ESPM 10 April 3, 2001 Lecture Material and References

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Lecture Materials

Remote Sensing—Tool; Electromagnetic spectrum; expands potential info.

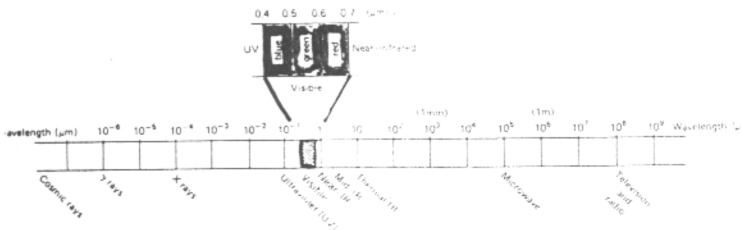


Figure 1.3 The electromagnetic spectrum.

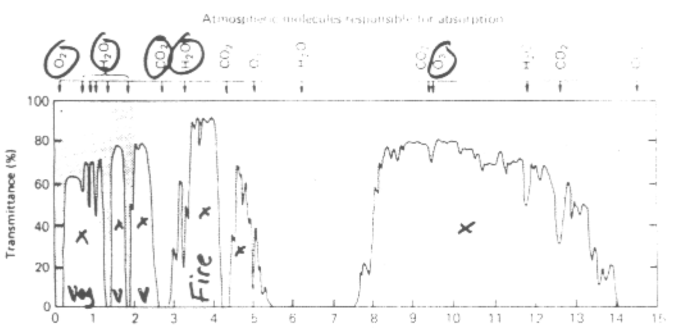


Figure 5.14 Atmospheric absorption of the wavelength range 0 to 15 μm. Note the presence of atmospheric windows in the thermal wavelength regions 3 to 5 μm and 8 to 14 μm. (Adapted from [24].)

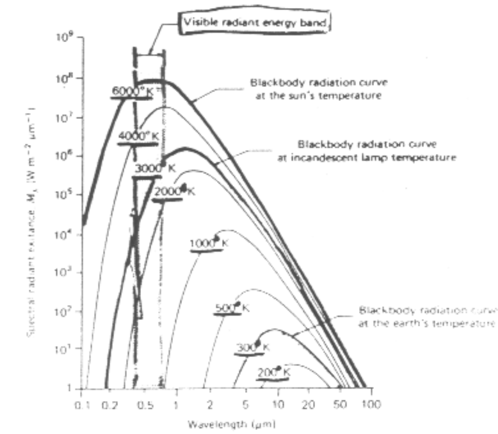


Figure 1.4 Spectral distribution of energy radiated from blackbodies of various temperatures. (Note that spectral radiant exitance M_λ is the energy emitted per unit wavelength interval. Total radiant exitance M is given by the area under the spectral radiant exitance curves.)

Remote Sensing Terminology -- **Resolutions**

Spectral – what wavelengths **Spatial -- area measured**

Radiometric – how many levels **Temporal – how often measured**

Human Eye: 400 – 700 nanometers; ~1-3 cm @ 20 m; 16-32 b/w or ~ 100 colors
Information on the human eye can be found in:Sensation and Perception by Coren, S., Ward, L.M., and Enns, J. T., 5th Edition. ISBN: 0155080504 (1999), among many other sources.

Remote Sensing Systems: Thaddeus Lowe's balloons; Corona; electro-optical systems (Landsat, Ikonos, Seawifs, GOES, AVHRR, MODIS, etc.)
History of Remote Sensing: **Thaddeus Lowe and his American Civil War Balloons** can be found at http://www.civilwarhome.com/lowebio.htm
A good reference book on the **Corona program** is: *Eye in the Sky: The Story of the Corona Spy Satellites*. 1999, Day, D. A., Logsdon, J.M., and Latell, B. editors. Smithsonian Inst. Press, ISBN 1560988304 and on the web at http://hallhistory.com/military/114.shtml. For more information, go on Google and look for "Corona Spy Satellite".

Electromagnetic Radiation Equations:

1. Speed of light = $3*10^8$ m/seconds = wavelength * frequency = c

2. Planck's equation, or the energy radiated by a body of a given temperature:

$$M_\lambda = \frac{2 \pi h c^2}{\lambda^5 \cdot (e^{hc/\lambda k \cdot T} - 1)}$$

λ = wavelength; h = ~$6.6*10^{-34}$ j.sec; k=$1.38*10^{-23}$ j/K (Planck's constant); T = temperature (K)

3. Total energy flux (all wavelengths) can be approximated by $= \sigma T^4$

where $\sigma = 5.67 * 10^{-8}$ w/(m^2*K^4) S. Boltz. constant

4. Wavelength of maximum energy flux can be determined by **Wien's Law**:

Wavelength max (micrometers) = 2893/T

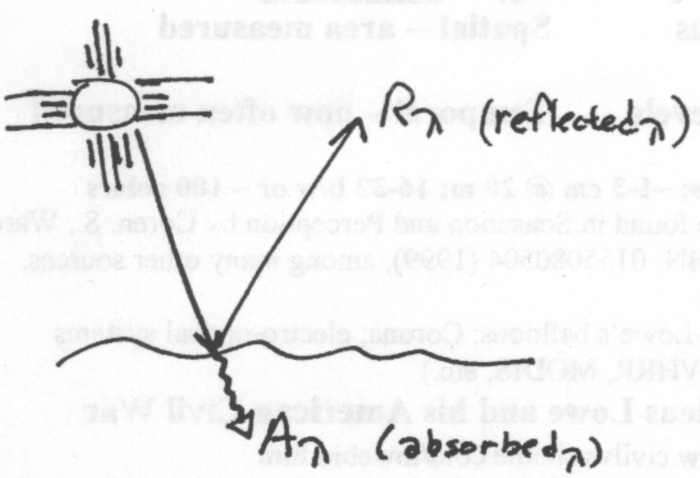
Sun's temperature = ~5900 Kelvin. Kelvin temperature = C + 273
Maximum flux thus at 2893/5900 = 0.5 micrometers or 500 nanometers

Spectral reflectance, spectral transmission, and spectral absorption

$R_\lambda + T_\lambda + A_\lambda = 1.0$

$R = \frac{\text{Reflected flux}_\lambda}{\text{Incoming flux}_\lambda}$

$A = \frac{\text{Absorbed}_\lambda}{\text{Incoming}_\lambda}$



T = intermediate form

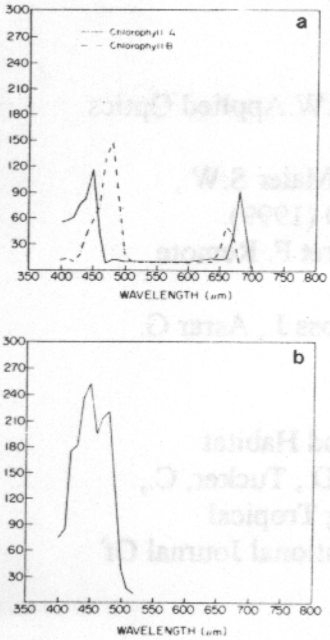
$R_\lambda + A_\lambda = 1.0$

Background information on remote sensing can be found on Prof. Gong's ESPM web site: http://www.CNR.Berkeley.EDU/~gong/textbook/

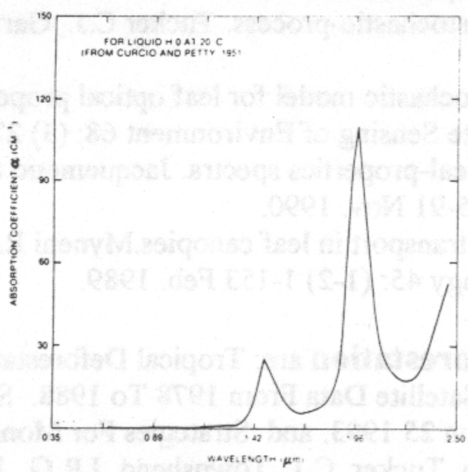
How Plants reflect light: Reflection = Incoming Flux - Absorption

What absorbs? Chlorophyll, caroteoids, liquid water

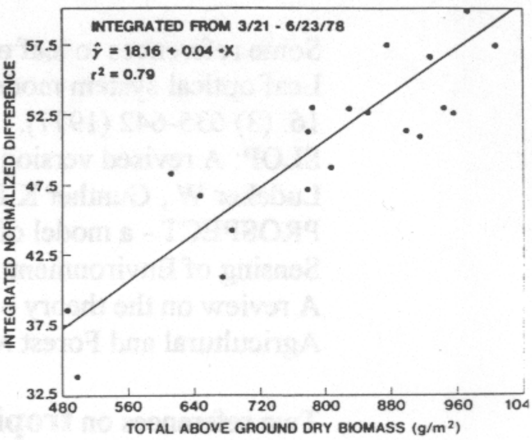
Absorption curves for cholorophyll, carotenoids, and water look like these:



ABSORPTION COEFFICIENTS OF LIQUID H_2O



ABSORPTION COEFFICIENTS OF PLANT PIGMENTS



AVHRR data and African semi-arid grasslands 1399

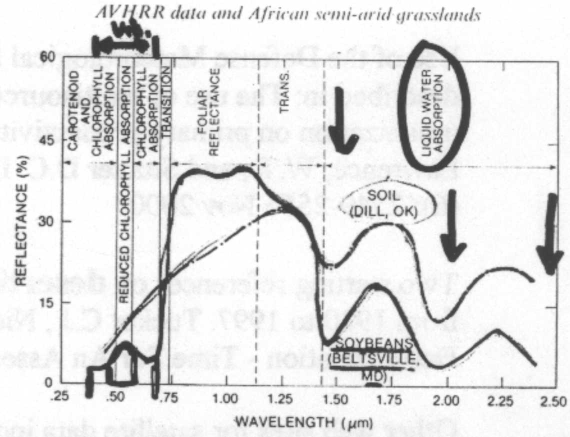
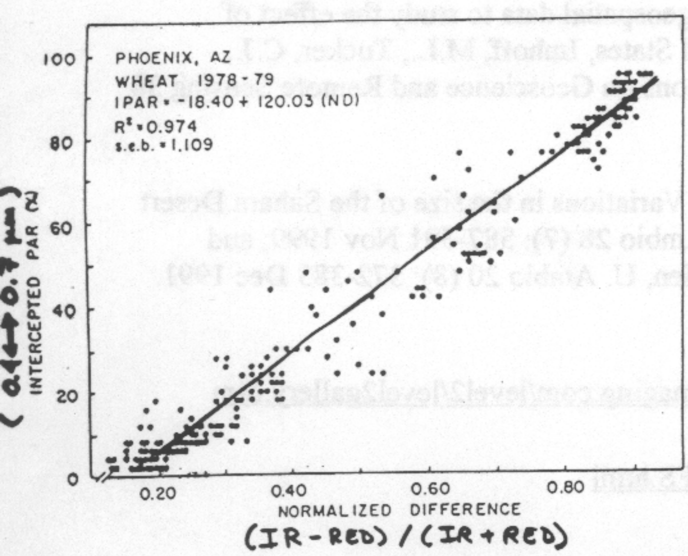


Figure 3. Delineation of the 0·4–2·5 μm region into spectral intervals where different biophysical properties of green vegetation control the reflectance of incident solar irradiance from the vegetation in question. Sample spectral reflectance curves for green vegetation and soil are also included to illustrate why some wavelengths have greater spectral contrasts than others.



Near Infrared and **Red** reflected radiation is directly related to the **absorbed PAR**

absorbed PAR drives **photosynthesis,** ergo Near Infrared and Red provide

a remote sensing estimate of the **potential** or **capacity** for photosynthesis

can be applied from ground, from air, and from space

Scanning Electron Micrographs of leaves can be found at:
http://www.atmos.berkeley.edu/~still/images/

out-of-print books on this topic are:
Probing Plant Structure; A Scanning Electron Microscope Study of Some Anatomical Features in Plants and the Relationship of These Structures to Physiological Processes. John Troughton and Lesley A. Donaldson, circa 1970 something. and *Plants; A Scanning Electron Microscope Survey*. John Troughton, circa 1970 something.

Some references to leaf optical properties are:
Leaf optical system modeled as a stochastic-process. Tucker C.J., Garratt M.W.Applied Optics 16: (3) 635-642 (1977).
SLOP: A revised version of the stochastic model for leaf optical properties. Maier S.W., Ludeker W., Gunther K.P., Remote Sensing of Environment 68: (3) 273-280 (1999).
PROSPECT - a model of leaf optical-properties spectra. Jacquemoud S., Baret F. Remote Sensing of Environment 34: (2) 75-91 Nov. 1990.
A review on the theory of photon transport in leaf canopies.Myneni R.B., Ross J., Asrar G. Agricultural and Forest Meteorology 45: (1-2) 1-153 Feb. 1989.

Two references on **tropical deforestation** are: Tropical Deforestation and Habitat Fragmentation in The Amazon - Satellite Data From 1978 To 1988. Skole, D., Tucker, C., Science 260 (5116): 1905-1910 Jun 25 1993. and Strategies For Monitoring Tropical Deforestation Using Satellite Data. Tucker, C.J., Townshend, J.R.G., International Journal Of Remote Sensing 21 (6-7): 1461-1471 Apr 15 2000.

Use of the Defense Meteorological Satellite Program (**DMSP**) **"low light level"** data are described in: The use of multisource satellite and geospatial data to study the effect of urbanization on primary productivity in the United States, Imhoff, M.L., Tucker, C.J., Lawrence, W.T., and Stutzer D.C. IEEE Transactions on Geoscience and Remote Sensing 38 (6): 2549-2556 Nov 2000.

Two starting references on **desertification** are: Variations in the size of the Sahara Desert from 1980 to 1997. Tucker C.J., Nicholson S.E. Ambio 28 (7): 587-591 Nov 1999; and Desertification - Time For An Assessment? Hellden, U. Ambio 20 (8): 372-383 Dec 1991.

Other web sites for satellite data include:
Ikonos Satellite information: http://www.spaceimaging.com/level2/level2gallery.htm
Landsat: http://landsat.gsfc.nasa.gov/
SeaWiFS: http://seawifs.gsfc.nasa.gov/SEAWIFS.html
AVHRR data: http://www.saa.noaa.gov/