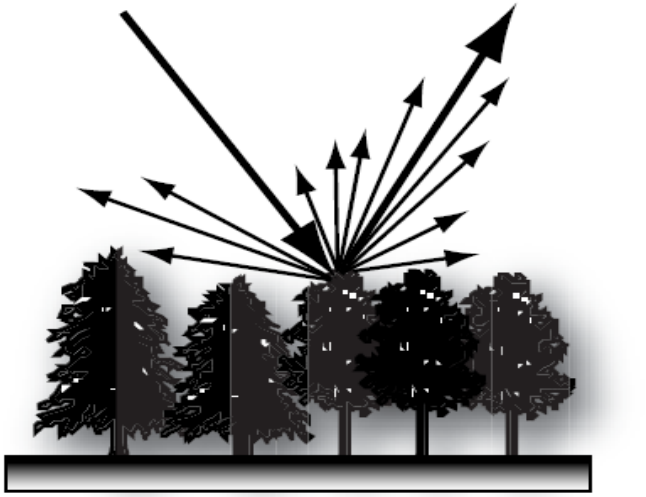
Specular versus Diffuse Reflectance



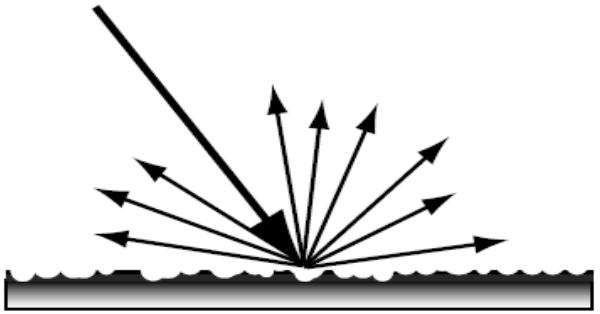
a. Perfect specular reflector.



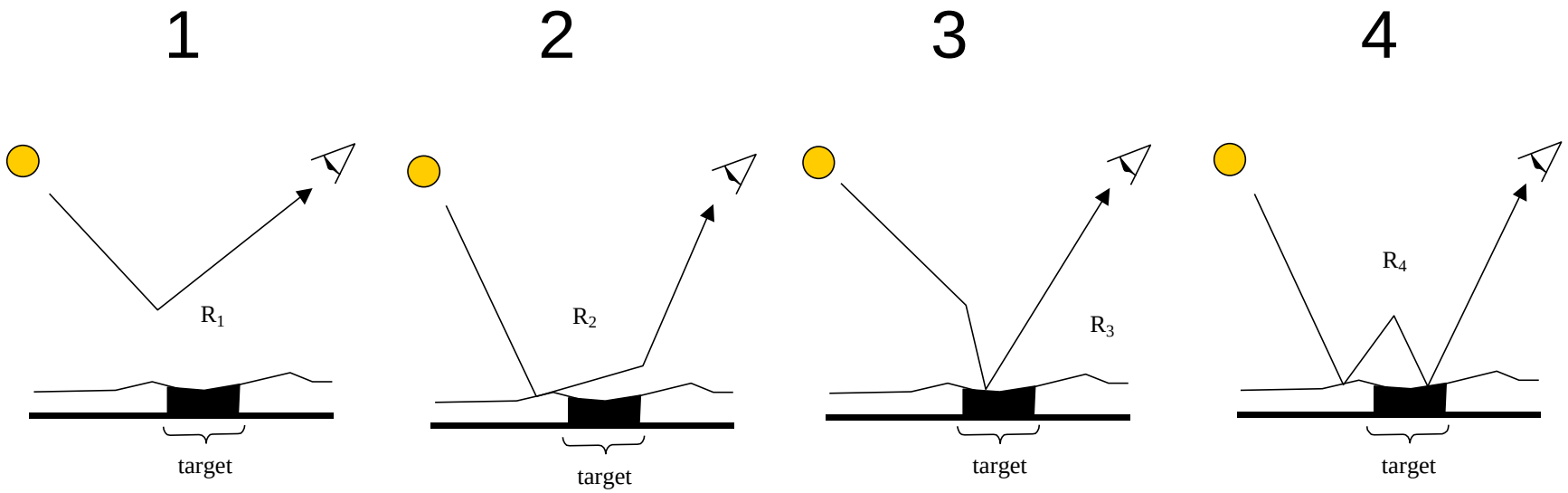
b. Near-perfect specular reflector.



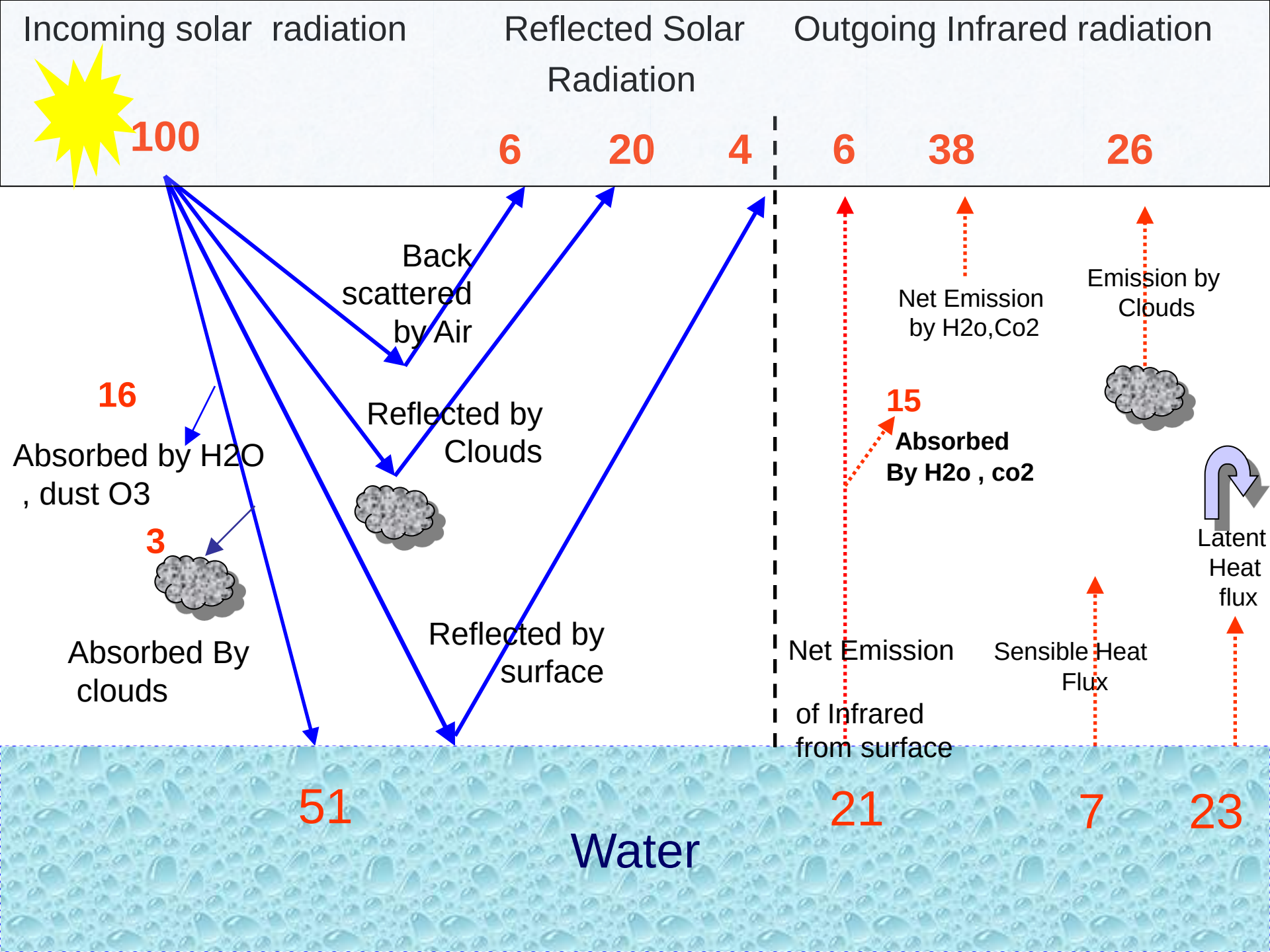
c. Near-perfect diffuse reflector.



d. Perfect diffuse reflector, or
Lambertian surface.



1- Atmospheric irradiance
2- Reflectance outside target scattered into path
3- Diffuse atmospheric irradiance
4- Multiple-scattered surface-atmosphere interactions


Incoming solar radiation
Reflected Solar Radiation
Outgoing Infrared radiation
100
6
20
4
6
38
26
Back scattered by Air
Net Emission by H2o,Co2
Emission by Clouds
16
Absorbed by H2O , dust O3
Reflected by Clouds
15
Absorbed By H2o , co2
3
Latent Heat flux
Absorbed By clouds
Reflected by surface
Net Emission of Infrared from surface
Sensible Heat Flux
51
21
7
23
Water

References

IMAGE INTERPRETATION IMAGE INTERPRETATION , Seventh Edition, Lillesand T. M., Kiefer R. W., Chipman J. W., WILEY press , USA , 2015

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Internet Remote Sensing Lectures sites