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

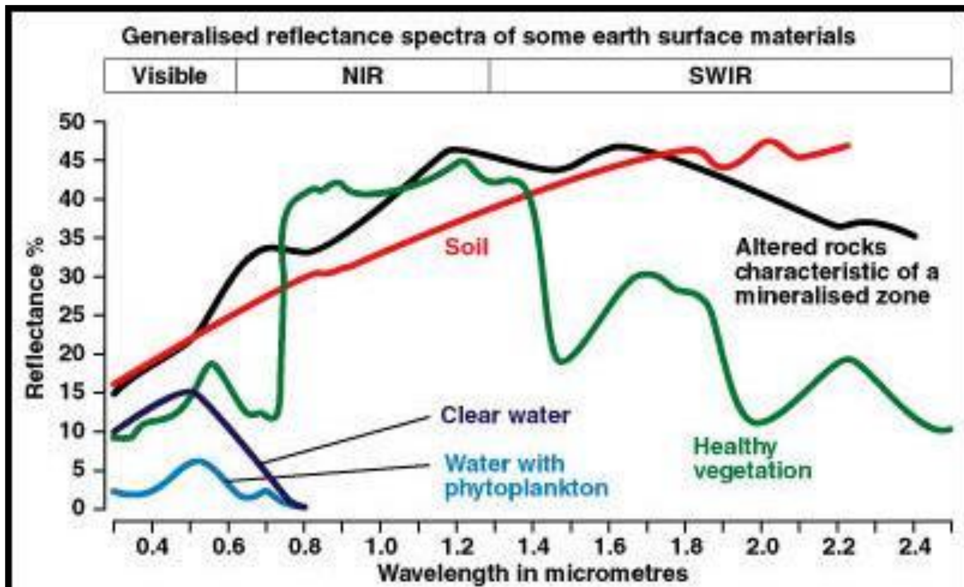
30 meter resolution

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)

IRS Satellite Series

The Indian Space programme has the goal of harnessing space technology for application in the areas of communications, broadcasting, meteorology and remote sensing.

The important milestones crossed so far are Bhaskara-1 and 2 (1979) the experimental satellites, which carried TV Cameras and Microwave Radiometers.

The **Indian Remote Sensing Satellite (IRS)** was the next logical step towards the National operational satellites, which directly generates resources information in a variety of application areas such as forestry, geology, agriculture and hydrology. IRS -1A/1B, carried Linear Imaging Self Scanning sensors LISS-I & LISS-II. IRS-P2 was launched in October 1994 on PSLV-D2, an indigenous launch vehicle. IRS-1C was launched on December 28, 1995, which carried improved sensors like LISS-III, WiFS, PAN Camera, etc. IRS-P3 was launched into the sun synchronous orbit by another indigenous launch vehicle PSLV - D3 on 21.3.1996 from Indian launching station Sriharikota (SHAR). IRS-1D was launched on 29 September, 1997 and IRS-P4 was launched on 26 – 5 1999 onboard PSLV from Shriharikota.

Earth Observation Satellites

Starting with IRS-1A, in 1988, ISRO has launched many operational remote sensing satellites in operation. Currently 13 operational satellites are in sun-synchronus orbit – Resourcesat -1, 2, 2A, Cartosat-1, 2, 2A, 2B, RISAT and 2, Oceansat-2, Megha-Tropiques, SARAL and SCATSAT-1, and four in Geostationary orbit-INSAT-3D, Kalpana and INSAT-3A, INSAT-3DR. Varieties of instrument has been sent onboard these satellites are used to provide necessary data in diversified spectral, spatial, and temporal resolution for country and global usage. The data from these satellites are used for several applications covering agriculture, water resources, urban planning, rural development, mineral prospecting, environment, forestry, ocean resources and disaster management.

Communication Satellite

The Indian National Satellite (INSAT) system is one of the largest domestic communication satellite system in Asia-Pacific region with nine operational communication satellites placed in GSAT-6,7,8,9,10, 12, 14, 15, 16 and 18. The INSAT system provides services to telecommunications, television broadcasting, satellite newsgathering, societal applications, weather forecasting, disaster warning and Search and rescue operations.

Launching Vehicles

- The Geosynchronous Satellite Launch Vehicle usually known by its abbreviation, GSLV operated by the Indian Space Research Organization (ISRO). It was developed to enable India to launch INSAT –type satellites into the geostationary orbit and to make India less dependent on foreign rockets.

- The Polar Satellite Launch Vehicle commonly known by its abbreviation PSLV, developed to allow and operated by the Indian Space Research Organization (ISRO). It was developed to allow India to launch its Indian Remote Sensing satellite into sunsynchronus orbit

Satellite Name	Launch	Sensors Types	Types	No. of Bands	Resolution (meters)	Swath Width (km)	Revisit Time
IRS-1A	1988	LISS-I	Multispectral	4	72.5	148	
		LISS-II	Multispectral	4	36.25	74	
IRS-1B	1991	LISS-I	Multispectral	4	72.5	148	22 days
		LISS-II	Multispectral	4	36.25	74	
IRS-1C	1995	WiFS	Multispectral	2	189	810	5 day
		LISS-III	Multispectral	3	23.6	142	24-25 days
				1	70.8	148	
			PAN	PAN	1 5.8	70	
IRS-1D	September - 1997	WiFS	Multispectral	2	189	810	5 day
		LISS-III	Multispectral	3	23.6	142	24-25 days
				1	70	148	
		PAN	PAN	1	6	70	
IRS-P4 (Oceansat)	26 May, 1999	OCM	Multispectral	8	360 m	1420 km	2 days
		MSMR	RADAR	4	120, 80, 40 and 40 kms	1360 km	
IRS – P6 (Resourcesat-1)	17 Oct, 2003	AWiFS	Multispectral	4	56	740	5 days
		LISS-III	Multispectral	4	23	142	24 days
		LISS-IV	Multispectral	3	5.8	23.9 MX mode 70 PAN mode	24 days

Satellite Name	Launch	Sensors Types	Types	No. of Bands	Resolution (meters)	Swath Width (km)	Revisit Time
CARTOSAT–1 (IRS-P5)	5 May 2005	PAN	PAN	1	2.5	30	5 days
IMS-1 28	April 2008	MX	Multispectral	4	37	151	
		HySI	Hyperspectral Imager	64	505.6	125	
CARTOSAT-2A (IRS P8)	28 April 2008	PAN	PAN	1	0.8	16	
RISAT-2	April 2009	SAR-X			3-8 m	10 km, 50 km [Max Swath: 650 km]	
IRS 2B (Oceansat 2)	24 Sept, 2009	OCM	Multispectral		236m	1440	2 days
		SCAT				1400	
CARTOSAT–2B	12 July 2010	PAN	PAN	1	1	9.6	5 days
RESOURCESAT 2	20 April 2011	AWiFS	Multispectral	4	56	740	5 days
		LISS-III	Multispectral	4	23.5	141	24 days
		LISS-III 4	Multispectral	4	23.5	141	

Sensors

Linear Imaging Self Scanning (LISS) Camera used in IRS-1A & B- It has four spectral bands in the range of 0.45 to 0.86 mm (0.45 to 0.53 mm to 0.59 mm, 0.62 to 0.68 mm and 0.77 to 0.86 mm) in the visible and near infrared range with two different spatial resolution of 72.5 m

(Panchromatic camera (PAN)

The PAN camera is configured to provide the imageries of the earth in visible spectrum, in a panchromatic band (0.5-0.75 µm) with a geometric resolution from altitude of 817 km 5.8 m

and a swath of 70 km. The camera uses an off-axis reflective type optics system consisting of three mirror

High Resolution Linear Imaging Self-Scanner (LISS-IV)

LISS-IV sensor onboard IRS – P6 operates in three spectral bands in the visible and near infrared VNIR) or PAN mode with 5.8 meter spatial resolution's.

Ocean color monitor (OCM)

OCM is a solid state camera operating in eight narrow spectral bands. The camera is used to collect data on chlorophyll concentration, detect and monitor phytoplankton blooms and obtain data on atmospheric aerosols and suspended sediments in the water.

Multi-frequency Scanning Microwave Radiometers (MSMR)

MSMR, which operates in four microwave frequencies both in vertical and horizontal polarisation is used to collect data on sea surface temperature, wind speed, cloud water content and water vapour content in the atmosphere above the ocean.