CHAPTER 2: Radiometric Measurements Principles

REFERENCE: Remote Sensing of the Environment
Pearson Prentice Hall
Energy-matter interactions in the atmosphere at the study area and at the remote sensor detector.
RADIANT ENERGY (Q):
is the energy carried by a photon.
Unit: Joules (J)

RADIANT FLUX (Φ):
is the time rate of flow of radiant energy.
Unit: watts (W = J s\(^{-1}\))

\[ Φ = \frac{dQ}{dt} = \text{Joules} = \text{Watts} \]

seconds

A derivative is the instantaneous rate of change of a function.
RADIANT INTENSITY (I):

Is a measure of the radiant flux proceeding from the source per unit solid angle in a specified direction.

Unit: watts steradian$^{-1}$

\[ I = \frac{d\Phi}{d\omega} = \text{watts steradian} \]

Solid Angle ($\omega \cdot \Omega$):
Is equal to the spherical surface area ($A$) divided by the square of the radius ($r$).

Unit: steradian

\[ \Omega = A/r^2 \]
Radiance (L)

Radiance in certain wavelengths ($L_\lambda$) is:

- the radiant flux ($\Phi$)
- per unit solid angle ($\Omega$)
- leaving an extended source area in a given direction ($\theta$)
- per unit projected source area ($A$)

Units:
- watts per meter squared per steradian ($W \text{ m}^{-2} \text{ sr}^{-1}$)

$L_\lambda = \frac{\Phi_\lambda}{\Omega A \cos \theta}$

$L$ is a function of direction, therefore the zenith and azimuth angles must be considered.
The concept of **radiance** leaving a specific projected source area on the ground, in a specific direction, and within a specific solid angle.
FIELD RADIOMETRY

Radiance ($L_\lambda$)

Radiance ($L$)
REFLECTANCE

\[ R(\lambda) = \frac{\text{Sample Radiation (}\lambda\text{)}}{\text{Reference Radiation (}\lambda\text{)}} \times 100 = \text{Reflectance Percent} \]
REFLECTANCE

Reflectance spectra of rocks and vegetation

Wavelength, microns (10^-6 metres)

Reflectance, %

Vegetation, Sandstone, Limestone, Shale

Atmospheric Absorption Bands

Band 4, Band 5, Band 7

Reflect IR Wavelengths
RADIANCE FLUX DENSITY

Irradiance is a measure of the amount of radiant flux incident upon a surface per unit area of the surface measured in watts m\(^{-2}\).

Exitance is a measure of the amount of radiant flux leaving a surface per unit area of the surface measured in watts m\(^{-2}\).
RADIANCE & IRRADIANCE

Irradiance (E)

\[ L_\lambda \]

\[ \text{diffuser} \]

\[ \text{filter} \]

\[ \text{detector} \]

\[ E_\lambda (\vec{r}, \vec{n}; \lambda) \]
REMOTE SENSING REFLECTANCE

It is a measurement of how much downwelling light that hits a surface is reflected by the object.

\[ R_{rs} = \frac{L_w}{E_d} = \text{upwelling radiance} \]  
\[ \text{Ed} \quad \text{downwelling irradiance} \]

Unit: steradians\(^{-1}\)
REMOTE SENSING REFLECTANCE

![Graph showing Remote Sensing Reflectance (sr-1) vs Wavelength (nm) for different substances. The graph includes lines for Rrs Sand, Rrs Algae, and Rrs Coral. The y-axis ranges from 0 to 0.06, and the x-axis ranges from 300 to 900 nm.]
Digital values from the images are converted to calibrated radiance values at different wavelengths (bands).