The Energy Source

Remote sensing requires information to be transmitted from one place to another.

A source of energy is required to carry the information. *ElectroMagnetic energy*

EM energy can be described as waves.

All EM waves can be described with: $$s = \lambda f$$

where

$\mathbf{s}$ = speed of the wave - *(m/sec)*
λ = wavelength of the wave - *(m/cycle)*
$\mathbf{f}$ = frequency of the wave - *(cycles/sec (Hz))*

A continuum of wavelengths is called a *spectrum*.
A subset of that continuum is called a *band.*

The visible *band* of wavelenths is part of the full *spectrum* of EM radiation. Within the visible spectrum, blue light represents a band of short λ while red light represents a band of longer λ.

The λ of the energy determines its: depth of penetration,
absorbtion by the medium
spatial resolution

All matter emits EM radiation. Energy emitted by a blackbody is described by:

Stefan-Boltzman Law	and	*Wien's Displacement Law*
$M = \sigma T^4$		$\lambda_m = \frac{A}{T}$

where

M = radiant exitance ($W\ m^{-2}$)	λ_m = wavelength of peak exitance (μm)
σ = constant ($W\ m^{-2}\ K^{-4}$)	A = constant (μm °K)
T = material temperature (°K)	T = material temperature (°K)

What gets through the atmosphere

Between the sensor and the target, EM radiation must pass through the atmosphere at least once - sometimes twice.

EM radiation interacts with the atmosphere by:

Scattering

Rayleigh Scattering - from particles *smaller* than the λ of the energy source, (e.g. atmospheric molecules) and is proportional to λ^{-4}.

Nonselective Scattering - from particles *larger* than λ of the energy source, (e.g. water droplets) and is independent of λ.

Absorbtion

H_20, CO_2, O_3 in the atmosphere absorb specific bands of EM energy and act as filters, creating atmospheric "windows" through which energy can pass.

The λ and amount of energy that arrives at the surface of the earth is determined by both the solar irradiance spectrum (how much enters the top of the atmosphere) and the atmospheric gasses that control the "windows".

What happens to the energy that gets through?

EM energy incident on the earth is *Reflected*, *Absorbed* and *Transmitted*.

By Conservation of Energy:

$$E_I(\lambda) = E_R(\lambda) + E_A(\lambda) + E_T(\lambda)$$

This depends on the λ of the energy and the properties of the target material.

Transmitted energy doesn't come back.
Absorbed energy is re-emitted in a different band (e.g. thermal IR).
Reflected energy comes back in different forms, depending on λ and the surface properties.

Specular reflector - perfect 1 directional reflection from a *smooth* surface.
Diffuse reflector - perfect omni-directional relflection from a *rough* surface.

Most materials lie somewhere between the two perfect reflectors.

If the λ of the energy is much shorter than the surface roughness then the reflection will be more diffuse. This determines the choice of λ energy for active and passive source systems.

Active source systems, such as altimeters, measure the *distance* from the sensor to the target and therefore require most energy to be reflected in a single direction. Therefore, these systems generate their own *longer* λ *energy* such as radar. Other active source systems measure the surface properties (e.g. roughness, wetness) of the target and the fraction of backscattered energy at the scale of the particular λ used.

Passive source systems, such as scanners and radiometers, rely on diffuse reflection and measure the *reflectance* and *emittance* of the target material at specific *shorter* λ using the sun and the earth as energy.

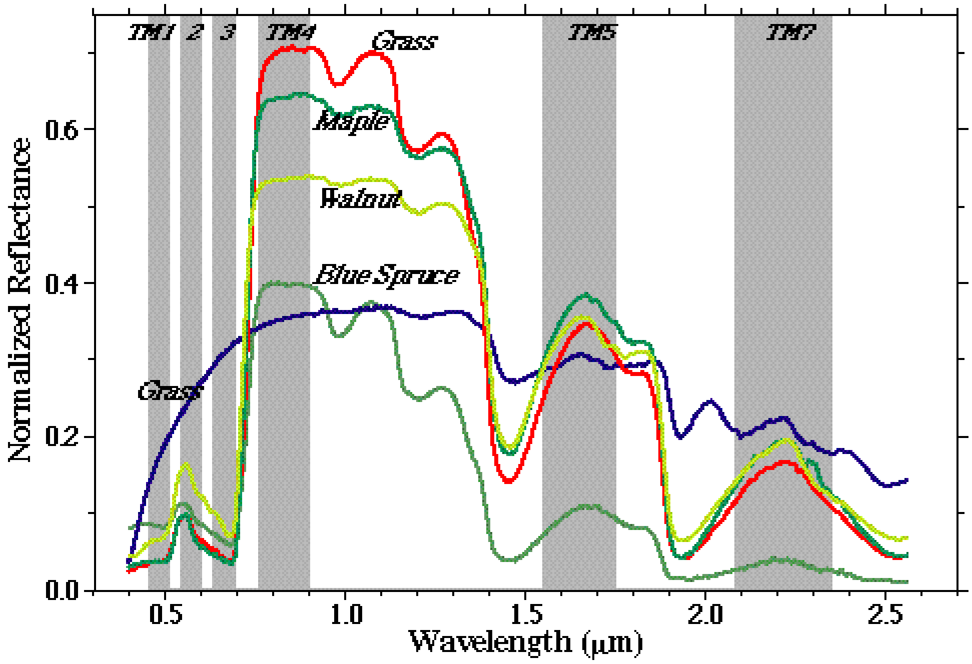
The *albedo* of a material refers to how much (%) incident energy it reflects and absorbs. Very reflective materials have a high albedo.

Different materials absorb and reflect different amounts of EM energy depending on the λ of the energy. The reflectance of a material at different λ is given by its *spectral reflectance pattern.*

MultiSpectral scanners can distinguish different materials by exploiting differences in the spectral reflectance patterns of different target materials. Intelligently designed sensors take into account the atmospheric windows.

Reflectance patterns of target materials, such as soils and vegetation, are not constant but depend on time varying factors such as water content. Temporal variation in reflectance patterns can be exploited to monitor changes in environmental conditions such as soil moisture and vegetation health.

Vegetation exhibits characteristic reflectance patterns as a result of chlorophyl and leaf structure. Most green plants show low reflectance in visible red and blue bands with stronger reflectance in visible green and very strong reflectance in the VNIR. This characteristic reflectance makes it possible to discriminate between vegetation and other target materials and to estimate vegetative biomass.



Rocks and soils also exhibit characteristic reflectance patterns as a result of molecular absorbtion of specific elements (e.g. iron) in the minerals on the target surface. Characteristic differences between the surface reflectance and emissive properties of rocks makes it possible to further discriminate rock types using combinations of visible, reflected IR and thermal IR radiation.