Remote Sensing – Introduction
EMR Spectrum

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CE 259: Remote Sensing and GIS in Water Resources and Environmental Engg(3:0)

Syllabus: Basic concepts of remote sensing; Airborne and space borne sensors; Digital image Processing; Geographic Information System; Applications to rainfall-runoff modeling, Watershed management, Irrigation management, soil moisture estimation, Drought and Flood monitoring, Environment and ecology; Introduction to Microwave remote sensing and Global Positioning System (GPS); Digital Elevation Modeling; Use of relevant software for Remote sensing and GIS applications.

References:

1. Remote Sensing and Image Interpretation
   T.M. Lillesand and R.W. Kiefer, John Wiley & Sons, 2002.
2. Remote Sensing – Principles and Interpretation
   F.F. Sabins Jr, W.H. Freeman & Co., New York, 1986.
3. An Introduction to Geographical Information Systems
   I. Heywood, S. Cornelius and S. Carver, Pearson Education, 1998.
4. Remote sensing in water resources management: The state of the art
   Bastiaanssen, W.G.M., International Water Management Institute, Colombo, Sri Lanka, 1998.

http://www.civil.iisc.ernet.in/~nagesh/rs_gis.htm

Evaluation

- **Assignments (10%)**
- **Surprise Tests (15%)**
- **Class Test (15%)**
- **Seminar (20%)**
- **Final Test (40%)**

Remote Sensing

Remote Sensing is the science and art of obtaining information about an object, area or phenomenon through the analysis of data acquired by a device that is not in physical contact with the object, area or phenomenon under investigation.

Examples

1. Eyes are living examples (EMR distribution)
2. Sonar (like bats): Acoustic wave distribution
3. Gravity Meter: Gravity force distribution

Remote Sensing

DATA ACQUISITION

DATA ANALYSIS

Sensing System

Data Products

Interp-retation

Infor-mation

Users

Passive RS

Active RS

Satellite
High Altitude Arial
Low Altitude Arial
Ground Level

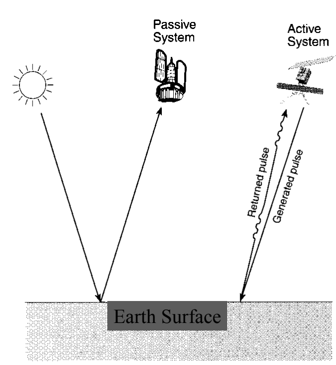
Reference Data
Pictorial
Numerical/ Digital

Visual
Digital

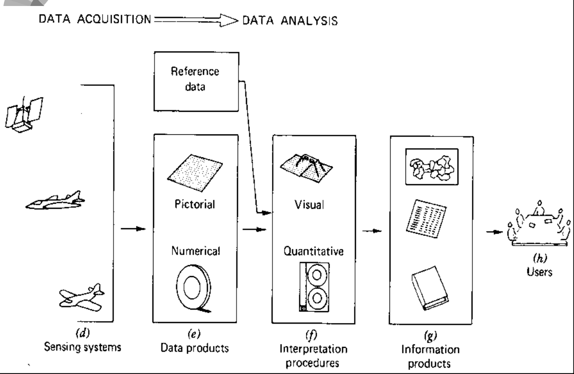
Maps/ Photos
Numerical
Reports

End Users

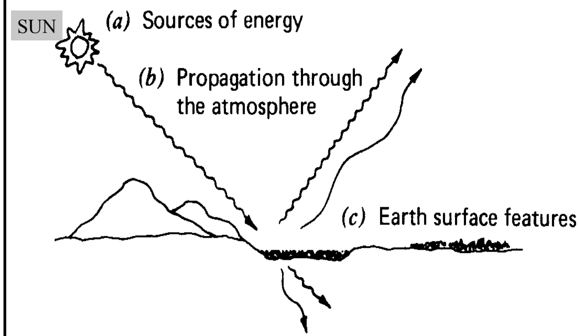
Passive and Active Remote Sensing



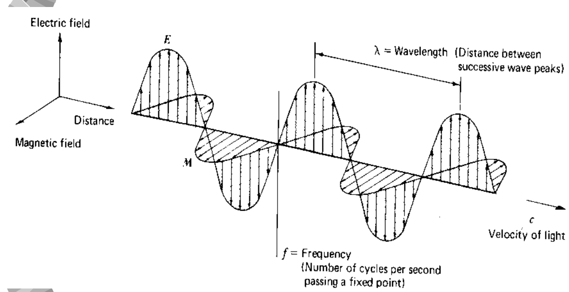
Remote Sensing



Remote Sensing



Electromagnetic Wave



- Sinusoidal Electric Wave (E)
- Magnetic Wave (M)
- Right angels to the source

$\lambda = c/f$
λ is wave length (μm)
f is Frequency
c is Celerity (3×10^8 m/s)

EMR

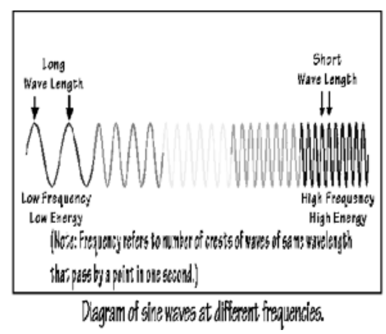
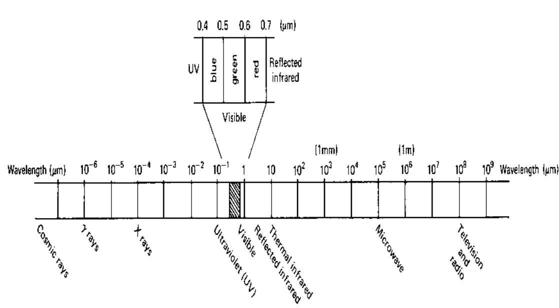
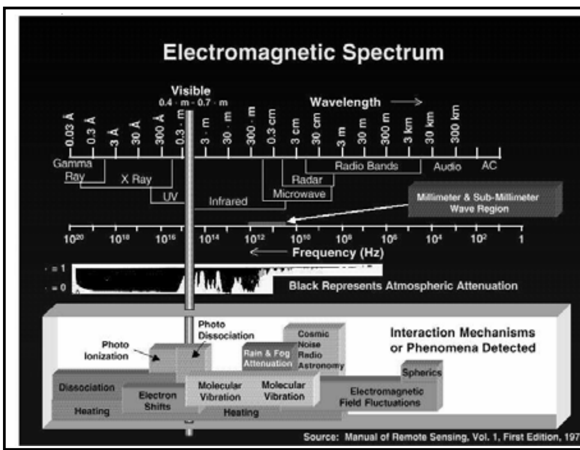


Diagram of sine waves at different frequencies.

EMR Spectrum





EMR Energy

- Energy of a quantum
  $E = h f$
  E in Joules (J)
  h – Planck's constant, 6.626 x 10^{-34} J sec
  f – Frequency

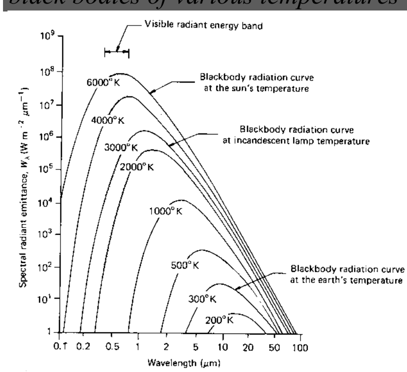
  $E = h c / \lambda$
  - Energy of a quantum is inversely proportional to its wavelength
  - Longer the wavelength, the lower its energy content
  - The low energy content of long wavelength means that, in general, systems operating at long wavelength must 'view' large areas of the earth in order to obtain a detectable signal

EMR Source

- Sun is the primary source
- All matter at temperature above absolute zero (0°K or –273° C) continuously emit EMR
- Energy emitted is, among other things, a function of surface temperature.
- Stefan-Boltzmann Law (Black body)
  - $W = \sigma T^4$
  - W – *Total radiant emittance* in W m^{-2}
  - σ – Stefan-Boltzmann constant, 5.6697 x 10^{-8} $Wm^{-2}{}^{o}K^{-4}$
  - T – Absolute temperature (0°K) of the emitting material
- Energy from an object varies as T^4.
  Increases rapidly with increase in Temperature

A black body is a hypothetical ideal radiator that totally absorbs and re-emits all energy incident upon it

Spectral distribution of energy radiated from black bodies of various temperatures



Total radiant emittance is given by the area under the spectral radiant emittance curve

Peaks shift toward shorter wavelengths as temperature increases

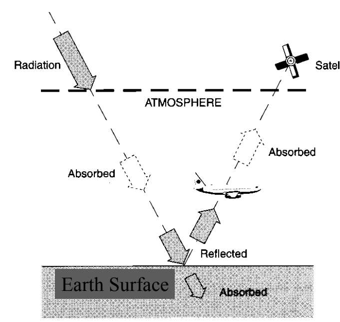
Wien's Displacement Law ($\lambda_{max} = A/T$)

As we heat iron rod, its color changes successively to shorter wavelengths

- Dull red, to orange, to yellow, eventually to white.

Energy Interactions in the Atmosphere

- All radiation detected by sensors passes through some distance of the atmosphere



Energy Interactions (Contd..)

- Scattering & Absorption
- **Scattering**
  - Scattering is unpredictable distribution of radiation by particles in the atmosphere
  - *Rayleigh scatter* is common when radiation interacts with particles which are smaller in diameter than the wavelength.
    - Inversely proportional to fourth power of wavelength
    - Short wavelengths get scattered more
    - A *blue sky* is a manifestation of *Rayleigh scatter*
    - *Rayleigh scatter* is primary cause for 'haze' in imagery (results in bluish-gray photos) (Blue Filter)

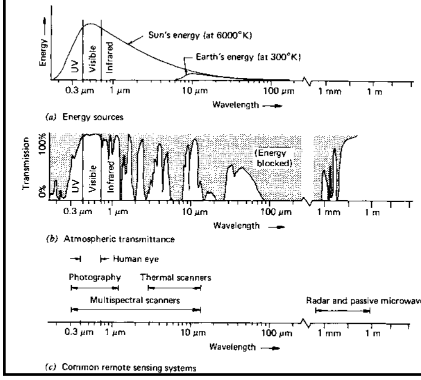
Scattering (Contd..)

- **Mie Scatter** is common when radiation interacts with atmospheric particles diameters which are essentially equal to the wavelength.
  - Water vapour and dust are major causes of Mie scatter
  - Influences longer wavelengths when compared to *Rayleigh scatter*
  - *Mie scatter* is significant in overcast conditions
- Nonselective scatter is common when radiation interacts with particles which are much larger in diameter than the wavelength
  - Water droplets (5-100 μm) cause such scatter
  - Scatter all visible and reflected IR wavelengths
  - Fog and Clouds appear white

Absorption

- In contrast to scatter, atmospheric absorption results in effective loss of energy to atmospheric constituents.
  - Most efficient absorbers are water vapour, cadbon dioxide and ozone.
  - As absorption occurs in specific wavelengths, they strongly influence "where we look" spectrally with any sensor.
  - Wavelength ranges in which the atmosphere is particularly transmissive of energy are called Atmospheric Windows

Spectral characteristics of Energy sources, Atmospheric Effects and Sensing Systems



Wavelength is in logarithmic scale

Spectral Characteristics …

- Spectral sensitivity range of eye coincides with an atmospheric window and peak level of energy from the sun
- Emitted heat energy from the earth, is sensed through the windows at 3 5µm and 8 11 µm using Thermal scanners
- Multi Spectral Sensors sense simultaneously through multiple, narrow wavelength ranges that can be located at various points in visible through the thermal spectral regions
- Radar and Passive microwave systems operate through a window in the 1 mm to 1 m region

Sensor Selection

- Spectral sensitivity of the sensors available
- Presence or absence of atmospheric windows in the spectral range(s) in which one wishes to sense
- Source, magnitude, and spectral composition of the energy available in these ranges
- Manner in which the energy interacts with the features under investigation