Terminology

Radiant Energy (J)

Radiant Flux (J/s) \( \Phi \)

Radiant Flux Density (W/m\(^2\))

Irradiance (incident)
Radiant Exitance (emitted)

Radiant Spectral Flux Density (W/m\(^2\)/\(\mu\)m)

Most sensors yield these values

Radiant Intensity (W/sr) \( I \)

Radiance (W/m\(^2\)/sr)
Spectral Radiance (W/m\(^2\)/sr/\(\mu\)m) \( L_\lambda \)
Radiance Theorem: Radiance is conserved through a lossless medium

\[ L_0 = \frac{d^2\Phi \cdot r^2}{dA_0 \cos \theta_0 \, dA_1 \cos \theta_1} \]

\[ L = \frac{d^2\Phi}{dA \cos \theta \, d\Omega} \]

\[ d\Omega_0 = \frac{dA_1 \cos \theta_1}{r^2} \]
Radiance Theorem: Radiance is conserved through a lossless medium

\[ L = \frac{d^2\Phi}{dA_0 \cos \theta_0 \, d\Omega} \]

\[ L_0 = \frac{d^2\Phi \cdot r^2}{dA_0 \cos \theta_0 \, dA_1 \cos \theta_1} \]

\[ L_1 = \frac{d^2\Phi \cdot r^2}{dA_1 \cos \theta_1 \, dA_0 \cos \theta_0} \]

\[ L_0 = L_1 \]
Vibrational Energy

- Bonds in molecules act like springs.
- Vibrations can be
  - Symmetrical
  - Asymmetrical, and
  - Bending.

http://www.sbu.ac.uk/water/vibrat.html
Photopigments

Photosynthesis in plants:

\[6CO_2 + 6H_2O + h\nu \rightarrow C_6H_{12}O_6 + 6O_2\]

\text{sucrose}

- The frequency (wavelength) must be correct to be absorbed by some participant(s) in the reaction
- Some structure must be present to allow the reaction to occur

Chlorophyll:
Absorption of Visible Light by Photopigments

- Sunlight
- Chlorophyll b
- Phycocyanin
- B-Carotene
- Chlorophyll a

Wavelength, nm

Lehninger, Nelson and Cox
(a) Idealized absorption spectra

(b) Effects of broadening isolated for each of the lines shown in (a)

(c) Cumulative absorption spectra

Figure 3.14 Characteristics of absorption spectra.
Alunite as seen by three systems

- 5-10 nm
- 10-50 nm
- ~65-250 nm

Reflectance + Offset

Wavelength (μm)

FWHM

MODIS

TM

LAB
Absorption of EMR by Gases in the Atmosphere
The amount of radiation absorbed may be measured in a number of ways:

**Transmittance**, \( T = \frac{P}{P_0} \)

**% Transmittance**, \( \%T = 100 \times T \)

**Absorbance**, \( A = \log_{10} \frac{P_0}{P} = \log_{10} \frac{1}{T} = \log_{10} \frac{100}{\%T} = 2 - \log_{10} \%T \)

\( \Phi_0 (W) \), i.e., power in

\( P_0 \)
Unit volume ($l^3$) containing $m'$ absorption centers. Large enough mean free path that in a small volume, projecting the molecules onto one face results in no overlaps.
Atmospheric Structure
Continuously varying atmosphere

Approximation with 3 homogeneous layers
Figure 4.3  Contribution to downwelled radiance (or irradiance) from a unit volume.
(a) Plot of downwelled radiance from the morning sky in the visible region of the spectrum.
(b) Plot of downwelled radiance from the morning sky in the LWIR region of the spectrum.
Figure 4.4  Procedure for calculation of the angular downwelled radiance.
Figure 3.1  Solar energy paths.

Figure 3.3  Self-emitted thermal energy paths.