Remote Sensing

CHAPTER 1 / SECTION -1

(1- 1-1) Fundamentals of Remote Sensing

"Remote sensing is the science (and to some extent, art) of acquiring information about the Earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analyzing, and applying that information."

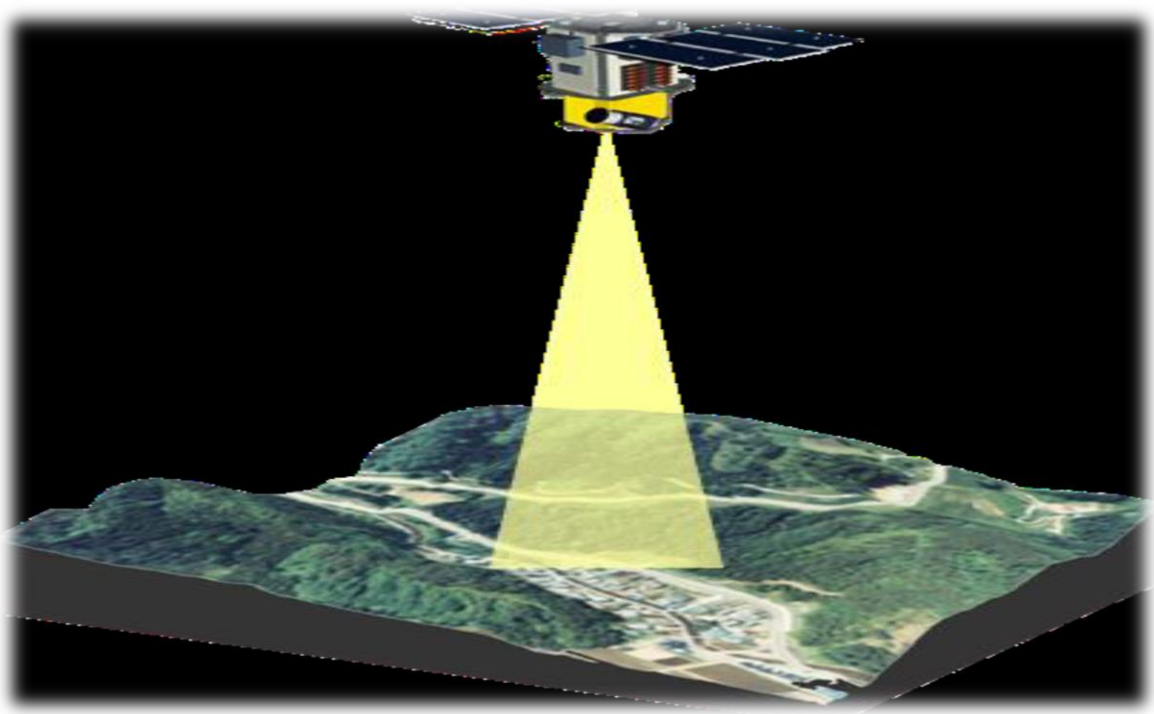
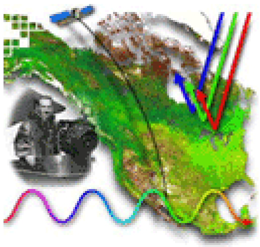


Fig. (1-1-1) Remote Sensing



(1-1-2) COMPONENTS IN REMOTE SENSING

1- Platform: -

The vehicle which carries a sensor. i.e., satellite, aircraft, balloon, etc...

2- Sensors: -

A device that receives electromagnetic radiation and converts it into a signal that can be recorded and displayed as either numerical data or an image.

Types of Remote Sensing

1-Passive Remote Sensing

2- Active Remote Sensing

1- Passive Remote Sensing: -

Remote sensing of energy naturally reflected or radiated from the terrain.

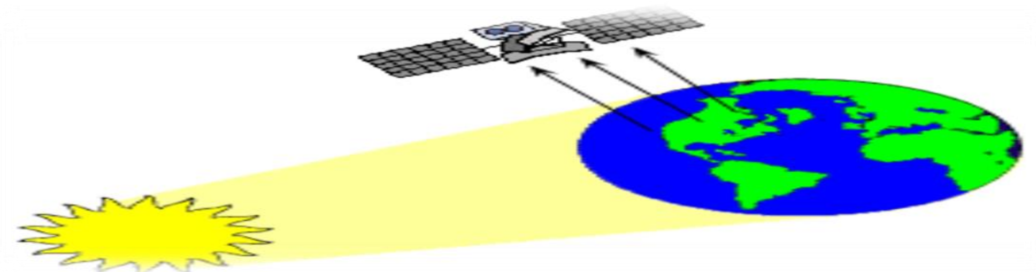
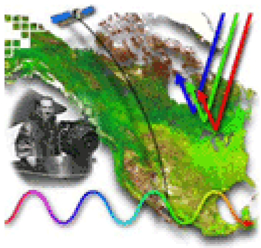


Fig. (1-1-2) Passive Remote Sensing



2-Active Remote Sensing

Remote sensing methods that provide their own source of electromagnetic radiation to illuminate the terrain. Radar is one example.

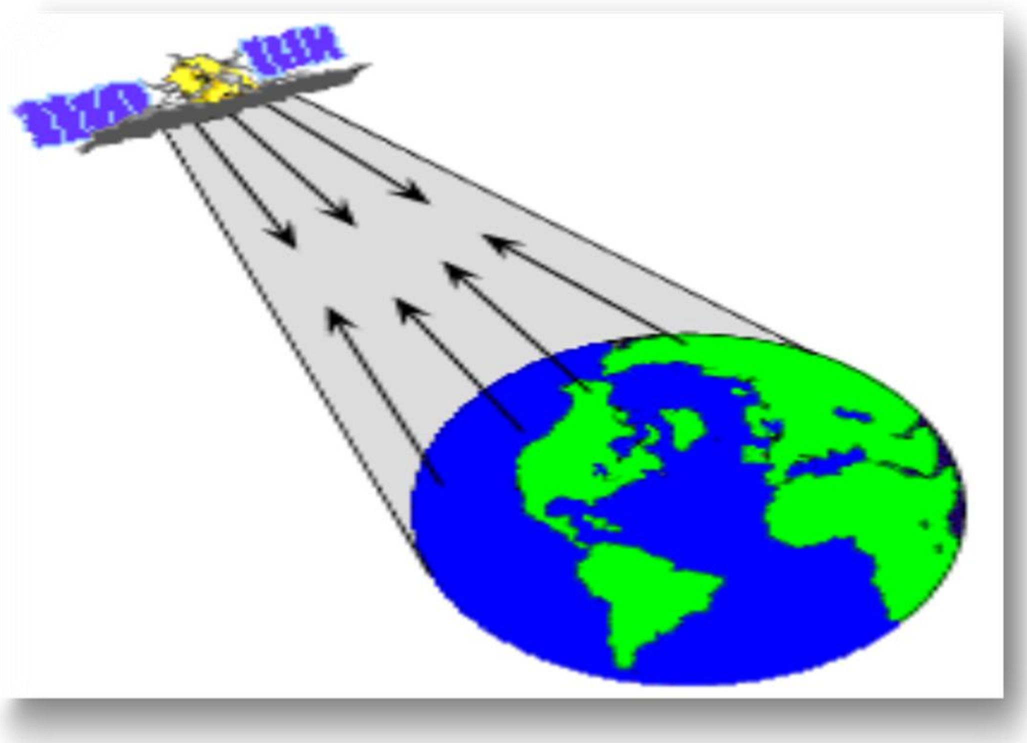
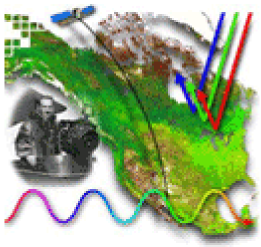


Fig. (1-1-3) Active Remote Sensing



In much of remote sensing, the process involves an interaction between incident radiation and the targets of interest. This is exemplified by the use of imaging systems where the following seven elements are involved. Note, however, that remote sensing also consists of the sensing of emitted energy and the use of non-imaging sensors.

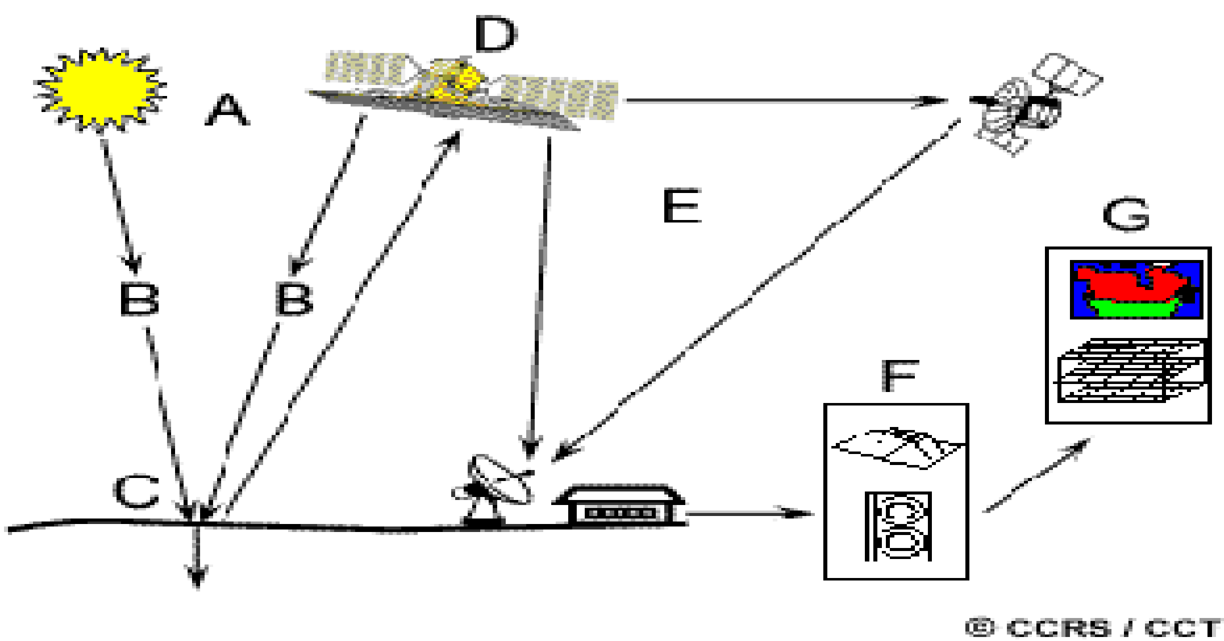
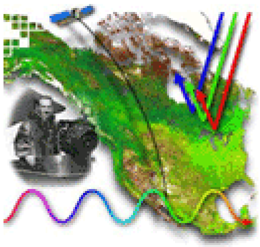


Fig. (1-1-4) Components in Remote Sensing



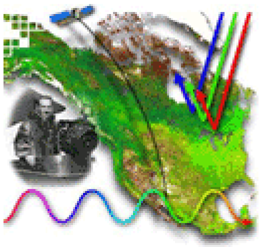
1. Energy Source or Illumination (A) – The first requirement for remote sensing is to have an energy source that illuminates or provides electromagnetic energy to the target of interest.

2. Radiation and the Atmosphere (B) – as the energy travels from its source to the target, it will come in contact with and interact with the atmosphere it passes through. This interaction may take place a second time as the energy travels from the target to the sensor.

3. Interaction with the Target (C) - once the energy makes its way to the target through the atmosphere, it interacts with the target depending on the properties of both the target and the radiation.

4. Recording of Energy by the Sensor (D) - after the energy has been scattered by, or emitted from the target, we require a sensor (remote - not in contact with the target) to collect and record the electromagnetic radiation.

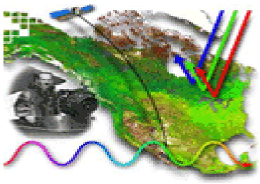
5. Transmission, Reception, and Processing (E) - the energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data are processed into an image (hardcopy and/or digital).



6. Interpretation and Analysis (F) - the processed image is interpreted, visually and/or digitally or electronically, to extract information about the target which was illuminated.

7. Application (G) - the final element of the remote sensing process is achieved when we apply the information we have been able to extract from the imagery about the target in order
to better understand it, reveal some new information, or assist in solving a particular problem.

These seven elements comprise the remote sensing process from beginning to end. We will be covering all of these in sequentially, building upon the information learned as we go. Enjoy the journey!



Section -2

(1-2-1) Electromagnetic Radiation

As was noted in the previous section, the first requirement for remote sensing is to have an energy source to illuminate the target (unless the target is emitting the sensed energy). This energy is in the form of electromagnetic radiation.

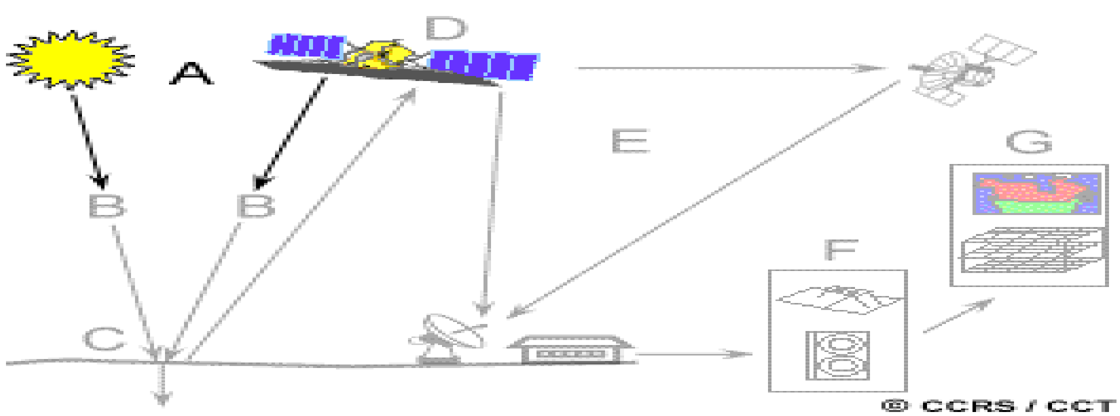
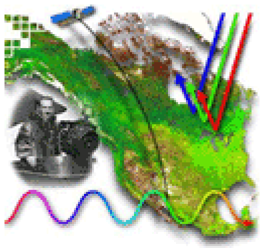


Fig. (1-2-1) Source of Electromagnetic Radiation

All electromagnetic radiation has fundamental properties and behaves in predictable ways according to the basics of wave theory.



Electromagnetic radiation consists of an electrical field(E), which varies in magnitude in a direction perpendicular to the direction in which the radiation is traveling, and a magnetic field (M) oriented at right angles to the electrical field. Both these fields travel at the speed of light (c).

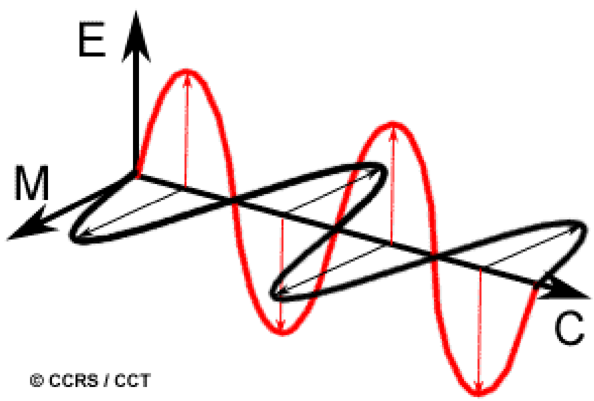
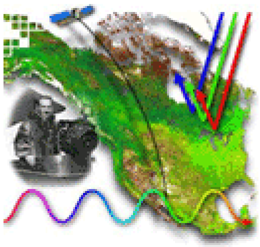


Fig. (1-2-2) Electro-Magnetic radiation

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



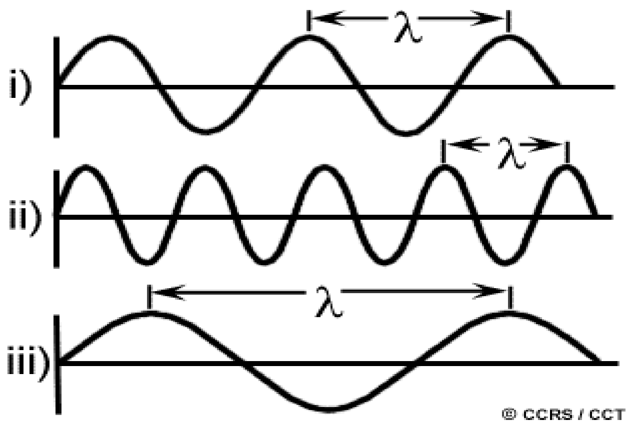
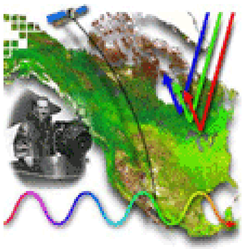


Fig. (1-2-3) wavelength and frequency

The wavelength is the length of one wave cycle, which can be measured as the distance between successive wave crests. Wavelength is usually represented by the Greek letter lambda (λ). Wavelength is measured in meters (m) or some factor of meters, such as nanometers (nm, 10^{-9} meters), (cm, 10^{-2} meters). Frequency 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.
Wavelength and frequency are related by the following: -



$$C = \lambda \upsilon \ldots\ldots\ldots\ldots (1\text{-}1)$$

Where:

λ = Wavelength (m)

υ = Frequency (cycle per second)

C = speed of light ($3\text{x}10^8$ m/sec)

Therefore, the two are inversely related to each other. The shorter the wavelength, the higher the frequency. The longer the wavelength, the lower the frequency. Understanding the characteristics of electromagnetic radiation in terms of their wavelength and frequency is crucial to understanding the information to be extracted from remote sensing data. Next, we will be examining the way in which we categorize electromagnetic radiation for just that purpose.

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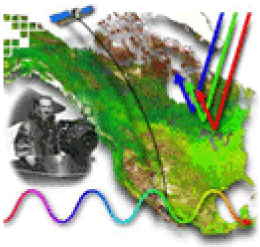


(1-2-2) The Electromagnetic Spectrum: -

The electromagnetic spectrum ranges from the shorter wavelengths (including gamma and X-rays) to the longer wavelengths (including microwaves and broadcast radio waves). Several regions of the electromagnetic spectrum are useful for remote sensing.

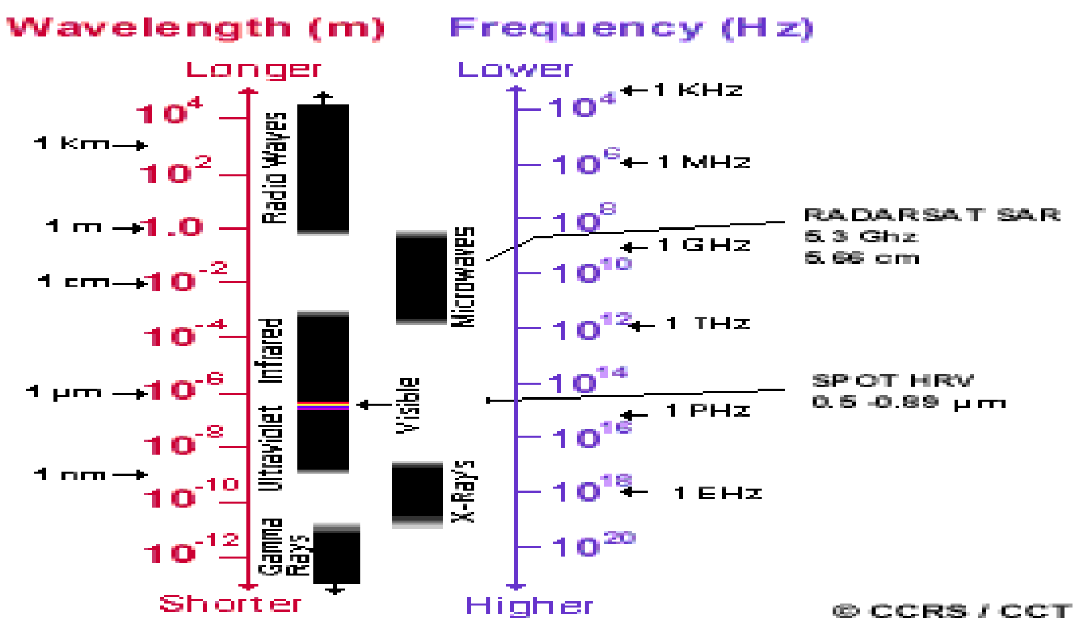
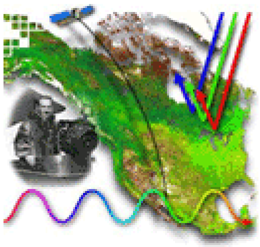


Fig. (1-2-4) The electromagnetic spectrum



For most purposes, the ultraviolet or UV portion of the spectrum has the shortest wavelengths, which are practical for remote sensing. This radiation is just beyond the violet portion of the visible wavelengths, hence its name. Some Earth surface materials, primarily rocks and minerals, fluoresce or emit visible light when illuminated by UV radiation.

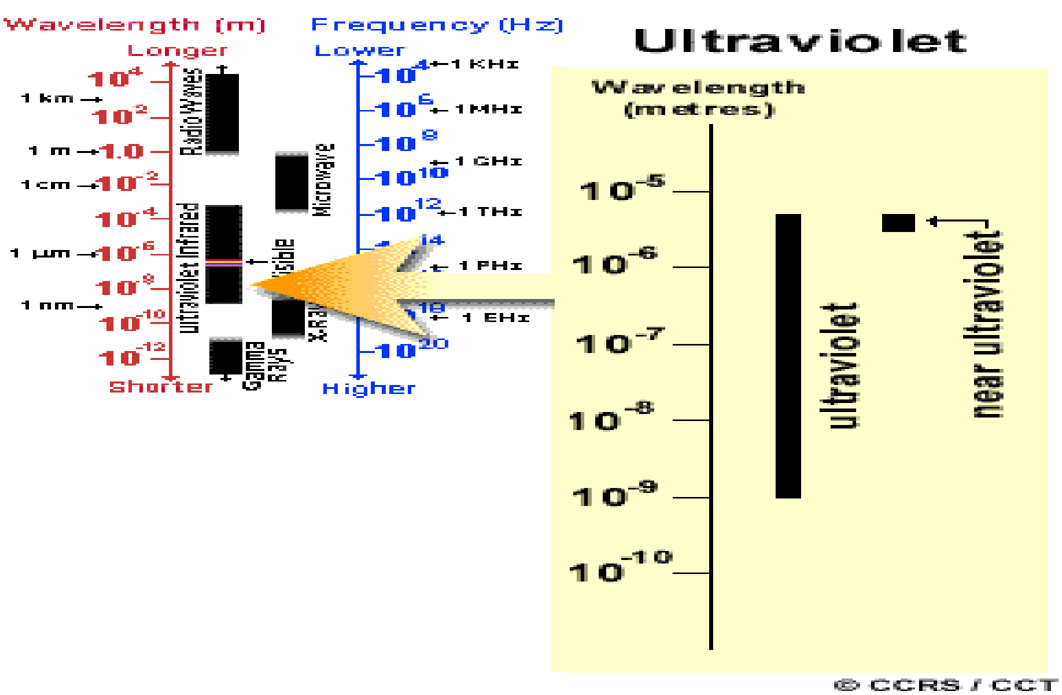
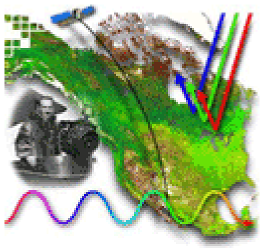


Fig. (1-2-5) Ultraviolet portion of the Electromagnetic spectrum



The light which our eyes - our "remote sensors" - can detect is part of the visible spectrum. It is important to recognize how small the visible portion is relative to the rest of the spectrum. There is a lot of radiation around us which is "invisible" to our eyes, but can be detected by other remote sensing instruments and used to our advantage.

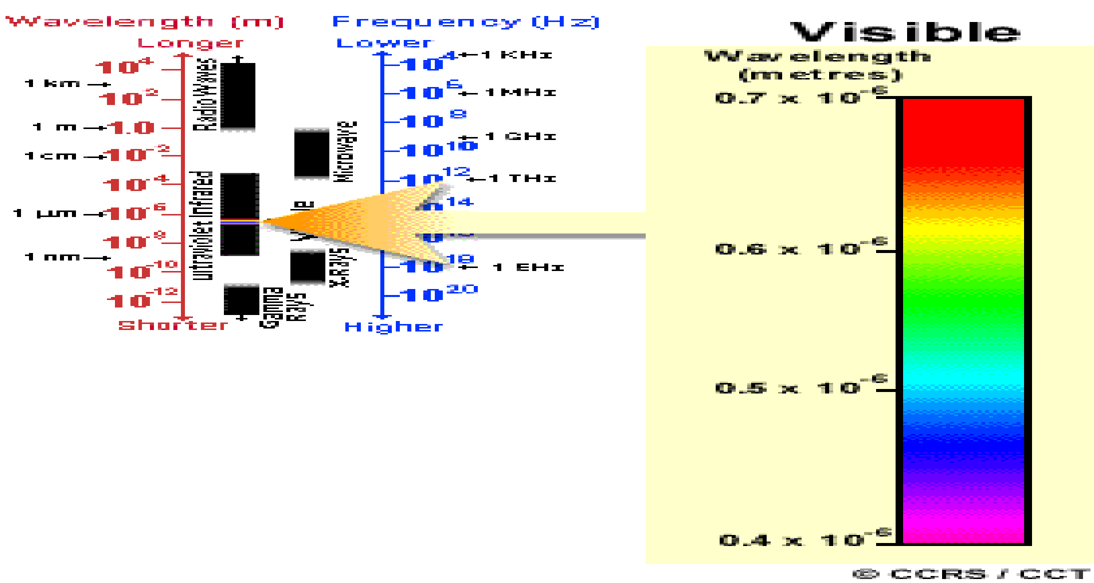
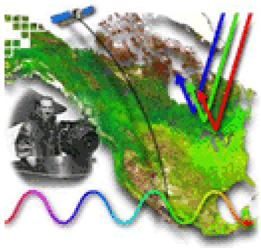


Fig. (1-2-6) Visible portion of the Electromagnetic spectrum



The visible wavelengths cover a range from approximately 0.4 to 0.7 µm. The longest visible wavelength is red, and the shortest is violet. Common wavelengths of what we perceive as particular colours from the visible portion of the spectrum are listed below. It is important to note that this is the only portion of the spectrum we can associate with the concept of colours.

- Violet: 0.4 - 0.446 µm
- Blue: 0.446 - 0.500 µm
- Green: 0.500 - 0.578 µm
- Yellow: 0.578 - 0.592 µm
- Orange: 0.592 - 0.620 µm
- Red: 0.620 - 0.7 µm

Blue, green, and red are the primary colours or wavelengths of the visible spectrum. They are defined as such because no single primary colour can be created from the other two, but all other colours can be formed by combining blue, green, and red in various proportions. Although we see sunlight as a uniform or homogeneous colour, it is actually composed of various wavelengths of radiation in primarily the ultraviolet, visible, and infrared portions of the spectrum. The visible portion of this radiation can be shown in its component colours when sunlight is passed through a prism, which bends the light in differing amounts according to wavelength.

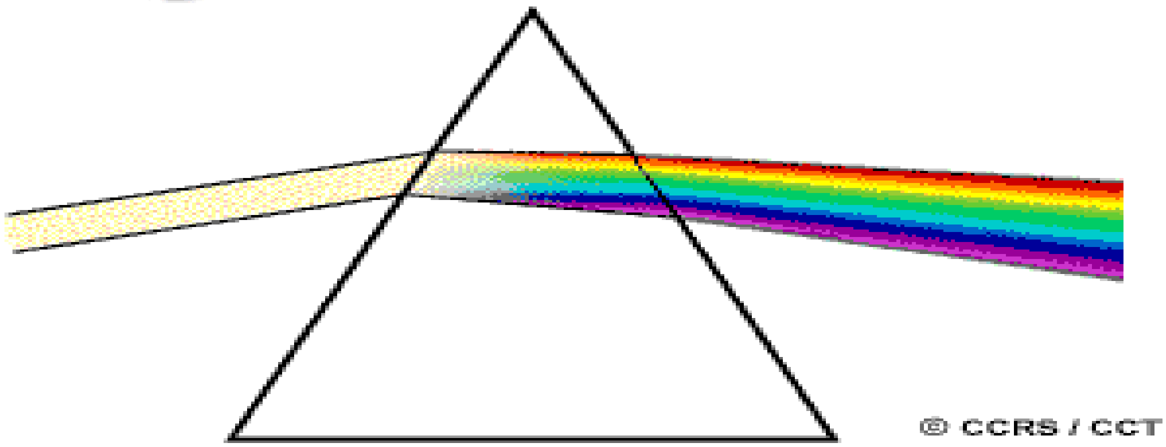
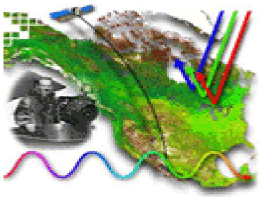


Fig. (1-2-7) The prism

The next portion of the spectrum of interest is the infrared (IR) region, which covers the wavelength range from approximately 0.7 µm to 100 µm - more than 100 times as wide as the visible portion! The infrared region can be divided into two categories based on their radiation properties - the reflected IR, and the emitted or thermal IR. Radiation in the reflected IR region is used for remote sensing purposes in ways very similar to radiation in the visible portion. The reflected IR covers wavelengths from approximately 0.7 µm to 3.0 µm. The thermal IR region is quite different from the visible and reflected IR portions, as this energy is essentially the radiation that is emitted from the Earth's surface in the form of heat. The thermal IR covers wavelengths from approximately 3.0 µm to 100 µm.



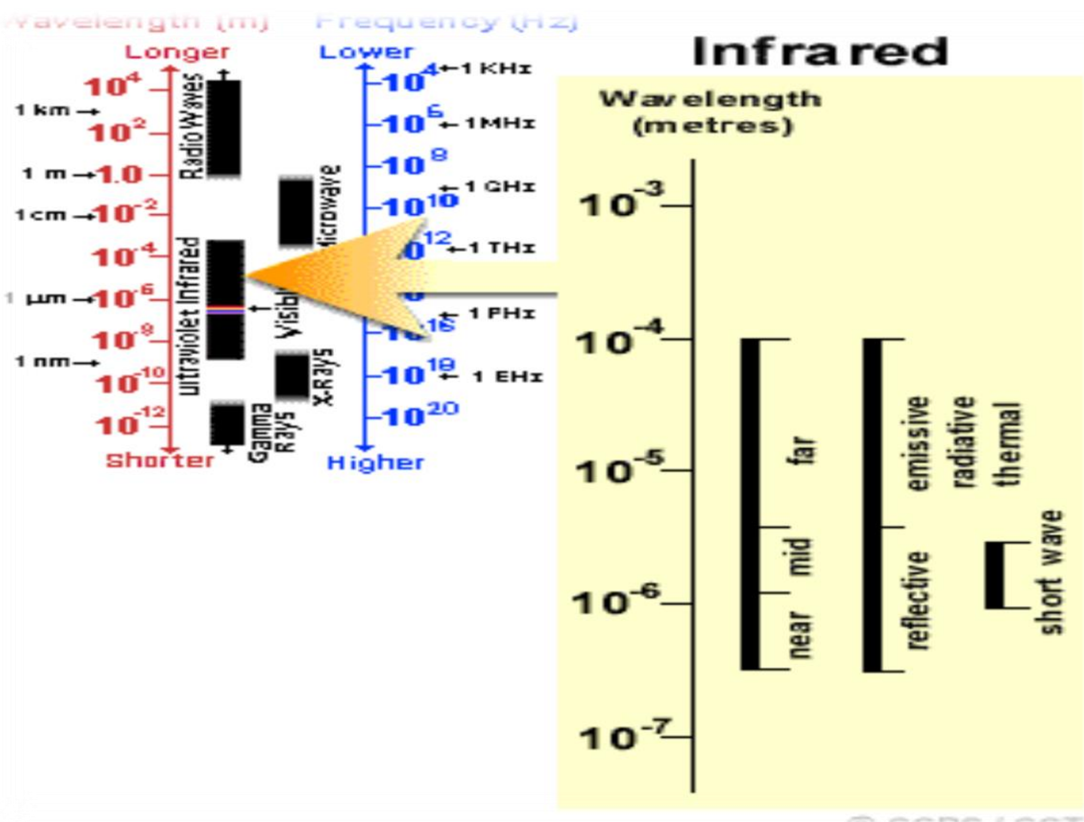
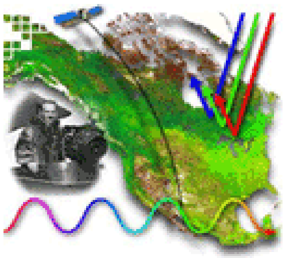


Fig. (1-2-8) Infrared (IR) region of the Electromagnetic spectrum

The portion of the spectrum of more recent interest to remote sensing is the microwave region from about 1 mm to 1 m. 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.

Because of the special nature of this region and its importance to remote sensing in Canada.



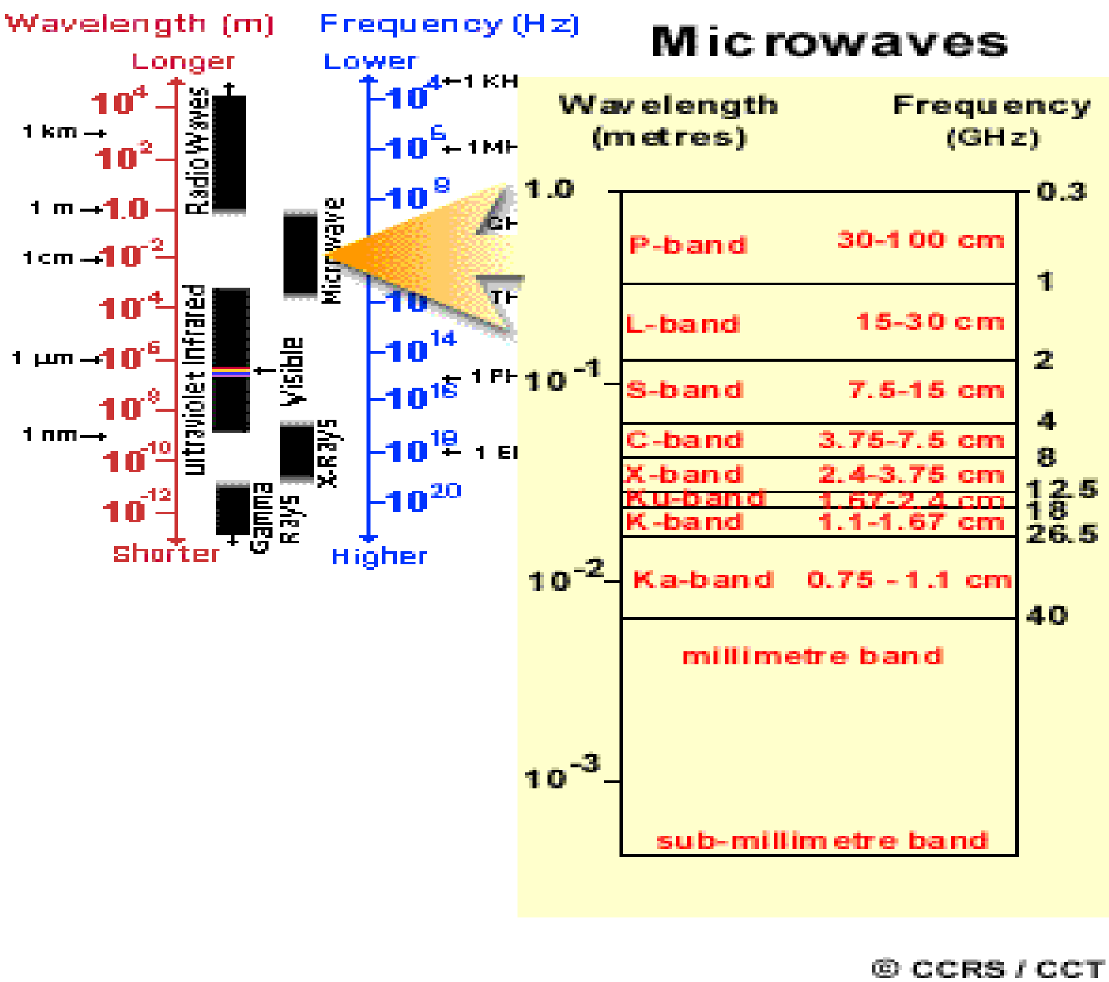


Fig. (1-2-9) The microwave region of the Electromagnetic spectrum