Remote Sen sing Definition, history and Principles

lecture 1

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objectives

- Remote Sensing (Definition)
- Remote Sensing (History)
- Remote Sensing (Applications)
- Electromagnetic spectrum

Remote sensing literature -Books

Askne, J. (1995). **Sensors and Environmental applications of remote sensing**, Balkema, Rotterdam, NL

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P.J. Curran, 1985. Physical aspects of Remote Sensing Longman Group UR Ltd, England.

Broad Definition of Remote Sensing

- ***Campbell, 1996:***
- ***'Remote sensing*** is the science of obtaining information about an object from measurements made at a distance from the object (i.e. without touching the object).'

- Remote Sensing of the Earth frequently measures electromagnetic radiation in one or more regions of the electromagnetic spectrum. This radiation can be reflected or emitted from the earth's surface.

Jensen, 2000: *'Measuring information about an object without touching it.'*

History of Remote Sensing

US Army Balloon Corps, early 1860s

- Birth of photography (1839)
- Photography from Balloons (1850-1900)
- Photography from aircraft (1909)
- First World War (1914 – 1918)
  - Aerial scouting and reconnaissance
- The discipline of photogrammetry was established (1920's)

History of Remote Sensing

- Radar developed (1930's)
- Second World War (1939 – 45)
  - Colour infra-red film used to detect camouflage
- The Cold War (1945 -91)
- Colour infra-red photography used to detect crop disease
- The term 'remote sensing' was first used (early 1960's)
- Space Race - Rockets & Satellites (60's and 70's)
- Commercial (i.e. civilian) Satellites (July 72 to date)
- Digital image processing

Boston, 1860 - taken from balloor

History of Remote Sensing

- Landsat 5 (1984) 25 years of operation & counting - original intended mission only 3yrs!
- Landsat 7 (1999)
- High spatial resolution satellite imagery IKONOS (1999) & Quickbird (2001)
- First satellite hyper-spectral sensor EO-1 (2001)
- LiDAR
- Google Earth brings remote sensing to everyone with internet access (2005)
- Landsat archive freely available (2009)

Why Use Remote Sensing?

- Large area coverage
- Synoptic view, continuous spatial coverage
- Information about hard to access areas
- Use sensors to ‘see’ in wavelengths not visible to human eye
- Make quantitative measurements about biogeophysical properties of earth’s surface
- Digital record of features and processes
- Repeat coverage
- Cost (field vs. image)

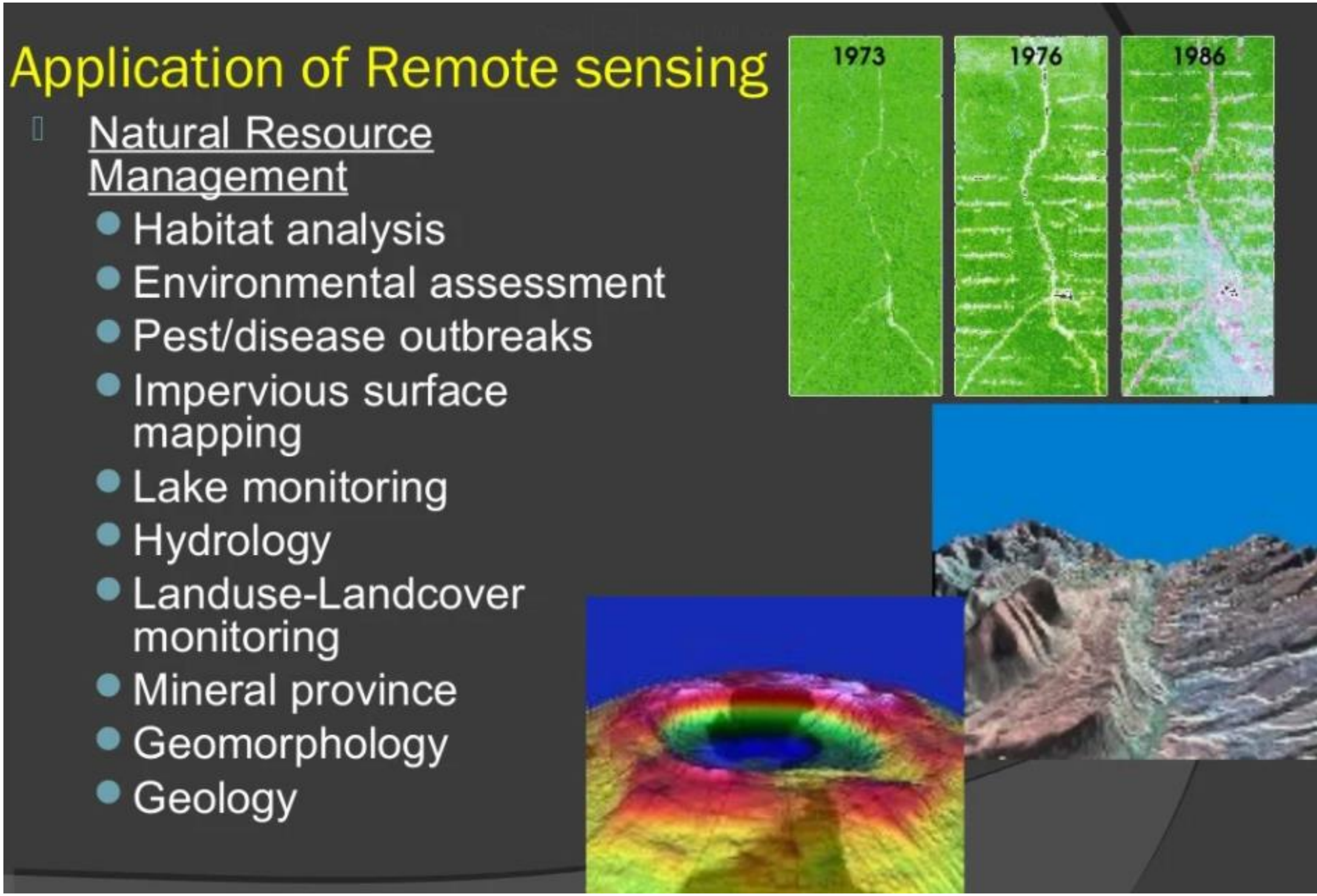
Who uses remote sensing?

- Military
- Many Government Departments
- Commonwealth Agencies (CSIRO, ERISS, etc)
- City Councils
- NGOs
- United Nations
- Private industry (SKM, EWL, ERA etc)
- Universities and research agencies

Application of Remote sensing

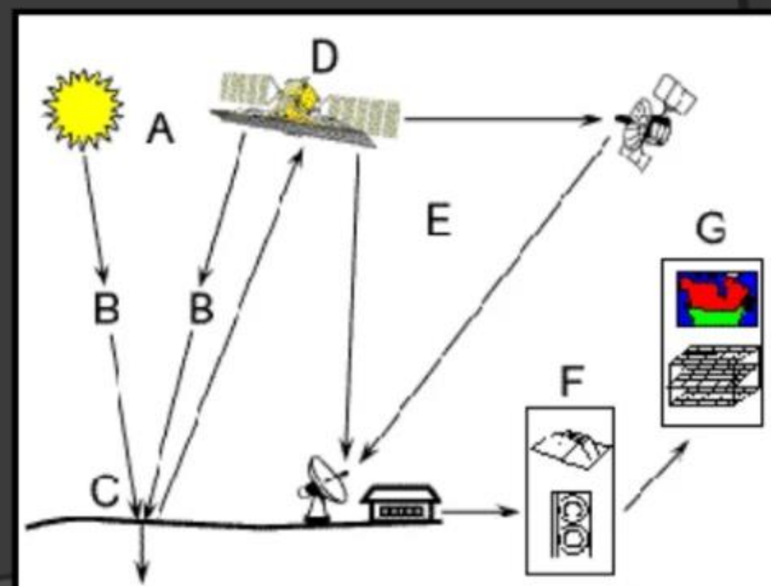
- Urbanization & Transportation
  - Updating road maps
  - Asphalt conditions
  - Wetland delineation
  - Urban Planning

- **Agriculture**
  - **Crop health analysis**
  - **Precision agriculture**
  - **Compliance mapping**
  - **Yield estimation**
  - Forest application


Application of Remote sensing
Natural Resource Management
Habitat analysis
Environmental assessment
Pest/disease outbreaks
Impervious surface mapping
Lake monitoring
Hydrology
Landuse-Landcover monitoring
Mineral province
Geomorphology
Geology
1973
1976
1986

Elements involved in Remote sensing

1. Energy Source or Illumination (A)
2. Radiation and the Atmosphere (B)
3. Interaction with the Object (C)
4. Recording of Energy by the Sensor (D)
5. Transmission, Reception and Processing (E)
6. Interpretation and Analysis (F)
7. Application (G)



SOURCE OF THE SUN'S ENERGY

The fusion process: Nuclear reactions where lightweight chemical elements (like hydrogen) form heavier elements (such as helium and carbon). This process converts matter (i.e. mass of an atom) to energy.

Albert Einstein in 1905 showed that: $\mathbf{E = mc^2}$

Where, E= Energy
m= mass
c=speed of light in a vacuum (3.0×10^8 m/s)

The Sun produces its energy by two fusion reactions:

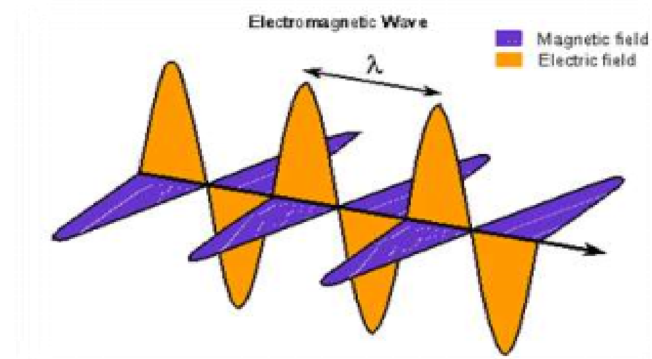
1. Proton-Proton (PP) – 88%
2. Carbon-Nitrogen-Oxygen (CNO) – 12%

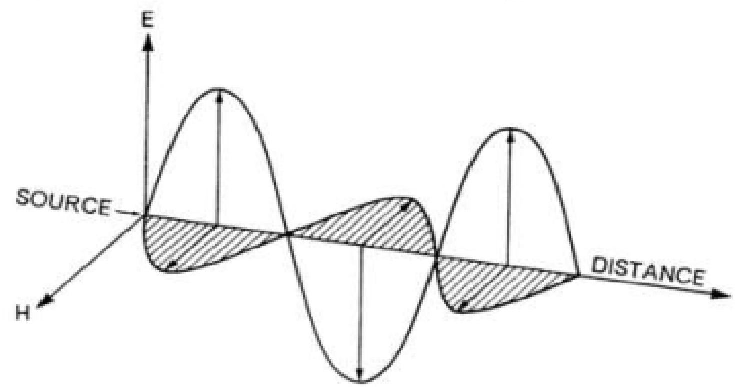
WAVE PROPERTIES

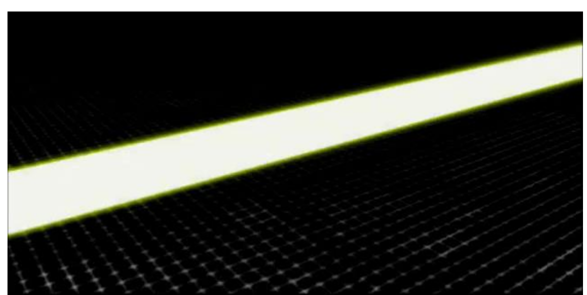
- **James Clerk Maxwell (1864): Theory of Electromagnetic Radiation**
- **This radiation is made of the electric and magnetic fields, that travel perpendicular to each other along the wave propagation.**
- **These waves can be described with wavelength and frequency.**
- **They vary proportional inverse and are related by the following equation:**

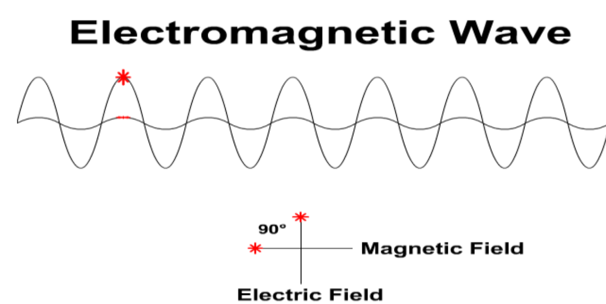
$$f = \frac{c}{\lambda}$$

where c = velocity of light (constant)







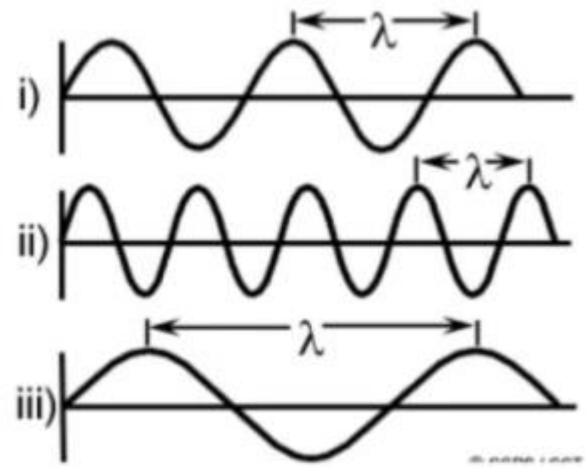


Electromagnetic Radiations (EMR)

- Two characteristics of electromagnetic radiation are particularly important for understanding remote sensing. These are the **wavelength** and **frequency**.

Wave length (λ) is the length of one wave cycle, which can be measured as the distance between successive wave crests. Wavelength is measured in metres (m)

Frequency (f) refers to the number of cycles of a wave passing a fixed point per unit of time. Frequency is normally measured in **hertz (Hz), equivalent to one** cycle per second, and various multiples of hertz



$$\lambda = \frac{c}{f}$$

Remember ! Two are inversely related to each other. The shorter the wavelength, the higher the frequency. The longer the wavelength, the lower the frequency

Units of Length Used in Remote Sensing

Unit	Distance	
Kilometer (km)	1,000 m	
Meter (m)	1.0 m	
Centimeter (cm)	0.01 m	$= 10^{-2}$ m
Millimeter (mm)	0.001 m	$= 10^{-3}$ m
Micrometer (μm)[a]	0.000001 m	$= 10^{-6}$ m
Nanometer (nm)		10^{-9} m
Ångstrom unit (Å)		10^{-10} m

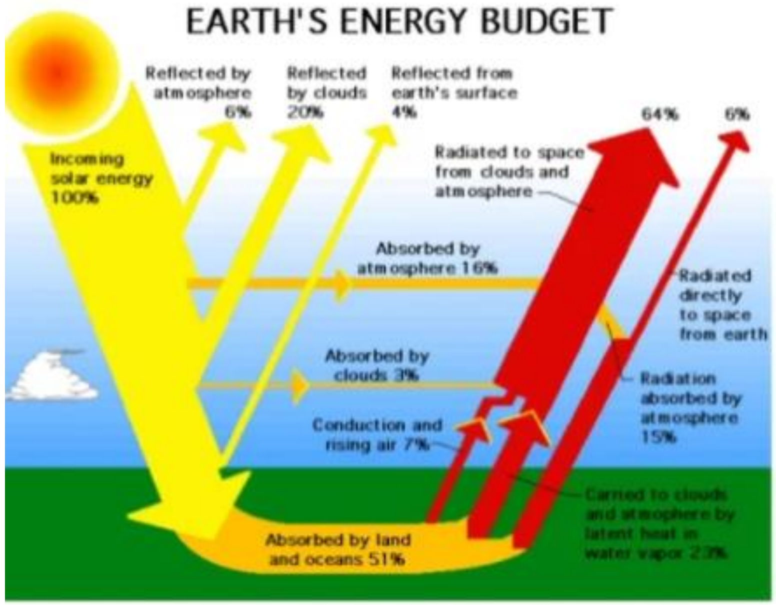
[a]Formerly called the "micron" (μ); the term "micrometer" is now used by agreement of the General Conference on Weights and Measures.

Frequencies Used in Remote Sensing

Unit	Frequency (cycles per second)
Hertz (Hz)	1
Kilohertz (kHz)	10^3 (= 1,000)
Megahertz (MHz)	10^6 (= 1,000,000)
Gigahertz (GHz)	10^9 (= 1,000,000,000)

Source of Electromagnetic Radiation

- Nuclear reactions within the Sun produce a full spectrum of electromagnetic radiation, which is transmitted through space without experiencing major changes.



As this radiation approaches the Earth, it passes through the atmosphere before reaching the Earth's surface.

Some is reflected upward from the Earth's surface; it is this radiation that forms the basis for photographs and similar images. Other solar radiation is absorbed at the surface of the Earth and is then reradiated as thermal energy.

Source of Electromagnetic Radiation

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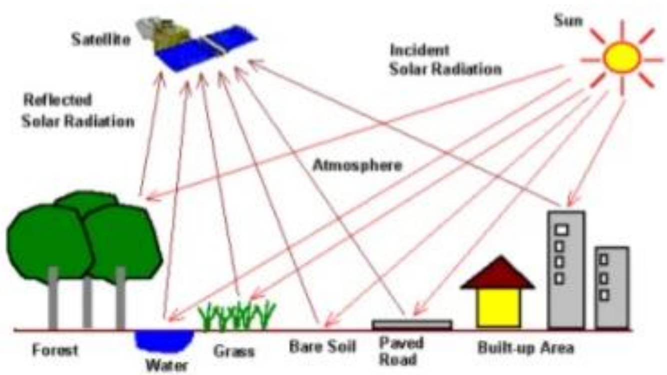
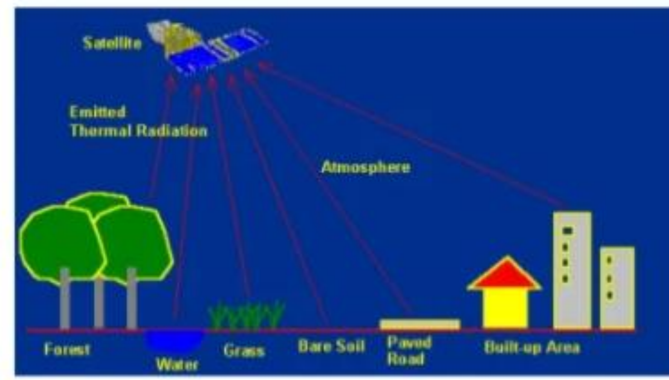


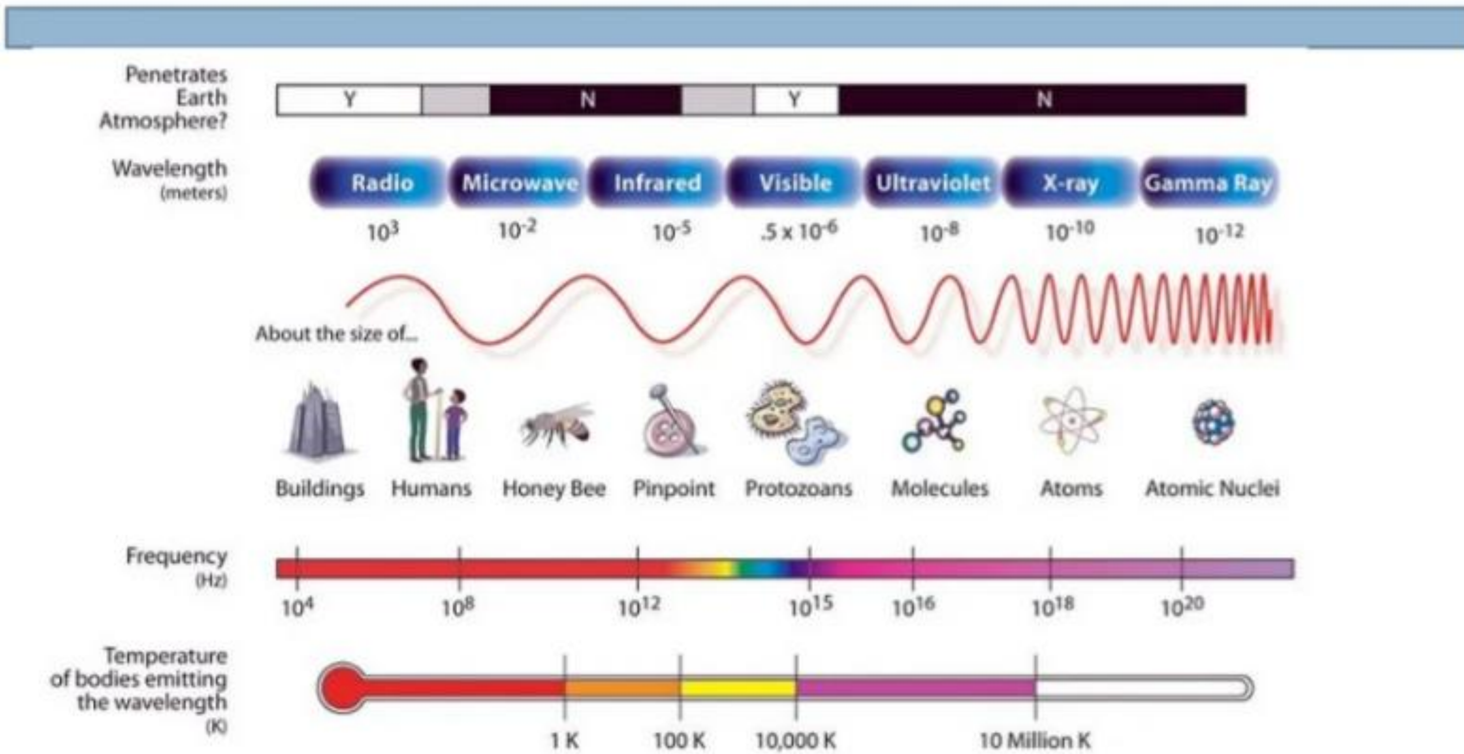
Remote sensing of reflected radiation



Remote sensing of emitted radiation

By recording emitted or reflected radiation and applying knowledge of its behaviour as it passes through the Earth's atmosphere and interacts with objects, remote sensing analysts develop knowledge of the character of features such as vegetation, structures, soils, rock, or water bodies on the Earth's surface.

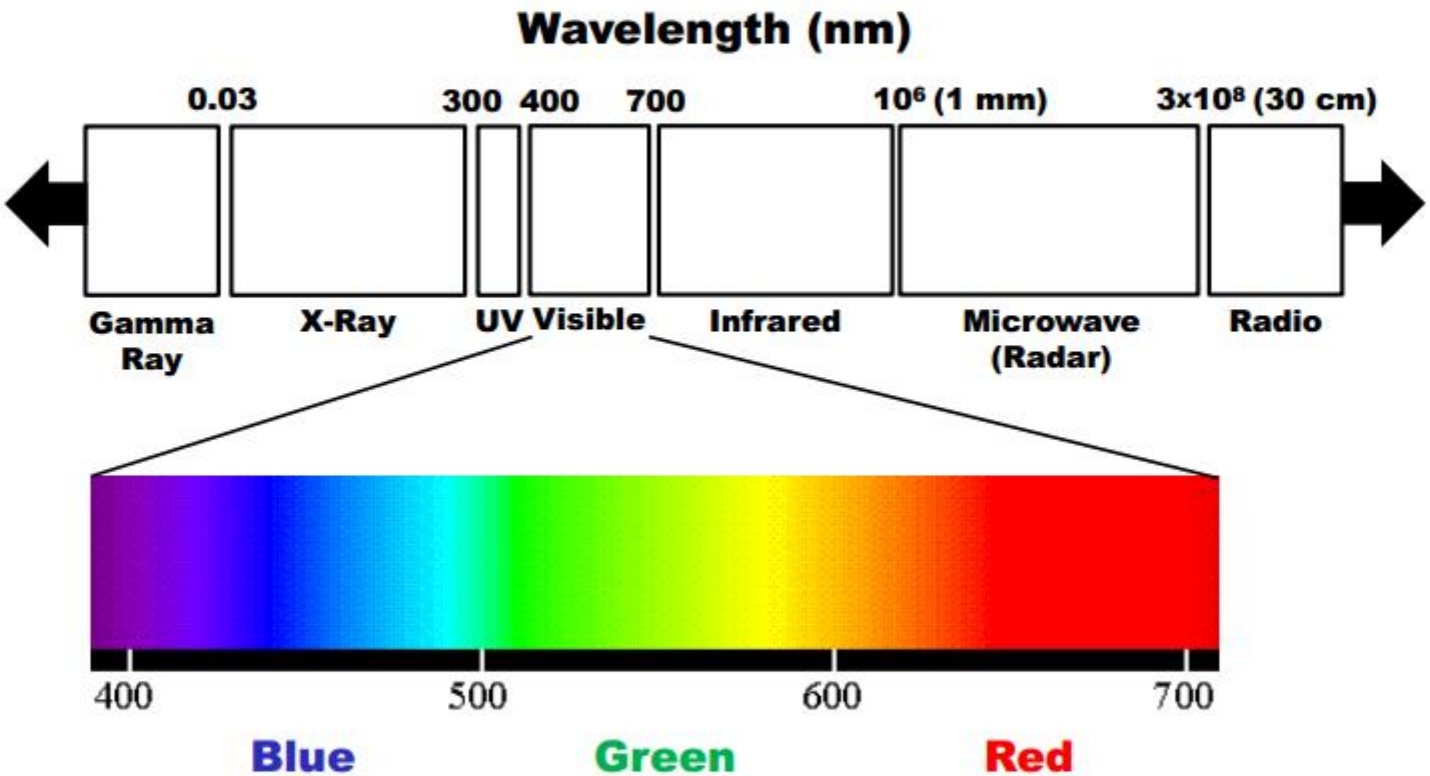
Electromagnetic (EM) Spectrum



The most familiar form of EMR is visible light, which forms only a small (but very important) portion of the full EM spectrum.

The large segments of this spectrum that lie outside the visible range require our special attention because they may behave in ways that are quite foreign to our everyday experience with visible radiation.

ELECTROMAGNETIC SPECTRUM



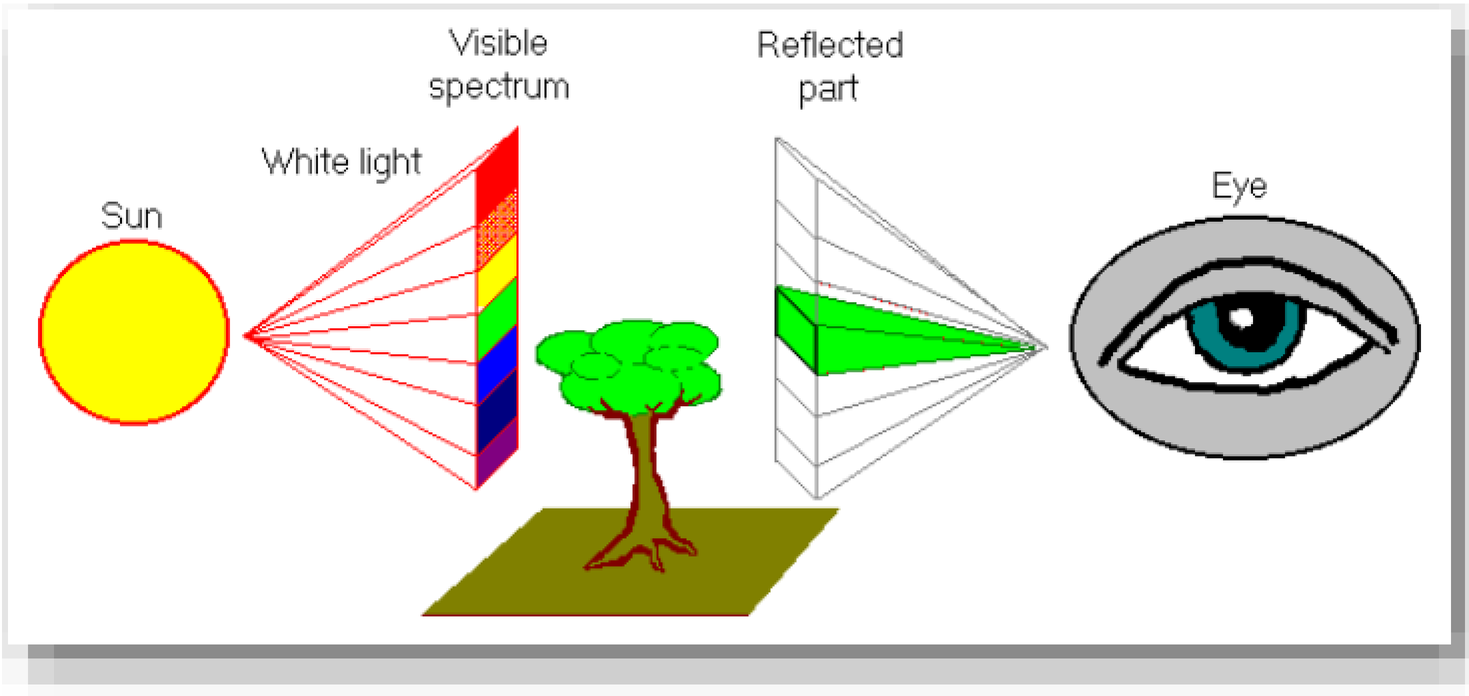
Electromagnetic (EM) Spectrum

Principal Divisions of the Electromagnetic Spectrum

Division	Limits		
Gamma rays	< 0.03 nm		
X-rays	0.03–300 nm		
Ultraviolet radiation	0.30–0.38 μm		
Visible light	0.38–0.72 μm		
Infrared radiation		reflective spectrum	Optical spectrum
Near infrared	0.72–1.30 μm		
Mid infrared	1.30–3.00 μm		
Far infrared	7.0–1,000 μm (1 mm)		
Microwave radiation	1 mm–30 cm		
Radio	≥ 30 cm		

- Two important categories are not shown in above Table. The *optical spectrum, from* 0.30 to 15 μm, defines those wavelengths that can be reflected and refracted with lenses and mirrors. The *reflective spectrum extends from about 0.38 to 3.0 μm; it defines that* portion of the solar spectrum used directly for remote sensing.

VISIBLE SPECTRUM



REFLECTION OF COLORS

The Visible Spectrum

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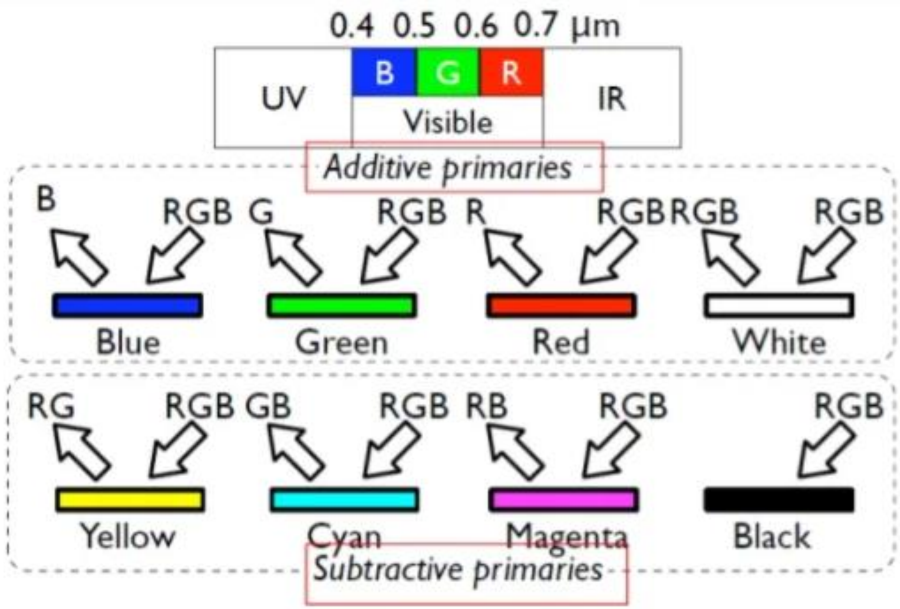


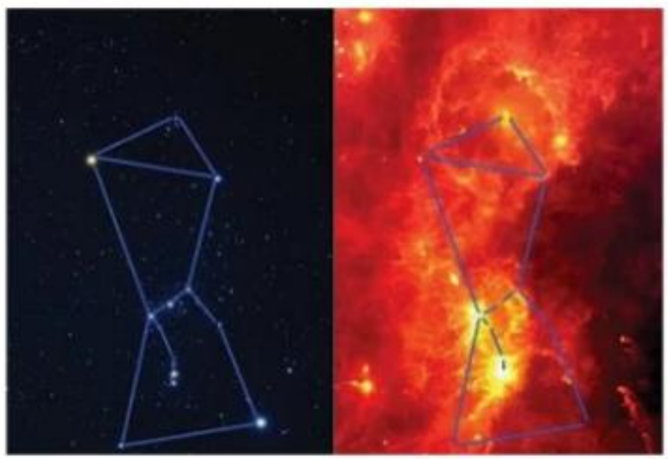
The color of an object is defined by the color of the light that it reflects . Thus a "blue" object is "blue" because it reflects blue light.

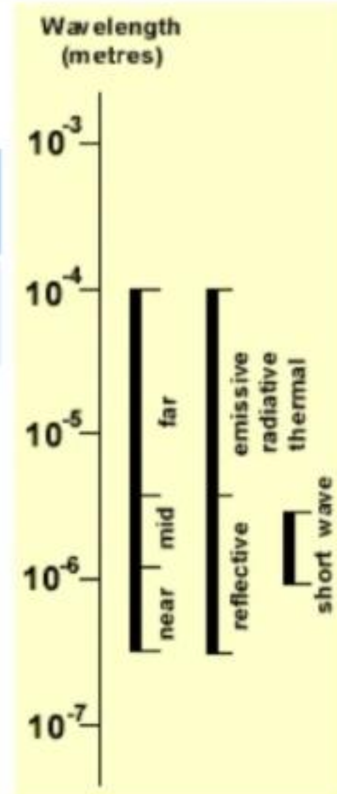
Intermediate colors are formed when an object reflects two or more of the additive primaries.

The Infrared Spectrum

- Wavelengths longer than the red portion of the visible spectrum are designated as the infrared region

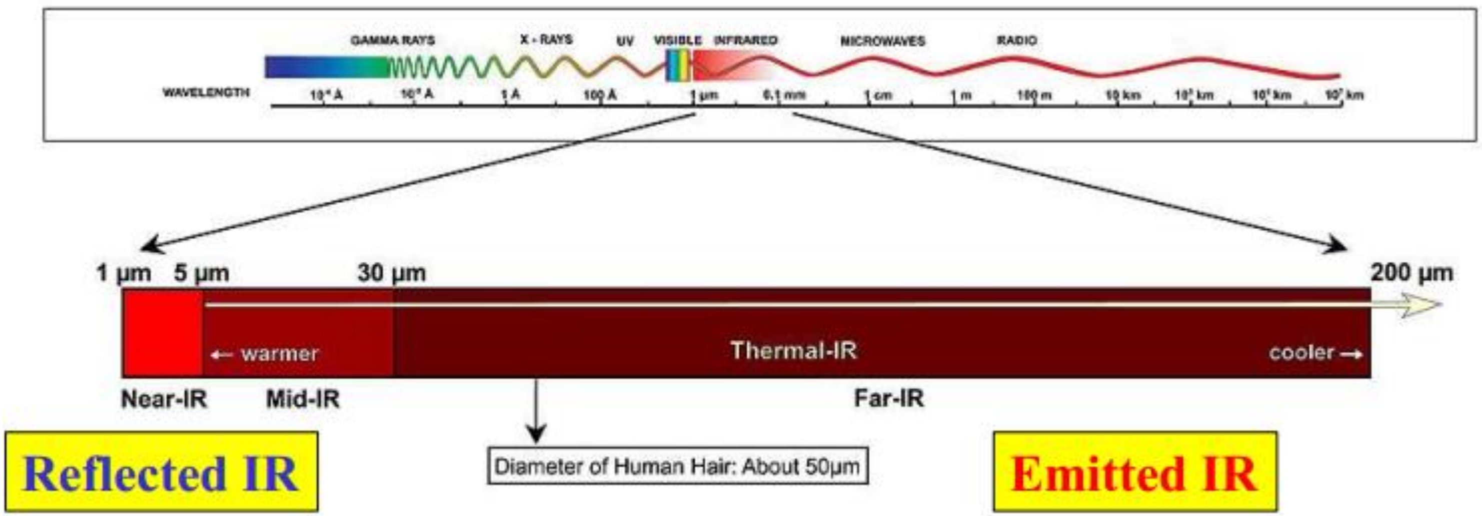
Infrared (0.7-15μm)		
Near infrared (0.72-1.3μm)	**Mid infrared** (1.3-3.0μm)	**Far infrared** (3-15μm)

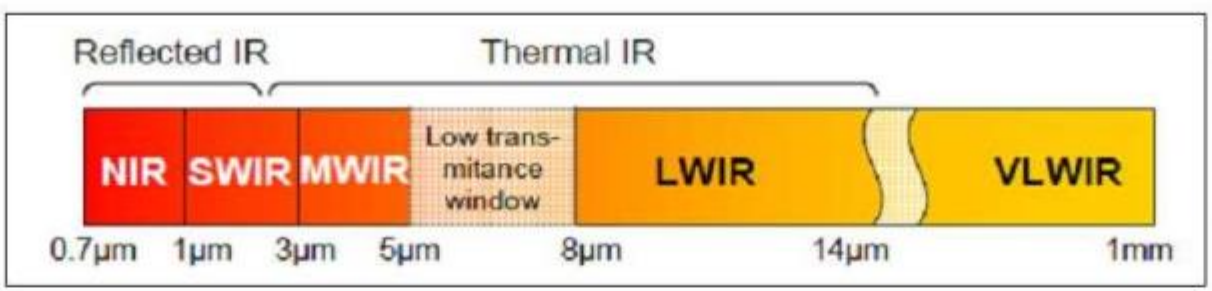




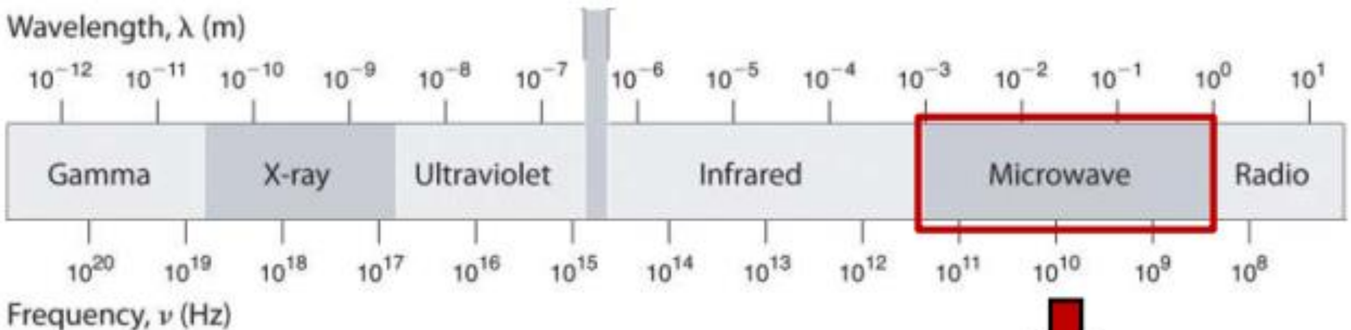
A photo of the Orion constellation in visible (left) and infrared (right). Although the infrared provides little indication to the exact location of the stars, it detects gas clouds throughout the constellation and other features totally invisible in the optical spectrum

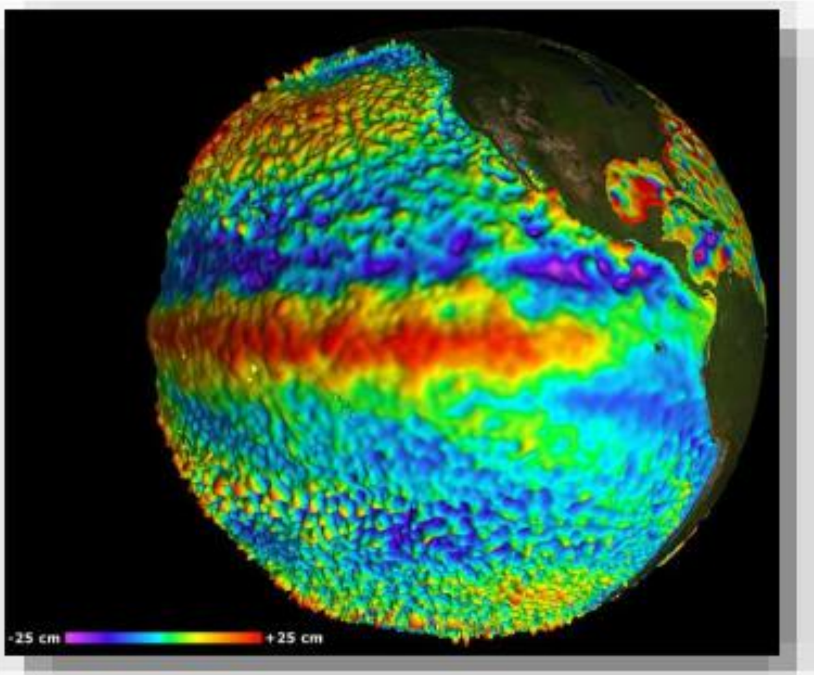
INFRARED SPECTRUM

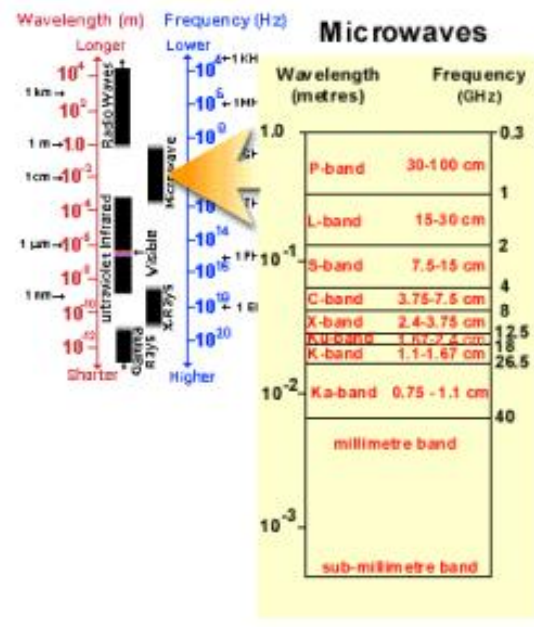




MICROWAVE ENERGY

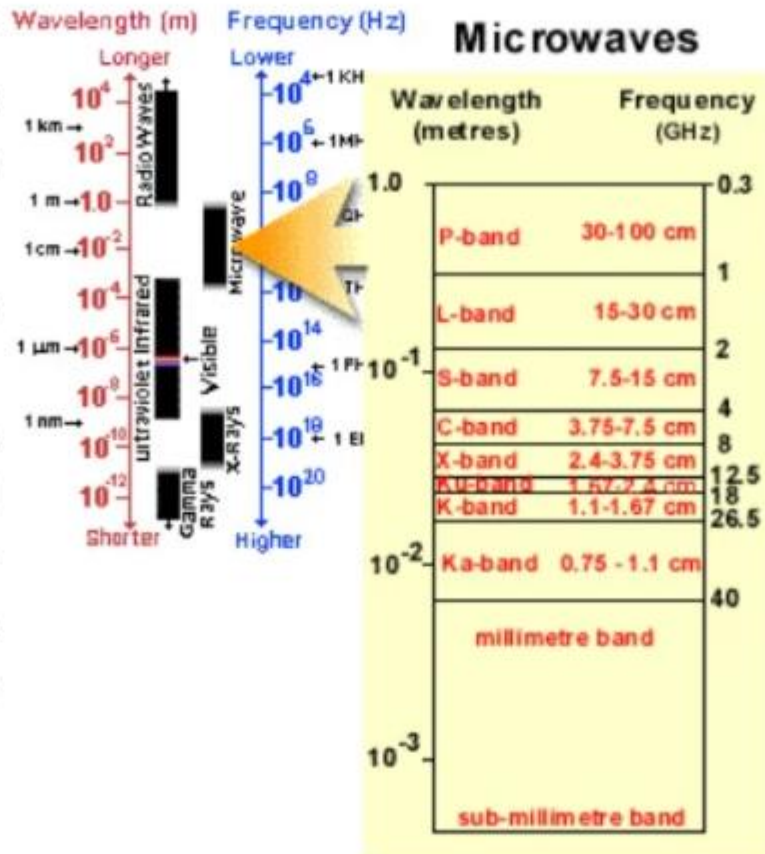






Microwave Spectrum

- The portion of the spectrum of more recent interest to remote sensing is the microwave region from about **1 mm to 1m.**
- This covers the longest wavelengths used for remote sensing.
- The shorter wavelengths have properties similar to the thermal infrared region while the longer wavelengths approach the wavelengths used for radio broadcasts.



The remote sensing using microwave spectrum is termed as microwave sensing

References

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Thank you