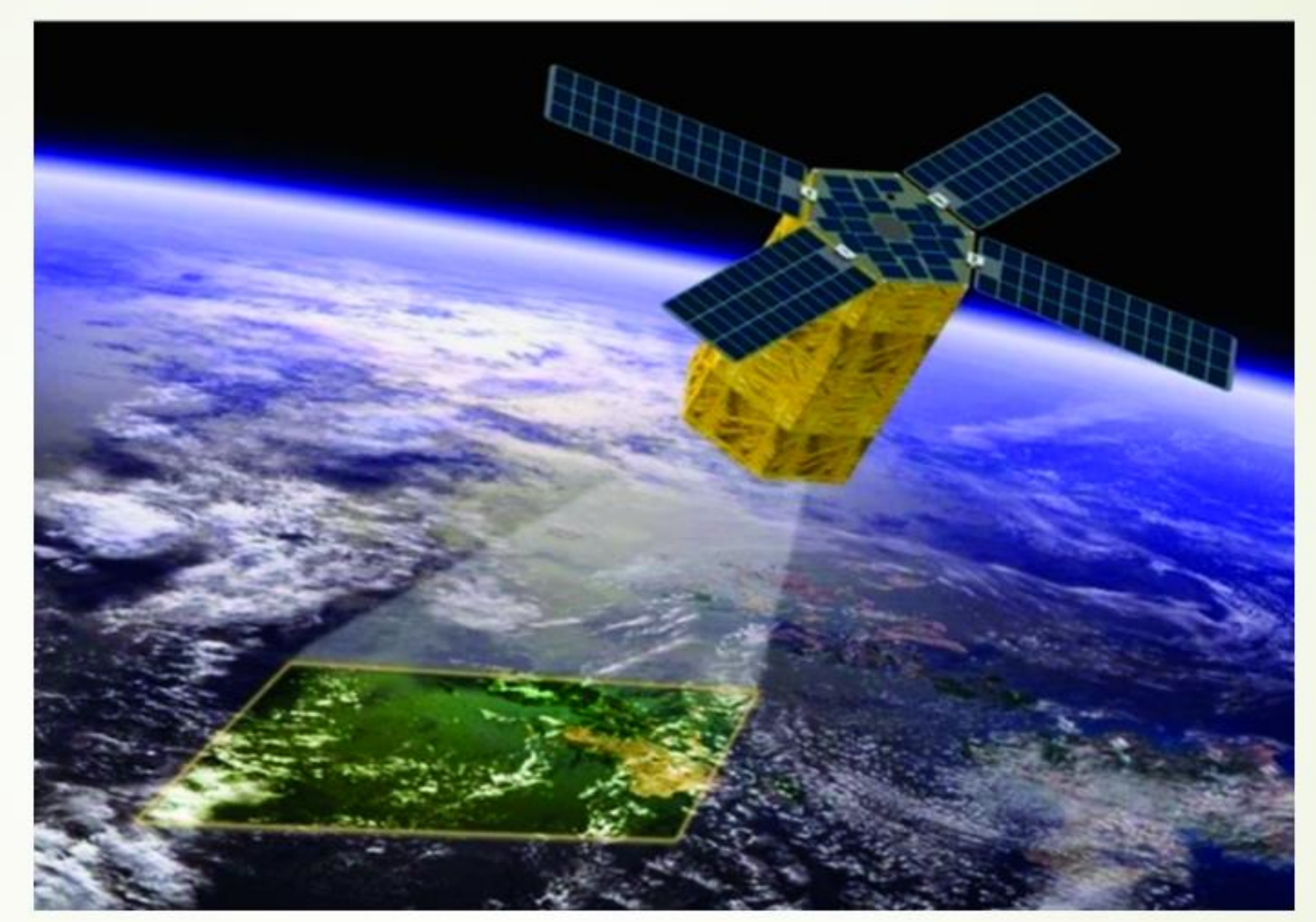
Introduction to Remote Sensing



Course instructor

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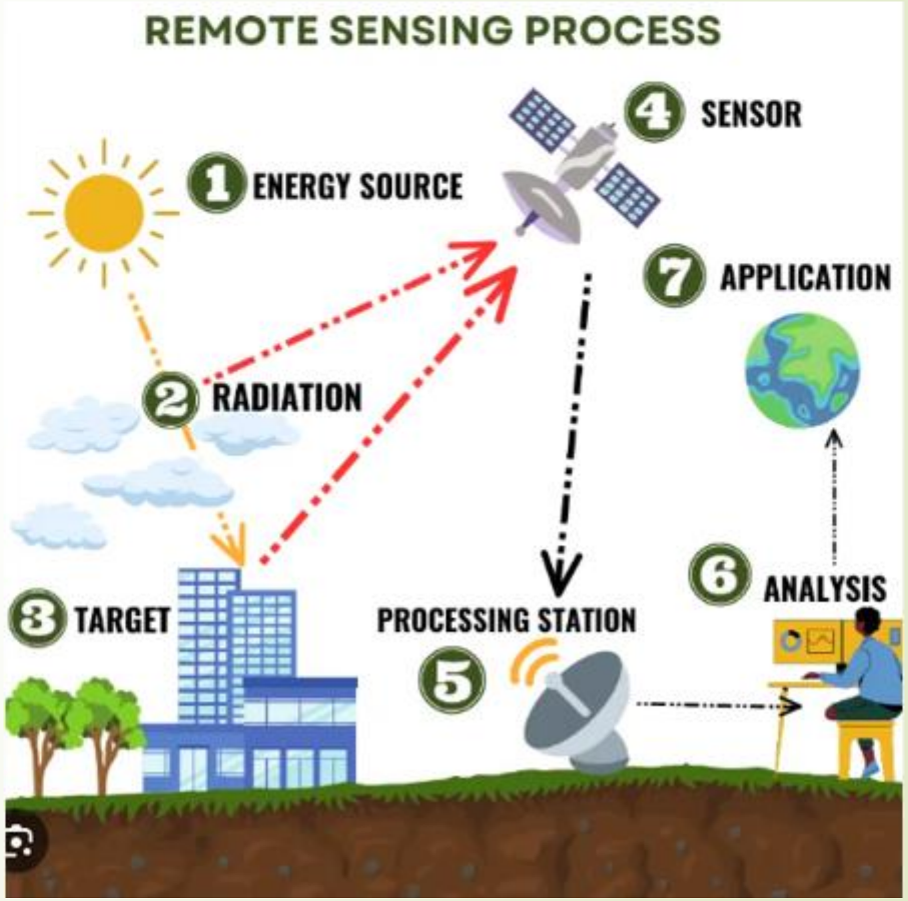
What is Remote Sensing?

- ❖ Remote sensing is the science (and to some extent, art) of acquiring information about the Earth's surface(object, area, without actually being in contact with it.
- ❖ This is done by sensing or recording reflected or emitted energy and processing, analyzing and applying that information.
- Energy source/ Illumination
- Radiation and the atmosphere
- Interaction with the target
- Recording of energy by the sensor
- Transmission, reception and processing
- Interpretation and analysis
- Applications



Remote sensing Platforms

- **Ground based platforms**

  - for detailed surface information

  - operate **on** the earth's surface

  e.g (ladder, crane, trucks, boats, towers)

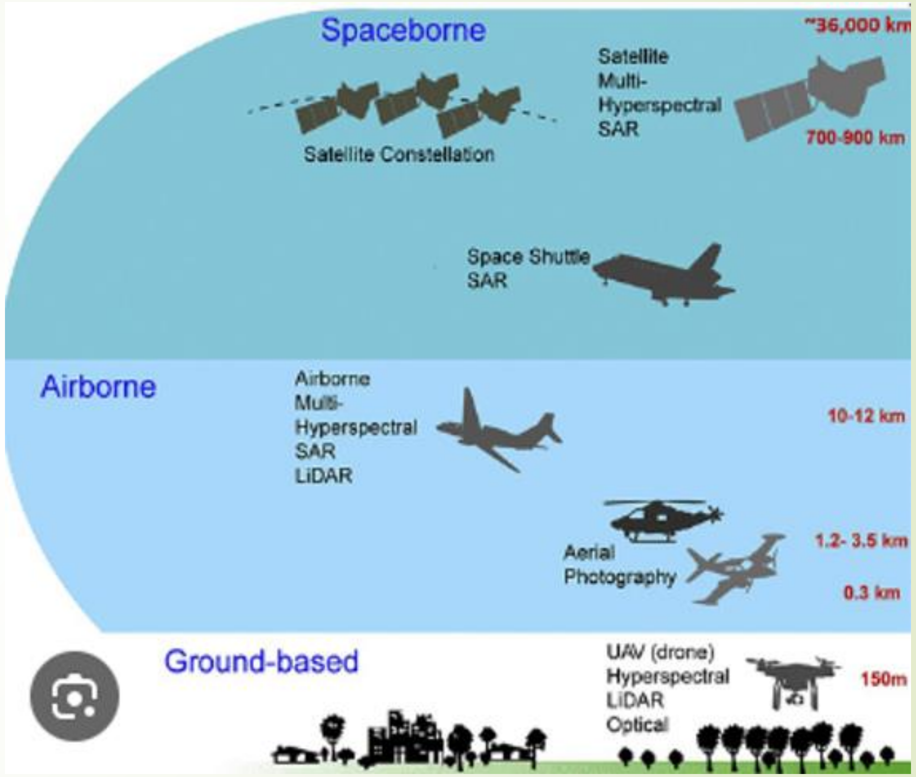
  - used for monitoring soil moisture, and vegetation growth

- **Air-borne platforms**- operate **in** the earth's atmosphere (primarily used for aerial photographs)

  e.g Airplanes, rockets, helicopters, balloons and drones

- **Spaceborne remote sensing**- platforms operate in space (space shuttle or satellite) orbiting the earth

  -Using different types of sensors, we can capture a variety of data using satellites (Multi Spectral, Hyper Spectral)



Types of remote sensing

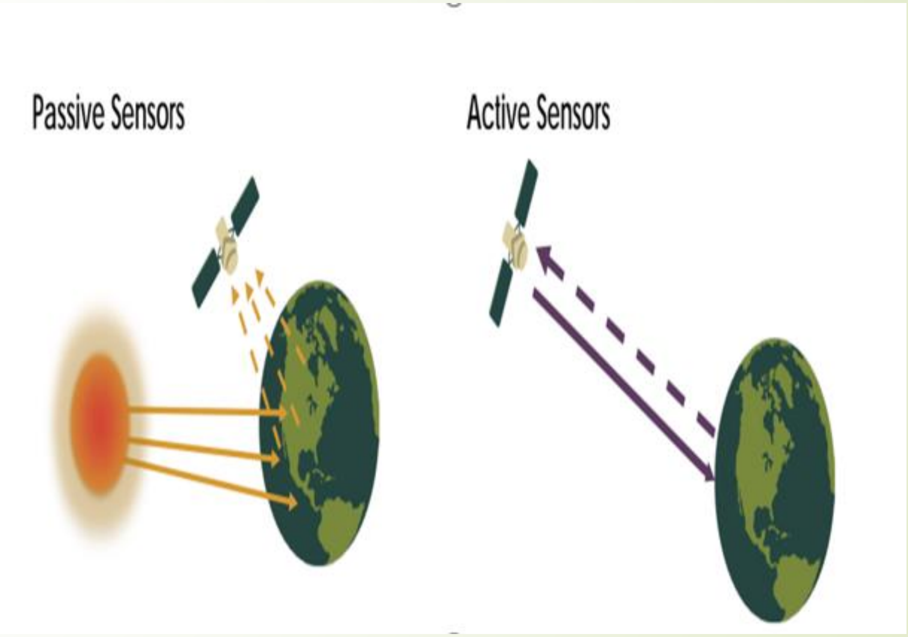
- Passive remote sensing

 - sensor uses energy released by other sources such as sun or naturally emitted thermal or microwave energy

- Active remote sensing

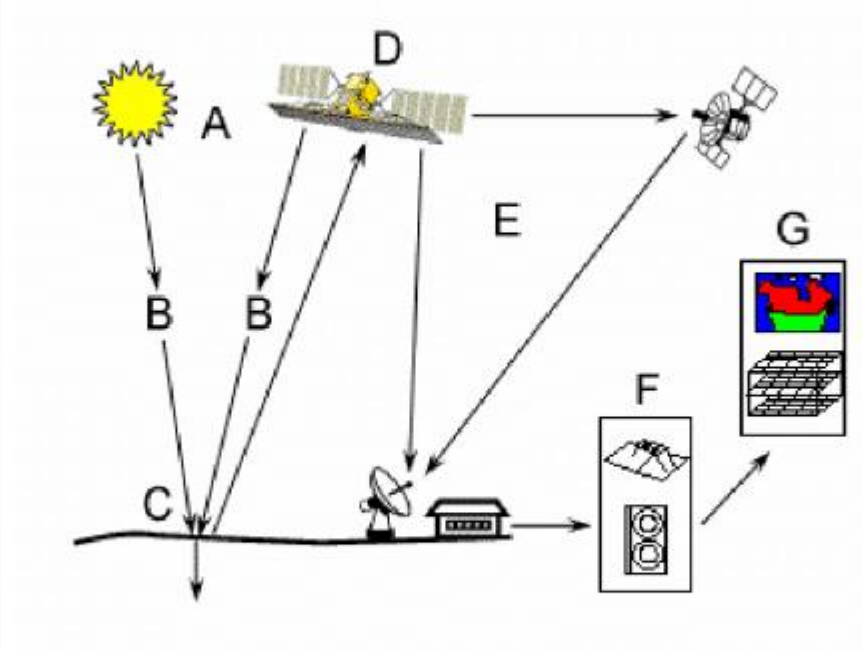
 - when a sensor uses its own energy source for illumination

 -They emit radiation, it hits the target and reflected back to the sensor and then gets sensed and measured e.g Lidar and Radar sensors



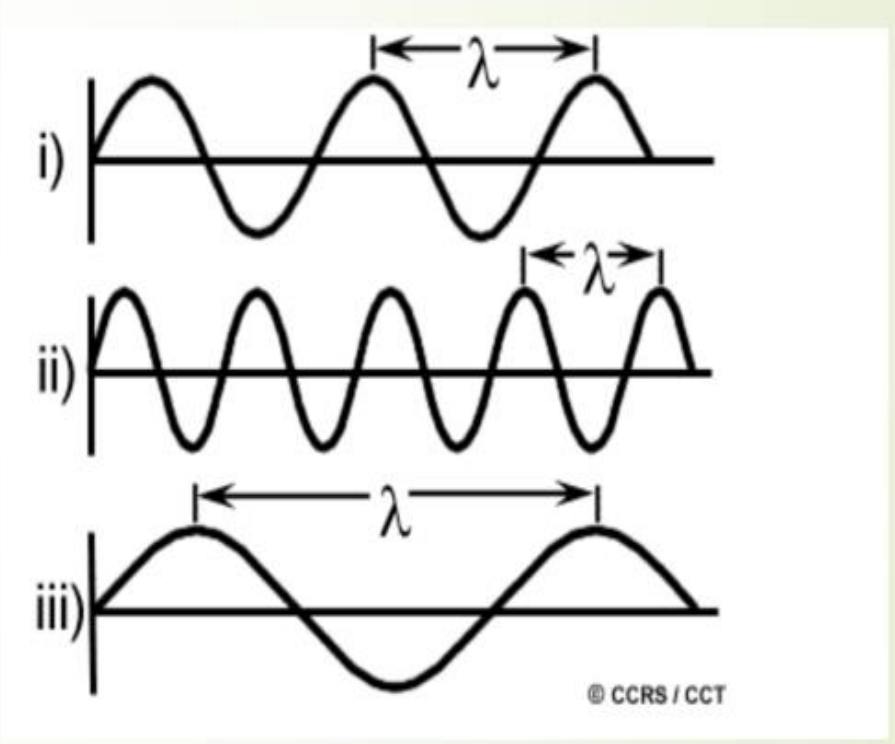
Remote sensing process

- **1. Energy Source or Illumination (A)** - the first requirement for remote sensing is to have an energy source which 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.



Electromagnetic spectrum

- The first requirement for remote sensing is to have an energy source to illuminate the target (unless the sensed energy is being emmited by the target
- All EM radiation has fundamental properties and behaves in predictable ways according to the basics of wave theory
- There are two characteristics of EM that are important in remote sensing
- Wavelength-length of one wave cycle(measured in meters, nanometers,, micrometers)
- Frequency- number of cycles of a wave passing through a fixed point in time (measured in hertz)
- The higher the frequency the shorter the wavelength



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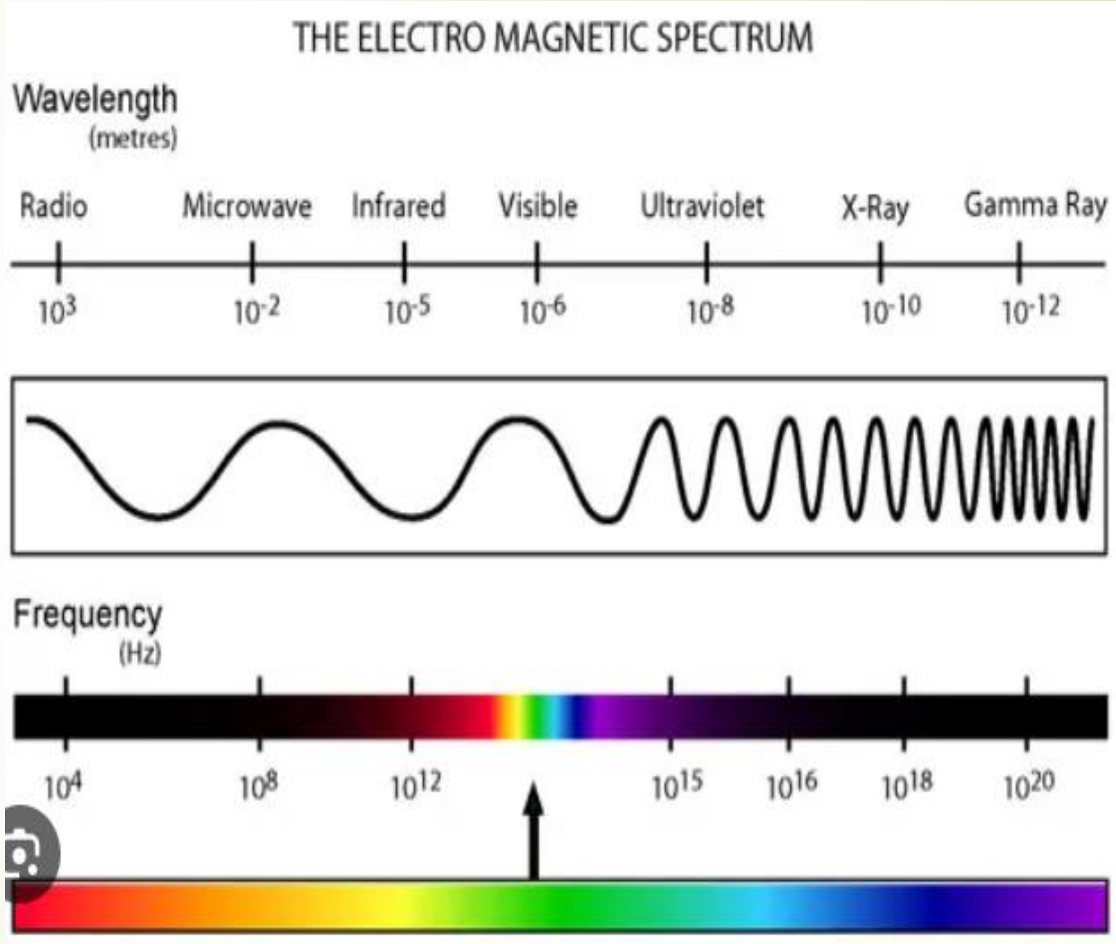
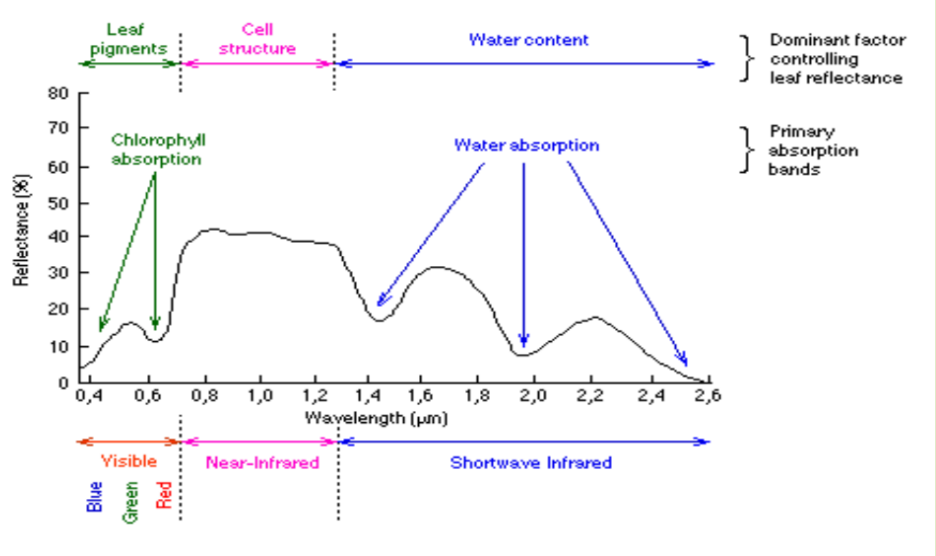
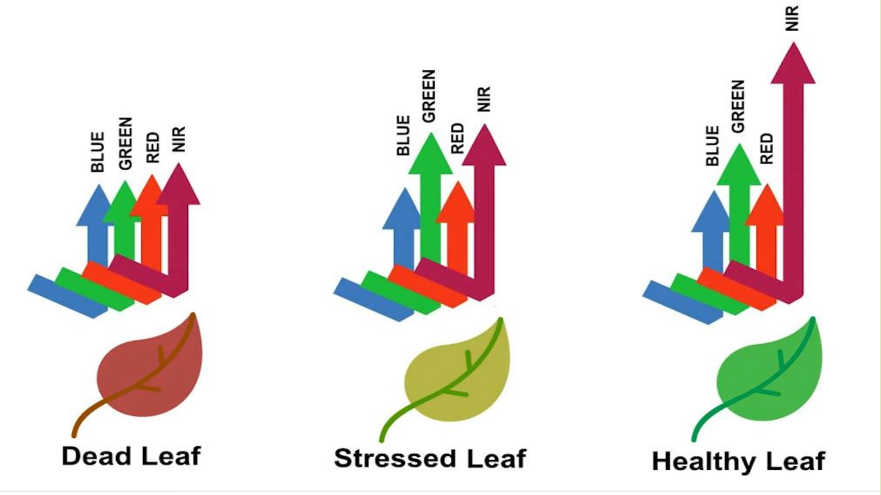
- EM spectrum is entire range of all types of electromagnetic energy emitted by the sun and other objects (visible light, ultra violet light, infrared waves, radio waves, x-rays and gamma rays)
- Sensors measure electromagnetic radiation at specific wavelengths
- Understanding of characteristics of electromagnetic radiation is crucial in understanding the information to be extracted from remote sensing data
- The key portions of the EM spectrum useful in remote sensing are:
- Visible Light - It is useful for observing vegetation, water bodies, and urban areas.
- True color and false color images can be generated using this range.
- Near-Infrared (NIR) (0.7 - 1.3 µm): NIR is particularly useful for vegetation analysis because healthy vegetation reflects more NIR light than unhealthy or sparse vegetation. It is also used for soil moisture and water body detection.
- SWIR is used for detecting moisture content in soil and vegetation, distinguishing between clouds and snow, and identifying different types of minerals and rocks.
- Thermal Infrared (TIR) (3 - 14 µm): This range is used to measure surface temperature and thermal properties. It is valuable for studying heat emissions, vegetation stress, and urban heat islands.
- Microwave (1 mm - 1 m): Microwave remote sensing includes both active (radar) and passive systems. Radar systems (1 cm - 1 m) can penetrate clouds and provide surface information regardless of weather conditions or daylight. Passive microwave sensors (1 mm - 1 cm) are used for measuring soil moisture, sea surface salinity, and atmospheric water vapor.



Vegetation Spectral profile

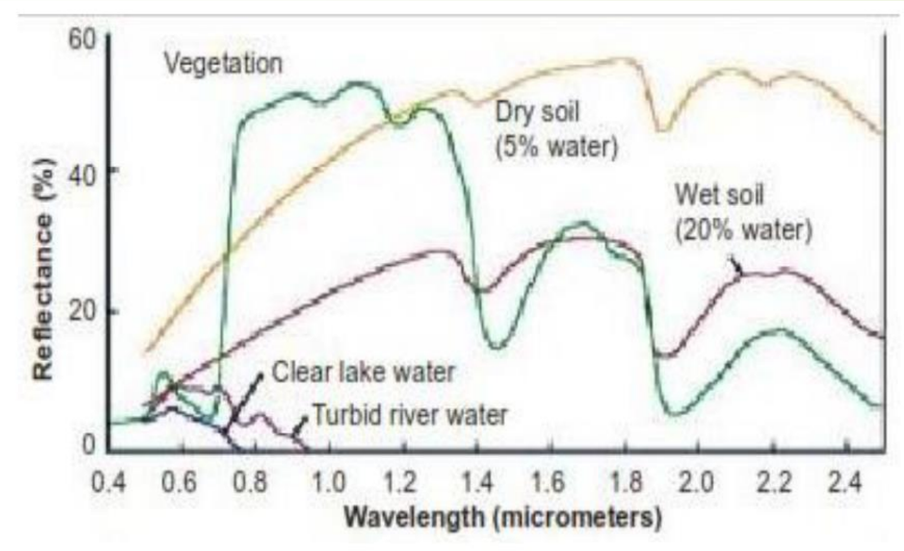
- Spectral profile- the variation of reflectance or emittance of a material or surface across different wavelengths of the electromagnetic spectrum
- The spectral characteristics of vegetation vary with wavelength.
- Vegetation will reflect radiation differently in different portions of the EM spectrum depending on the characteristics of a particular plant
- The spectral reflectance curve of healthy green vegetation has a significant minimum of reflectance in the visible portion of the electromagnetic spectrum resulting from the pigments in plant leaves.
- • Plant pigment in leaves called chlorophyll strongly absorbs radiation in the red and blue wavelengths but reflects green wavelength.
- • Reflectance increases dramatically in the near infrared wavelength
- • Measuring and monitoring the near infrared reflectance is one way that scientists determine how healthy particular vegetation may be.





Reflectance of water

- The water curve is characterised by a high absorption at near infrared wavelengths range and beyond.
- Thus water looks blue or blue green due to stronger reflectance at these shorter wavelengths
- Factors that affect the variability in reflectance of a waterbody are depth of water, materials within water and surface roughness of water
- Turbid water has a higher reflectance in the visible region than clear water.
- This is also true for waters containing high chlorophyll concentrations.

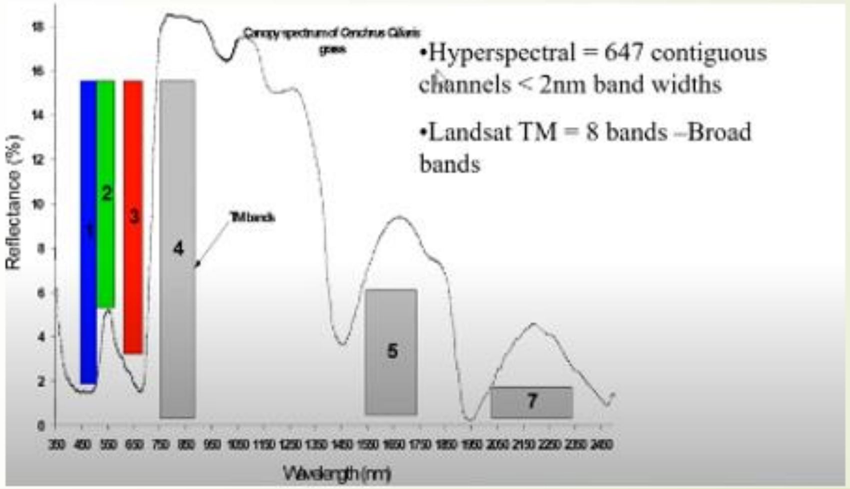


Multi-spectral RS & Hyperspectral RS

- Multispectral remote sensing involves use of several broad wavelength bands.
- Hyperspectral imaging systems acquire images in over one hundred, contiguous and narrow spectral bands
- MS- is useful to discriminate land surface features and landscape patterns
- Hyperspectral imagery allows for the identification and characterization of materials, as well as inferring biological and chemical processes. .
- MSS -Landsat TM has been in existence for the past 30 years
- It has bands in the blue, red, green, the near infra red(NIR) and part of the near short wave infrared regions

 - there is a gap between about 850 and 1420 nanometers, meaning the sensor does not see anything within that region

- Hyperspectral sensor- the vegetation profile is contiguous(no gap) because the sensor collects information in every band



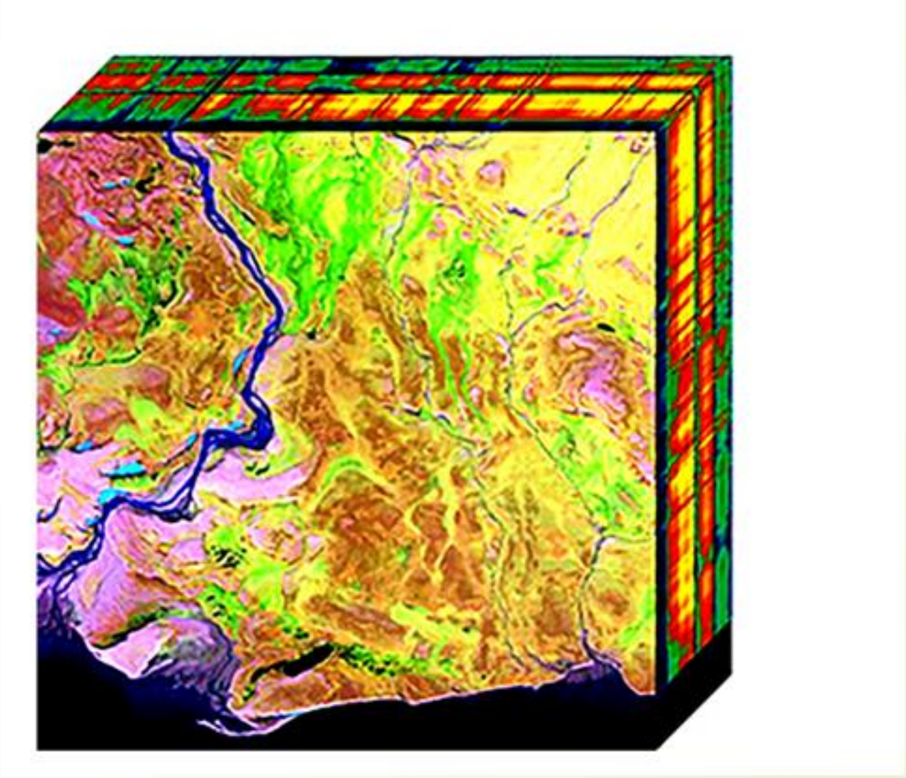
Hyperspectral data cube

- When using hyperspectral data you come up with a hyperspectral cube

-This is one image captured by several scenes

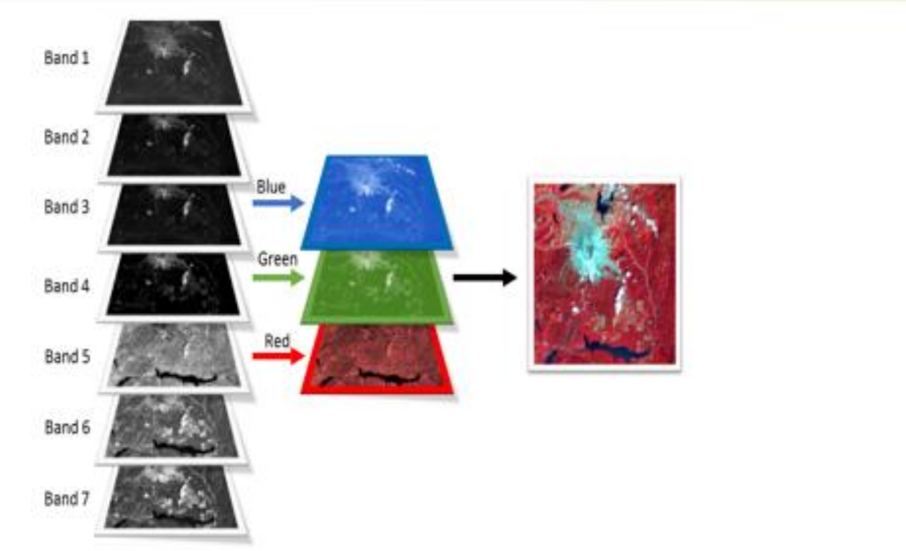
-Which means several bands (about 640 bands) capture information within one particular area

-This will result in big data since a lot of information is provided for a particular area, requiring a lot of computational resources



Multispectral sensing

- Multispectral sensors, simultaneously measure data in multiple regions of the electromagnetic spectrum, including visible light, near and short wave infrared.
- The range of wavelengths measured by a sensor is known as a band
- Bands can represent any portion of the electromagnetic spectrum, including ranges not visible to the eye, such as the infrared or ultraviolet sections
- Each band of a multispectral image can be displayed one band at a time as a grey scale image, or in a combination of three bands at a time as a color composite image.



Monitoring of vegetation by remote sensing

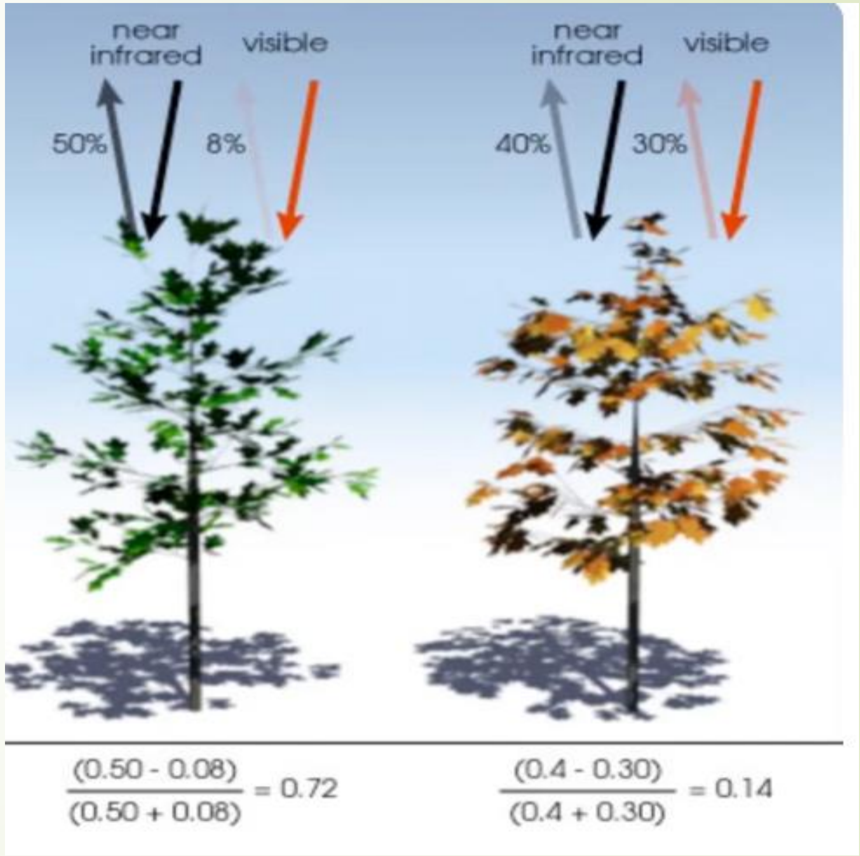
- Monitoring of vegetation is one of the most common types of monitoring to be conducted by remote sensing
- The **monitoring** of vegetation by remote sensing is conducted mainly with images collected by multi-spectral optical sensors aboard satellites (such as OLI/Landsat-8, MSI/Sentinel-2), and can also be conducted with images collected by unmanned aerial vehicles (drones)
- The diversity of sensors and types of platforms for acquisition of images currently available allows observing vegetation on a wide variety of spatial and temporal scales
- Detection of vegetation allows verifying its occurrence in a given locality, accompanying its changes over time and quantifying its area and scope, by means of digital interpretation and image processing

Automatic detection of vegetation

- Algorithms used -Support Vector Machine, Decision Trees, Random Forest, Artificial Neural Networks.
- These algorithms are now implemented and available in various open source and commercial software (such as ENVI, ArcGIS Pro and Qgis) and in packages implemented in R language (such as the Caret package).
- Google earth Engine has gained momentum
- NDVI (Normalized Difference Vegetation Index)- One of the best known vegetation indices which is broadly applied to various studies of vegetation by remote sensing
- Other vegetation indices include SAVI, Modified SAVI

Extraction of vegetation indices

- NDVI (Normalized Difference Vegetation Index)- One of the best known vegetation indexes which is broadly applied to various studies of vegetation by remote sensing
- Example of the application of NDVI using an MSI/Sentinel-2 image
- NDVI = (NIR - R) / (NIR + R)
- SAVI
- Classification of such remote sensing images involves assigning a semantic label to an image, which can be done either at pixel level, or at object level, or at scene level of the image.



Applications of remote sensing

- Land use/land cover change analysis
- Vegetation quality monitoring
- Urban expansion analysis
- Water quality monitoring
- Assessing dynamics of informal settlements
- Flood disaster management