Remote sensing: General concepts

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Remote Sensing

Measurement from a distance

The art and science involving the detection, identification, classification, delineation, and analysis of earth surface features and phenomena using imagery acquired from terrestrial, aircraft and satellite platforms equipped with photographic and non-photographic sensors using visual and Digital interpretation techniques

Sensors: a device that records EM Energy

Platforms: carrier bed used to carry a sensor

- *Ground based*
- *Aircraft*
- *Satellite*

Remote Sensing Sensors

Sensor is a device that gathers energy (EMR or other), converts it into a signal and presents it in a form suitable for obtaining information about the target under investigation. These may be active or passive depending on the source of energy.

Sensors used for remote sensing can be broadly classified as those operating in Optical Infrared (OIR) region and those operating in the microwave region.OIR and microwave sensors can further be subdivided into ***passive*** *and* ***active****.*

Active sensors: use their own source of energy. Earth surface is illuminated through energy emitted by its own source; a part of it is reflected by the surface in the direction of the sensor, which is received to gather the information.

Passive sensors: receive solar electromagnetic energy reflected from the surface or energy emitted by the surface itself. These sensors do not have their own source of energy and cannot be used at night time, except thermal sensors. Again, sensors (active or passive) could either be imaging, like camera or sensor, which acquire images of the area and non-imaging types like non-scanning radiometer or atmospheric sounders.

Instantaneous field of view (IFOV)

A measure of the spatial resolution of a remote sensing imaging system. Defined as the angle subtended by a single detector element on the axis of the optical system. IFOV has the following attributes

Solid angle through which a detector is sensitive to radiation

The IFOV and the distance from the target determines the spatial resolution. A low altitude imaging instrument will have a higher spatial resolution than a higher altitude instrument with the same IFOV.

It is defined the solid angle through which a detector is sensitive to radiation (units is mrad).

IFOV = D/F radian

GRE = (D/F) x H meter

Where,

D=detector dimension, F=focal length, and H=flying height

A measure of the spatial resolution of a remote sensing

Satellite orbital characteristics

Altitude*: It is the distance (in Km) from the satellite to the mean surface level of the* earth. The satellite altitude influences the spatial resolution to a large extent.

***Inclination angle*: The angle (in degrees) between the orbit and the equator.** The inclination angle of the orbit determines the field of view of the sensor and which latitudes can be observed. If the inclination angle is 60° then the satellite flies over the earth between the latitudes 60° South and 60° North, it cannot observe parts of the earth above 60° latitude.

***Period:* It is the time (in minutes) required to complete one full orbit.** A polar satellite orbiting at an altitude of 800km has a period of 90mins.

Repeat Cycle (Temporal resolution): It is the time (in days) between two successive identical orbits.

Swath: As a satellite revolves around the Earth, the sensor sees a certain portion of the Earth's surface. The area is known as swath. The swath for satellite images is very large between tens and hundreds of kilometers wide.

- ***Ascending pass and Descending pass:*** ***The near polar satellites travel northward on one*** side of the earth (ascending pass) and towards South Pole on the second half of the orbit (descending pass). The ascending pass is on the shadowed side while the descending pass is on the sunlit side. Optical sensors image the surface on a descending pass, while active sensors and emitted thermal and microwave radiation can also image the surface on ascending pass.
- ***Perigee: It is the point in the orbit where an earth satellite is closest to the earth.***
- ***Apogee: It is the point in the orbit where an earth satellite is farthest from the earth.***

Resolution

Resolution is defined as the ability of the system to render the information at the smallest discretely separable quantity in terms of distance (spatial), wavelength band of EMR (spectral), time (temporal) and/or radiation quantity (radiometric).

- **Spectral resolution = part of the EM spectrum measured**
- **Radiometric resolution = smallest differences in energy that can be measured**
- **Spatial resolution = smallest unit-area measured**
- **Revisit time (temporal resolution) = time between two successive image acquisitions over the same area**

Spatial Resolution:

It is also called ground resolution element (GRE).

Ground Resolution = H x IFOV

A "High Resolution" image refers to one with a small resolution size. Fine details image. can be seen in a high resolution image. On the other hand, a "Low Resolution" image is one with a large resolution size, i.e. only coarse features can be observed in the image. Images where only large features are visible are said to have coarse or low resolution. In fine resolution images, small objects can be detected.

10 meter resolution

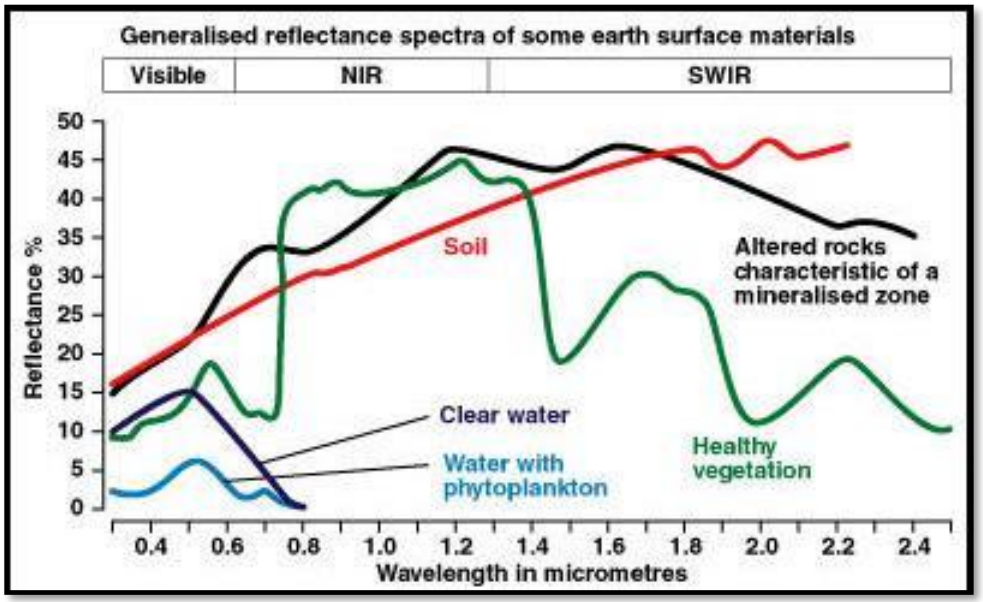
30 meter resolution

80 meter resolution

Spectral Resolution

Spectral resolution describes the ability of the sensor to define fine wavelength intervals i.e. sampling the, thereby allowing the spectral spatially segmented image in different spectral intervals irradiance of the image to be determined.

Simply put, it refers to the number and narrowness of bands in the spectrum in which the instrument can take measurements



Different classes of features and details in an image can be distinguished by water comparing their responses over distinct wavelength ranges. Broad classes such as and vegetation can be separated using broad wavelength ranges (VIS, NIR), whereas specific classes like rock types would require a of fine wavelength ranges to separate them. Hence

Temporal Resolution

Temporal resolution is also called as the repetivity of the satellite; it is the capability of the satellite to image the exact same area at the same viewing angle at different periods of time. The temporal resolution of a sensor depends on a variety of factors, including the satellite/sensor capabilities, the swath overlap and latitude. It is an important aspect in remote sensing when

- *persistent cloud offers limited clear views of the earth's surface*
- *short lived phenomenon need to be imaged (flood, oil slicks etc.)*
- *multi temporal comparisons are required (agriculture application) the changing appearance of a feature over time can be used to distinguish it from near similar features (wheat/maize)*

Radiometric Resolution

This is a measure of the sensor to differentiate the smallest change in the spectral between various targets.

Geostationary satellite

- Altitude ~ **36,000km**
- Orbit inclination~**0**
- Period of orbit- **24hours**
- **Global coverage requires several geostationary satellite in orbits at different latitudes.** Its coverage is limited to 70°N to 70°S latitudes and one satellite can view one-third globe
- Good for repetitive observations, **poor for spatially detailed data**
- Large distortions at high latitudes
- **W-E satellite orbiting Earth**
- Mainly used for communication and meteorological applications–**GOES, METEOSAT, INSAT etc.**

Sun synchronous Satellite

- Altitude ~**700-800km**
- Orbit inclination ~ **98.7º**
- Orbital period ~ **90minutes**
- Sun-synchronous, near- polar, near-circular
- Satellite orbit is fixed in space (basically **north-south): Earth rotates beneath it (west-east)**
- Cross the equator(N-S)at **10.30am local time Satellite Orbital plane is near polar and the altitude is such that the satellite passes each place at same local sun-time.**
- The satellite's orbit and the rotation of the Earth work together to allow complete coverage of the Earth's surface, after it has completed one complete cycle of orbits. Through these satellites the entire globe is covered on regular basis and gives repetitive coverage on periodic basis. All the remote sensing resource satellites may be grouped in this category.
- Cover entire globe – **LANDSAT series, SPOT, NOAA, IRS series etc.**

Some Land Imaging Satellites

LANDSAT	(USA)
SPOT	(France)
IRS	**(India)**
NOAA	(USA)
IKONOS	(USA)
RADARSAT	(Canada)
ERS	(Europe)
ENVISAT	(Europe)
JERS	(Japan)