Remote Sensing Review Notes - GLG 105

- *Remote sensing* – collection and interpretation of info about an object (surface) without being in physical contact with that object (surface)

    - Usually involves methods that use electromagnetic energy (light, heat, radio waves, etc.)

- Geophysical surveys are a bit different in that they measure force fields like gravity, magnetism, electrical conductivity, etc., but they achieve similar goals

- Examples of remote sensing include aerial photography (uses visible light)

- Metric (SI) units and *scientific notation* are typically used in remote sensing lingo (as with any science)

    - Kilometer (km) = 1000 m = 10^3 m
    - Meter (m) = 1 m = 10^0 m
    - Centimeter (cm) = 0.01 m = 10^{-2} m
    - Millimeter (mm) = 0.001 m = 10^{-3} m
    - Micrometer (μm) = 0.000001 m = 10^{-6} m (AKA *micron*)
    - Nanometer (nm) = 0.000000001 m = 10^{-9} m

    - Second (sec) = unit of time ($1/60^{th}$ of a minute)

- Electromagnetic energy involves all energy that moves at the speed of light in a harmonic (regular, repeating) wave pattern
    - When it hits a surface, it behaves as though composed of little particles or packets of energy known as *photons*
    - Speed of light (c) in a vacuum is 299,793 km/sec
        - (typically rounded to 3 x 10^8 m/sec)

- *Wavelength* (λ) of electromagnetic waves is the distance from the crest of one wave to the crest of the next, usually expressed in microns or nanometers

- *Frequency* (ν) of light is the number of waves (or cycles) that pass by in a second

- $c=\lambda\nu$

- Electromagnetic radiation that encounters matter (i.e., hits a surface) is referred to as *incident* radiation, which can then be:
    - *Transmitted*, or passed through, the surface, typically changing direction or *refracting* an amount based on the difference in the speed of light from the first medium (air, water, vacuum) to the next (solid or liquid surface)
    - *Absorbed*, which involves basically heating up the surface
    - *Emitted* by the surface, typically at longer wavelengths

- *Scattered*, that is, deflected in all directions
- *Reflected*, that is, bounced off the surface forward at an angle equal to that at which it hit it (angle of incidence)
    - *Reflection* occurs when a surface is "smooth" relative to the wavelength of the incident radiation (i.e., the local bumpiness or roughness is at a scale that is comparable to or less than the wavelength of the incident light)

- The *electromagnetic spectrum* is the continuum of energy that ranges in wavelength from nanometers to meters, travels at the speed of light, and can travel through a vacuum (such as outer space)
    - All matter radiates a range of electromagnetic energy, with the wavelength of peak intensity being shorter and shorter the higher the temperature of the object or surface
        - The Sun, with a surface temp. of ~5700 K, radiates at its peak in the *visible* light portion of the E-M spectrum

- Regions of the E-M spectrum (classified by wavelength) include:
    - Gamma ray (<0.03 nm)
    - X-ray (0.03 – 3.0 nm)
    - Ultraviolet/UV (0.03 – 0.4 μm)
    - Visible (0.4 – 0.7 μm)
    - Infrared/IR (0.7 to 100 μm)
        - "Thermal" IR is emitted radiation due to the temp of planetary surfaces), and is typically defined based on atmospheric "windows" through the CO_2, H_2O and O_3 in Earth's atmosphere)
    - Microwave (0.1 – 30 cm)
        - *Radar* is the "active" form of microwave remote sensing, where beams are "shined" at the surfaces being observed
    - Radio (>30 cm)

- Systems used for remote sensing are determined by what features one is trying to observe and any atmospheric gases and/or clouds that one must look through
    - Water vapor, carbon dioxide and ozone gases all have wavelengths where they absorb E-M energy and thus block observation of any underlying surface (atmospheric "windows" are narrow wavelength ranges where no absorption takes place, so we can "see" through to the surface)
    - Earth's atmosphere absorbs all wavelengths shorter than about 0.3 μm, making life on Earth possible!

- *Passive* remote sensing systems record the energy that naturally radiates or reflects from a surface

- *Active* remote sensing systems supplies its own energy source to illuminate the surface, and the energy that is scattered or reflected back is recorded
    - Flash photography and radar systems are examples

- An *image* is a pictorial representation, using any wavelength or imaging device
    - Photographs are images recording wavelengths between 0.3 and 0.9 μm that can be recorded on photographic film
    - Images have fundamental properties including:
        - ♣ *Scale* – the ratio of distance between two points in an image to the actual distance on the surface
        - ♣ *Brightness* – magnitude of response produced in the eye by light
        - ♣ *Contrast* – difference between brighter and darker parts of an image
        - ♣ *Resolution* – minimum separation between two objects that can be distinguished as separate in an image (NOT the size of the smallest object that can be seen – objects may be seen that are smaller than the theoretical resolving power of imaging systems)