# CHAPTER 2

## Principles of Remote Sensing

### 2.1 Introduction

This chapter presents the principles of remote sensing and is primarily based on the properties of the electromagnetic spectrum and the geometry of airborne or satellite platforms relative to their targets. This chapter provides a background of remote sensing, including discussions of energy sources, electromagnetic spectra, atmospheric effects, interactions with the target or ground surface and the geometry of image acquisition. It also presents some applications of Remote Sensing in the field of earth observation.

### 2.2 Remote Sensing

Remote sensing can be defined as a process of gathering information about an object, area or phenomenon without direct contact with it. We can gather information about our surroundings through the reflectance of visible light energy from some external source (such as the sun or an electric light bulb) as it reflects from the objects of our field of view. In contrast to this a thermometer, is not a remote sensing device as it must be in contact with the phenomenon it measures the temperature of human body.

Remote Sensing is the science and art of acquiring information (spectral, spatial, and temporal) about objects, surface area, or phenomenon, without coming into physical contact with the objects, or surface area, or phenomenon under investigation [13]. It is composed of three parts, the target - objects or phenomena of an area; the data acquisition - through certain instruments; and the data analysis - again by some devices. This definition is so broad that the vision system of human eyes, sonar sounding of the sea floor, ultrasound and x-rays used in medical sciences, are all included. The target can be as big as the earth, the moon and other planets, or as small as biological cells that can only be seen through microscopes.

## 2.2.1 Basic Components of Remote Sensing

The process involves an interaction between incident radiation and the target of interest (Fig 1). This is exemplified by the use of imaging systems where the following seven elements are involved.

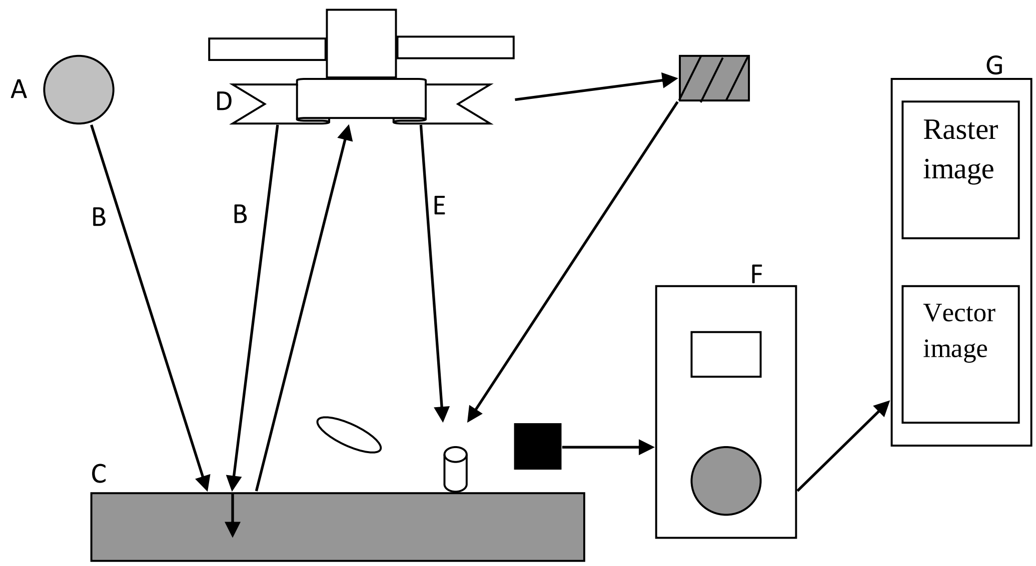



Fig 2.1: Block Diagram of Remote-sensing

1) ***Energy Source (A):*** The first requirement for remote sensing is to have an energy source which provides electromagnetic energy to the target of interest.
2) ***Radiation and the Atmosphere (B):*** The energy travels from source to the target, it will come in contact with and interact with the atmosphere it passes though. 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 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.

6) ***Interpretation and Analysis (F):*** The processed image is interpreted, visually and/or digitally or electrically, 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. [13-17].

## 2.3 History of Remote Sensing

The technology of remote sensing is growing day-by-day. With new types of platforms for better observations of earth using advanced sensors (such as microwave and hyper spectral sensor), the analysis and processing of data are making remote sensing more beneficial to the society. The remote sensing tools are not only useful for decision making at the grassroots level but also are useful for understanding the global changes issues [19].

The following are the brief history of Indian earth observation satellites:

| Mission | Year of Launch | Sensors | Sensor Specification |
|---|---|---|---|
| Bhaskara-I / II | 1979 / 1981 | Microwave Radiometer (SAMIR) | 19/22/31 GHz |
| IRS-1A, 1B | 1988, 1991 | LISS-I Multispectral | Resol. :72.5 m, Swath: 148 km |
| | | LISS-II Multispectral | Resol.:36.25 m, Swath: 142 km |
| IRS-P2 | 1994 | LISS-II Multispectral | Resol:36 m; Swath:148 km |
| IRS-1C, 1D | 1995, 1997 | Panchromatic | Resol.:5.8 m, Swath: 70 km |
| | | LISS-III Multispectral | Resol.: 23.5m, 70.5 m, Swath : 141 km |
| | | WiFS | Resol.:188.3 m, Swath: 810km |
| IRS-P3 | 1996 | WiFS | Resol.:188.3 m, Swath: 810km |
| | | MOS-A,B,C | Resol.: 0.5- 1.5 km, Swath : 248 |
| IRS-P4 (Oceansat-1) | 1999 | OCM Ocean colour monitor | Resol.: 360 m , 20 nm Spectral Swath: 1420 km |
| | | MSMR Microwave Radiometer | 6.6, 10.75, 18, 21 GHz channels Resol.: 40-120 km, 1□K Accuracy; Swath: 1360 km |

Table 2.1: Indian Earth Observation Satellites

## 2.4 Types of Remote Sensing

### 2.4.1 Visual Remote Sensing

The human visual system is an example of a visual remote sensing system in general sense. The sensors in human visual system are of two types - photosensitive cells and the retina of the eyes. The retina is sensitive only to the total light intensity. The information needs a carrier to travel from the object to the eyes as the object is kept away from the eye. In this case, the information carrier is the visible light, a part of the electromagnetic spectrum. The visual Remote sensing system is also known as Passive Remote Sensing system which depends on an external source of energy to operate [22].

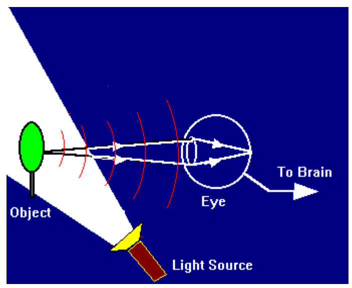



Fig 2.2: Visual Remote-sensing

### 2.4.2 Optical Remote Sensing

When the images are taken by camera from high above in space, the optical sensor detects the solar radiation reflected or scattered from the ground. Different objects such as water, soil, vegetation, buildings and roads reflect visible and infrared light in different ways. All the objects are having different colors and brightness under sun, thus interpretations of optical images require the knowledge of the spectral reflectance signatures of the various materials (natural or man-made) covering the surface of the earth [20, 22].

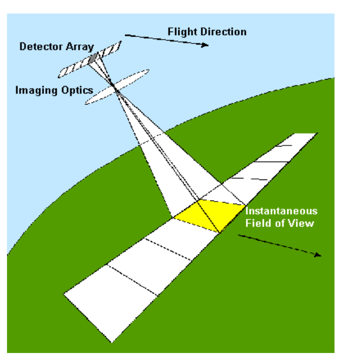



Fig 2.3: Optical remote sensing

## 2.4.3 Infrared Remote Sensing

The satellites which carry active microwave sensors it emit the pulses of microwave radiation to illuminate the areas to be captured. The sizes of the images of the earth surface are formed by measuring the microwave energy scattered by the ground or sent back to the sensors. These types of satellites carry their own "flashlight" for emitting microwaves to illuminate their targets in the earth. Thus the images can be acquired either in day or at night time. Microwaves sensor has a special feature as it can penetrate the cloud obstacle easily. Therefore, Images can be captured even when the earth surface is covered by clouds. The electromagnetic radiation in the microwave wavelength region is used in remote sensing to provide useful information about the Earth's atmosphere, land and ocean [19, 20, 22].

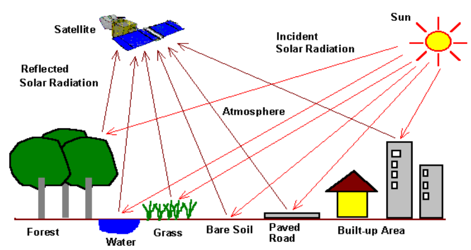



Fig 2.4: Infrared Remote-sensing

## 2.4.4 Radar Remote Sensing

Using radar system, geography scientist can easily and effectively map out of a territory. Radar basically works with radio signals, it sends the signal to the ground and waits till the signal returns back after hitting the ground. It is possible to create a very accurate map (topographic) by calculating the amount of time it takes to return from the ground. The major advantage of using radar is, it can penetrate thick clouds as well as moisture present in the atmosphere while travelling the signals. This allows scientists to accurately map areas such as rain forests, which are otherwise too obscured by clouds and rain. Imaging radar systems are versatile sources of remotely sensed images, providing day night, all-weather imaging capability.

Radar images are useful to map geologic structure, soil types, vegetation and crops, ice and oil slicks on the ocean surface [19, 22].

Fig 2.5: Radar Remote-sensing

## 2.4.5 Satellite Remote Sensing

The remote sensing satellites are equipped with sensors looking down to the earth. They constantly observe the earth as they go round in predictable orbits. Orbital platforms collect and transmit data from different parts of the electromagnetic spectrum. The usefulness of satellite remote sensing include different areas of the earth sciences such as natural resource management, agricultural fields, and usage and conservation, national security, ground-based and stand-off collection on border areas [20, 22].

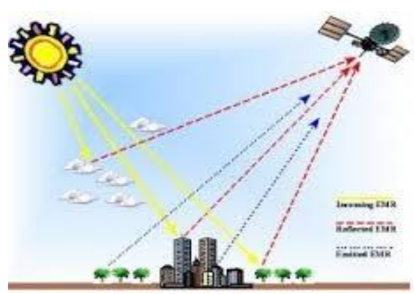
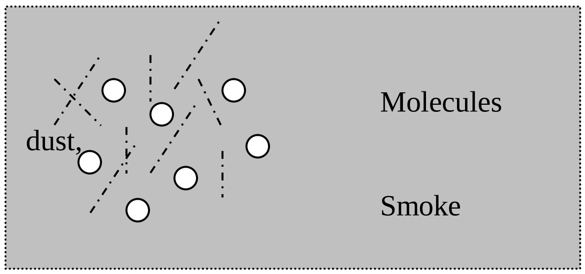


Fig 2.6: Satellite Remote-sensing

## 2.5 Energy Interactions in the Atmosphere

The atmosphere has different effects on the Electro Magnetic (EM) radiation transfer at different wavelengths. The atmosphere can have a profound effect on intensity and spectral composition of the radiation that reaches a remote sensing system. These effects are caused primarily by the atmospheric scattering and absorption.

The redirection of EM energy by the suspended particles in the air is scattering. The different size of particle will have different effects on the EM energy propagation.




Different Diameter

The atmosphere can be divided into a number of well marked horizontal layers on the basis of temperature. Troposphere: It is the zone where weather phenomena and atmospheric turbulence are most marked [13, 19, 20, 21]. It contains 75% of the total molecular and gaseous mass of the atmosphere and virtually all the water vapour and aerosols.

Height: 8 - 16 km (pole to equator)

Stratosphere: 50 km Ozone

Mesosphere: 80 km

Thermosphere: 250 km

Exosphere: 500 km ~ 750 km

## 2.6 Application of Remote-sensing

Remote sensing data can be used for various applications in three different ways. These are,

i) Mapping and Monitoring of earth resources.

ii) Retrieval of bio-geo-physical parameters, which are used in models to predict the changes in geosphere and biosphere.

iii) Management/Decision Support, where remote sensing derived information is used to arrive at decisions for sustainable management of earth resources [22].

Some of the typical Remote Sensing applications are shown below [10]

***Meteorology* -** Study of atmospheric temperature, pressure, water vapor, and wind velocity.

***Oceanography* -** Measuring sea surface temperature, mapping ocean currents, and wave energy spectra and depth sounding of coastal and ocean depths.

***Glaciology* -** Measuring ice cap volumes, ice stream velocity, and sea ice distribution.

***Geology* -** Identification of rock type, mapping faults and structure.

***Geodesy* -** Measuring the figure of the Earth and its gravity field.

***Topography and cartography* -** Improving digital elevation models.

***Agriculture* -** Monitoring the biomass of land vegetation.

***Forest* -** Monitoring the health of crops, mapping soil moisture.

***Botany* -** Forecasting crop yields.

***Hydrology* -** Assessing water resources from snow, rainfall and underground aquifers.

***Disaster Warning and Assessment* -** Monitoring of floods and landslides, monitoring volcanic activity, assessing damage zones from natural disasters.

***Planning Applications*** **-** Mapping ecological zones, monitoring deforestation, monitoring urban land use.

***Oil and Mineral Exploration*** **-** Locating natural oil seeps and slicks, mapping geological structures, monitoring oil field subsidence.

***Military*** **-** Developing precise maps for planning, monitoring military infrastructure, monitoring ship and troop movements.

***Urban*** **-** Determining the status of a growing crop.

***Climate*** **-** The effects of climate change on glaciers and Arctic and Antarctic regions

***Sea*** **-** Monitoring the extent of flooding.

***Rock*** **-** Recognizing rock types.

***Space program*** **–** It is the backbone of the space program.

***Seismology*** **-** As a premonition.

There are various fields in which remote sensing applications have been shown to be highly useful, which include agriculture, water resources, forest and ecosystem, disaster management, infrastructure development, atmospheric and oceanic sciences and many others.

## 2.6.1 Advantages and Limitations of Remote Sensing

Advantages of remote sensing are:

a) It provides data of large areas.

b) It can provide data of highly remote and inaccessible regions by human.

c) It enables to obtain imagery of any region over a continuous time period through which any anthropogenic or natural changes in the earth surface can be analyzed easily.

d) It is relatively less expensive compared to employing a team of surveyors

. e) Data can be collected rapidly.

f) Maps can be produced for interpretation.

***Limitations of Remote Sensing are:***

a) To interpret the data certain skill level is required.

b) It always it needs cross verification with the ground survey data.

c) It may create confusion by taking data from multiple sources.

d) Objects can be misclassified or confused

e) Due to the relative motion of sensor and source, image distortions may occur.

## 2.7 Chapter Summary

- ✓ Analysis and modelling of GIS Remote sensing provide spatial data of large area.
- ✓ Basic thematic products are available.
- ✓ To retrieve quantitative data, model coupling and image processing are often needed.
- ✓ Commercial software available for combined evaluation RS
- ✓ Merging of data should be done carefully.