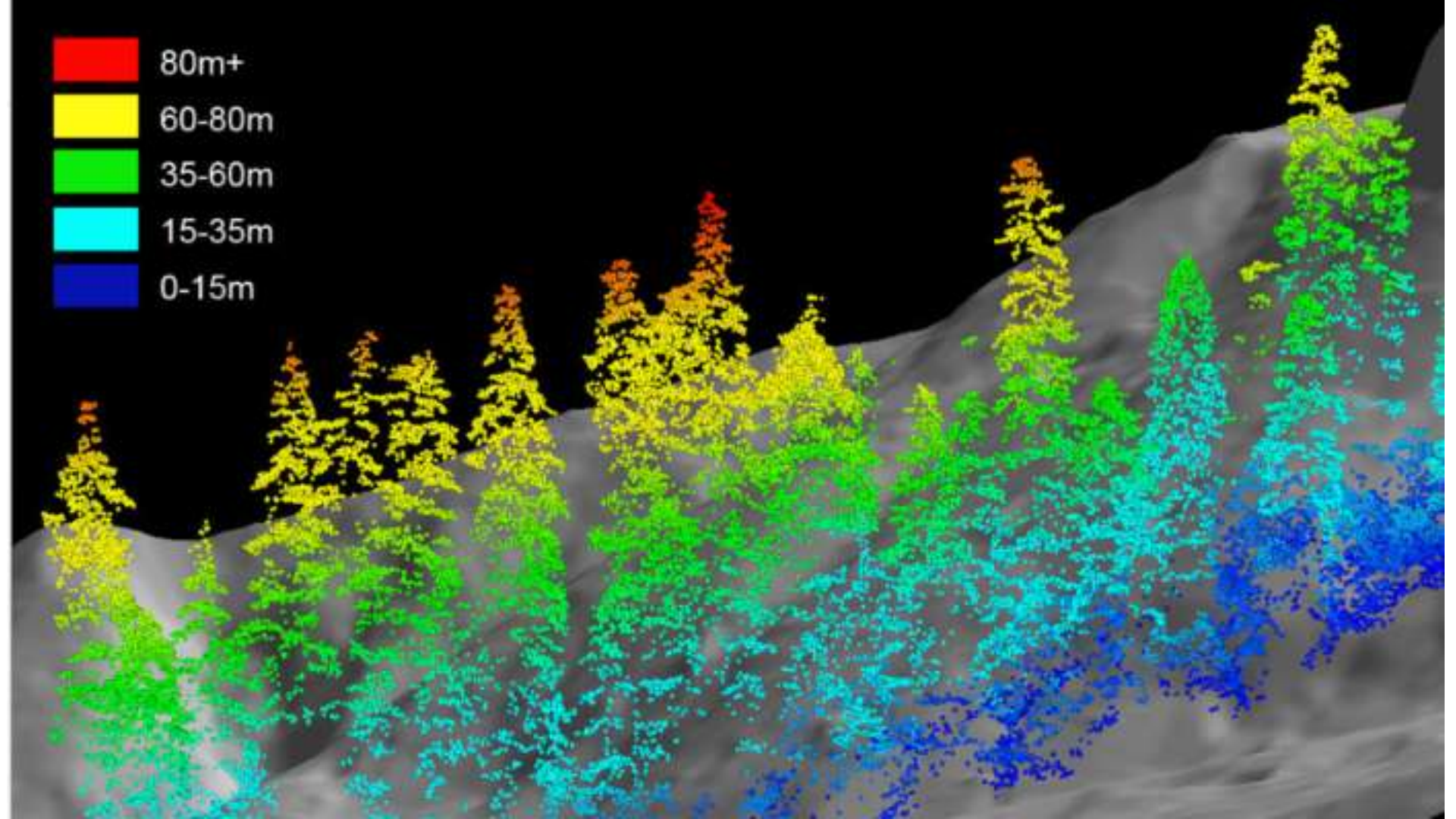
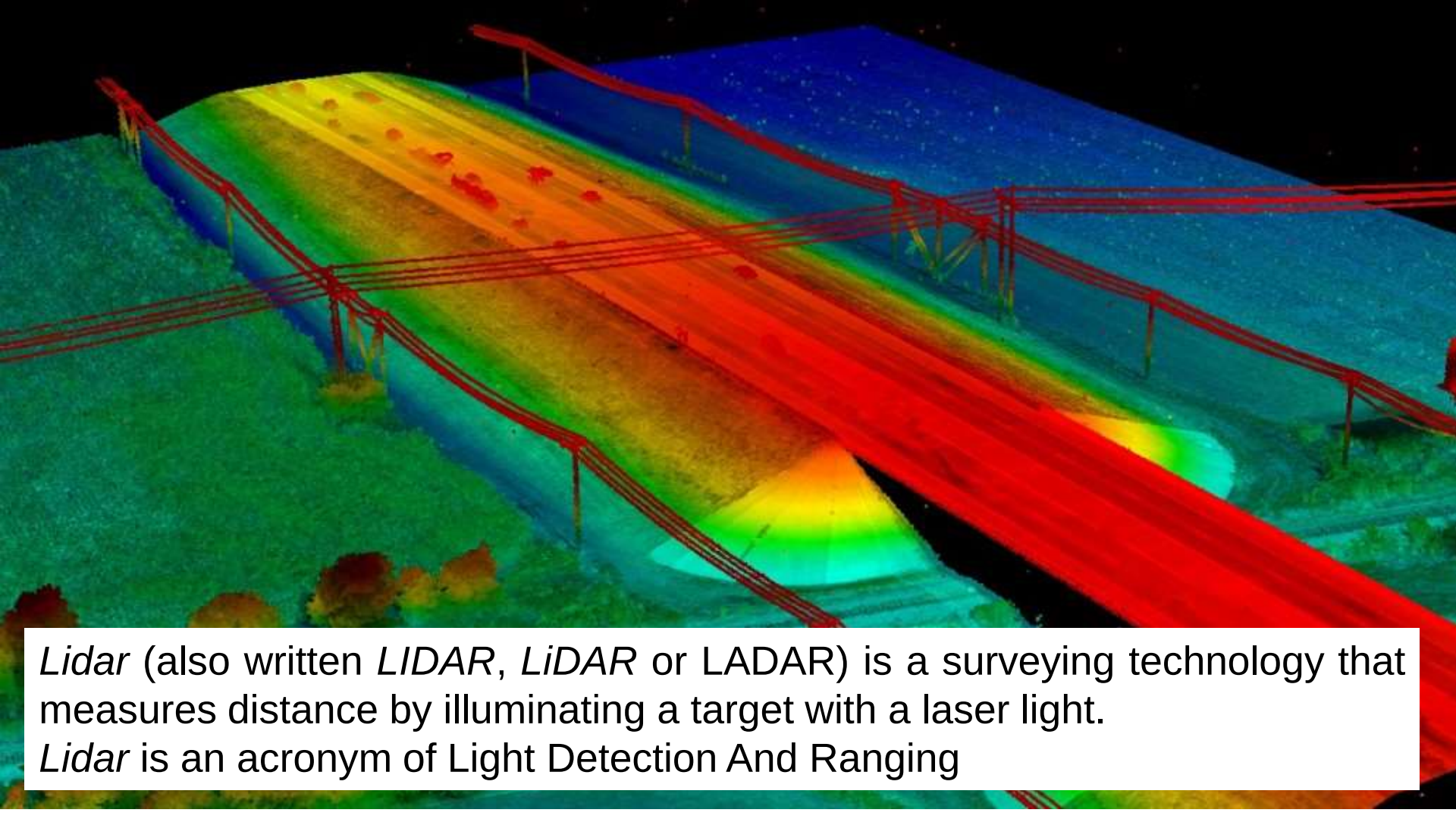
REMOTE SENSING
(REMOTE SENSING & GIS)

UNIT – II

Dr. Swarnima Singh, DDU Gorakhpur University


80m+
60-80m
35-60m
15-35m
0-15m



Lidar (also written *LIDAR*, *LiDAR* or LADAR) is a surveying technology that measures distance by illuminating a target with a laser light.
Lidar is an acronym of Light Detection And Ranging

Topics

1. Basic Concepts
2. Data and Information
3. Electromagnetic Spectrum
4. EMR Energy Interaction with Atmosphere and Earth Surface Features
5. Indian Satellites and Sensors
6. False Color Composition (FCC)
7. Introduction to Digital Data and Visual Interpretation Techniques
8. Advantages and Limitations

Introduction

Remote Sensing is the science and art of acquiring data **(spectral, spatial, and temporal)** about objects, area, or phenomenon, without coming into physical contact with the objects, or phenomenon under investigation.

Electro-magnetic radiation which is reflected or emitted from an object is the usual source of remote sensing data.

A device to detect the electro-magnetic radiation reflected or emitted from an object is called a **"remote sensor" or "sensor".** Cameras or scanners are examples of remote sensors.

A vehicle to carry the sensor is called a **"platform"**. Aircraft or satellites are used as platforms.

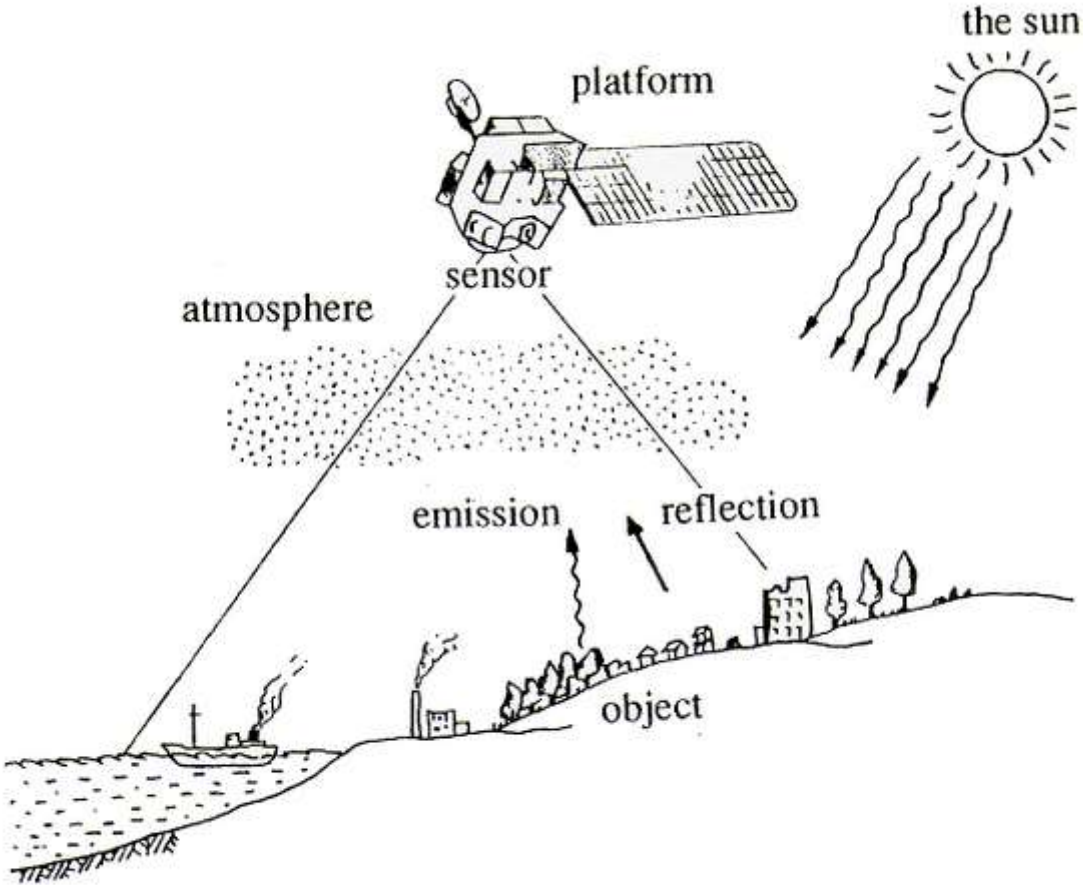
Data vs Information

Data can be any character, text, words, number, pictures, sound, or video. Data usually refers to raw data, or unprocessed data.

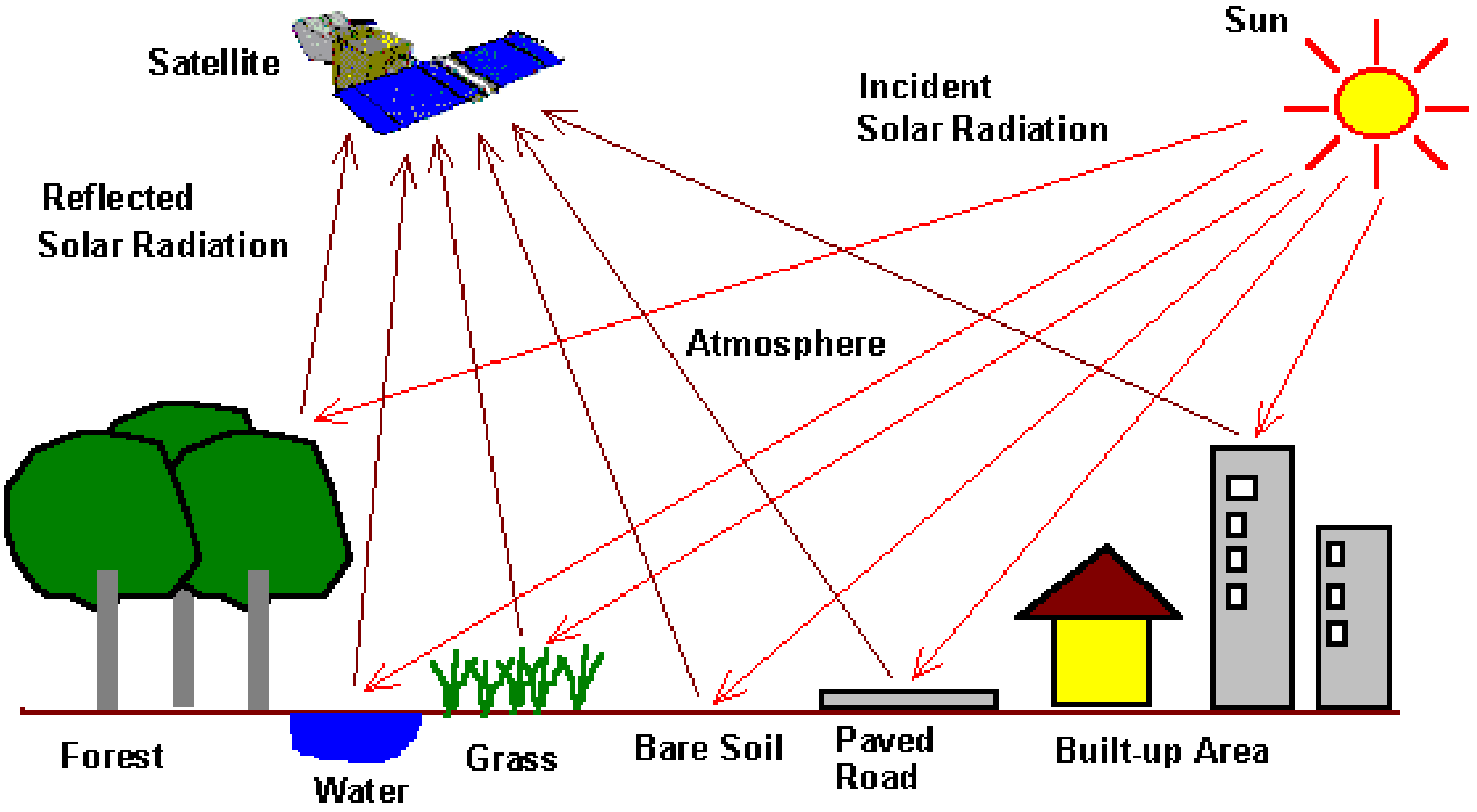
Ex.: Aerial Photograph, Satellite Image etc.,

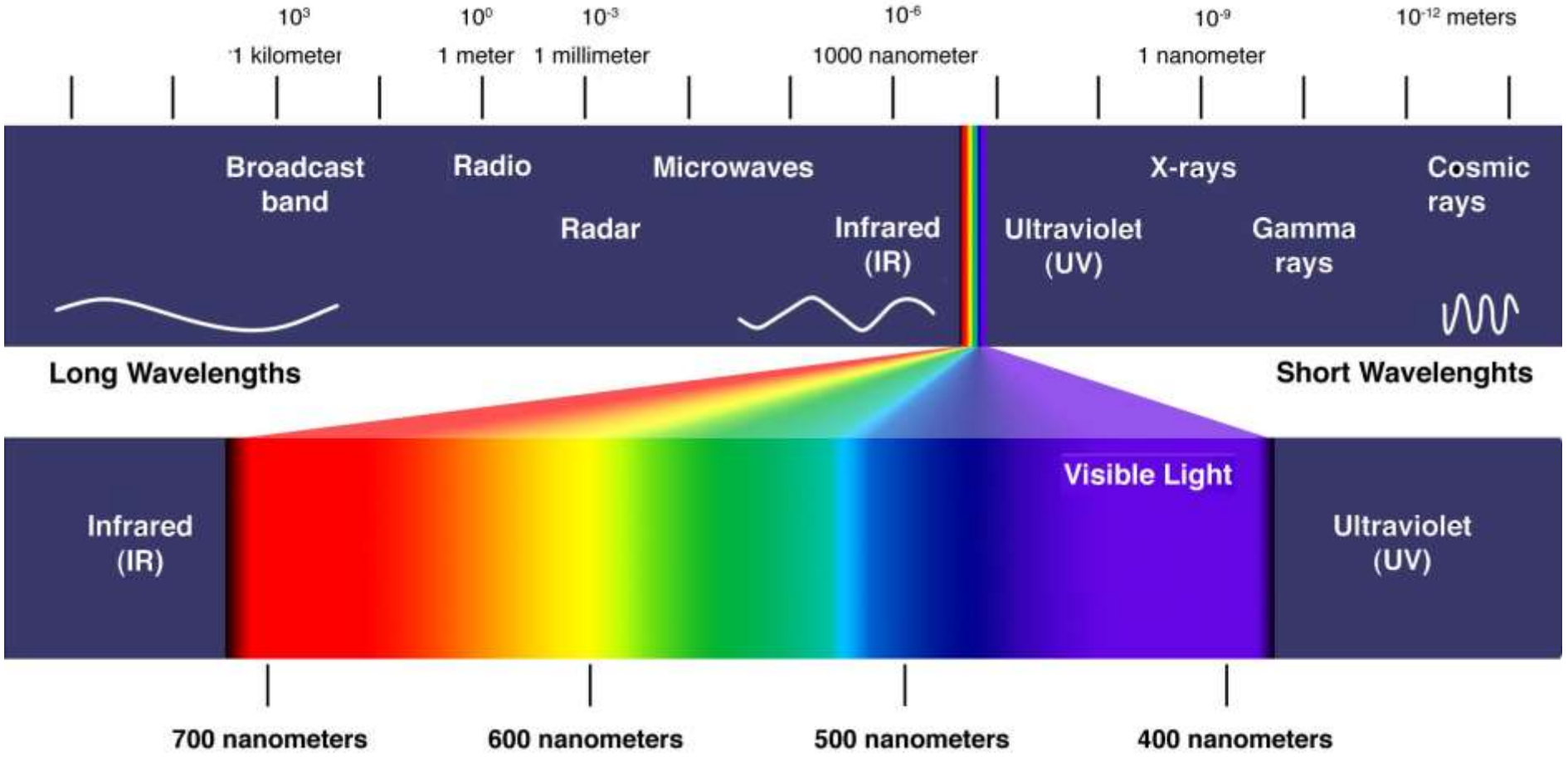
Once the data is analyzed, it is considered as information.

Ex: Topography, Contours, Elevation, Roads, Buildings etc.,

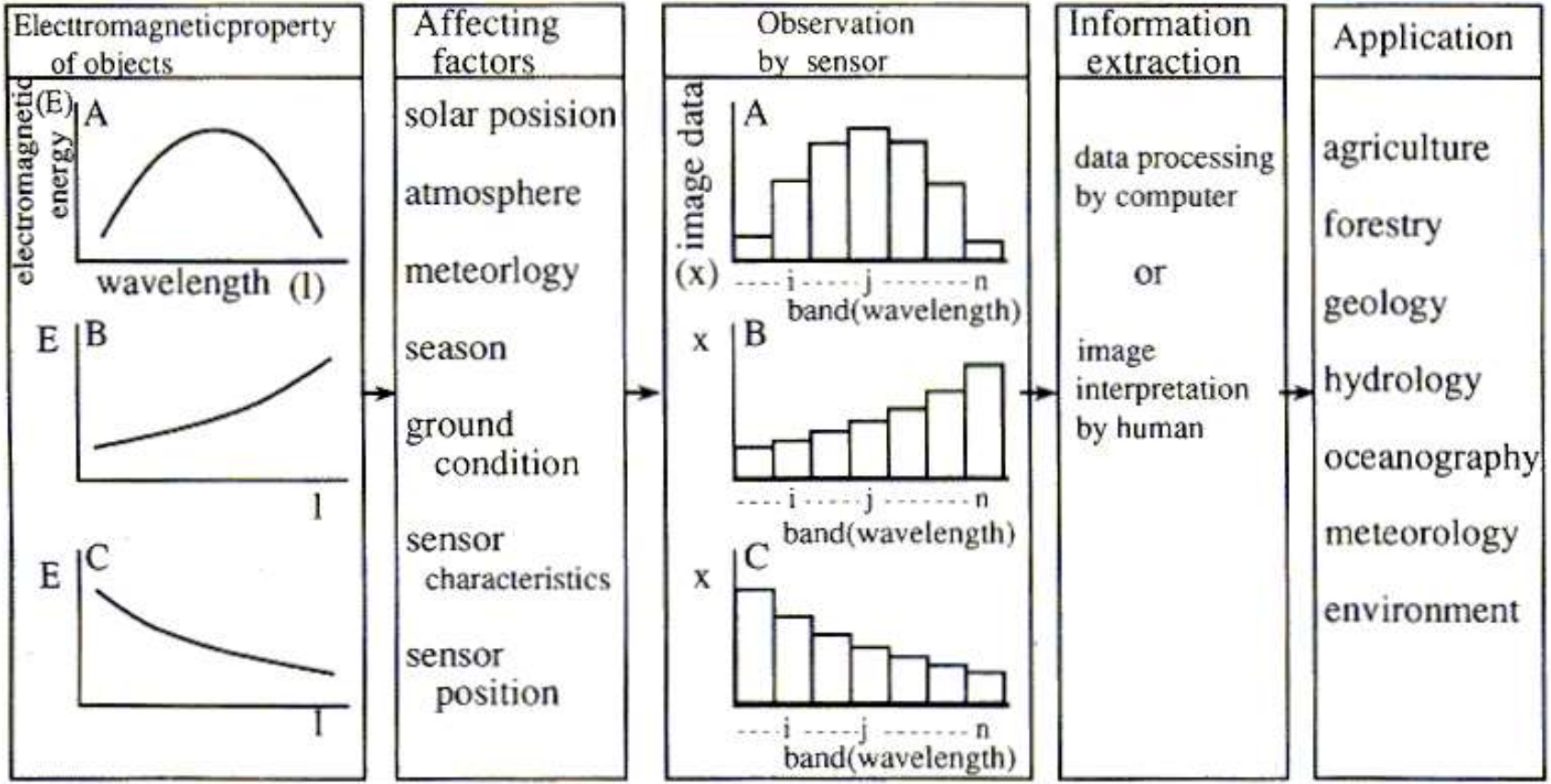


Data collection by remote sensing


Satellite
Sun
Incident
Solar Radiation
Reflected
Solar Radiation
Atmosphere
Forest
Water
Grass
Bare Soil
Paved
Road
Built-up Area



Medium = Electro Magnetic Radiation (EMR)



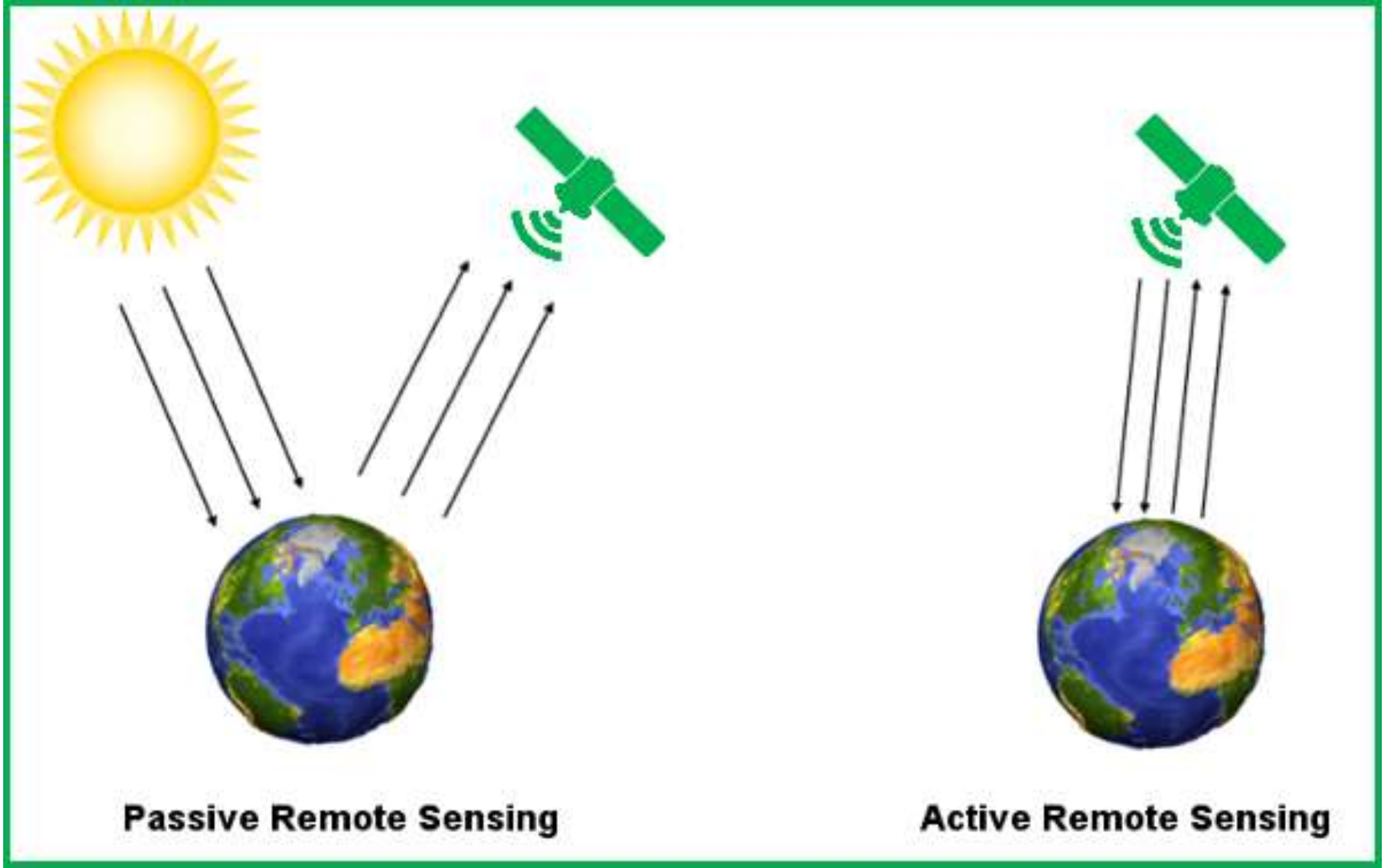
Flow of remote sensing

Types of Remote Sensing

1. **Visible and Reflective Infrared Remote Sensing**
   The energy source used in the visible and reflective infrared remote sensing is the sun. The sun radiates electro-magnetic energy with a peak wavelength of 0.5 m

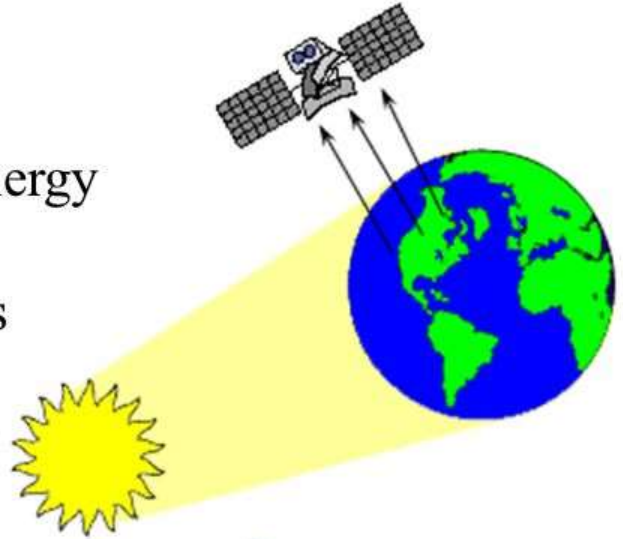
2. **Thermal Infrared Remote Sensing**
   The source of radiant energy used in thermal infrared remote sensing is the object itself, because any object with a normal temperature will emit electro-magnetic radiation with a peak at about 10 μm

3. **Microwave Remote Sensing**
   a) Passive Microwave Remote Sensing
   b) Active Microwave Remote Sensing. Ex. Radar


Passive Remote Sensing
Active Remote Sensing

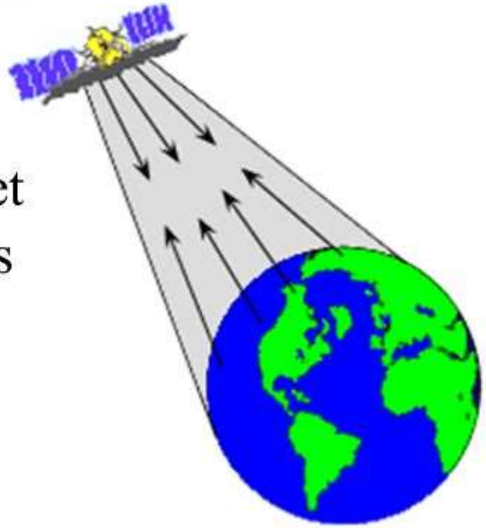
Passive Sensors

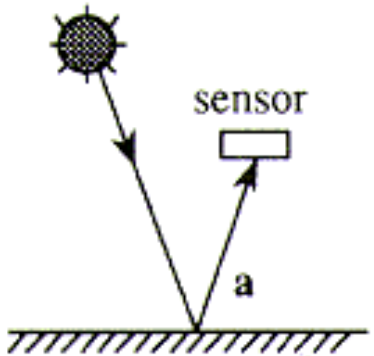
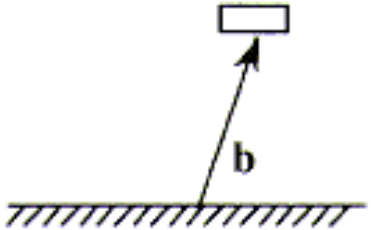
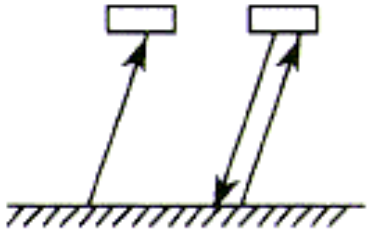
Measure ***naturally-available*** energy (eg. thermal infrared radiation emitted from the Earth 24 hours per day, but solar reflected radiation only during solar day)

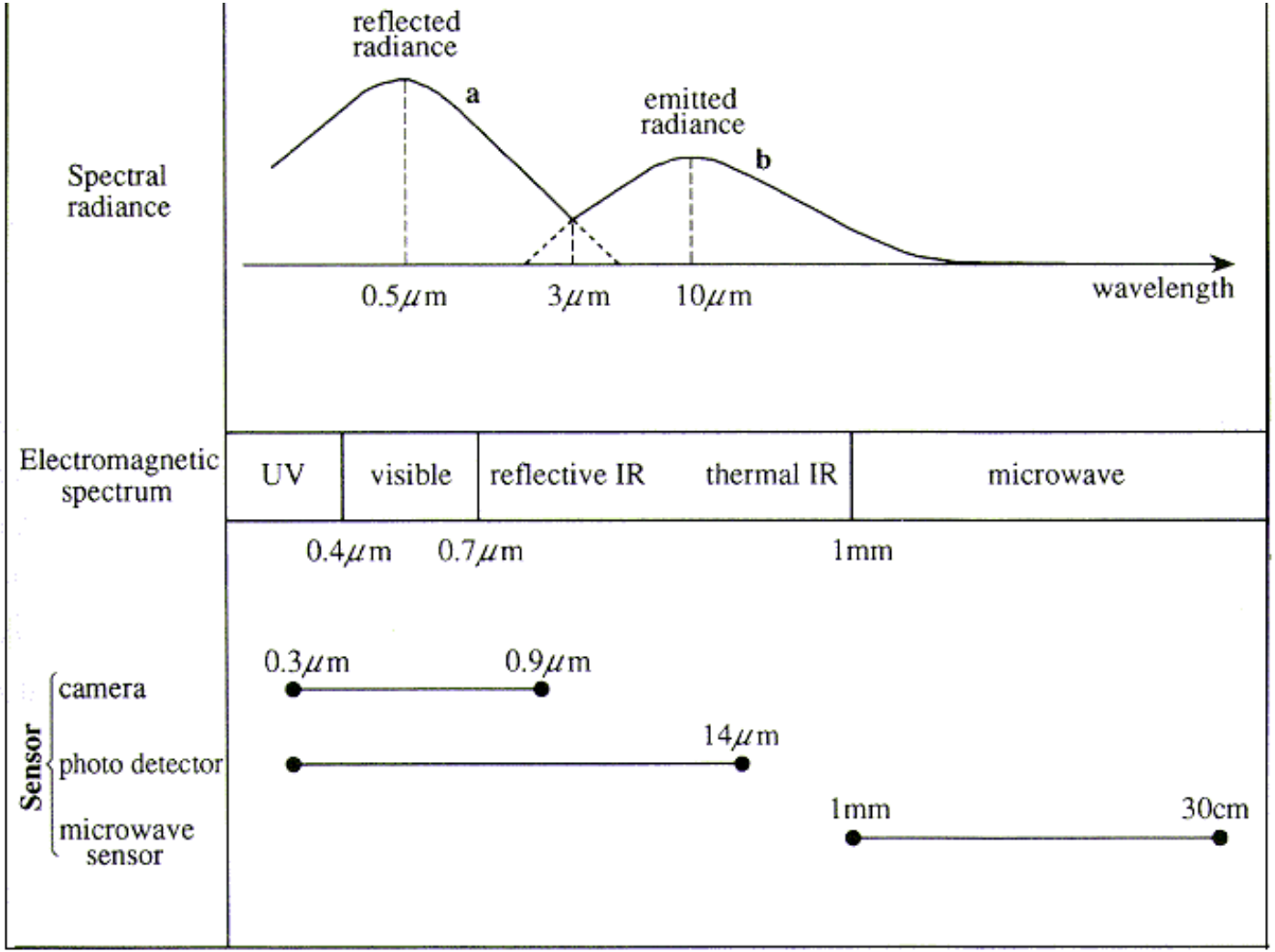


Active Sensors

Sensor ***emits radiation*** toward target
Reflected radiation in emitted bands are detected and measured (eg. microwaves emitted)



	Visible · reflective IR remote sensing	Thermal IR remote sensing	Microwave remote sensing	
				
Radiation source	the sun	object	object	radar
Object	reflectance	thermal radiation (temperature, emissivity)	microwave radiation	backscattering coefficient


reflected radiance
a
emitted radiance
b
Spectral radiance
0.5μm
3μm
10μm
wavelength
Electromagnetic spectrum
UV
visible
reflective IR
thermal IR
microwave
0.4μm
0.7μm
1mm
Sensor
camera
photo detector
microwave sensor
0.3μm
0.9μm
14μm
1mm
30cm

Energy Interaction with Atmosphere

There are three ways in which the total incident energy will interact with atmosphere. These are

1. Absorption
2. Scattering
3. Refraction
4. Reflection.

Energy Interaction with Atmosphere

Absorption:

Absorption is the process by which radiant energy is absorbed and converted into other forms of energy. Ozone, carbon dioxide, and water vapour are the three main atmospheric constituents that absorb radiation.

a) Ozone serves to absorb the harmful (to most living things) ultraviolet radiation from the sun.
b) Carbon dioxide referred to as a greenhouse gas. This is because it tends to absorb radiation strongly in the far infrared (thermal infrared) portion of the spectrum which serves to trap this heat inside the atmosphere.
c) The water vapour in the atmosphere absorbs much of the incoming long wave (thermal) infrared and shortwave microwave radiations. The presence of water vapour in the lower atmosphere varies greatly from location to location and at different times of the year.

Energy Interaction with Atmosphere

Scattering:

Scattering is unpredictable diffusion of electromagnetic radiation by atmospheric particles. It occurs when particles or large gas molecules present in the atmosphere interact with and cause the EMR to be redirected from its original path.

The amount of scattering takes place depends on several factors including the wavelength of the radiation, the diameter of particles or gases, and the distance the radiation travels through the atmosphere

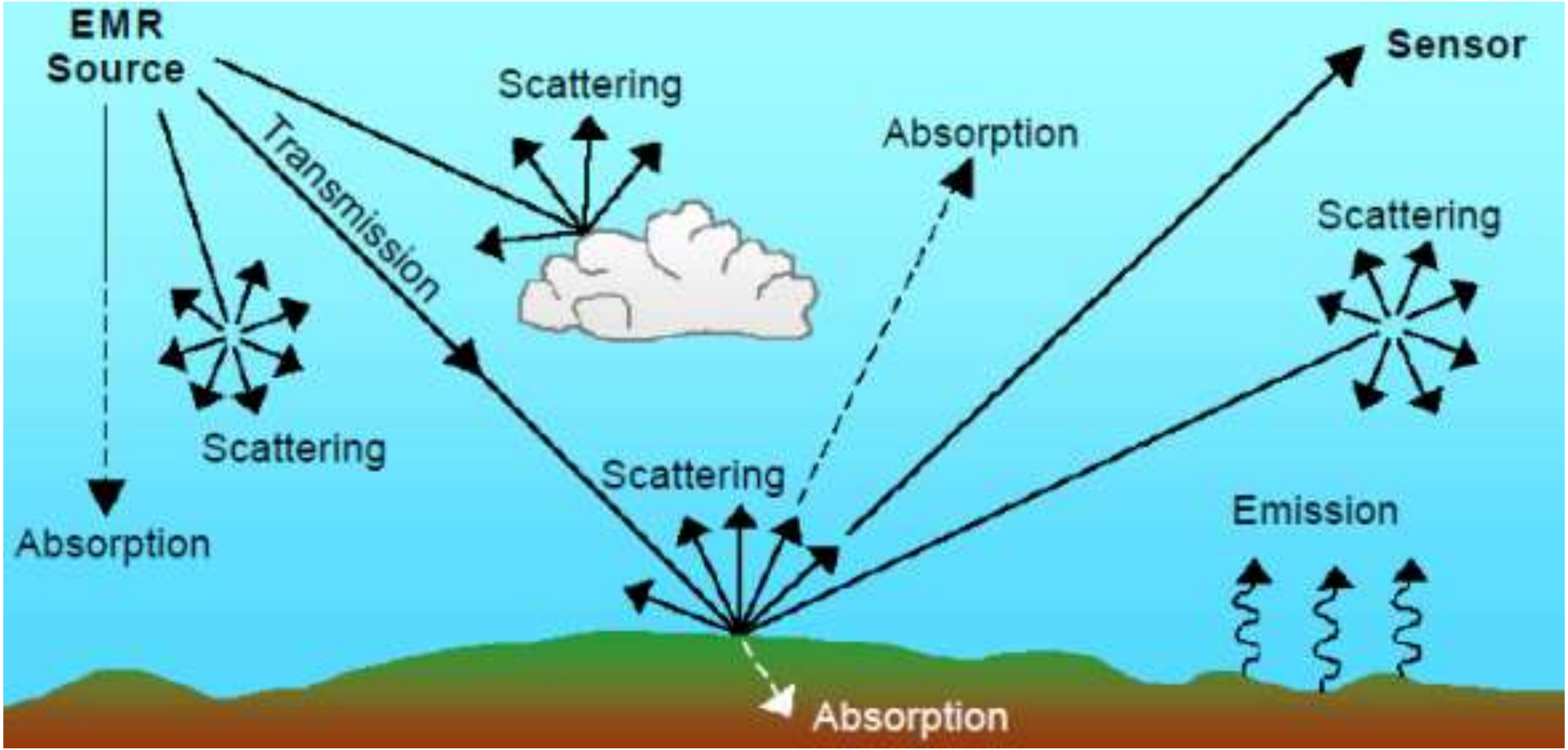
Refraction:

Refraction is the deflection of EM radiation as it passes from one medium with one refractive index to a medium with a different refractive index.

Energy Interaction with Atmosphere

Reflection is the process whereby radiation ‘bounces off’ an object like the top of a cloud, a water body, or the terrestrial earth.

Reflection differs from scattering in that the direction associated with scattering is unpredictable but in case of reflection it is predicable. Reflection exhibits fundamental characteristics that are important in the remote sensing.


EMR
Source
Scattering
Transmission
Absorption
Sensor
Scattering
Scattering
Absorption
Scattering
Emission
Absorption

Reflectance

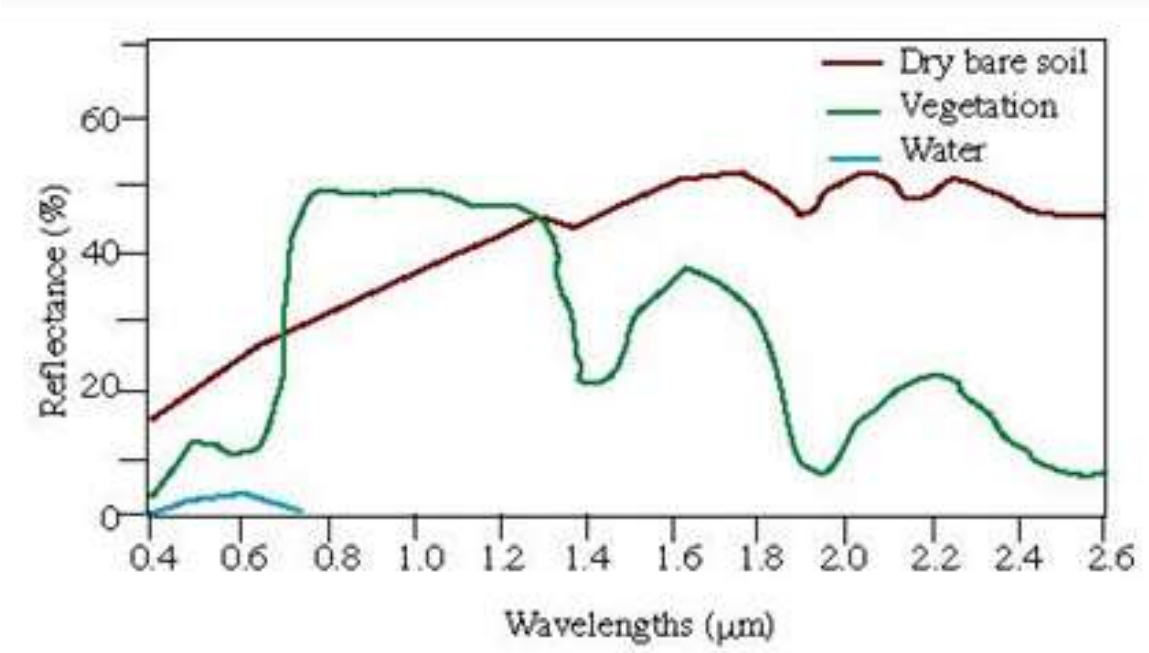
In remote sensing, electro-magnetic energy reflected or emitted from objects is measured. The measurement is based on either **radiometry or photometry**, with different technical terms and physical units.

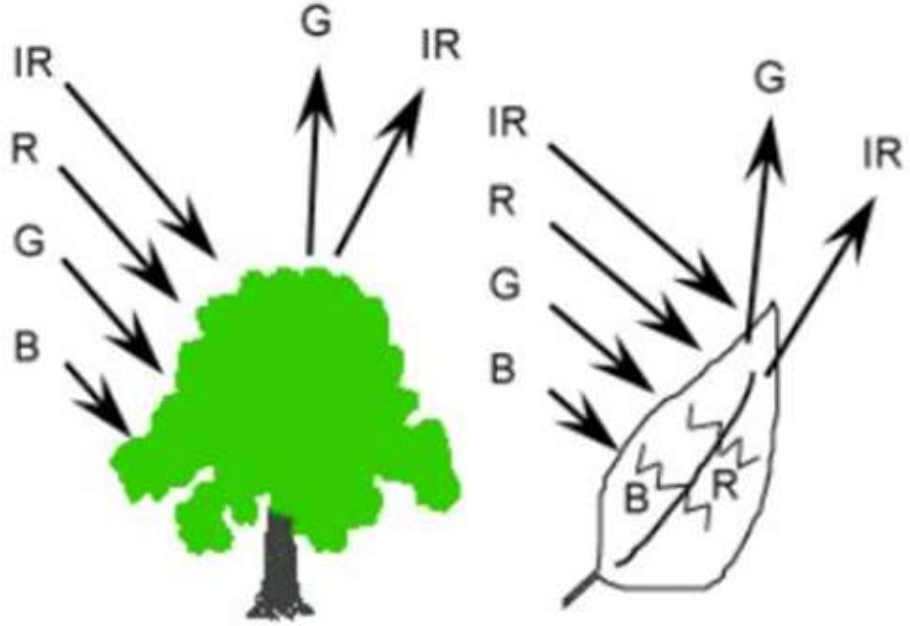
Radiometry is used for physical measurement of a wide range of radiation from x-ray to radio wave, while **photometry** corresponds to the human perception of visible light based on the human eye's sensitivity.

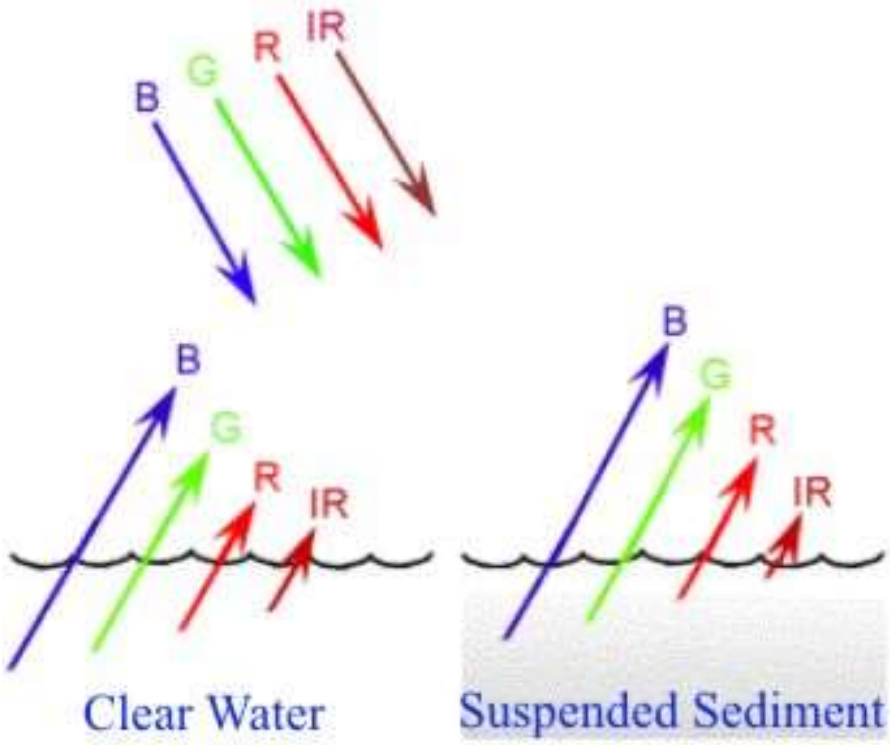
Reflectance is defined as the ratio of incident flux on a sample surface to reflected flux from the surface.

Spectral Reflectance

Spectral reflectance is assumed to be different with respect to the type of land cover.




IR
R
G
B
G
IR
IR
R
G
B
G
IR
B
R


B
G
R
IR
B
G
R
IR
Clear Water
B
G
R
IR
Suspended Sediment

Advantages of Remote Sensing

1. **Synoptic View**
   facilitates the study of various earths' surface features in their spatial relation to each other and helps to delineate the required features and phenomena.
2. **Repeativity**
   satellites provide repetitive coverage of the earth and this temporal information is very useful for studying landscape dynamics, and other land features and change detection analysis.
3. **Accessibility**
   Remote sensing process made it possible to gather information about the area when it is not possible to do ground survey like in mountainous areas and foreign areas. Passive remote sensing can be used in all weather and all time of a day.

Advantages of Remote Sensing

4. **Time saving**
   Since information about a large area can be gathered quickly, the techniques save time and efforts of human. It also saves the time of fieldwork.
5. **Cost Effective**
   It is a cost-effective technique as again and again fieldwork is not required and also a large number of users of different disciplines can share and use the same data.

Limitations of Remote Sensing

1. Expensive to collect, interpret, or analyze data.
2. Powerful active remote sensor system, such as lasers or radars that emit their own EMR, can be intrusive and affect that phenomenon being investigated.
3. Remote sensing instruments like in situ instruments often become uncalibrated, resulting in uncalibrated remote sensing data.
4. Inability of many sensors to obtain data and information through cloud cover and the relatively low spatial resolution achievable with many satellite-borne earth remote sensing instruments.
5. In addition, the need to correct for atmospheric absorption and scattering and for the absorption of radiation through water on the ground can make it difficult to obtain desired data and information on particular variables.

Types of Satellites

India has launched 84 Indian satellites (as of 22 June 2016) of many types since its first in 1975
The organisation responsible for India's satellite program is the **Indian Space Research Organisation (ISRO).**

Types:

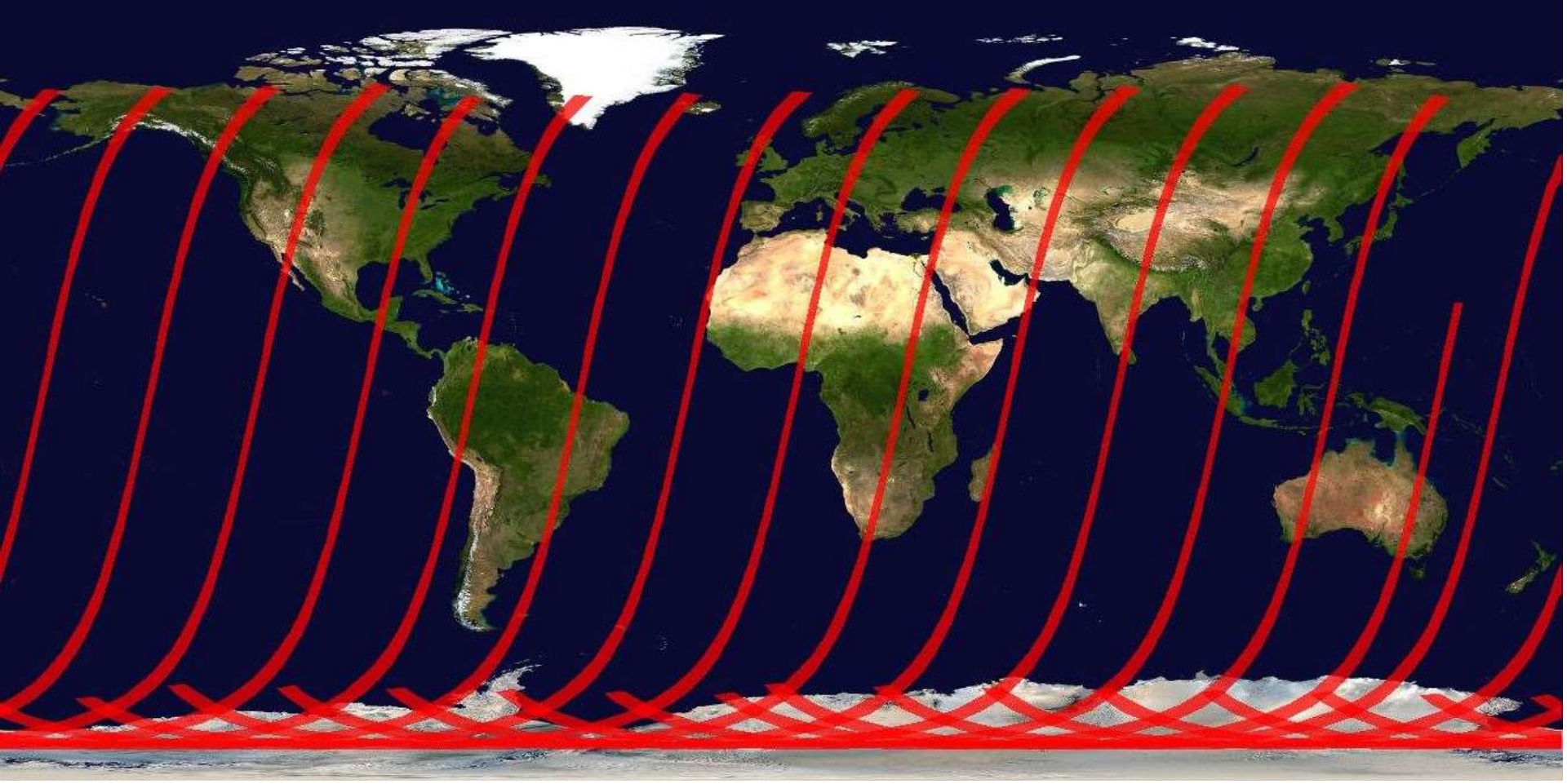
1. Indian Remote Sensing Satellites (IRS; Polar) - Altitude around 700km to 800km – Earth Observation
2. Indian National Satellites (INSAT; Geosynchronous) - Altitude around 36000 km - Communication

SATELLITE	LAUNCHED ON	LAUNCH VEHICLE	REMARKS
ARYABHATTA	1975	u-11 Interkosmos	India's First Experimental Satellite
BHASKARA - I	1979	C-1 Interkosmos	1st Experimental Remote Sensing Satellite
INSAT -1A	1982	Delta 3910 PAM-D	Multi-purpose Communication & Meteorology Satellite
IRS – 1A	1988	Vostok	First Remote Sensing Satellite
KALPANA (METSAT)	2002	PSLV-C4	First Meteorological Satellite
EDUSAT	2004	GSLV-F01	India's First Educational Satellite
IRNSS-1A	2013	PSLV-C22	Navigation Satellite for GPS RTK

Sr. No.	Satellite	Date of Launch	Launch Vehicle	Status
1	IRS 1A	17 March 1988	Vostok, USSR	Mission Completed
2	IRS 1B	29 August 1991	Vostok, USSR	Mission Completed
3	IRS P1 (also IE)	20 September 1993	PSLV-D1	Crashed, due to launch failure of PSLV
4	IRS P2	15 October 1994	PSLV-D2	Mission Completed
5	IRS 1C	28 December 1995	Molniya, Russia	Mission Completed
6	IRS P3	21 March 1996	PSLV-D3	Mission Completed
7	IRS 1D	29 September 1997	PSLV-C1	Mission Completed
8	IRS P4 (Oceansat-1)	27 May 1999	PSLV-C2	Mission Completed
9	Technology Experiment Satellite (TES)	22 October 2001	PSLV-C3	In Service
10	IRS P6 (Resourcesat-1)	17 October 2003	PSLV-C5	In Service
11	IRS P5 (Cartosat 1)	5 May 2005	PSLV-C6	In Service
12	Cartosat 2 (IRS P7)	10 January 2007	PSLV-C7	In Service
13	Cartosat 2A (IRS P?)	28 April 2008	PSLV-C9	In Service
14	IMS 1 (IRS P?)	28 April 2008	PSLV-C9	In Service
15	Oceansat-2	23 September 2009	PSLV-C14	In Service
16	Cartosat-2B	12 July 2010	PSLV-C15	In Service
17	Resourcesat-2	20 April 2011	PSLV-C16	In Service

CHARACTERISTICS OF INDIAN REMOTE SENSING SATELLITES

Satellite Launch date	Sensor	Bands	Spatial resolution (m)	Swath (km)	Radiometric resolution (bits)	Repitivity (days)
IRS-1A	LISS-I	4 VNIR	72.5	148	7	22
(March 17, 1988)	LISS-II	4 VNIR	36.25	72	7	22
IRS-1B	LISS-I	4 VNIR	72.5	148	7	22
(August 29, 1991)	LISS-II	4 VNIR	36.25	72	7	22
IRS-P2	Modified	4 VNIR	32	72	7	22
(October 15, 1994)	LISS-II					
IRS-1C	WiFS	2 VNIR	188	810	7	5
(December 28, 1995)	LISS-III	3 VNIR	23.5	141	7	24
		1 SWIR	70.5	148	6	24
	PAN	1 PAN	5.8	70	6	5
IRS-P3	WiFS	2 VNIR	188	810	7	5
(March 21, 1996)	MOS	13 VNIR	520	200	16	24
IRS-1D	WiFS	2 VNIR	188	810	7	5
(September 29, 1997)	LISS-III	3 VNIR	23.5	141	7	24
		1 SWIR	70.5	148	6	24
	PAN	1 PAN	5.8	70	6	5
IRS-P4 (Oceansat)	MSMR	4 Freq.	50, 75 & 150 km	1400		2
(May 26, 1999)	OCM	8 VNIR	360	1420	12	2



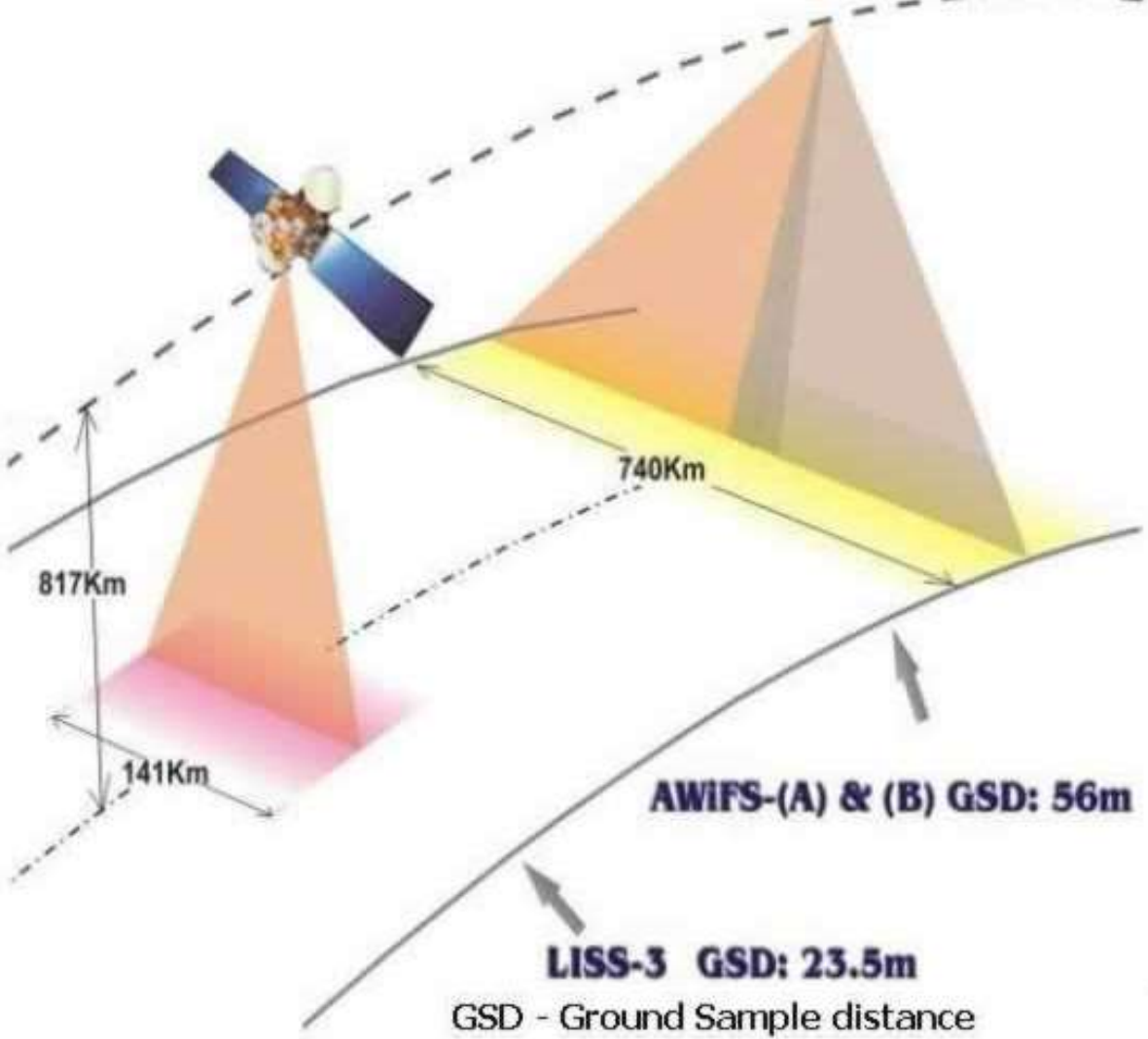
Repetitively

Linear imaging & self scanning sensor (LISS III):-

This payload was on board on IRS IC & ID satellite. It had three bands operating in visible & NIR region & one band SWIR. The characteristics are given below.

Band width(μm.)	0.45-0.52, 0.52- 0.59, 0.62-0.68, 0.77- 0.86 1.55-1.77
Swath	141 km

SWAT
H


740Km
817Km
141Km
AWiFS-(A) & (B) GSD: 56m
LISS-3 GSD: 23.5m
GSD - Ground Sample distance

Panchromatic Imaging System

- A single channel sensor is used to detect radiation
- If range of wavelength and the visible range become same then the imagery will appear as a black and white photograph taken from space

Satellite	Launched Date	Sensor	Resolution (m)	Purpose
IRS-1A	17.03.1988	LISS-I	72.5	First operational remote sensing satellite for large scale mapping.
IRS-1C	28.12.1995	PAN	< 6	PAN data is of finer spatial resolution used to sharpen or increase the resolution of coarser resolution imagery. It is also used in various geological, biological, and engineering surveys and mapping.
		LISS-III	23.6	LISS-III had improved spatial resolution. Land and vegetation observation. WiFS data used for very large scale mapping; mainly used for ocean monitoring.
		Wide Field Sensor (WiFS)	189	

Satellite	Launched On	Sensor	Resol. (m)	Purpose
IRS-P4 / Oceansat	26.05.1999	Ocean Colour Monitor (OCM)		To study surface winds and ocean surface strata, observation of chlorophyll concentrations, monitoring of phytoplankton blooms, study of atmospheric aerosols and suspended sediments in the water.
		Multi - frequency Scanning Microwave Radiometer (MSMR)		
IRS P6 / Resourcesat-1	17.10.2003	LISS-IV	5.8	Monitoring of vegetation dynamics, crop yield estimates, disaster management support etc.
		LISS-III	23.5	
CARTOSAT-1	05.05.2005	PAN	2.5	The first IRS Satellite capable of providing in-orbit stereo images. Used for Cartographic applications at cadastral level, urban and rural infrastructure development and management, as well as applications in Land Information System (LIS) and Geographical Information System (GIS). It provides stereo pairs required for generating DEM, Ortho Image products.
CARTOSAT-2	10.01.2007	PAN	1	Same as CARTOSAT-1.
RISAT-2	20.04.2009	Synthetic Aperture Radar (SAR)		It is useful in all weather remote sensing application. Disaster Management applications.
RISAT-1	26.04.2012	Synthetic Aperture Radar (SAR)		Enables imaging of the surface features during both day and night under all weather conditions enable applications in agriculture, particularly paddy monitoring in kharif season and management of natural disasters like flood and cyclone.

False Color Composition (FCC)

The display colour assignment for any band of a multispectral image can be done in an entirely arbitrary manner. In this case, the colour of a target in the displayed image does not have any resemblance to its actual colour. The resulting product is known as a false colour composite image.

LANDSAT 7 (Launched on April 15, 1999 by NASA)

R,G,B	Description
3,2,1	The “nature colour” combination. It provides the most water penetration.
4,3,2	Standard “false-colour” combination. Vegetation shows in red.
7,4,2	The “nature-like” combination. Sand, soil and minerals show in multitude of colour. Fires would appear in red. It provides clear imagery in desert region.
7,5,3	The “nature-like” combination. Sand, soil and minerals appear in variety of colour.
5,4,1	Good for agricultural studies. Healthy vegetation shows in bright green colour.
7,5,4	Provides best atmospheric penetration. Vegetation shows in blue. Useful for geological study.
7,3,1	Rocks may appear in variety of colour. Good for the geological study.

- Pancromatic image
- True-color image →
- False-color image ↘

Pancromatic Image

Band 2 + Band 3 + Band 4

(False Color)

Band 1 + Band 2 + Band 3

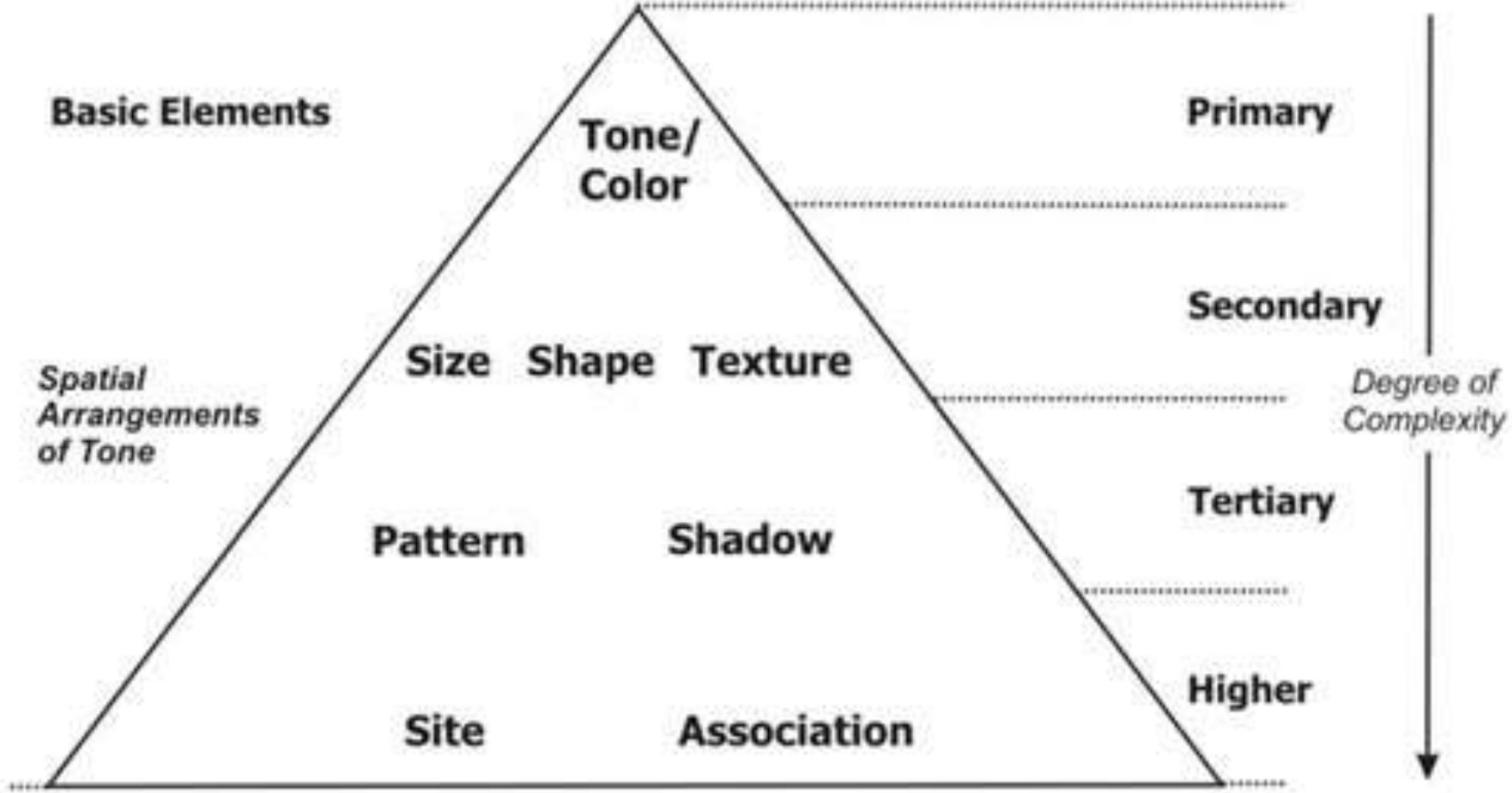
(True Color)

Visual Interpretation Techniques

Analysis of Remote Sensing Imagery involves the identification of various targets in an image, and those targets may be environmental or artificial features.

Elements of Visual Interpretation:

1. **Tone:** Relative brightness or colour of objects in an image
2. **Shape:** Form, Structure, or Outline of object
3. **Size:** It's a function of scale. Ex.: Ware House or Residential Building
4. **Pattern:** Spatial arrangement of visibly discernible objects. Ex.: Urban Roads, Buildings in a Colony
5. **Texture:** Arrangement and frequency of tonal variation in particular areas of an image. Ex.: Grass Lands (Smooth Texture), Forest (Rough Texture)
6. **Shadow:** Provide an idea of the profile and relative height of a target or targets.
7. **Association:** Relationship between other recognizable objects or features in proximity to the target of interest. Ex.: Residential areas associated with Playgrounds.


Basic Elements
Tone/
Color
Primary
Secondary
Size Shape Texture
Spatial
Arrangements
of Tone
Degree of
Complexity
Tertiary
Pattern
Shadow
Higher
Site
Association

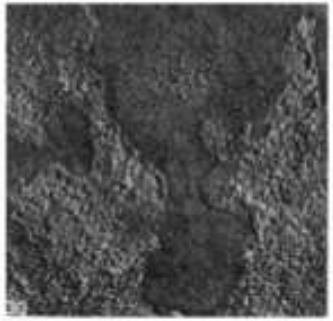
Elements of Image Interpretation

Shape
(depends on the object outline)

Size
(relative to one an other)

Tone
(brightness-hue, color)

Site
(location helps recognition)



Texture
(smooth or coarse)

Shadow
(helps to determine height)

Association
(features that are normally found near object)

Pattern


Airport
Bareland
Beach
Bridge
Commercial
Desert
Farmland
FootballField
Forest
Industrial
Meadow
Mountain
Park
Parking
Pond
Port
RailwayStation
Residential
River
Viaduct

Reference

Textbook of Remote Sensing and Geographical Information Systems