CE-317 GIS/RS Application to Civil Engineering
Spring 2011

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- Lecture 09: RS

Presentation Outline

- Concept of RS
- Principle of Electromagnetic Radiation
- Electromagnetic Spectrum
- Characteristics of RS Data
- Spatial, Spectral, Radiometric, Temporal Resolution.
- RS Data Interpretation and Analysis

Concept of Remote Sensing

- Remote sensing refers to "*the activities of* ***recording***, ***observing***, *and* ***perceiving*** *(sensing)* ***objects or events*** *in far-away (****remote****) places"*.
- In remote sensing, the sensors are not in **direct contact** with the objects or events being observed.

Concept of Remote Sensing

- In a more restricted sense, remote sensing refers to "*the science and technology of* ***acquiring information*** *about the* ***earth's surface*** *(i.e., land and ocean) and atmosphere using* ***sensors*** *onboard"*
- **airborne** (e.g., aircraft or balloons)

  or

- **spaceborne** (e.g., satellites and space shuttles) platforms

Concept of Remote Sensing

- **Electromagnetic radiation** normally is used as the information carrier in remote sensing.
- The **output** of a remote sensing system is usually an **image** representing the scene being observed.
- A further step of **image analysis** and interpretation is required to **extract useful information** from the image.

Concept of Remote Sensing

- Depending on the scope, remote sensing may be broken down into:

1. **satellite** remote sensing (when satellite platforms are used)
2. **photography and photogrammetry** (when photographs are used to capture visible light)
3. **thermal** remote sensing (when the thermal infrared portion of the spectrum is used)

Concept of Remote Sensing

4. **radar** remote sensing (when microwave wavelengths are used)
5. **LiDAR** remote sensing (when laser pulses are transmitted toward the ground and the distance between the sensor and the ground is measured based on the return time of each pulse).

Concept of Remote Sensing

- The technology of remote sensing evolved gradually into a scientific subject after World War II.
- Its early development was driven mainly by military uses.

Principles of Electromagnetic Radiation

- Electromagnetic radiation is a form of energy with the properties of a wave, and its major source is the sun.
- Solar energy traveling in the form of waves at the speed of light (denoted as c and equals to 3×10^8 ms^{-1}) is known as the electromagnetic spectrum.
- $C=\lambda \times \mu$
- Where λ = wave length and μ = frequency

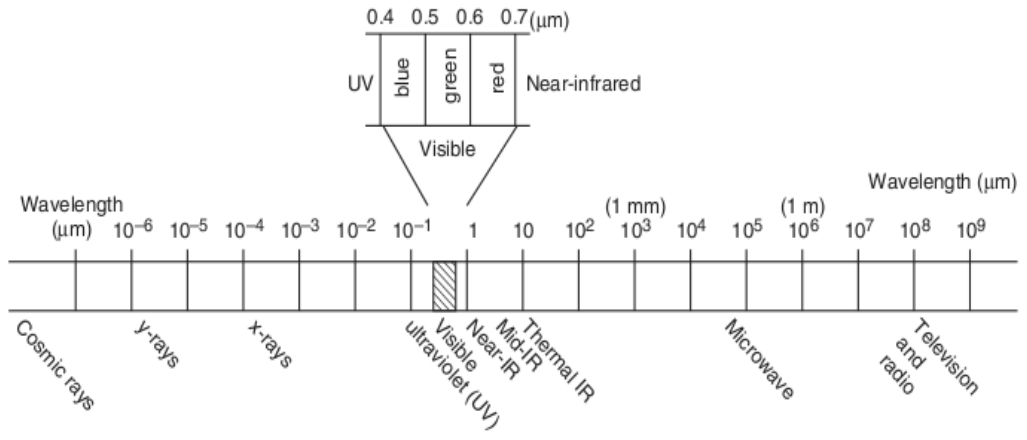

FIGURE 1.1 Major divisions of the electromagnetic spectrum.

Electromagnetic Spectrum

- Major divisions of the electromagnetic spectrum, ranging from **short-wavelength, high-frequency** waves to **long-wavelength, low-frequency** waves, include:

1. gamma rays
2. X-rays
3. ultraviolet (UV) radiation
4. visible light

Electromagnetic Spectrum

5. infrared (IR) radiation
6. microwave radiation
7. and radiowaves.

Electromagnetic Spectrum

- The **visible spectrum** has a great utility in satellite remote sensing and for the identification of different **objects by their visible colors** in photography. (**0.4–0.7 μm** wavelength)
- Infra-red waves can be further partitioned into the **near-IR**, **mid-IR**, and **far-IR** spectrum, which includes thermal radiation. (from visible range to about **1 mm** in wavelength)
- IR radiation can be measured by using **electronic detectors.**

Electromagnetic Spectrum

- IR images obtained by sensors can yield important information on the **health of crops** and can help in visualizing **forest fires** even when they are enveloped in an opaque curtain of smoke.
- Microwaves are emitted from the earth, from objects such as **cars** and **planes**, and from the **atmosphere**. (1 mm to 30 cm)
- These microwaves can be detected to provide information, such as the **temperature** of the object that emitted the microwave.

Electromagnetic Spectrum

- Because their wave-lengths are so long, the energy available is quite small compared with visible and IR wavelengths.
- Therefore, the fields of view must be large enough to detect sufficient energy to record a signal.

Electromagnetic Spectrum

- Most **passive microwave** sensors thus are characterized by low spatial resolution.
- **Active microwave** sensing systems (e.g., radar) provide their own source of microwave radiation to illuminate the targets on the ground.
- **Transmission** refers to the movement of energy through a surface.

Electromagnetic Spectrum

- The ratio of transmitted radiation to the incident radiation is known as **transmittance**.
- **Reflectance** is the term used to define the ratio of the amount of electromagnetic radiation reflected from a surface to the amount originally striking the surface.
- When a surface is smooth, we get **specular reflection** but for rough surface we get **diffuse reflection**.

Electromagnetic Spectrum

- A portion of this energy then is **reemitted**, as **emittance**.
- Using their reflectance differences, we can distinguish these common earth-surface materials.

Reflectance of Earth Surface Materials

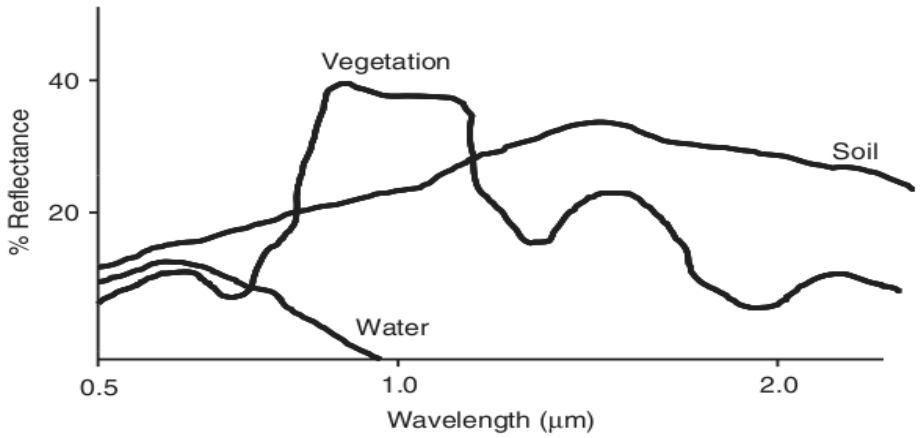

FIGURE 1.2 Spectral signatures of water, vegetation, and soil.

Characteristics of Remotely Sensed Data

- All sensing systems detect and record energy "**signals**".
- Remote- sensing systems include: **aerial cameras** and **video recorders, electronic scanners**, **linear/area arrays**, **laser scanning systems**, etc.
- Data can be **analog** or **digital.**

Characteristics of Remotely Sensed Data

- The success of data collection from remotely sensed imagery requires an understanding of four basic resolution characteristics, namely, **spatial**, **spectral**, **radiometric**, and **temporal resolution.**

Spatial Resolution

- Spatial resolution "*is a measurement of the minimum distance between two objects that will allow them to be differentiated from one another in an image"*.
- It is a function of sensor altitude, detector size, focal size, and system configuration.
- Types are **High Spatial Resolution** and **Course Spatial Resolution**.

Spectral Resolution

- Spectral resolution of a sensor refers *"to the number and size of the bands it is able to record"*.

Radiometric Resolution

- Radiometric resolution refers to "*the sensitivity of a sensor to incoming radiance"*.
- That is, how much change in radiance there must be on the sensor before a change in recorded brightness value takes place.

Temporal Resolution

- Temporal resolution refers to *"the amount of time it takes for a sensor to return to a previously imaged location"*.
- Therefore, temporal resolution has an important implication in change detection and environmental monitoring.

Remote Sensing Data Interpretation and Analysis

- Remotely sensed data can be used to extract **thematic** and **metric** information, making it ready for input into GIS.
- Thematic information provides **descriptive data** about earth surface features.
- Themes can be as diversified as their areas of interest, such as **soil**, **vegetation**, **water depth**, and **land cover**.

Remote Sensing Data Interpretation and Analysis

- Metric information includes **location**, **height**, and their derivatives, such as **area**, **volume**, **slope angle**, and so on.
- Thematic information can be obtained through **visual interpretation** of remote sensing images (including photographs) or computer-based **digital image analysis**.
- Metric information is extracted by using the **principles of photogrammetry**.

Q n A

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