CHAPTER 13 INTRODUCTION TO REMOTE SENSING

Objectives

After studying this chapter, students should be able to:

- define remote sensing.
- name components of remote sensing.
- describe electromagnetic spectrum.
- list areas where remote sensing is applicable.
- describe the relationship between GIS and remote sensing.

13.1 Definition of Remote Sensing

Remote sensing is a general term that describes the action of obtaining information about an object with a sensor that is physically separated from that object. Such sensors rely upon the detection of energy emitted from or reflected by the object. The term remote sensing includes all activities from recording, processing, analyzing, interpreting, and finally obtaining useful information from the data generated by the remote sensing systems. Remote sensing systems are mostly used for surveying, mapping, and monitoring of resources and the environment.

Figure 13.1: Satellite interacting with the earth surface

13.1.2 Components of remote sensing

The following are major components of Remote sensing System:

Energy Source

i. Passive System: sun, irradiance from earth's materials.

ii. Active System: irradiance from artificially generated energy sources such as radar.

Platforms: Vehicle to carry the sensor (truck, aircraft, space shuttle, satellite, etc.)

Sensors: Device to detect electro-magnetic radiation (camera, scanner, etc.).

Detectors: Device handling signal data (photographic, digital, etc.)

Processing: Instrument handling Signal data (photographic, digital etc.)

Institutions: Organizations that are involved in execution at all stages of remote-sensing technology. These include international and national organizations, research centres, universities, etc.

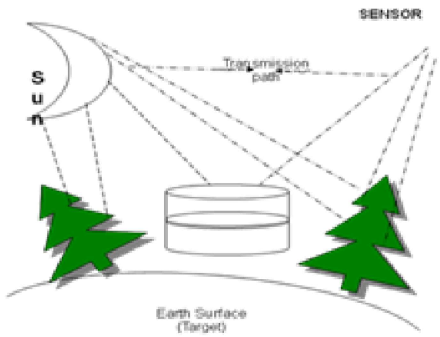

Figure 13.2: How a sensor collects information from the earth surface

13.2 The Electromagnetic Spectrum

The electromagnetic spectrum is the term used by scientists to describe the entire range of light that exists. The electromagnetic spectrum extends from below the low frequencies used for modern radio communication to gamma radiation at the short-wavelength (high-frequency) end, thereby covering wavelengths from thousands of kilometres down to a fraction of the size of an atom. The limit for long wavelengths is the size of the universe itself, while it is thought that the short wavelength limit is in the vicinity of the Planck length, although in principle the spectrum is infinite and continuous.

From radio waves to gamma rays, most of the light in the universe is invisible to man. The light to which our eyes are sensitive is just the beginning; it is a sliver of the total amount of light that surrounds us. Light is a wave of alternating electric and magnetic fields. It has a few fundamental properties that describe it. One is its frequency, measured in Hertz, which counts the number of waves that pass by a point in one second. Another closely related property is wavelength: the distance from the peak of one wave to the peak of the next. These two attributes are inversely related, the larger the frequency the smaller the wavelength and vice versa.

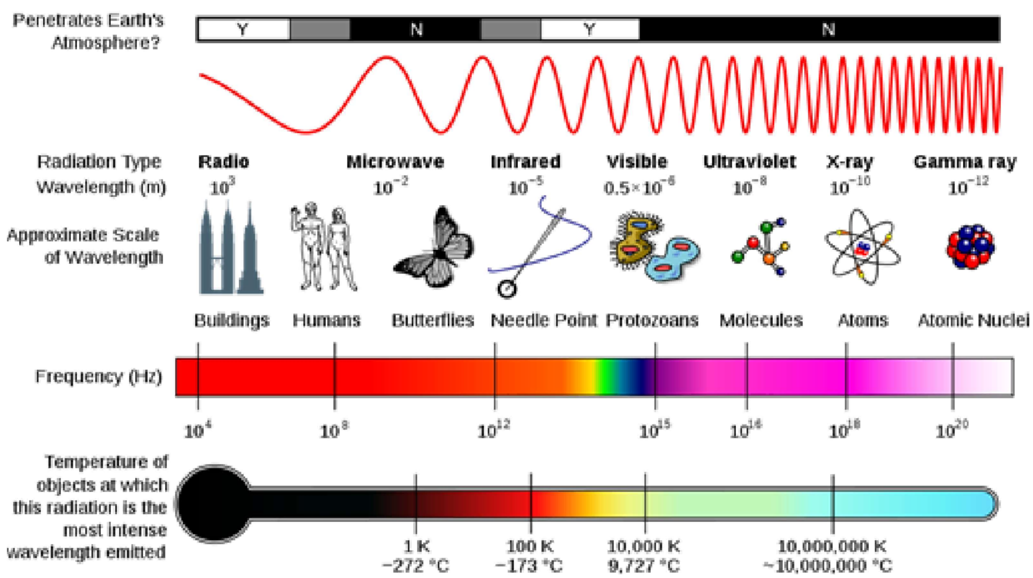

Figure 13.3: Electromagnetic Spectrum

The electromagnetic waves the eyes can detect are called the visible light. It oscillates between 400 and 790 terahertz (THz). That's several hundred trillion times a second. The wavelengths are roughly the size of a large virus: 390 – 750 nanometers (1 nanometer = 1 billionth of a meter). Human brain interprets the various wavelengths of light as different colors. Red has the longest wavelength, and violet the shortest. The entire electromagnetic spectrum is much more than just visible light. It encompasses of range of wavelengths of energy that our human eyes can't see. At wavelengths shorter than violet, we find the ultraviolet (UV) light. Ultraviolet ray has the ability to cause sunburn. Beyond UV, come the highest energies in the electromagnetic spectrum: X-rays and gamma rays. These energies are deadly to humans.

The electromagnetic spectrum describes all the wavelengths of light – both seen and unseen. Remote sensing relies on electromagnetic energy (EM). Electromagnetic energy can take several forms; however the most important source of electromagnetic energy is the sun which provides us with (visible) light, heat and ultra violet rays which can be harmful to our skin.

13.3 Remote Sensing Platforms

The vehicles or carriers for remote sensors are called the platforms. Typical platforms are satellites and aircraft, but they can also include radio-controlled airplanes, balloons kits for low altitude remote sensing, as well as ladder trucks for ground investigations. The key factor for the selection of a platform is the altitude that determines the ground resolution and which is also dependent on the instantaneous field of view (IFOV) of the sensor on board the platform.

Remote sensing data are recorded by sensors or imaging systems based on certain platforms. The platforms are mainly aircrafts and satellites. The imaging systems using aircrafts as platform are called photographic sensors while the ones using satellites as platform are called multi-spectral scanners. The photographic sensors are basically aerial cameras and these are one of the most important instruments in aerial photography or photo interpretation. We have two types of sensors namely:

Active Sensor- This detect the reflected or emitted electromagnetic radiation from natural sources. e.g Microwave Radiometer, Magnetic sensor, Gravimeter, Fourier Spectrometer and TV Camera.

Passive Sensors- This detects reflected responses from objects that are irradiated from artificially-generated energy sources such as radar. E.g Microwave Altimeter, Laser Water Depth Meter, Laser Distance Meter.

13.4 Remote Sensing Image Resolution

In general, resolution is defined as the ability of an entire remote-sensing system, including lens antennae, display, exposure, processing, and other factors, to render a sharply defined image. Resolution of a remote-sensing is of different types and namely they are:

i. **Spectral Resolution:** This is determined by the band-widths of the Electro-magnetic radiation of the channels used. High spectral resolution, thus, is achieved by narrow bandwidths width, collectively, are likely to provide a more accurate spectral signature for discrete objects than broad bandwidth.

ii. **Radiometric Resolution**: This is determined by the number of discrete levels into which signals may be divided.

iii. **Spatial Resolution**: This concerns the geometric properties of the imaging system. It is usually described as the instantaneous field of view (IFOV). The IFOV is defined as the maximum angle of view in which a sensor can effectively detect electro-magnetic energy.

iv. **Temporal Resolution**: is related to the repetitive coverage of the ground by the remote-sensing system. The temporal resolution of Landsat 4/5 is sixteen days.

13.5 Applications of Remote Sensing

Remote sensing is applicable to all areas of human endeavours. It has capability of providing useful help towards solving several environmental challenges confronting man. Application of remote sensing method might involve the following:

Monitoring Urban Development- urban development can be measured and monitored using remote sensing method. Related to this is monitoring and measuring land cover and land use changes over time. Figure 13.4 shows how urban growth occurs over time and in space. Urban development involves the changing of agricultural lands into built up areas. Grey areas are non-urban, typical of agricultural area. The black areas are where urban growth occurs.

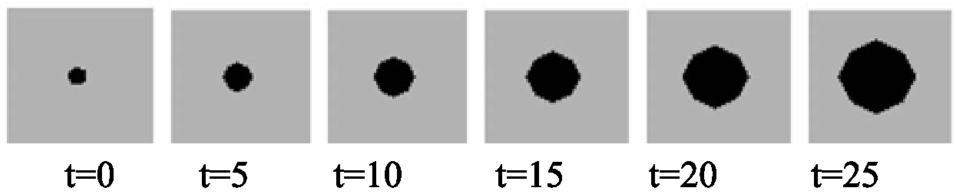

Figure 13.4: Monitoring urban growth in a plain area. (Black cells are urban; grey cells are non-urban;'t' is time step.)
Source: Liu, 2009.

Disaster Management and Environmental Monitoring

Remote sensing method affords us the opportunity of rapid response with respect to disaster management and environmental monitoring. The ecological disasters which often plague humans include forest fires, landslides, tsunamis; earthquake, flooding and oil spill.These disasters can now be better managed and monitored using the method of remote sensing. The method of remote sensing was used to monitor Hurricane Katrina in the U S. The floods that buried up to 80 percent of New Orleans during hurricane Katrina had noticeably subsided by September 15, 2005 as shown in figure 13.5a, when the top image was taken by the Landsat 7 satellite. The progress in draining the city is evident when the September 15 (top) image is compared with an image taken one week earlier. In the lower image, taken by the Landsat 5 satellite on September 7, black flood water covers much of the city. By September 15, the dark flood water had all but disappeared.

Fig. 13.5a: Hurricane Katrina

Monitoring Oil Spills and Oil Spill Fire

Oil spills and oil spill fire are common occurrence in areas of oil exploration. Oil spill may occur due to vandalisation of oil pipelines and oil vessel break up. It can also occur during crude oil drilling.

Fig. 13.5(a) *Elume Oil Spill Fire*

Fig. 13.5 (b): NNPC's Oil Spill at Atlas Cove (Niger Delta).

Monitoring Environmental Changes

Remote sensing is a useful method in monitoring environmental changes. Changes in water bodies, vegetation cover, temperature and rainfall can be monitored and determined using remote sensing method. Figure 13.6 shows changes that have taken place in Lake Chad areas between 1963 and 2005.

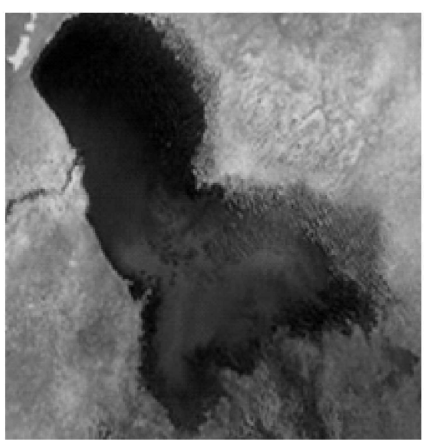

Fig. 13.6(a): Lake Chad in October 1963 from corona space photograph.

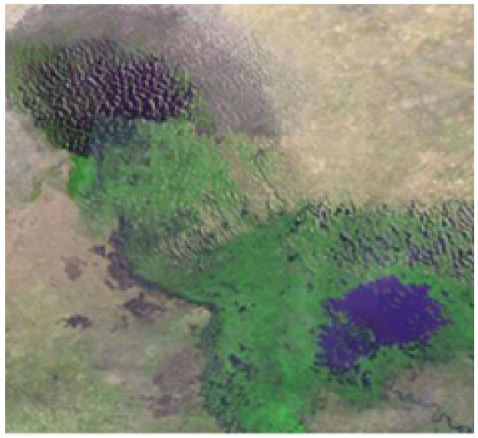

Fig. 13.6(b): Lake Chad in October 2005 from Nigeria SAT- 1 image.

Other areas of remote sensing application include monitoring and management of forest fire, disease surveillance, diffusion of diseases, land use land cove dynamics etc.

13. 6 Relationship Between GIS and Remote Sensing

Strong relationship exists between geographical information system (GIS) and remote sensing. GIS applications enable the storage, management, and analysis of large quantities of spatially distributed data. These data are associated with their respective geographic features. For example, water quality data would be associated with a sampling site, represented by a point. Data on crop yields might be associated with fields or experimental plots, represented on a map by polygons. A GIS can manage different data types occupying the same geographic space.

Remote sensing technologies are used to gather information about the surface of the earth from a distant platform, usually a satellite or airborne sensor. Most remotely sensed data used for mapping and spatial analysis is collected as reflected electromagnetic radiation, which is processed into a digital image that can be overlaid with other spatial data in the GIS environment. The remotely sensed data can provide timely information at low cost and in a form that is compatible with the requirements of a GIS. Therefore we can say remote sensing is a provider of raw materials (spatial data) for GIS.

Both GIS and digital remote sensing systems use similar equipment and similar computer program. The non remote sensing data from a GIS can be used to assist in the analysis of remotely sensed images. However, GIS has capabilities to provide a means of organizing diverse spatial data. It supports remote sensing in the areas of mission planning, collection, organization and visualization of reference data.

Remote sensing is a means of updating data in GIS, without this GIS will become obsolete and irrelevant. There are several avenues for incorporating remotely sensed data into the GIS in order to update data in GIS.

i. By manual interpretation of aerial images or satellite images.

By analyzing or classifying digital remote sensing data using automated methods to produce conventional (paper) maps and images, which are then digitized for entry into the GIS and

By analyzing or classifying using automated method, in order to retained in digital format for entry into the GIS, using reformatting or geometric corrections as required.

The interconnection and interrelationship between GIS and remote sensing is so strong to the point that one is not independent of the other. There is mutual dependency between GIS and remote sensing.

13.7 Advantage of Remote Sensing

The principal advantages of remote sensing are the speed at which data can be acquired from large areas of the earth's surface, and the possibility of obtaining data from comparatively inaccessible areas. The major advantages of this technique over ground-based methods of acquiring spatial data are as follows;

Synoptic View

Remote sensing process facilitates the study of various earths' surface features in their spatial relation to each other and helps to delineate the required features and phenomena.

Repetitive Ability

Remote sensing satellites provide repetitive coverage of the earth and this temporal information is very useful for studying landscape dynamics, phonological variations of vegetation and change detection analysis.

Accessibility

Remote sensing process made it possible to gather information about the area where it is not possible to do ground survey like in mountainous areas and foreign areas.

Time Conservation

Since information about a large area can be gathered quickly, the techniques save time and human efforts. It also saves time that would be unnecessarily spent on the field during fieldwork.

Cost Effectiveness

Remote sensing especially when conducted from space is an intrinsically expensive activity. Nevertheless, cost-benefit analysis demonstrates its financial effectiveness, and much speculation or developmental remote sensing activity can be justified in this way. It is a cost-effective technique as repeated fieldwork is not required and also a large number of users can share and use the same data produced.

Revision Questions

Objectives

The term “remote sensing” is a general term that describes the action of obtaining information about an object with a sensor that is

A. Physically detached from that object.
B. Physically separated from that object.
C. Physically closed from that object.
D. Physically connected from that object.

Remote sensing systems are mostly used for the following except

A. Surveying
B. Mapping, and monitoring of resources and the environment
C. Disease surveillance
D. Harvesting of rice farms

Which of these is not a component of remote sensing?

A. Sensor
B. Platform
C. Institution
D. GIS.

Gamma radiation is an example of

A. Short-wavelength
B. Long-wavelength

C. Middle-wavelength

D. Distant-wavelength

A wave of alternating electric and magnetic fields is refers to as

A. Frequency

B. Wavelength

C. Light

D. Wavelength

Which of these has the ability to cause sunburn?

A. X-rays

B. Gamma rays.

C. Ultraviolet ray

D. Visible rays

The term "IFOV" simply means

A. The Instantaneous Focal View

B. The Instantaneous Fixed View

C. The Instantaneous Field of View

D. the instantaneous Focus of Viewpoints

Spatial Resolution refers to the

A. Arithmetic properties of the imaging system

B. Geometric properties of the imaging system

C. Band-widths of the Electro-magnetic

D. Timing of data collection

The following are passive sensors except

A. Microwave Altimeter

B. Laser Water Depth Meter

C. Laser Distance Meter

D. T V Camera

The most important source of electromagnetic energy is

A. The sum

B. X-rays

C. The sun

D. Gamma rays

Answers

1. B 2. D 3. D 4. A 5. C 6. C 7. C 8. B 9. D 10. C

Essay

1. Define remote sensing.

(b) Enumerate the advantages of remote sensing.

2. With illustrated diagram describe extensively the electromagnetic spectrum.

3. Discuss five important areas of applications of remote sensing.

4. What is image resolution?

5. Discuss the relationship between remote sensing and the GIS