Remote Sensing 1: GEOG 4/585

Lecture 2.2.

Electromagnetic energy interactions

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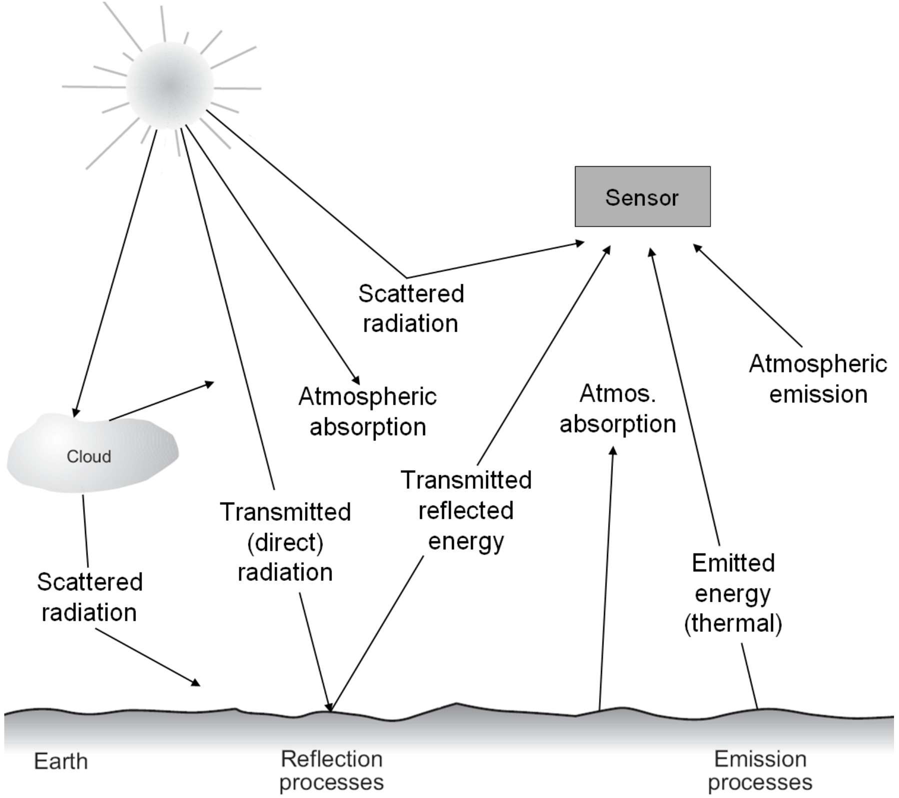
Office hours: Monday 15:00-17:00
in 165 Condon Hall

Required reading:
Principles of Remote Sensing pp 53-80

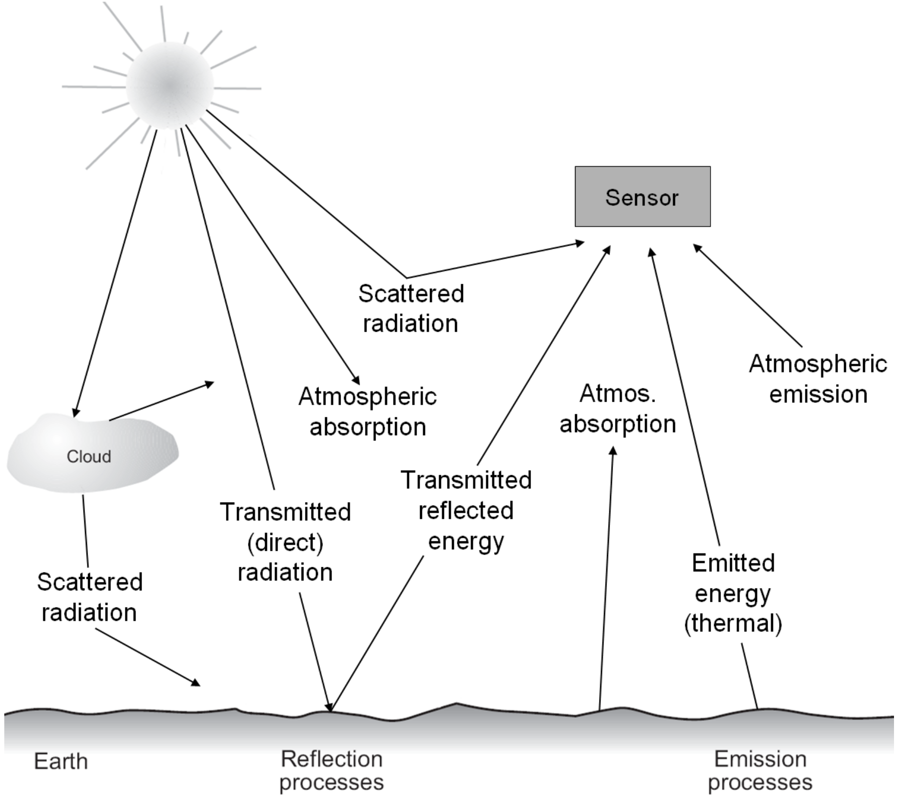
Overview

- Energy interaction with the atmosphere
- Energy interaction with the Earth's surface



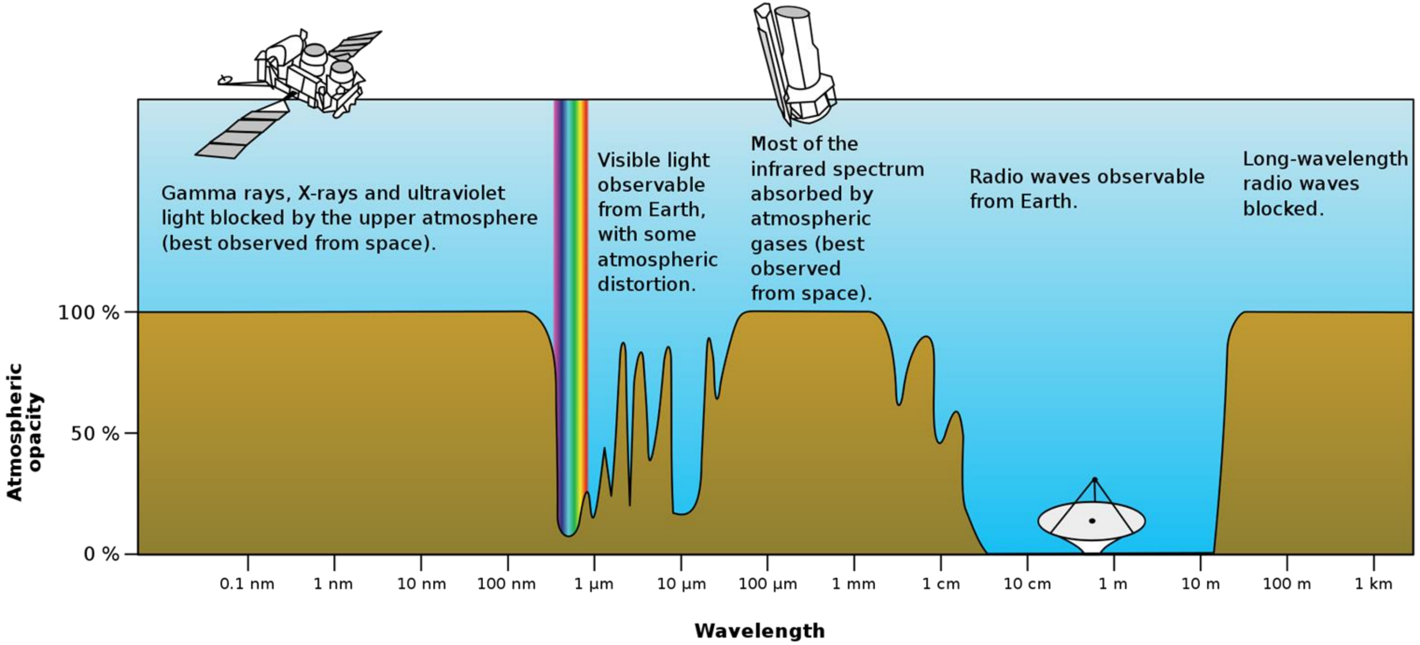
EMR in the atmosphere

- Once EMR is generated, it propagates through the Earth's atmosphere almost at the speed of light in a vacuum.
- Upon entering the atmosphere, the radiation may be <u>absorbed</u>, <u>scattered</u> or <u>transmitted</u>
- Some EMR reaches the surface where it again absorbed, scattered or <u>reflected</u>
- Our remote sensing instrument will receive EMR scattered from the atmosphere, reflected from surface

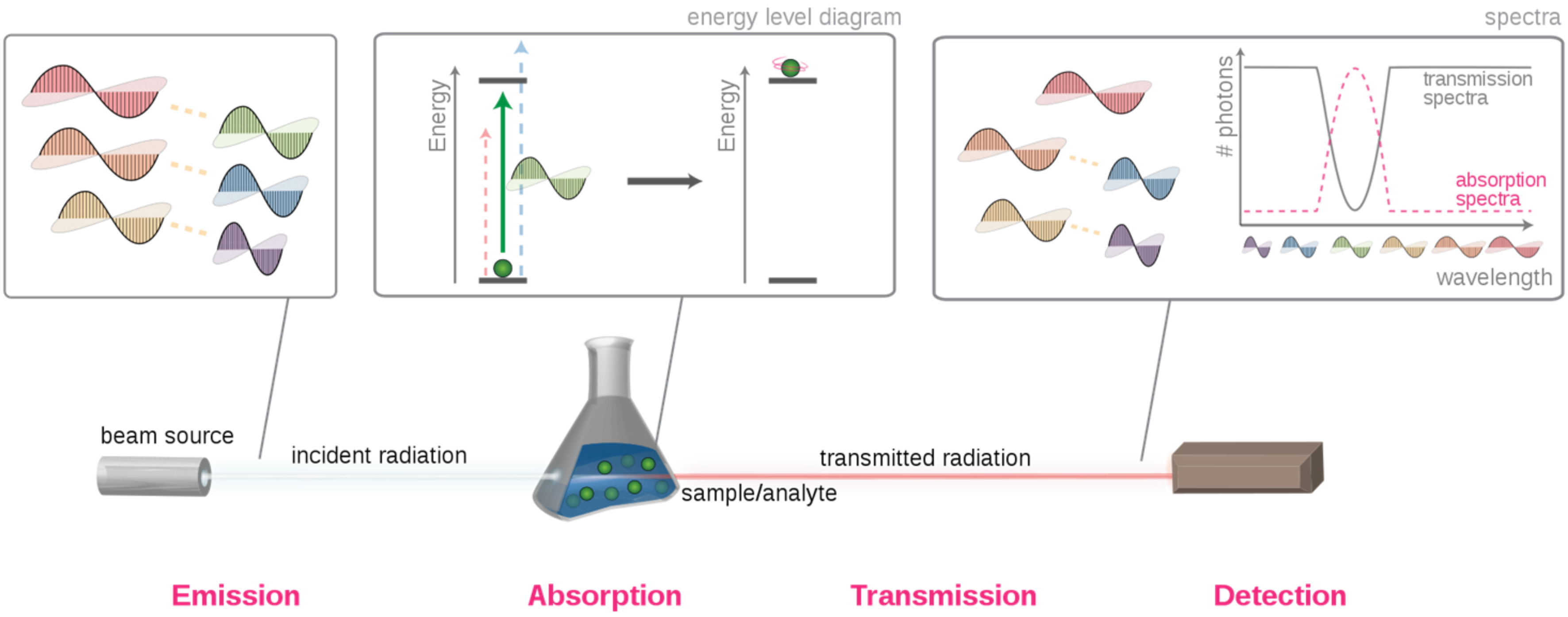


Atmospheric absorption

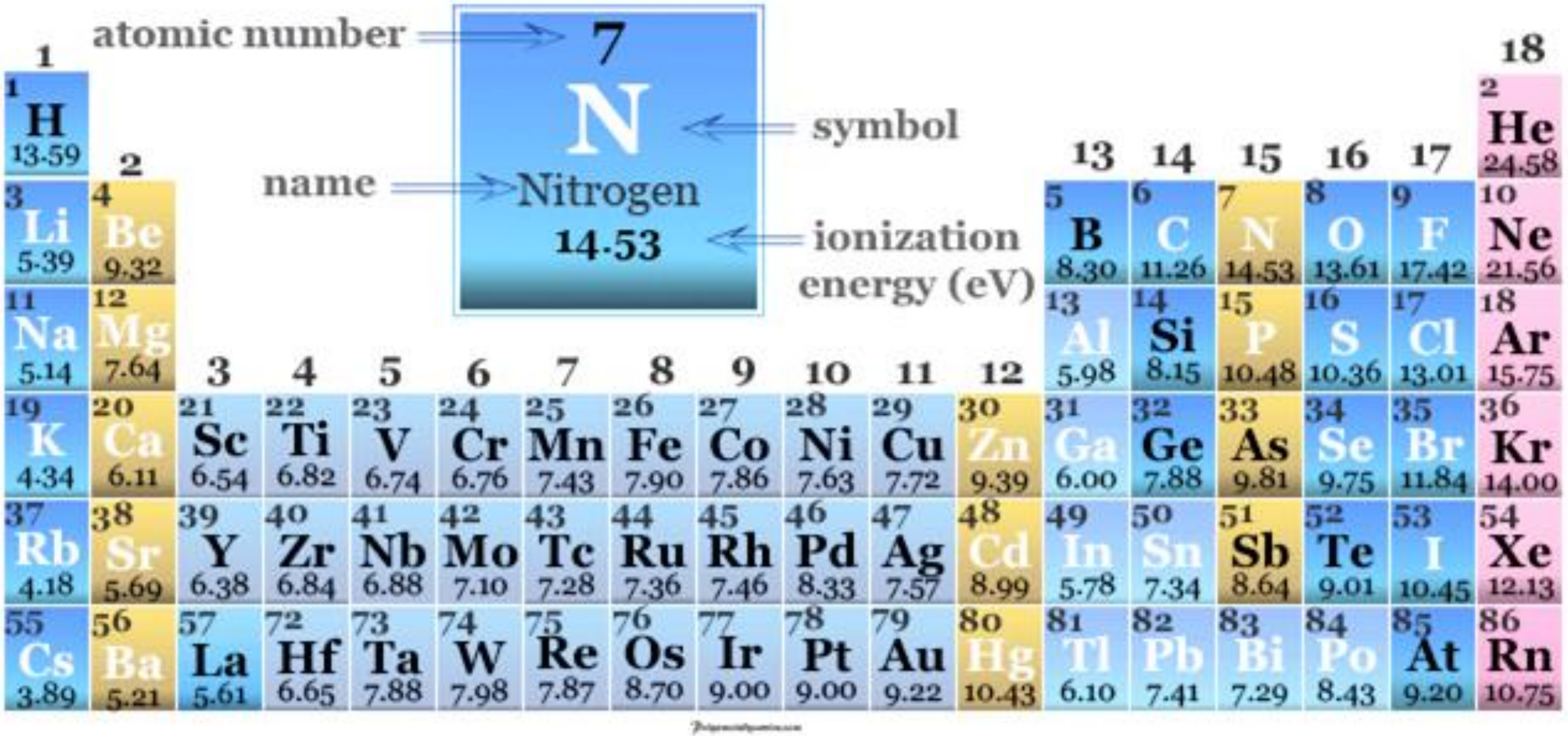
- Absorption is the process by which radiant energy is absorbed and converted into other forms of energy.
  - Ozone, carbon dioxide, and water vapor are the three most efficient absorbers of electromagnetic radiation.



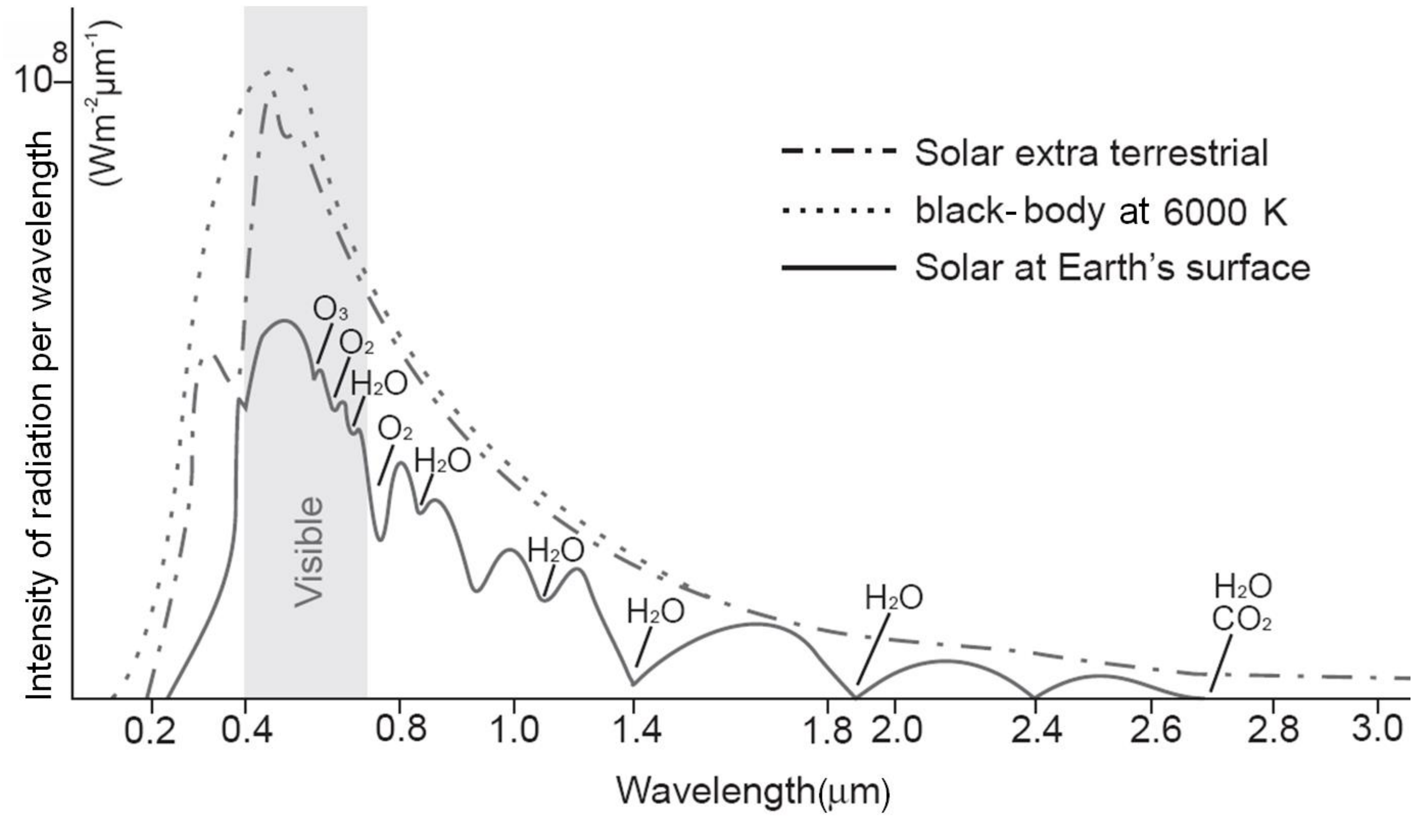
Atmospheric absorption



Ionization energy



Solar radiation



Atmospheric scattering

- Scattering occurs when radiation “bounces off” an object in an unpredictable manner
  - ... with no change in wavelength or frequency after

- Amount of scattering depends on:

  - <u>Amount</u> and <u>size</u> of particles and gases

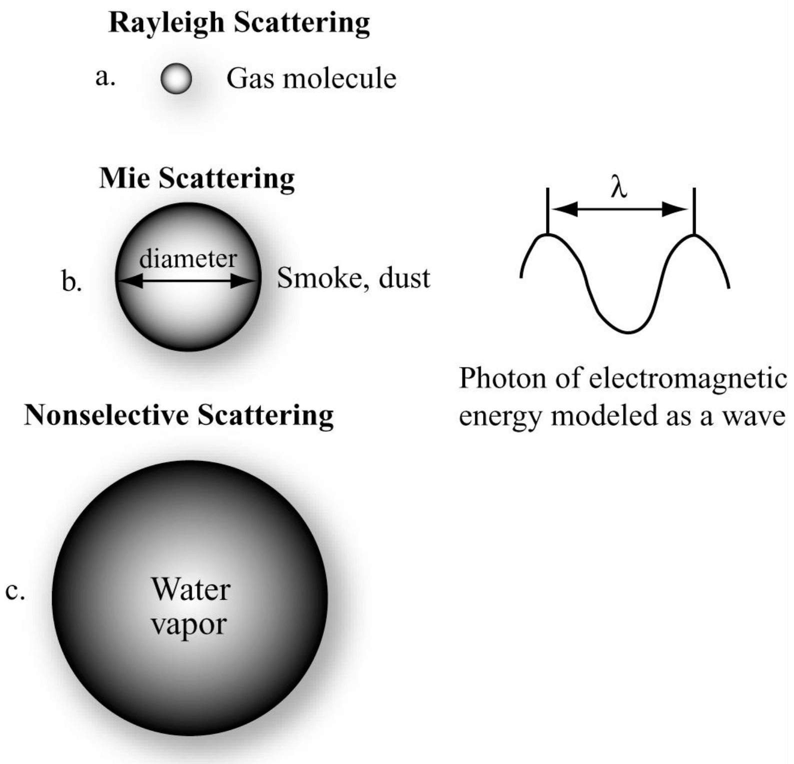
  - <u>Wavelength</u> of radiation

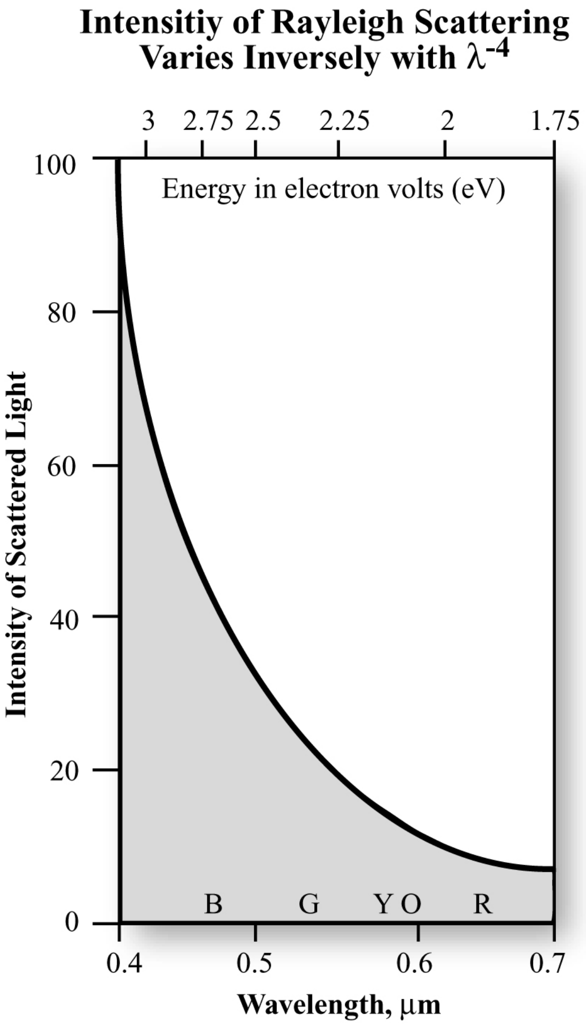
  - <u>Distance</u> that radiant energy travels through atmosphere

Scattering vs. particle size and wavelength

There are three main types of scattering:

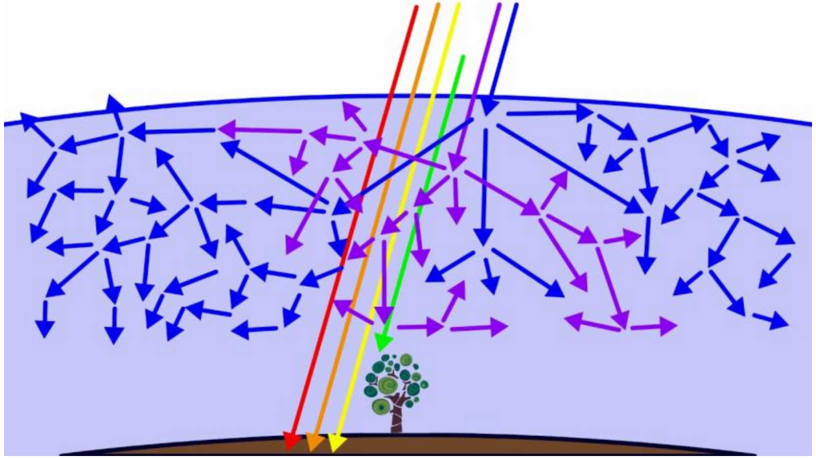
- Rayleigh Scattering
  - Particle size << λ_{light}
  - Highly dependent on wavelength
- Mie Scattering
  - Particle size ≈ λ_{light}
  - Not strongly wavelength dependent
- Non-selective scattering
  - Particle sizes >> λ_{light}





Rayleigh scattering

- Air molecules don't scatter all colors equally, shorter wavelengths scatter more than longer wavelengths
- Amount of scattering is inversely proportional to λ^4
- Scattering at 400 nm is ~9 times greater than 700 nm.



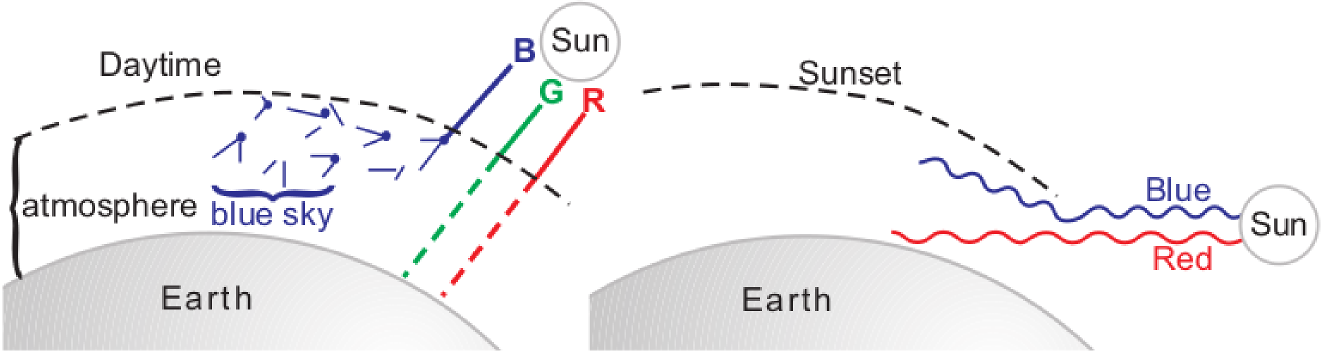
Rayleigh scattering

Explains why:

- the sky is blue…
  - Light that reaches eye is dominated by blue light which is more likely to scatter in atmosphere

- the sun is yellow
  - Blue light is preferentially scattered away

- sunsets are yellow/red…
  - Complete absence of blue light, only light that reaches eye is longer wavelengths



Mie and non-selective scattering

- Particles such as water droplets, ice crystals, smoke or dust particles in the atmosphere are equal to or several times the diameter of the visible wavelengths

- They scatter all colors in equal amounts

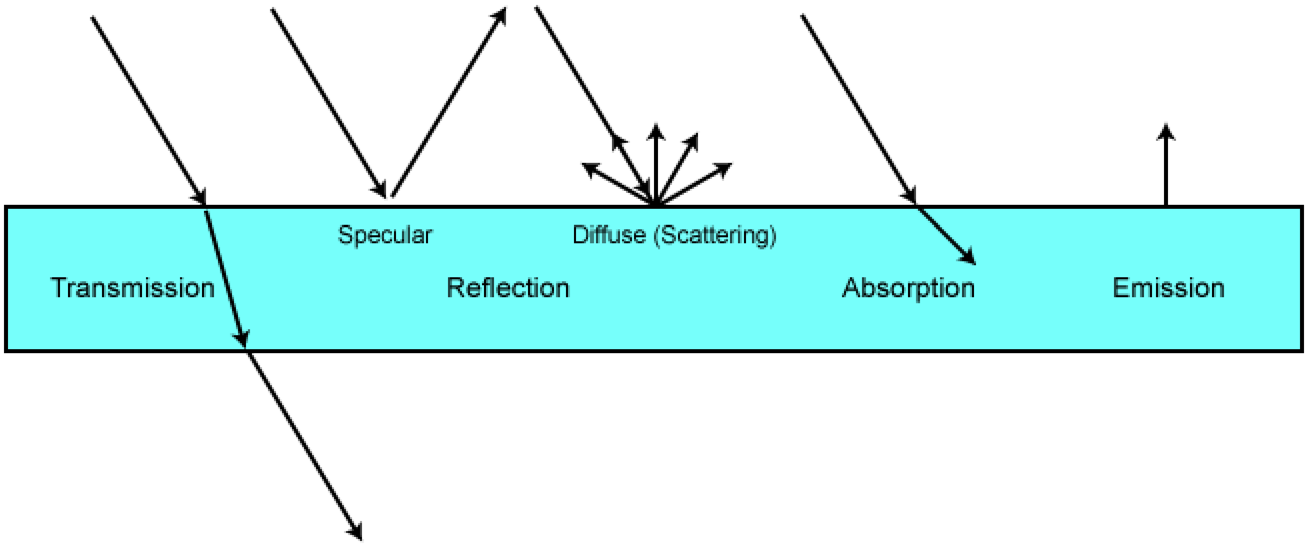
- Clouds, fog banks, and dust appear white.

Which image is from the space telescope?

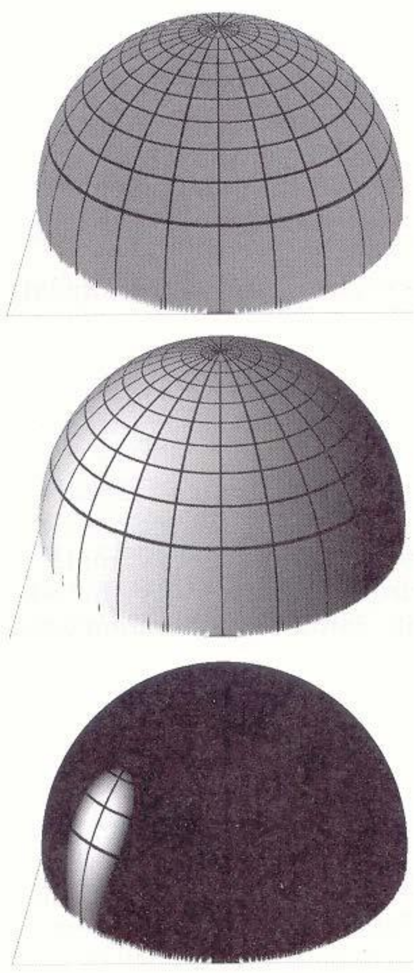
Why are mountains in the distance bluer?

Why are shadows not pitch black?

EMR interactions with Earth surface



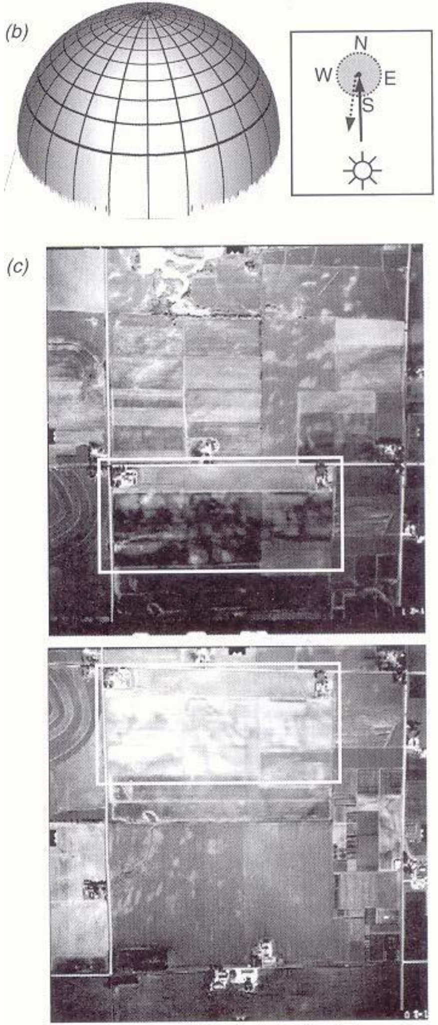
Types of reflection



<u>Diffuse reflection</u>: radiation reflects on a rough surface in all directions

<u>Specular reflection</u>: radiation reflects on a smooth surface – the “mirror” effect

...or somewhere inbetween



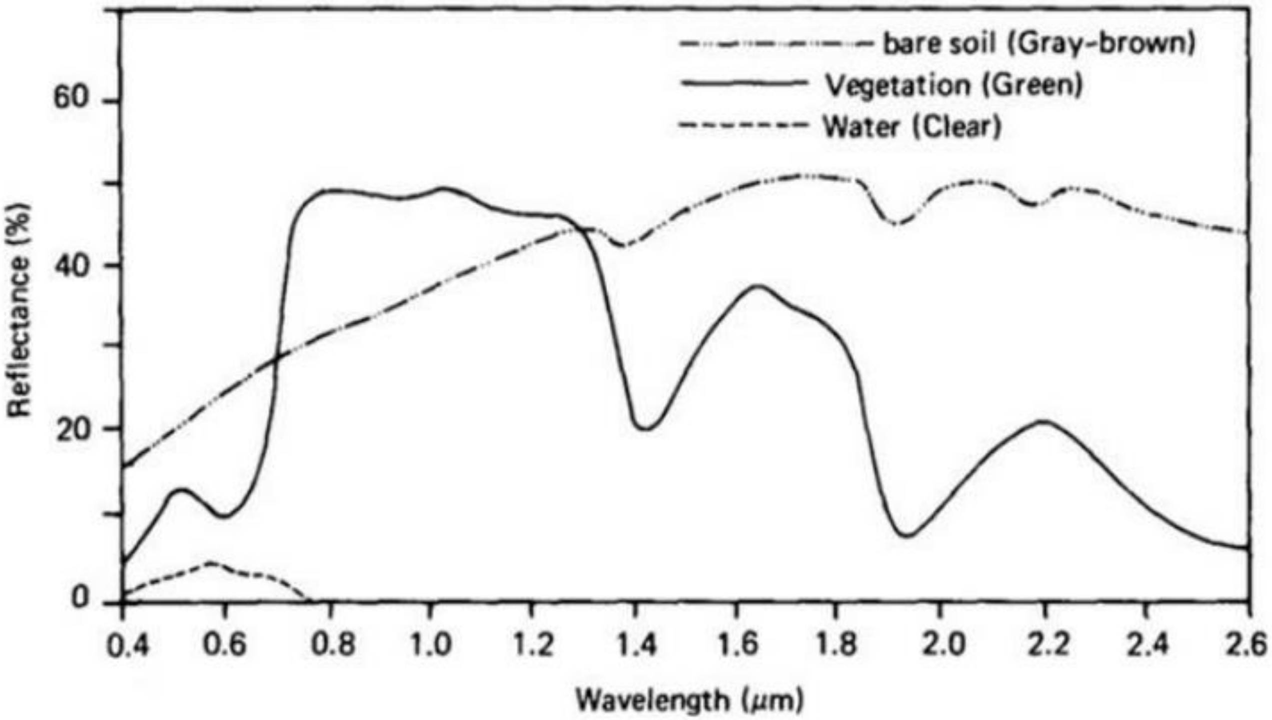
Specular reflection

Spectral reflectance

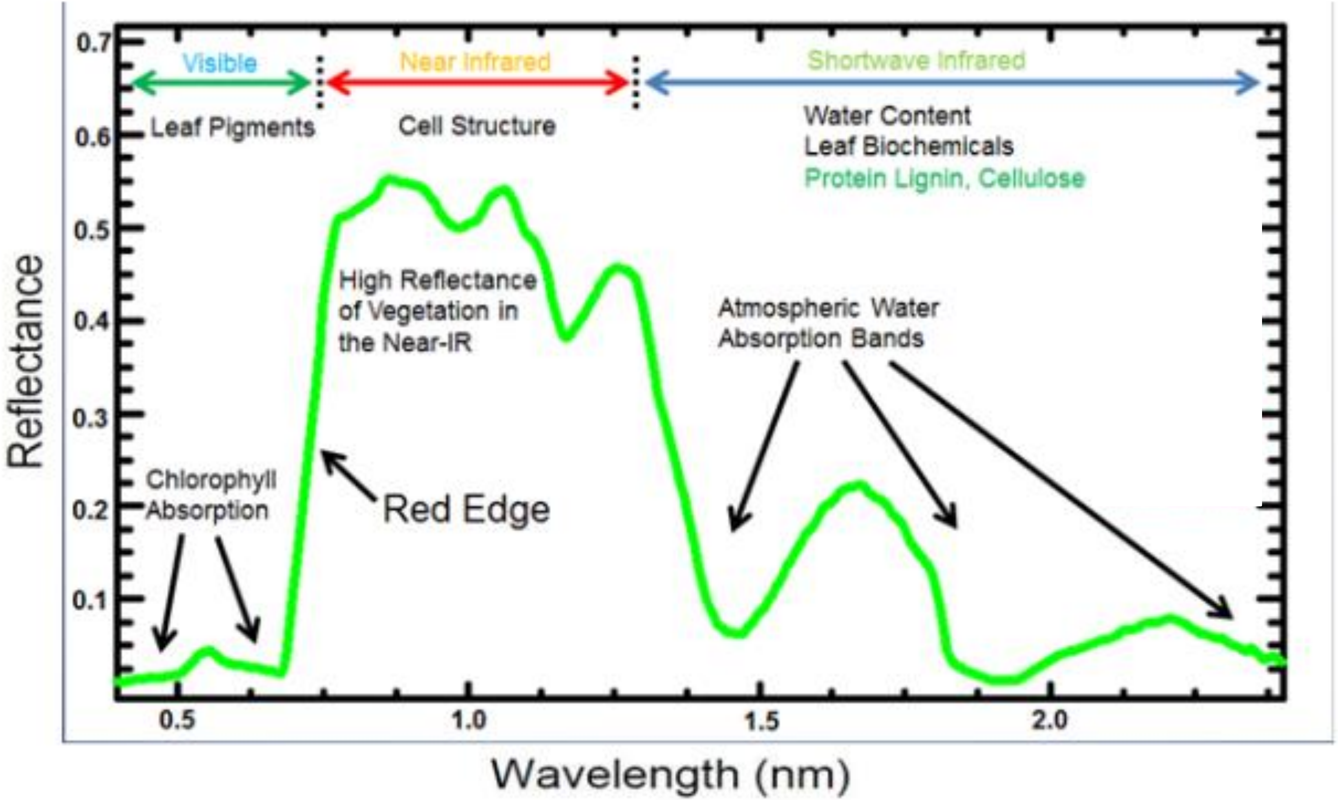
- Expressed as the ratio of energy reflected by the object to the energy incident on the surface, measured as a function of wavelength
- Reflectance = energy reflected by object / energy incident on object

Surface type	**Reflectance at 0.5 µm**
Grass	25%
Concrete	20%
Water	5-70%
Snow	80%
Forest	5-10%
Thick cloud	75%

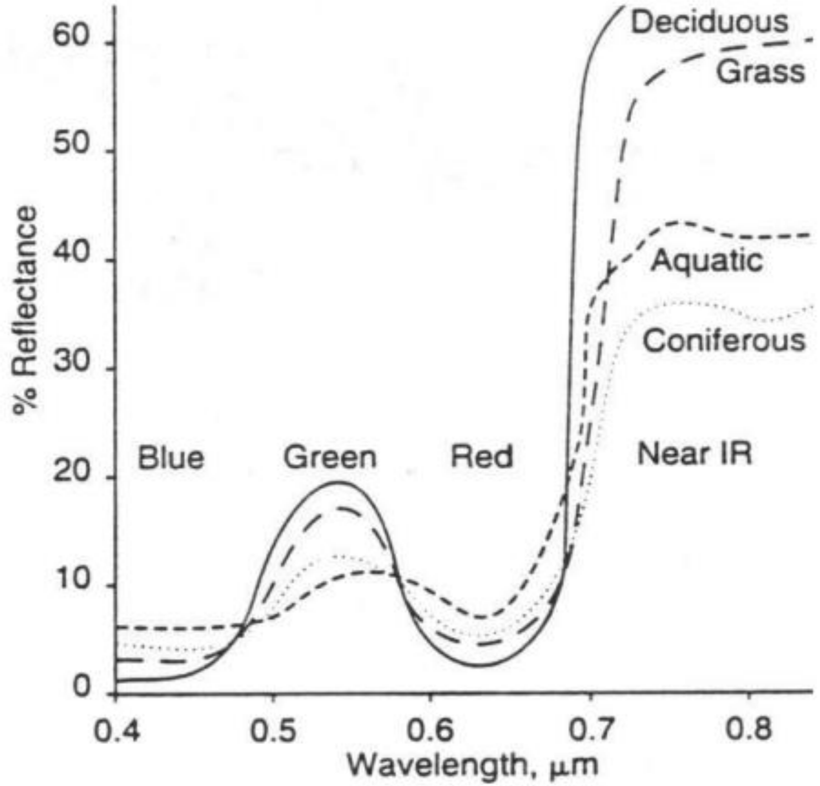
Spectral reflectance curves



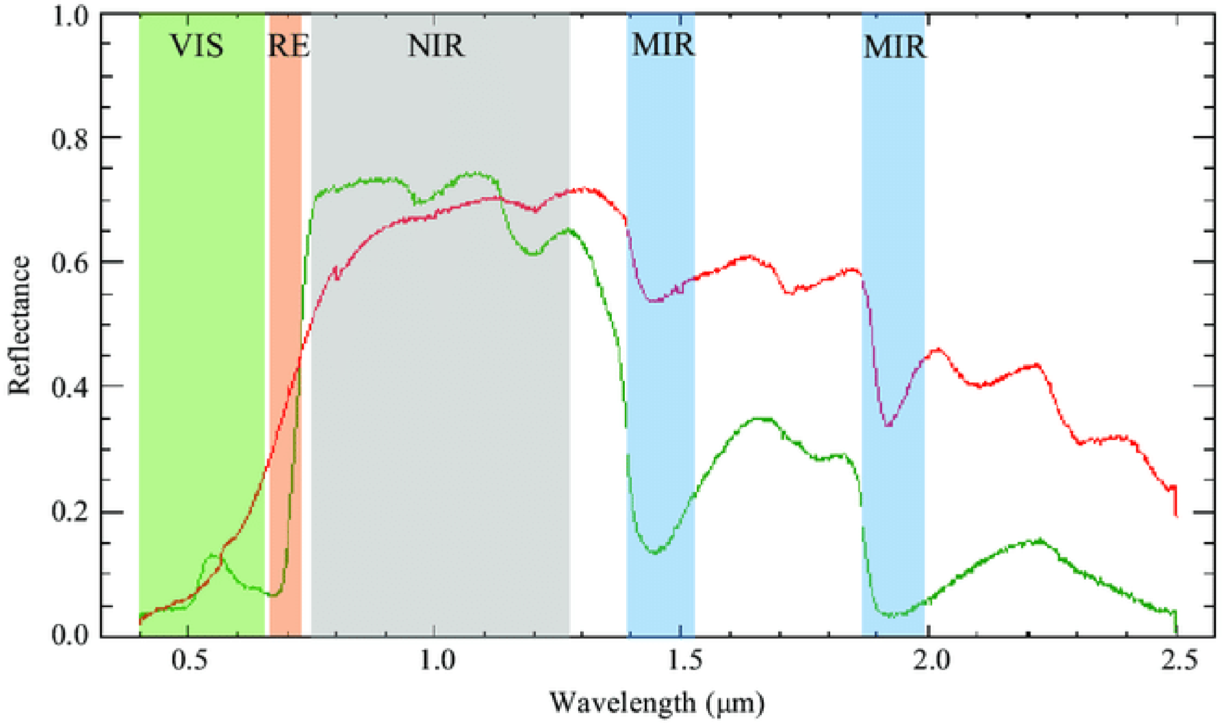
Spectral reflectance curves: healthy vegetation



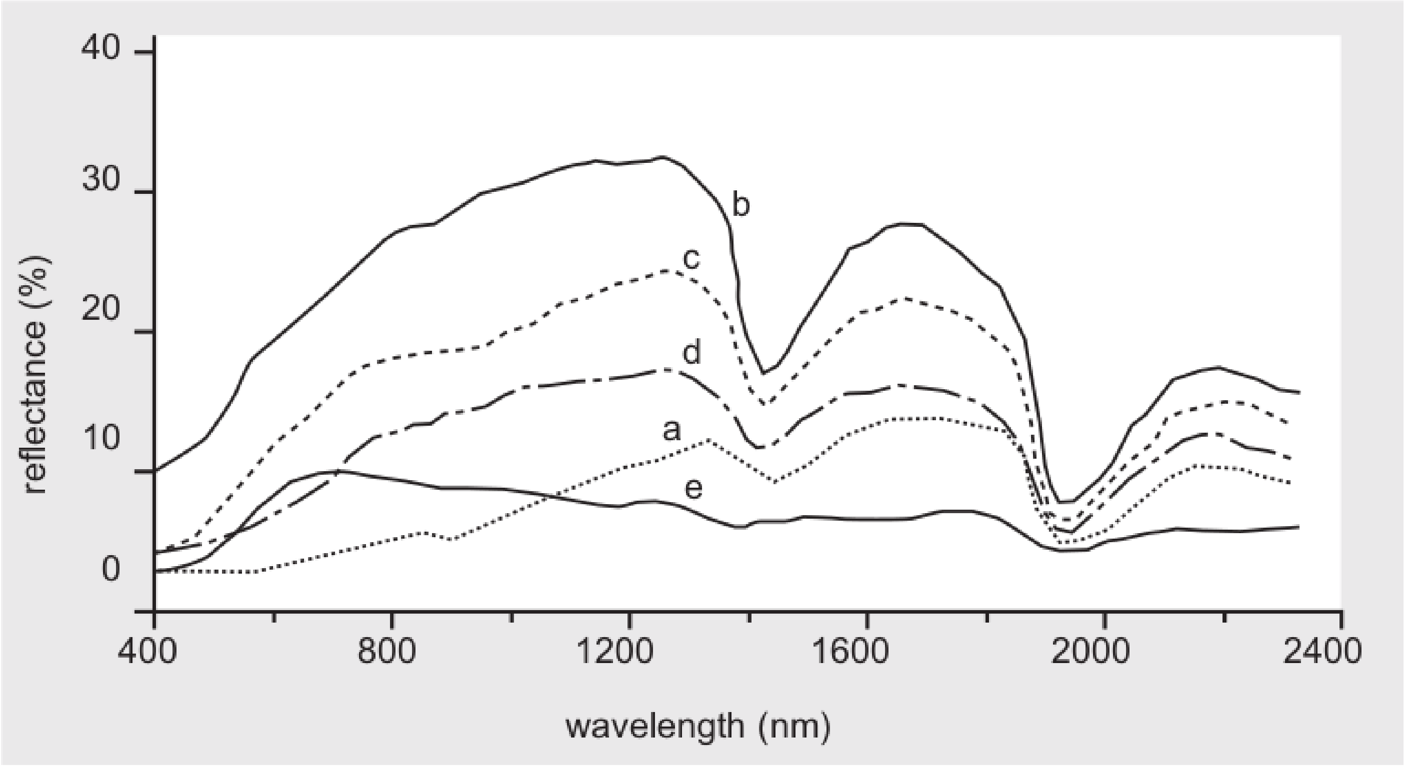
Spectral reflectance curves: healthy vegetation



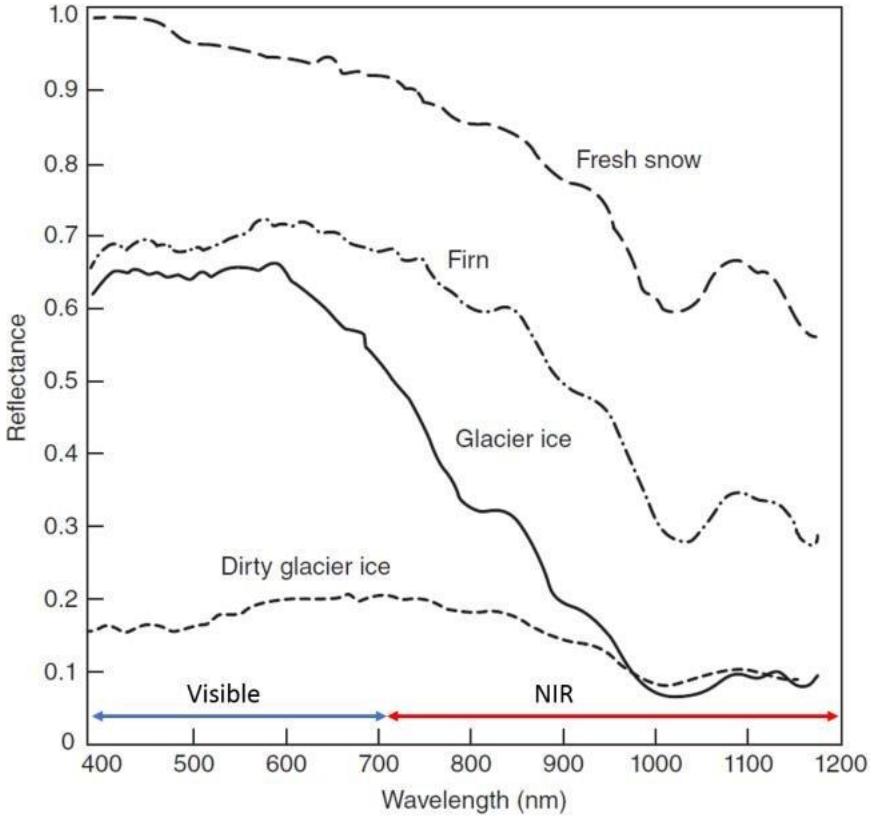
Healthy vs. stressed vegetation spectral curves



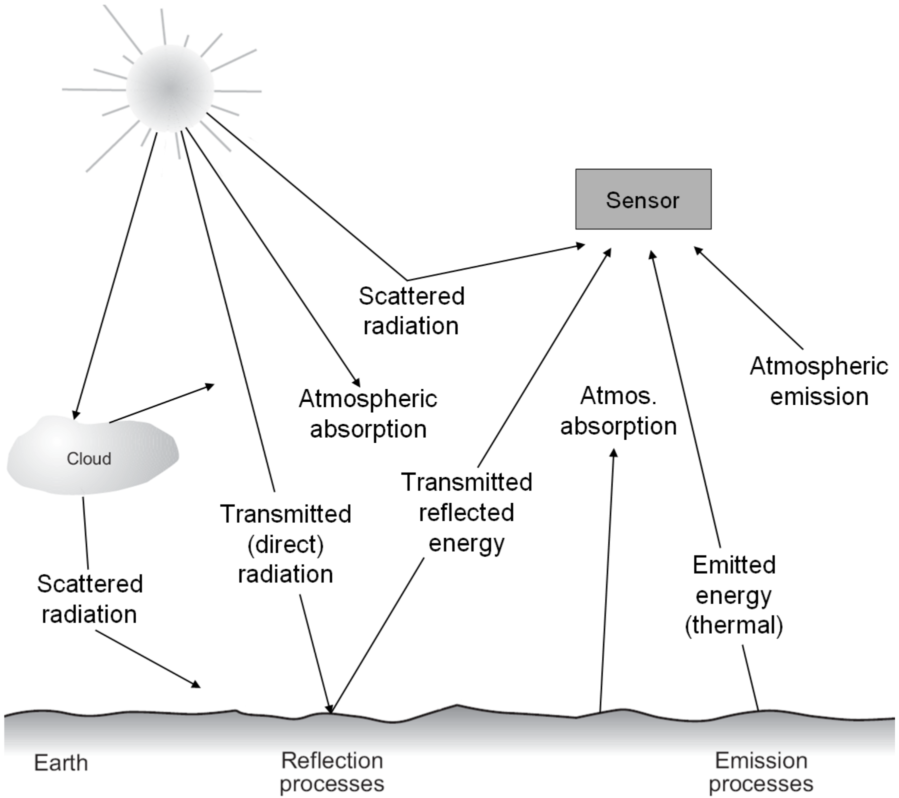
Spectral reflectance curves: bare soils



Spectral reflectance curves: glaciers



Summary



Sensor
Scattered radiation
Atmospheric absorption
Atmos. absorption
Atmospheric emission
Cloud
Transmitted (direct) radiation
Transmitted reflected energy
Emitted energy (thermal)
Scattered radiation
Earth
Reflection processes
Emission processes

Today’s lab

Lab Assignment #2: Spectral transformations

Objectives:

- Explore the use of spectral transforms to investigate the health of vegetation and the extent of snow across Oregon in July 2021.

Deadline: October 12 Tuesday 11:59 pm