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Choose the theme in which to view this presentation:

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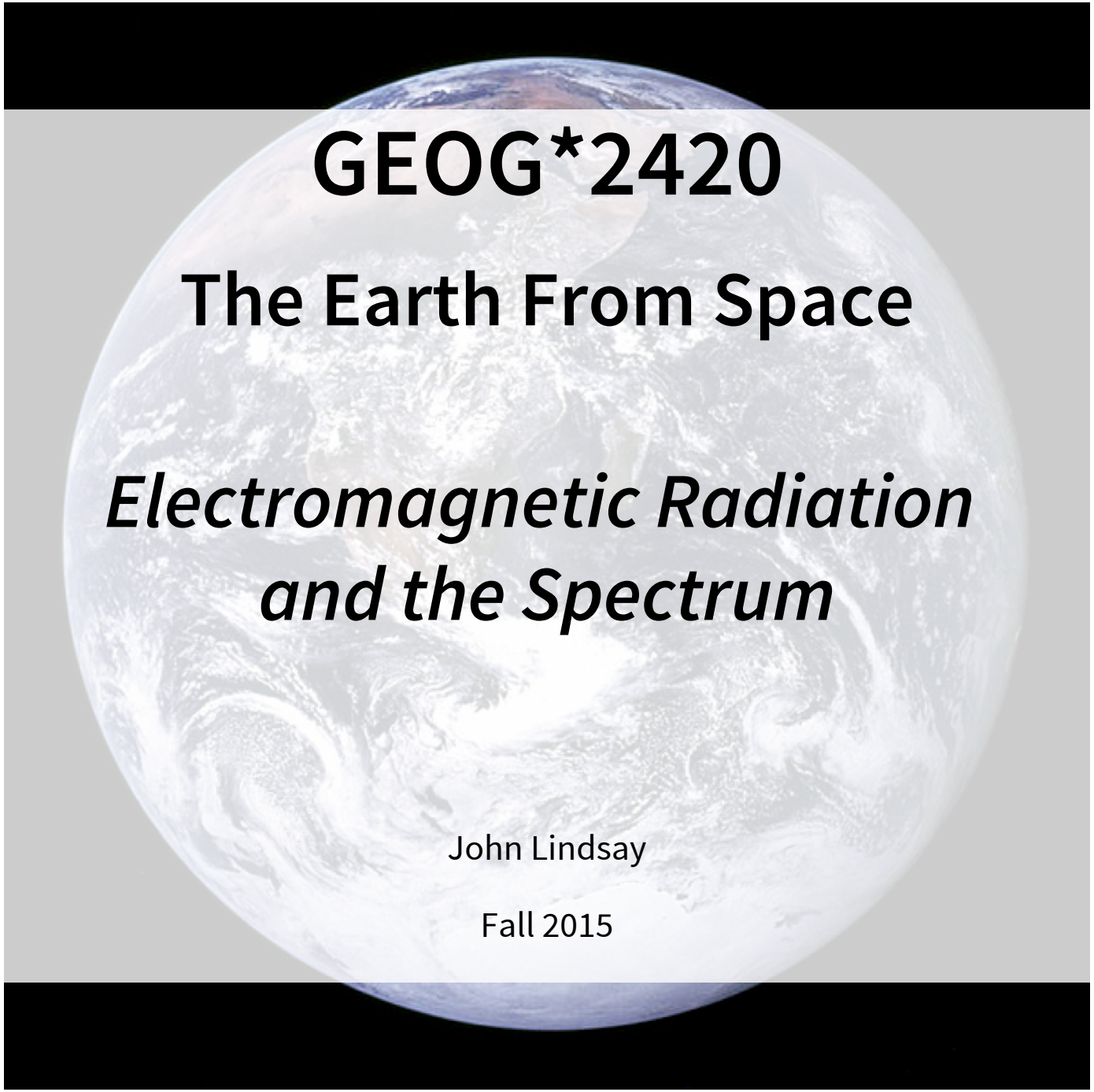


GEOG*2420

The Earth From Space

Electromagnetic Radiation and the Spectrum

John Lindsay

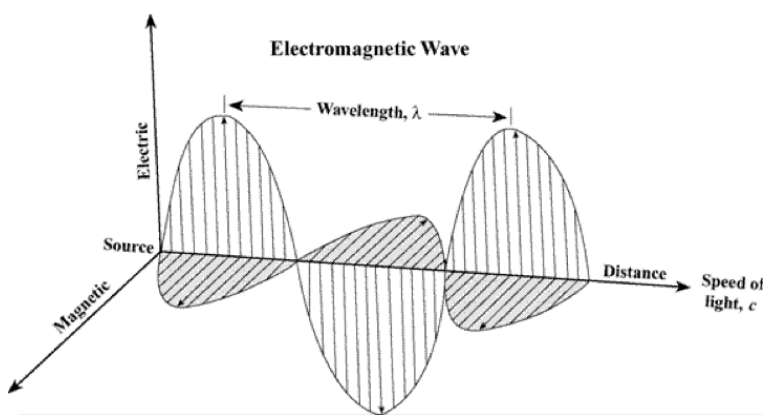
Fall 2015

Readings

JR Jensen Chapter 2

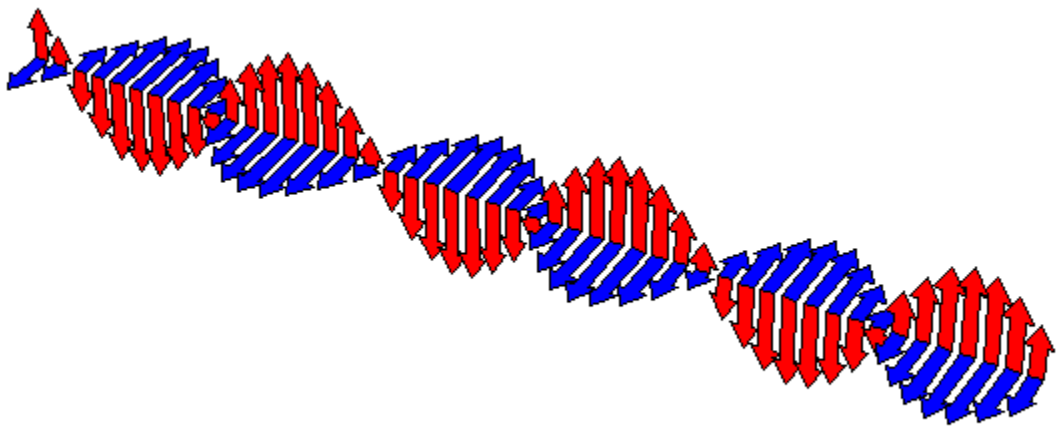
Wave Properties of EM radiation

- Maxwell (1831-1879) conceptualized EMR as wave traveling through space at the speed of light, *c*.
  - $c = 3x10^8$ m/s, enough to circle the Earth 7.5 times a second!
- The EM wave consists of two orthogonal fluctuating fields, one electric and one magnetic.



(source: Jensen, 2007)

Wave Properties of EM radiation



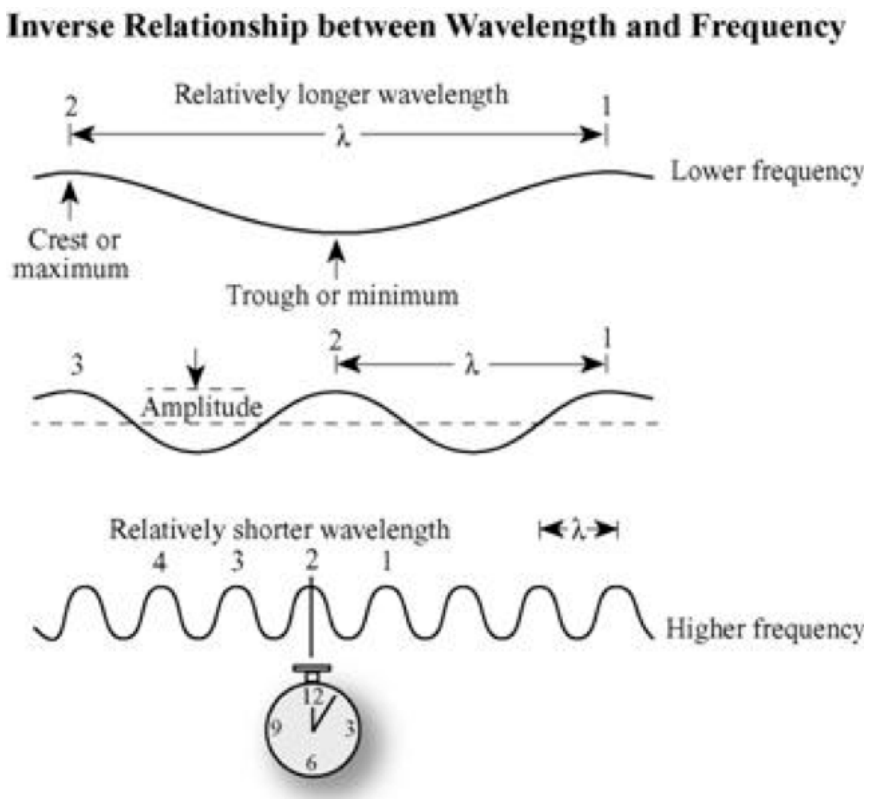
(source: http://www.molphys.leidenuniv.nl/monos/smo/index.html?basics/light_anim.htm)

Properties of EM radiation

- Wavelength (λ) – distance between maximums
- Frequency (ν) – number of wavelengths that pass per unit of time
- Long wave lengths = lower frequency and vice versa
- That is, ν is inversely proportional to λ such that:

$$\nu = \frac{c}{\lambda}$$

Properties of EM radiation

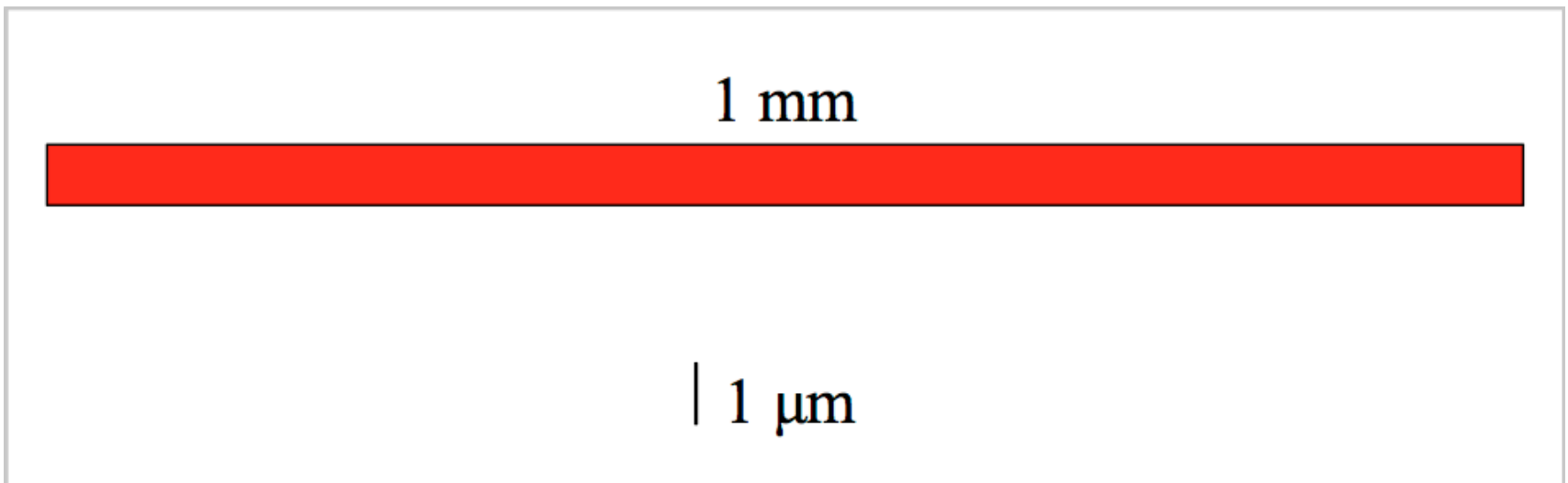


(source: Jensen, 2007)

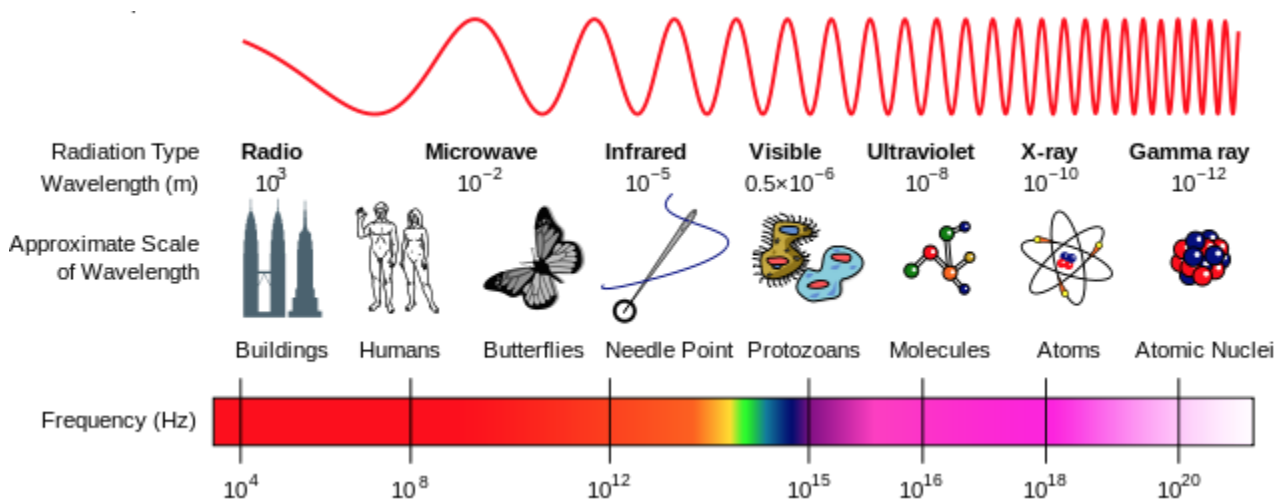
Common Units of Measurement

- Micrometre (not micrometer) µm: one millionth of a metre, 1×10^{-6} m
- Nanometre (nm): one billionth of a metre, 1×10^{-9} m or 1×10^{-3} µm
- Angstrom (Å): 0.1 nanometre or 1×10^{-10} m
- Also cm or metres for longer wavelengths

Common Units of Measurement

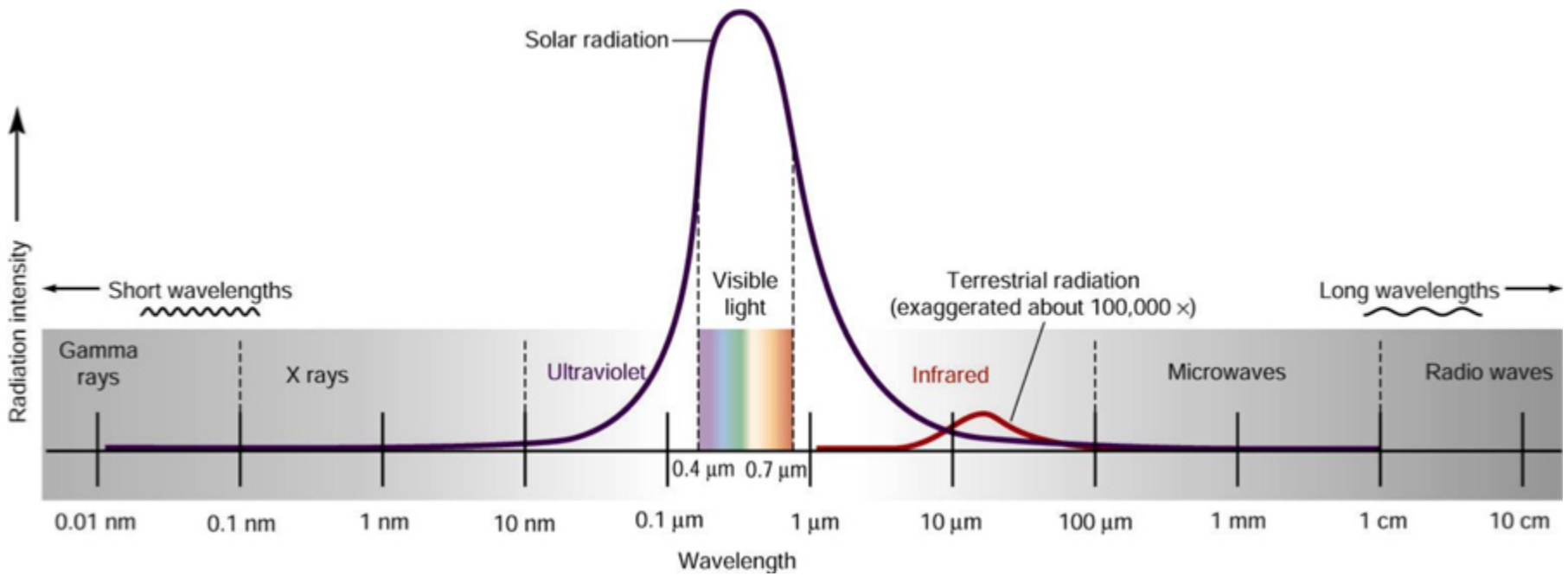


The Electromagnetic Spectrum

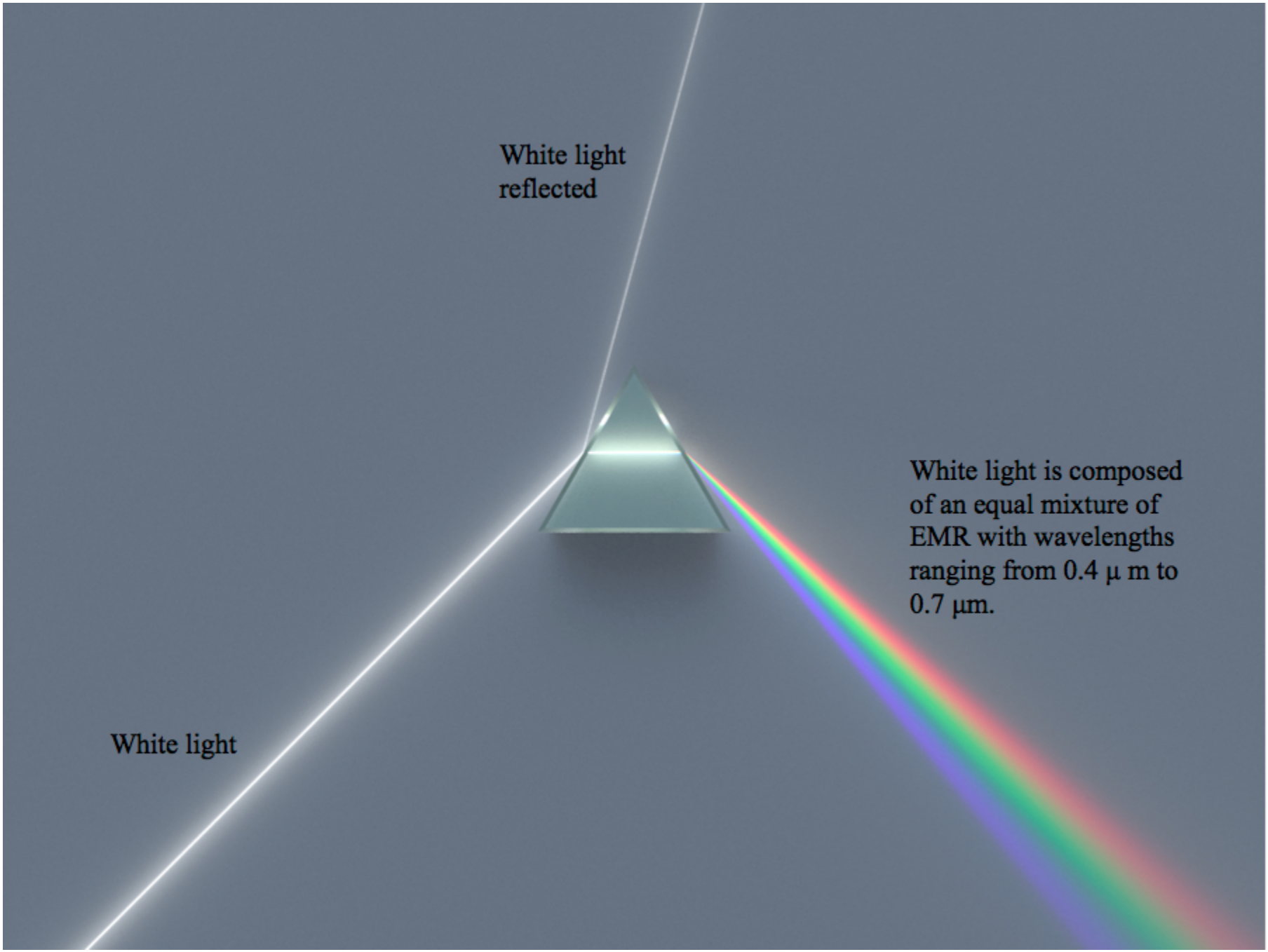


(source: "EM Spectrum Properties edit" by Inductiveload, information by NASA)

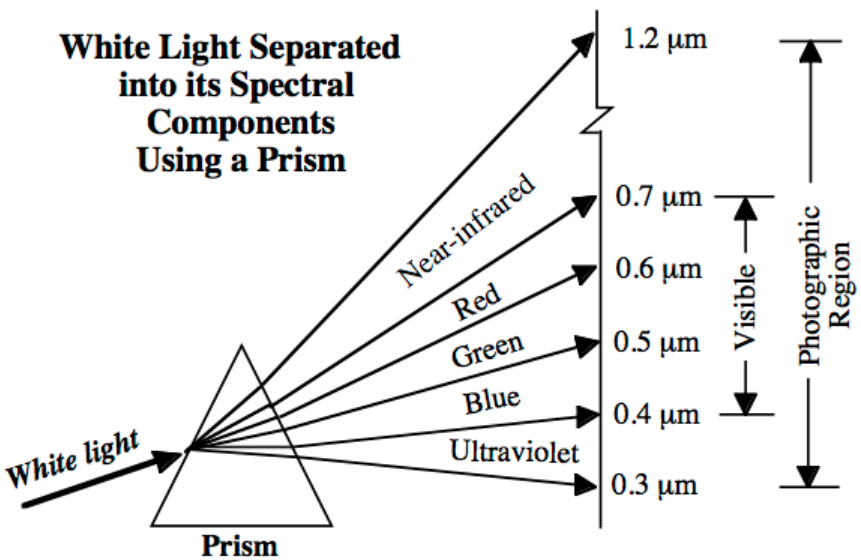
The Electromagnetic Spectrum



(source: Christopherson and Byrne, 2008)


White light
reflected
White light is composed of an equal mixture of EMR with wavelengths ranging from 0.4 μ m to 0.7 μm.
White light

The Electromagnetic Spectrum

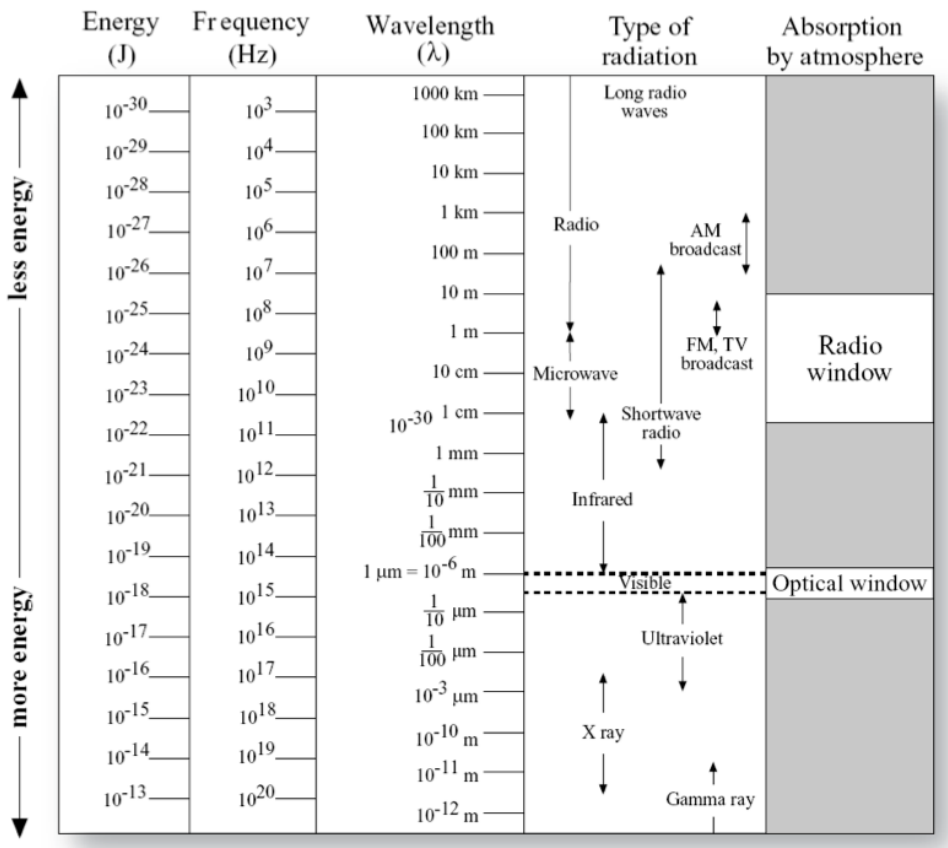


(source: Jensen, 2007)

Portions of the Spectrum Important for Remote Sensing

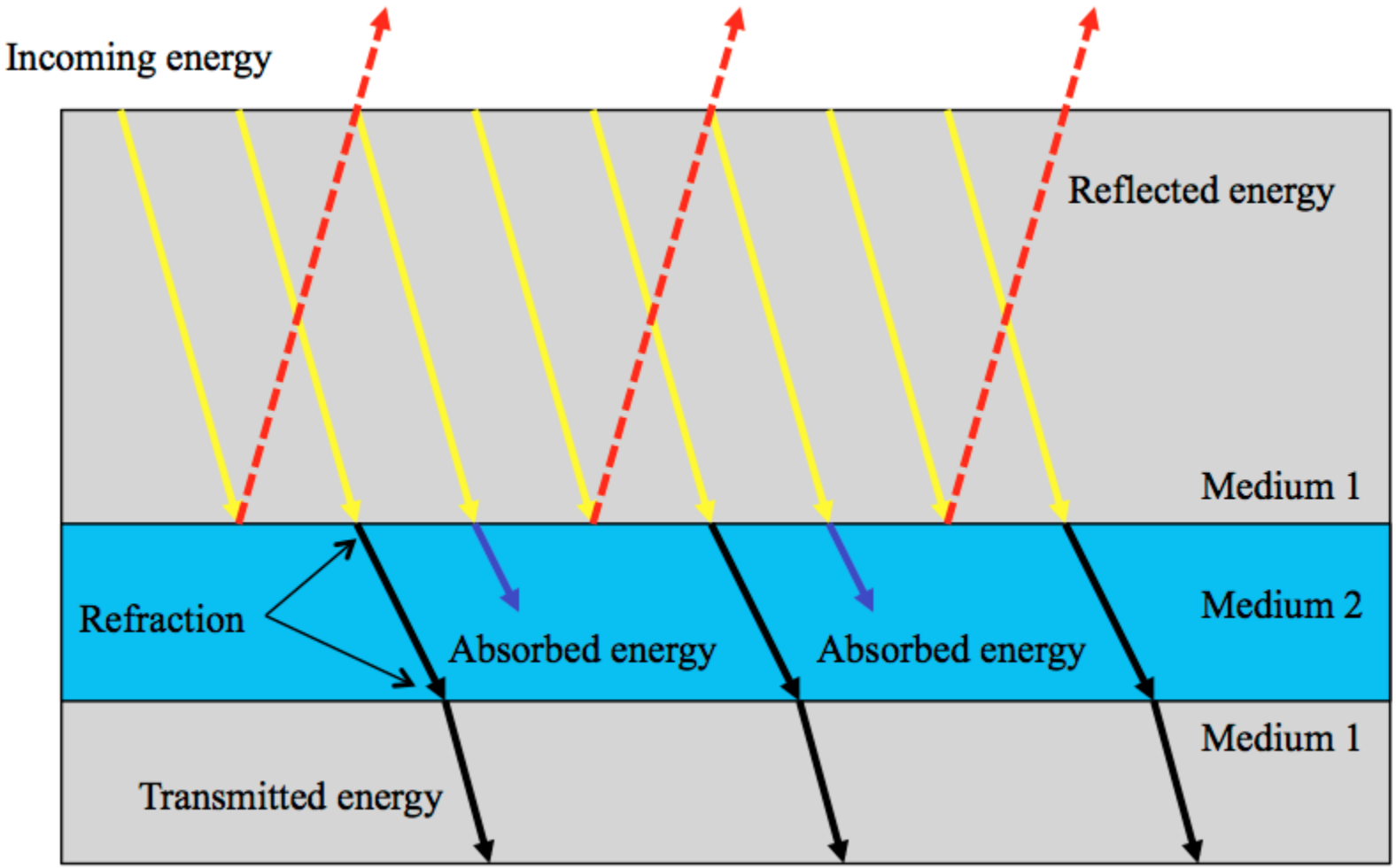
- Ultraviolet: .10 µm — .40 µm
- Visible: .40 µm — .70 µm
  - Blue: .40 µm — .50 µm
  - Green: .50 µm — .60 µm
  - Red: .60 µm — .70 µm
- Infrared: (.7—1) µm — 1000 µm, i.e. 1 mm
  - Near or reflected: (.7—1) µm to 3 µm
  - Mid-infrared: 3 µm to (25–50) µm
  - Far or thermal: (25–50) µm to 1000 µm
- Microwave 0.3 cm to 30.0 cm
- Note: All ranges are approximate

The amount of energy associated with EMR is inversely related to its wavelength



(source: Jensen, 2007)

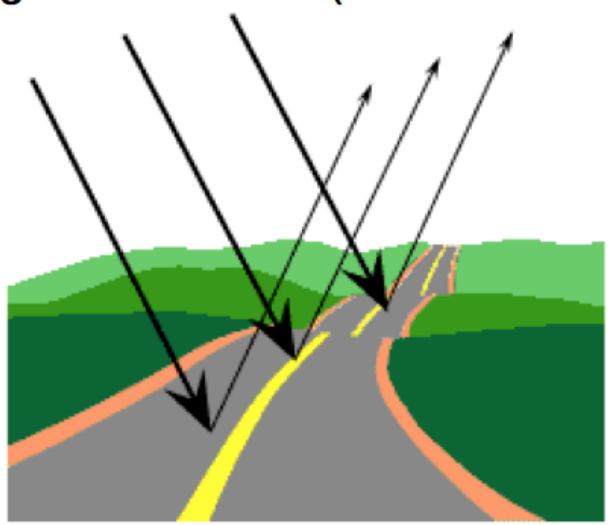
Interaction with matter



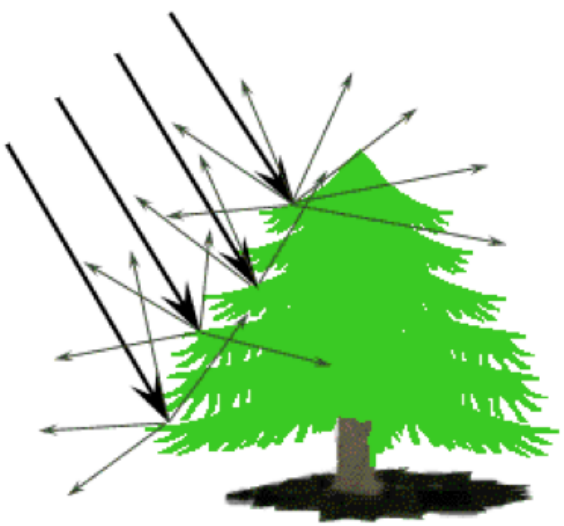
Reflectance

Reflectance is the ratio of energy reflected (bounced off) to the energy incident upon.

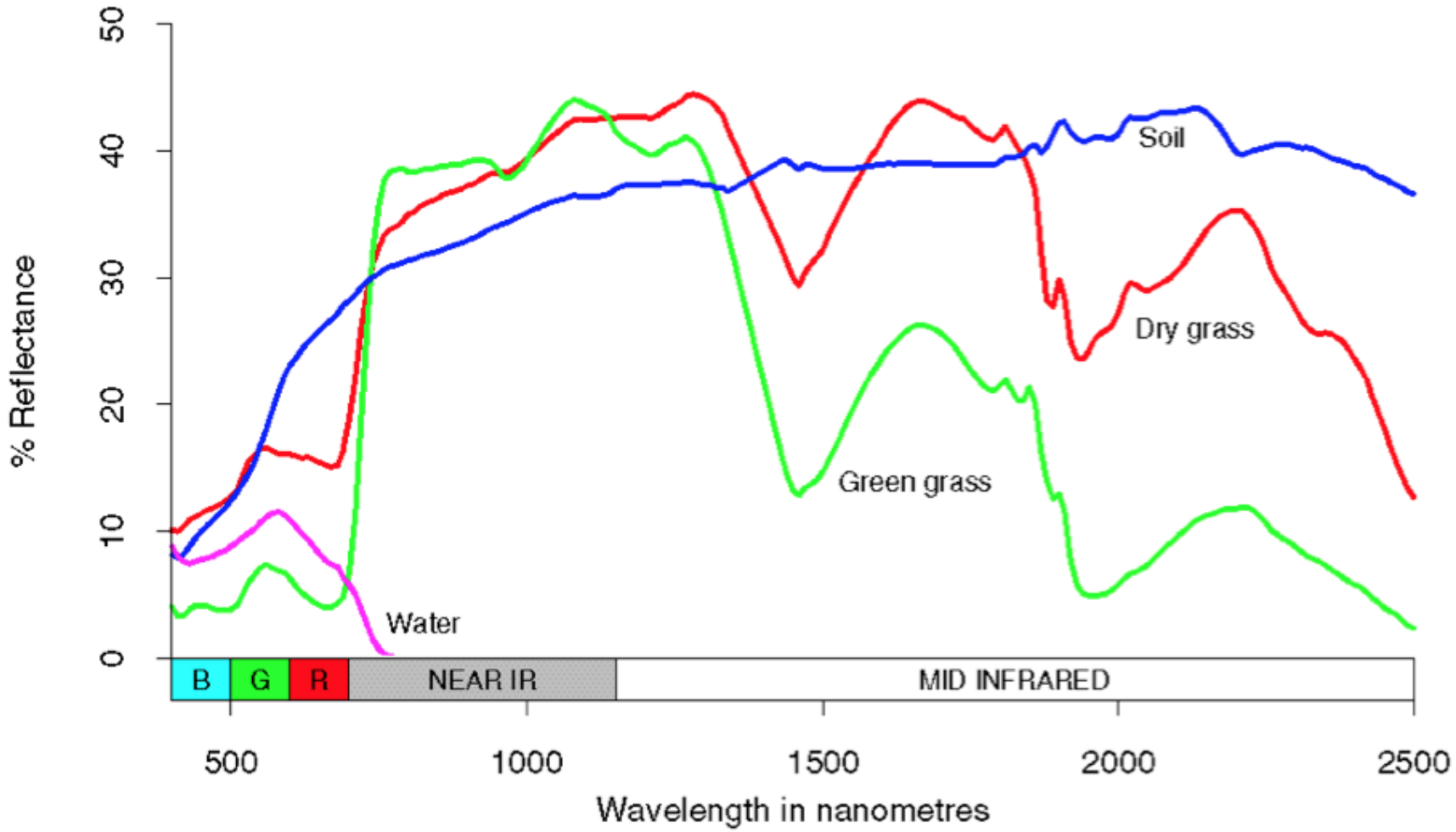
Specular or Mirror-like Reflection: energy is reflected in a single direction equal and opposite to the angle of incidence (smooth surfaces)



Diffuse Reflection: energy is reflected randomly in all directions (rough surfaces)



Reflectance

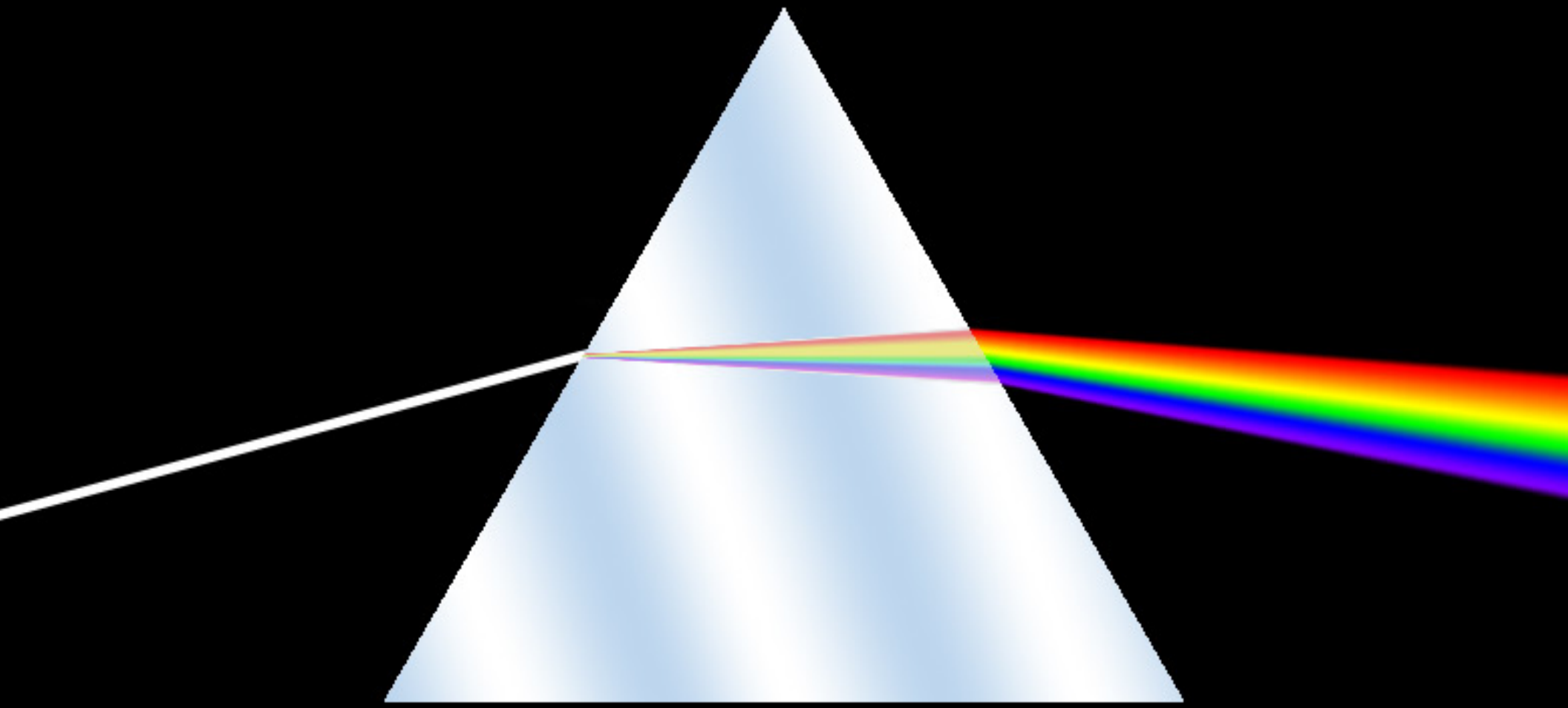


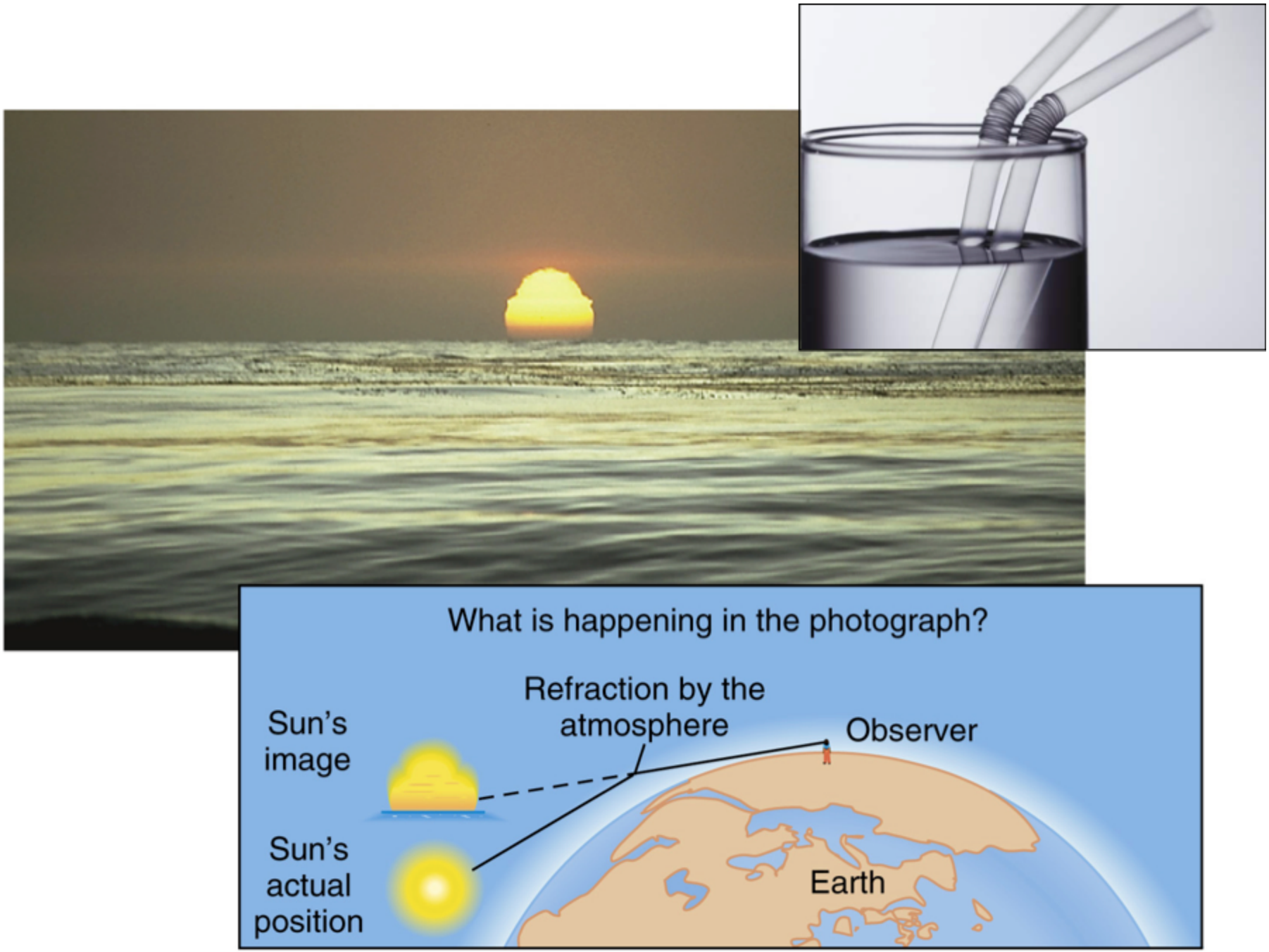
(source: NASA's Observatorium, 1999)

Transmittance and Refractance

- Transmittance is the propagation of energy through a medium.
- Refractance occurs when EMR is transmitted through the interface between materials of different optical density.

Refraction is bending of light due to a change in speed




What is happening in the photograph?
Refraction by the atmosphere
Observer
Sun's image
Sun's actual position
Earth

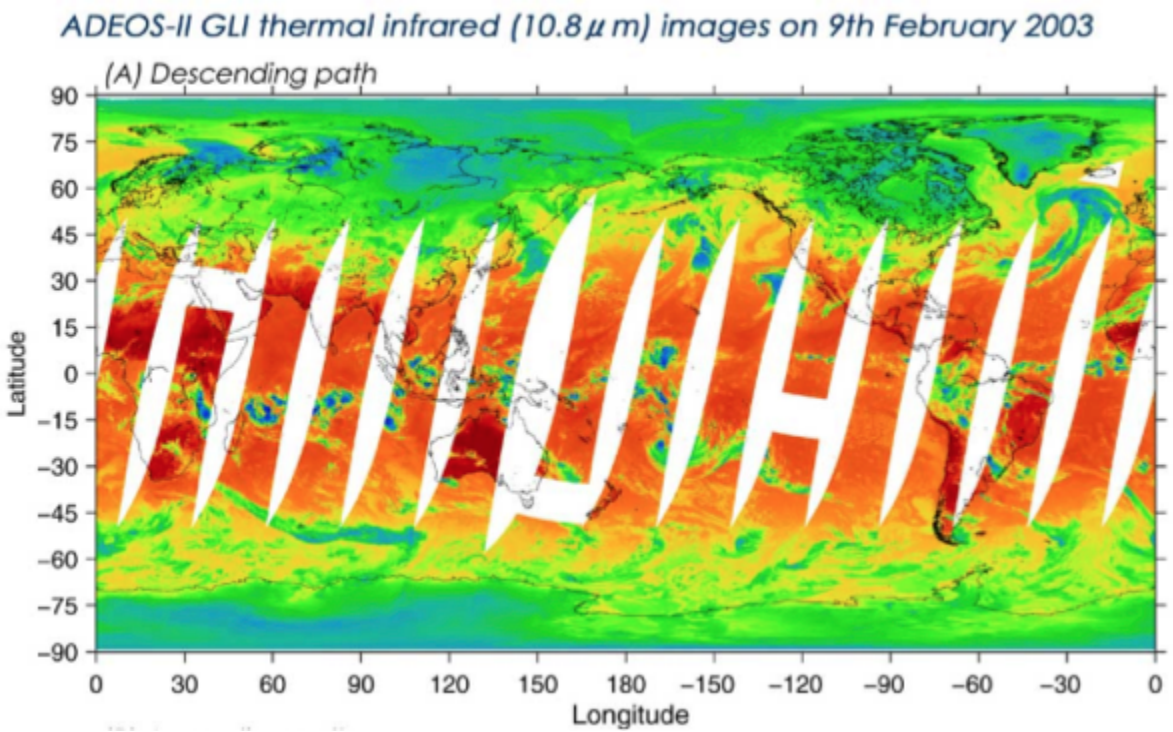
Absorptance

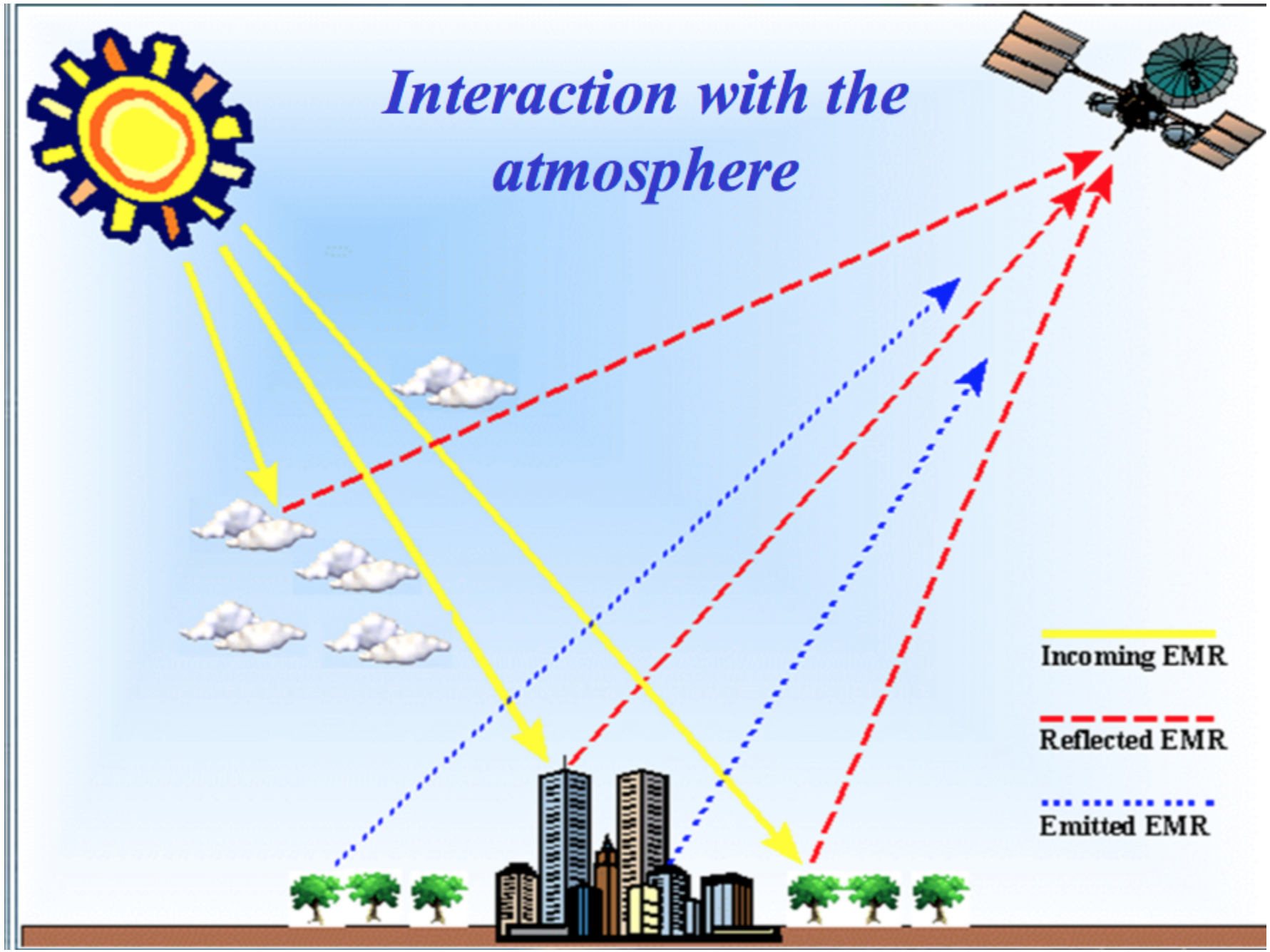
Why is the transmitted light from these filters coloured?

(source: http://www.aoe.com.au/filters.html)

Absorptance

- Absorbed energy is converted to some other form, e.g. heat.
- It is frequently re-radiated (emitted).

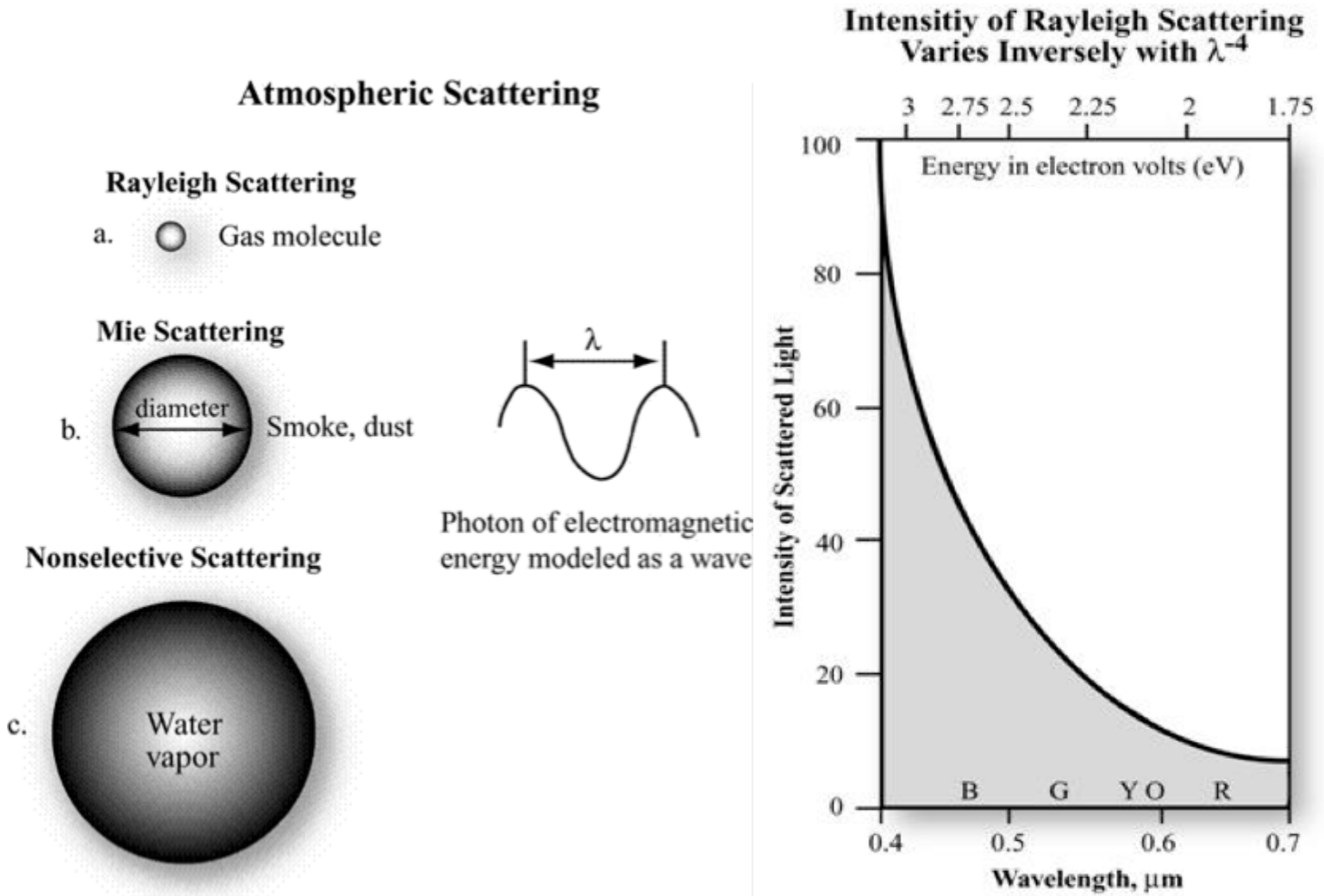



Interaction with the atmosphere
Incoming EMR
Reflected EMR
Emitted EMR

Atmospheric Scattering

- Results in a change in the path of a ray, but not the characteristics of light, i.e. the speed and wavelength.
- **Rayleigh Scattering**: diameter of matter is smaller (<0.1) than λ
- **Mie Scattering**: due to particles approximately equal to the λ (dust, pollen, water vapour)
- **Non-selective Scattering**: due to large particles (water droplets)

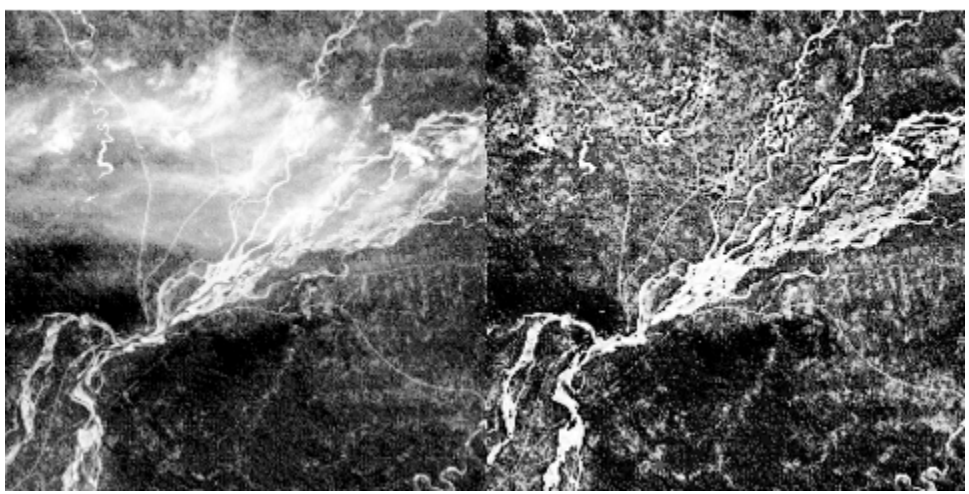
Atmospheric Scattering



(source: Jensen, 2007)

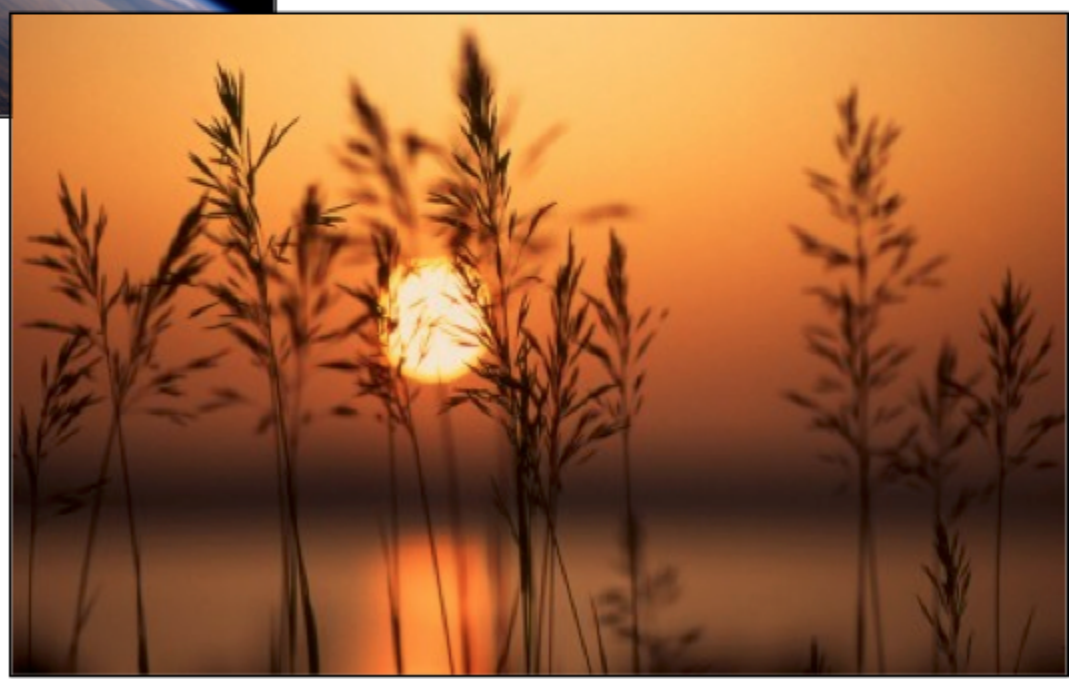
Atmospheric Scattering

Scattering degrades radiometric differentiation



(source: Unknown)

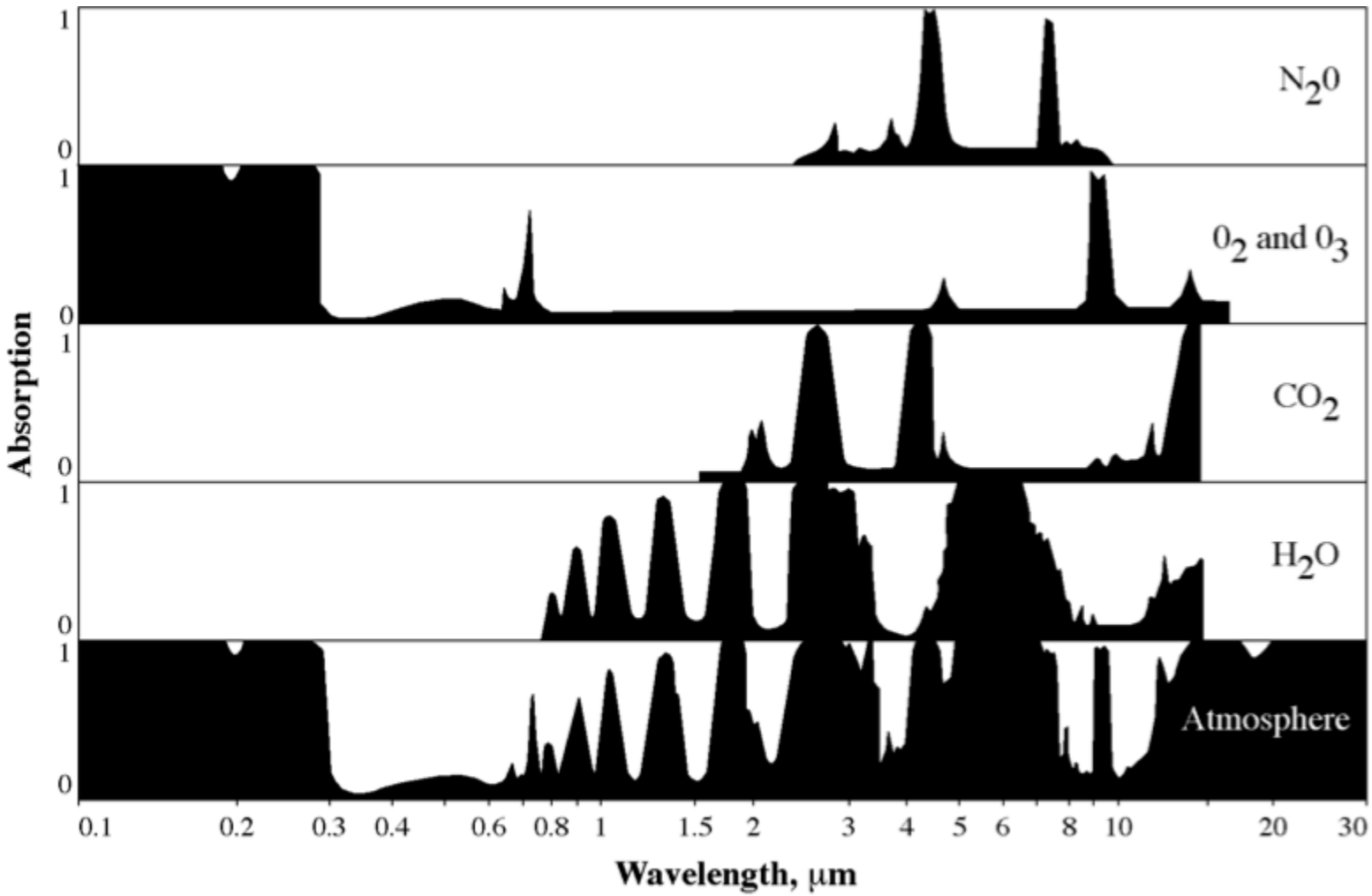
The blue sky results from the preferential scattering of the shorter blue wavelength of visible light...Rayleigh scattering!



Atmospheric Absorption

- Absorption occurs in the atmosphere due to interaction with water, carbon dioxide, ozone and nitrous oxide.
- This gives the atmosphere absorption bands where no EMR at a certain λ is available for remote sensing.

Atmospheric Windows



Black regions = absorption bands; white regions = atmospheric windows

(source: Jensen, 2007)