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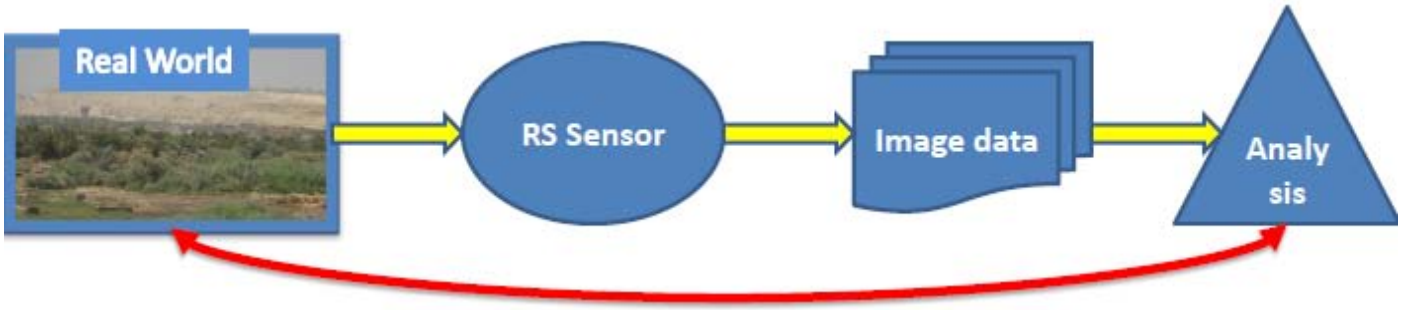
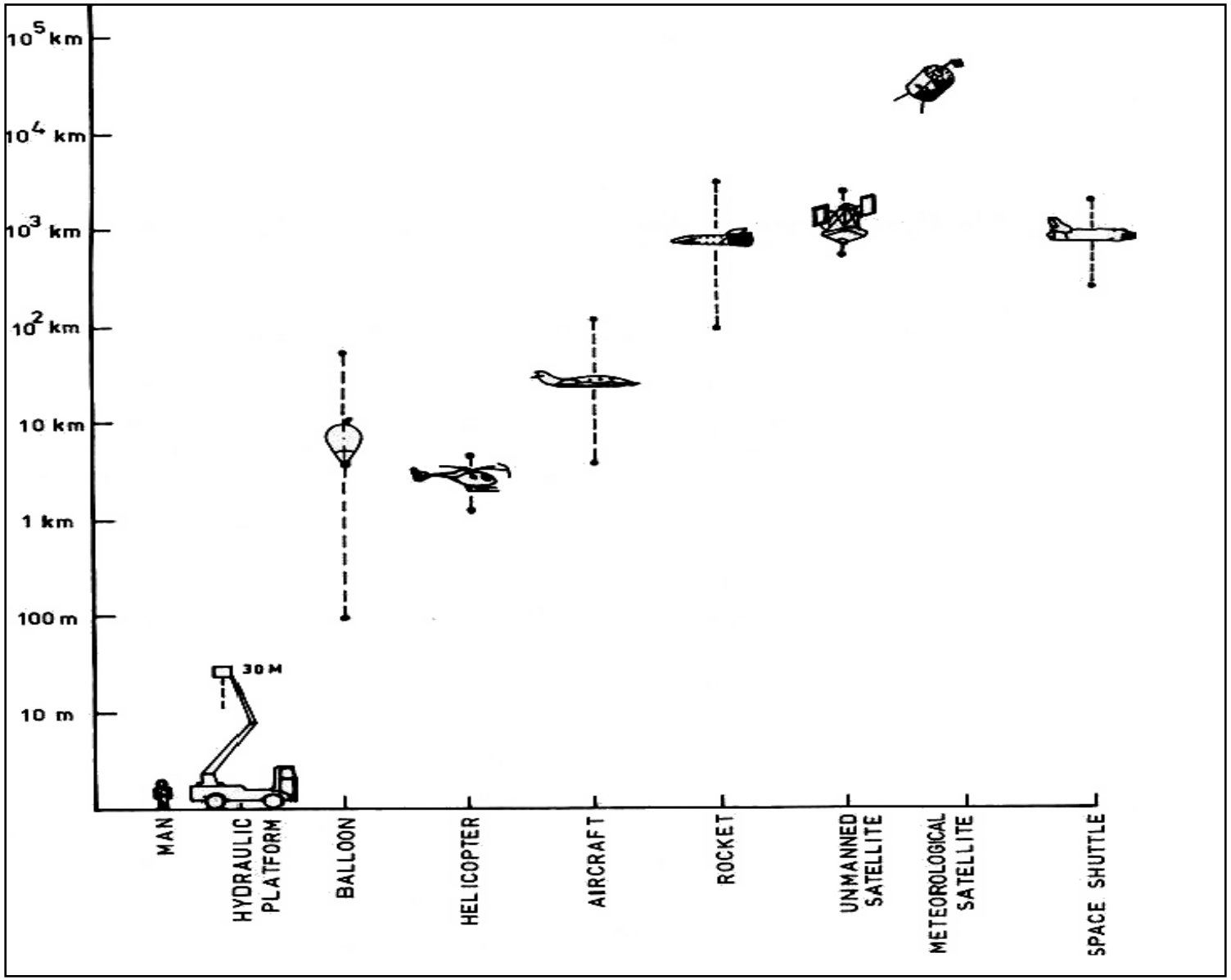
1- Earth observation

Is the measurement or acquisition of information of some property of an object or a phenomena by a recording device that is not in physical or intimate (direct) contact with the object or phenomena under study.



- **Earth observation includes**
  - Geophysical tools (e.g, ground penetration radar, gravity and aeromagnetic measurements …etc.)
  - Aircraft
  - Satellite sensors
  - Space shuttle
- **Earth observation Products** can be **analog** (e.g., photos) or **digital** images .
- Remotely sensed images need to be interpreted to yield thematic information (roads, crop lands, geologic rock units and structures… etc.) .



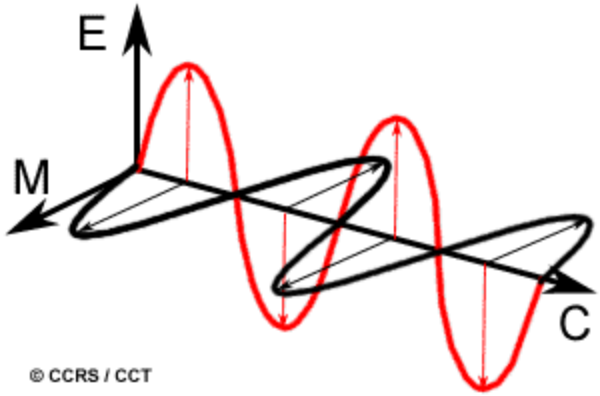
Different tools and levels of remote sensing

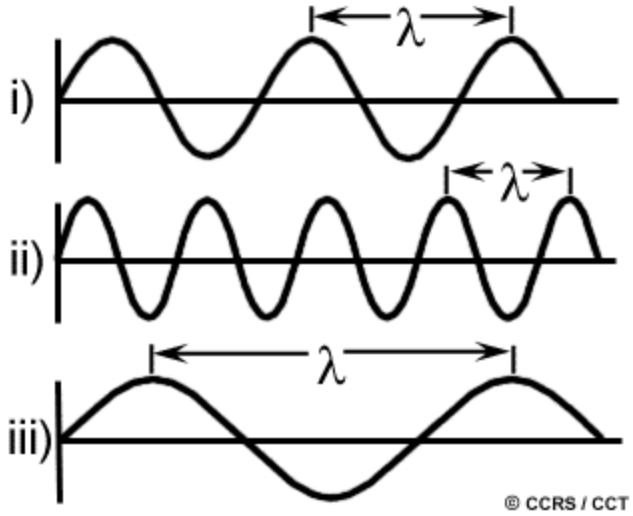
2- Electromagnetic radiation

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)

C = 300,000 km/sec approximately.

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





- The wavelength is the length of one wave cycle, which can be measured as the distance between two 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 **nanometres (nm, 10^{-9} metres), micrometres (µm, 10^{-6} metres) or centimeters** (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 formula:

$$C = \lambda V$$

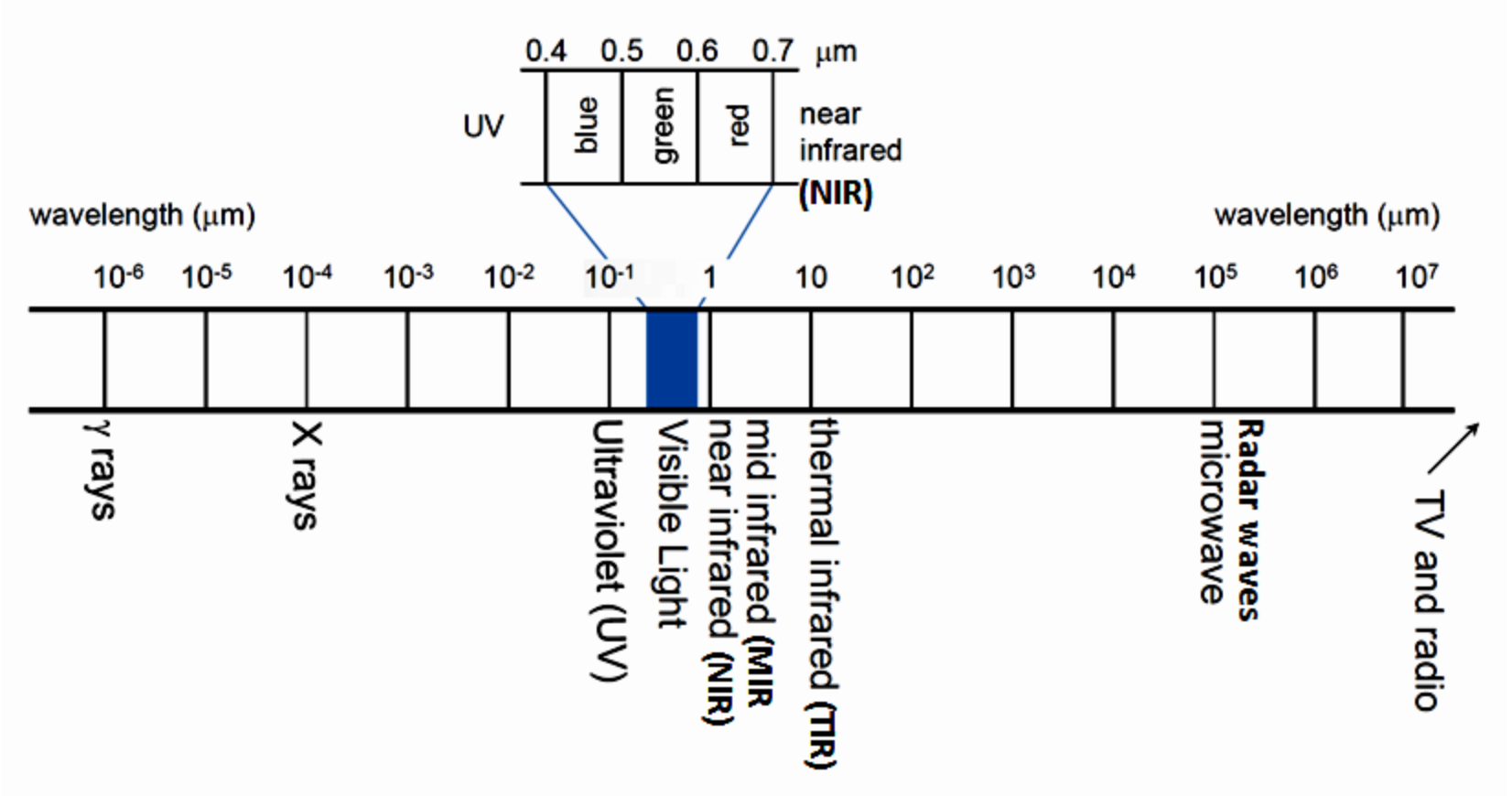
Where

λ = wave length (m)
V = Frequency (cycles per second, HZ)
C = Speed of light ($3X\ 10^{8}$ m/s)

- Therefore, the wavelength and frequency are inversely related.
- The shorter the wavelength, the higher the frequency.
- The longer the wavelength, the lower the frequency.

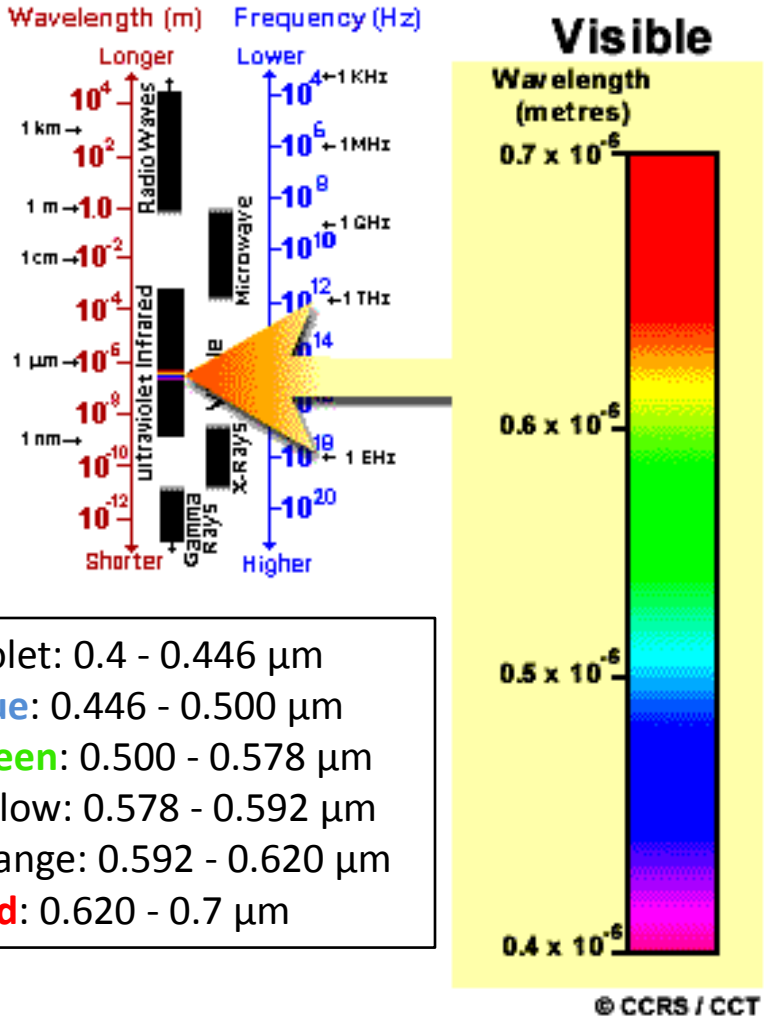
3-The Electromagnetic Spectrum

- The **electromagnetic spectrum** ranges from the shorter wavelengths (including gamma and x-rays) to the longer wavelengths (including microwaves and broadcast radio waves).
- There are several regions of the electromagnetic spectrum which are useful for remote sensing, e.g. visible light, IR, TIR, and Radar.



➢ Visible light range

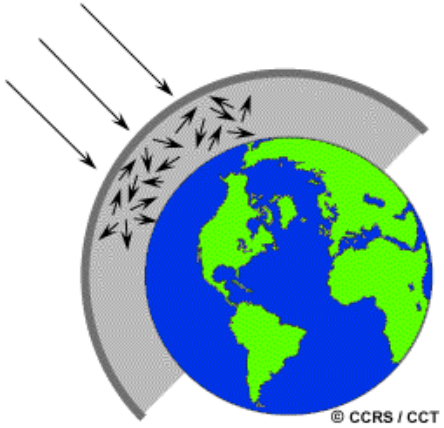
- The light which our eyes - our "remote sensors" - can detect is a part of the **spectrum.**
- It is important to recognize how small the visible portion is relative to the rest of the spectrum.
- There is a lot of radiation around us which is "**invisible**" to our eyes, but can be detected by other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



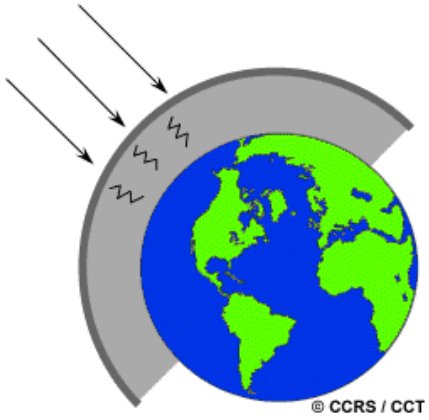
- The visible wavelengths cover a range from approximately **0.4 to 0.7** µm.
- The **longest** visible wavelength is **red** and the **shortest** is **violet**.
- Common wavelengths of the colours of the visible portion of the spectrum are listed below.
- **It is important to note that** this is the 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

➢ Interactions with the Atmosphere

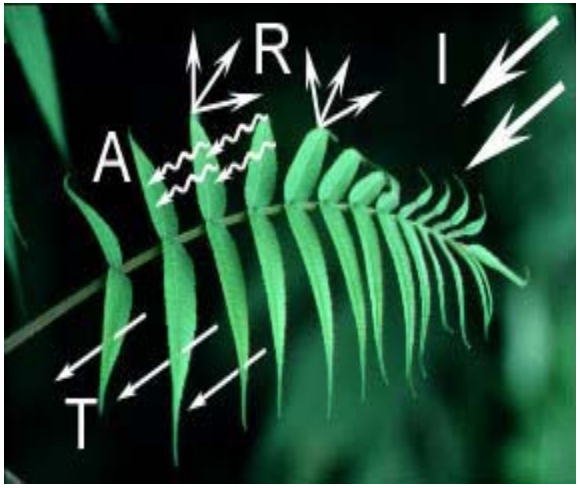


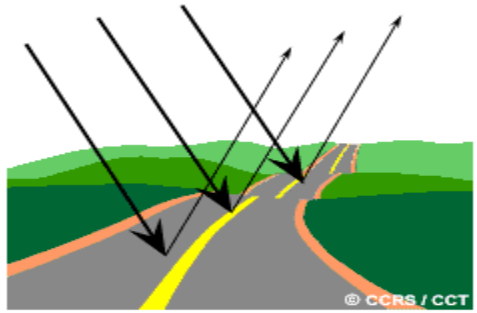
- Before radiation used for remote sensing reaches the Earth's surface, it has to travel through some distance of the Earth's atmosphere. Particles and gases in the atmosphere can affect the incoming light and radiation. These effects are caused by the mechanisms of **scattering** and **absorption.**
- **Scattering** occurs when particles or large gas molecules present in the atmosphere cause the electromagnetic radiation to be redirected from its original path. The degree of scattering depends on several factors including:
  - the wavelength of the radiation,
  - the abundance of particles or gases.
  - the distance the radiation travels through the atmosphere.
- As sunlight passes through the atmosphere, the shorter wavelengths (i.e. blue) of the visible spectrum are scattered more than the other (longer) visible wavelengths, that gives the sky its blue color.
- **Absorption** is the other main mechanism that work when electromagnetic radiation interacts with the atmosphere. In contrast to scattering, this phenomenon causes molecules in the atmosphere to absorb energy at various wavelengths. Ozone, carbon dioxide, and water vapour are the three main atmospheric constituents which absorb radiation. The atmosphere absorbs a great part of the **gamma, x-rayes and the ultraviolet rays.**



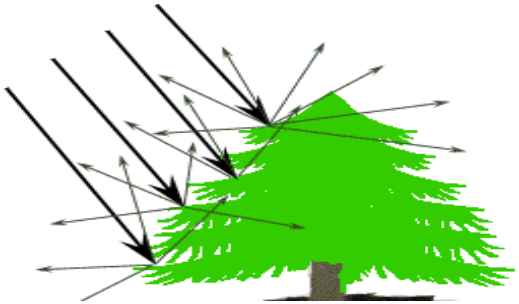
➢Radiation - Target Interactions

- Radiation that is not absorbed or scattered in the atmosphere reaches and interacts with the Earth's surface.
- There are three (3) forms of interaction that can take place when energy is **incident (I)** upon the surface**.**
- These are: **absorption (A); transmission (T); and reflection (R**). The total incident energy will interact with the surface in one or more of these three ways. The proportions of each will depend on the wavelength of the energy and the material and condition of the feature on the earth's surface.
- Absorption (A) occurs when radiation (energy) is absorbed into the target while transmission (T) occurs when radiation passes through a target. Reflection (R) occurs when radiation "bounces" off the target and is redirected. In remote sensing, we are most interested in measuring the radiation reflected from targets. We refer to two types of reflection, which represent the two extreme ends of the way in which energy is reflected from a target: **specular reflection and diffuse reflection.**

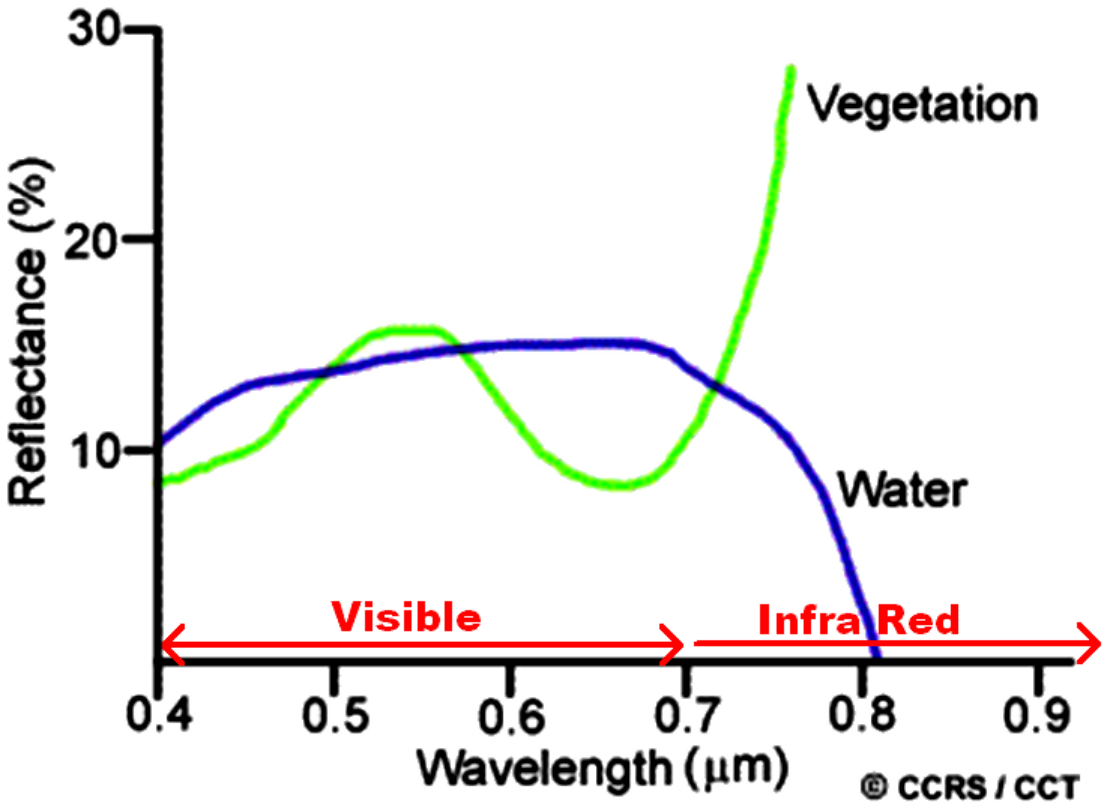




specular reflection



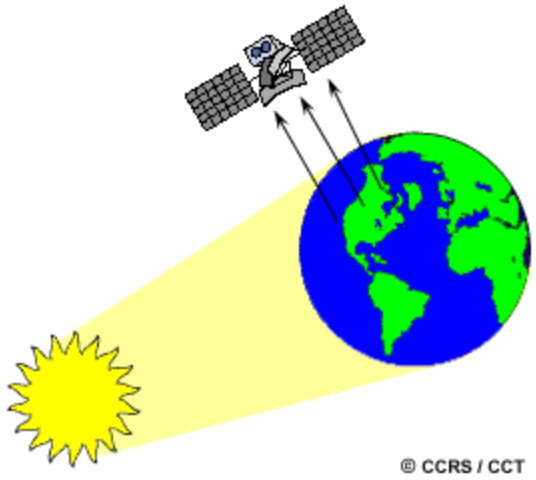
diffuse reflection.



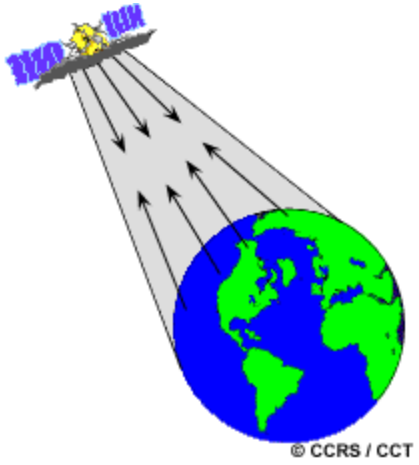
Water and vegetation may reflect somewhat similarly in the visible wavelengths but are different in behavior in the infrared region.

4- Passive and Active Sensing

- **passive sensors** are Remote sensing systems which measure energy that is naturally available (e.g. electromagnetic waves of the sun light)**.** Passive sensors can only be used to detect energy during the time when the sun is illuminating the Earth.
- **Active sensors,** provide their own energy source for illumination. The sensor emits radiation (e.g. Radar waves) which is directed toward the target to be investigated. The radiation reflected from that target is detected and measured by the sensor. Advantages for active sensors include the ability to obtain measurements anytime, regardless of the time of day or season.



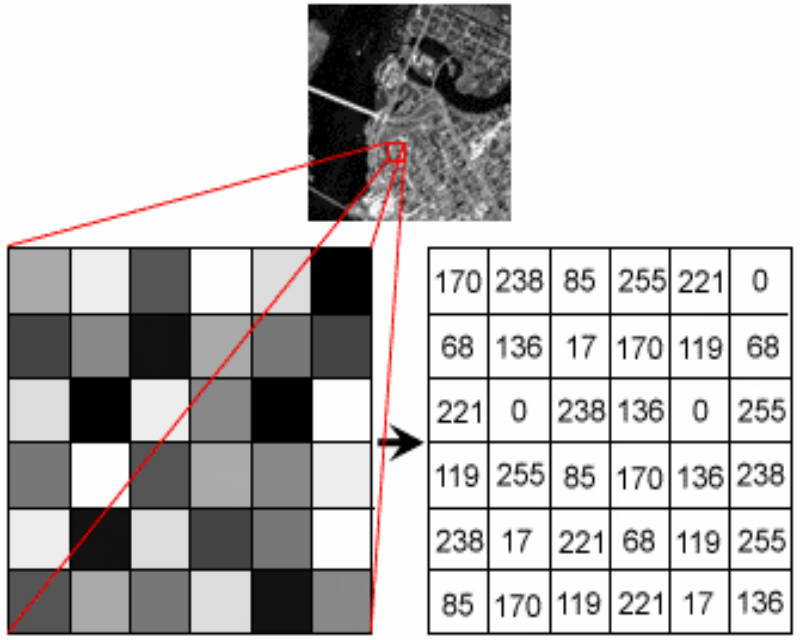
passive sensors



Active sensors

5-Characteristics of Images

- Electromagnetic energy may be detected either photographically (**analog image**) or electronically (**digital image-Raster data**).
- The **photographic process** uses chemical reactions on the surface of light-sensitive film to detect and record energy variations(e.g. x-ray films, infrared films and films used in ordinary photography).
- In **Digital images,** The image is represented and displayed in a **digital format** by subdividing the image into small equal-sized and shaped areas, called picture elements or **pixels,** and representing the **brightness** of each area with a numeric value or **digital number (DN).**
- If a photograph is scanned, the scanner subdivide it into pixels with each pixel assigned a digital number representing its relative brightness. Then the computer displays each digital value as different brightness levels.
- Satellite Sensors that record electromagnetic energy, electronically record the energy as an array of numbers in digital format right from the start. Sensors separate data into narrow wavelength ranges and store it in several **channels ,** referred to as **bands.**
- The data from one band can only be represented as different shades of black and white depending on the relative brightness (i.e. the digital value) of each pixel in the band. Data from three bands can be represented in RGB to form a colored image. In TM Lansat, bands 3,2,1 used as RGB produce a **natural color image**. Any other three bands used in RGB will produce a **false color image.**



170	238	85	255	221	0
68	136	17	170	119	68
221	0	238	136	0	255
119	255	85	170	136	238
238	17	221	68	119	255
85	170	119	221	17	136

N.B.:
Some of the figures and photos used in this lecture are used after previous iteratures for the purpose of teaching for students.