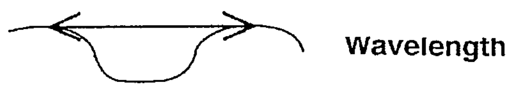
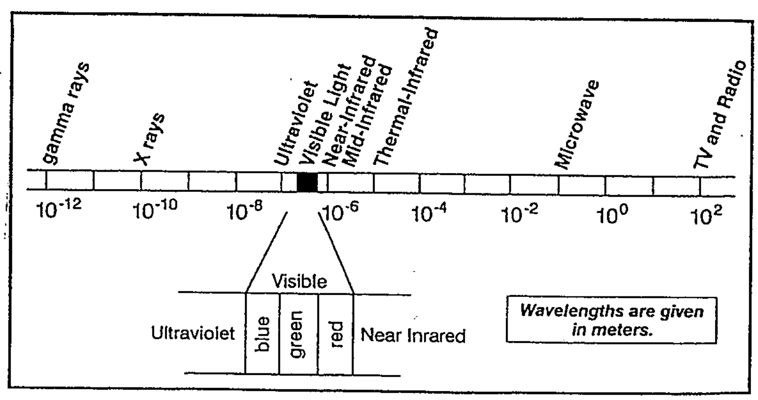
Teaching Activity: Satellite Imagery and Remote Sensing- Observing the Earth

Introduction: Beginning in 1957, satellites began carrying instruments to measure conditions in space near the Earth, and as the instrumentation improved, looking back at the Earth itself. Since that time satellite-borne cameras and sensors have charted the Earth's environment: its atmosphere, water, ice, and living organisms, using a technology known as *remote sensing*, the process of making and interpreting measurements of the Earth from space of airborne sensors. The scientific and technological innovations of the past 30 years which have emerged from analyzing satellite imagery have fundamentally altered our view of the planet.

A wide range of remote sensing techniques have emerged for mapping the Earth's environment. Almost all of them use sensors that record radiation traveling from the Earth outward into space, but differing in the type of radiation detected. The term radiation refers to the different wavelengths of electromagnetic radiation (light) reflected or emitted by an object. It can be said that the eye is a remote sensor; it receives and interprets *visible radiation* (light waves), providing us with about 90% of the information we receive about our environment. Visible light, however, is only one of many types of waves which make up the *electromagnetic spectrum.* This radiation forms a continuous spectrum in which the properties of the waves depend on their *wavelengths,* commonly measured in one of two units: the micron (micro-meter, µm) or the *namometer* (nm).

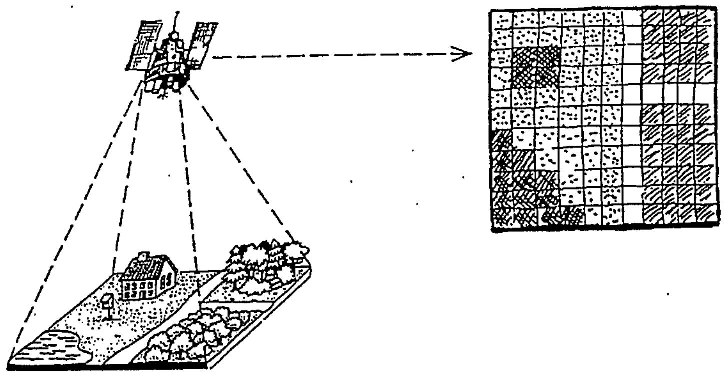


Visible light is closest to the middle of the spectrum; violet light has the shortest wavelength and red light the longest. On either side of the "band" of visible radiation are other wavelengths of value in remote sensing: reflected solar, thermal infrared, microwave, ultraviolet (UV), etc.) Each spectral region conveys a unique set of information about the Earth's environment. For example, since ozone absorbs ultraviolet radiation (UV), measurements of UV radiation are used to map ozone in the atmosphere. Microwaves are used to monitor the polar ice sheets in an effort to detect melting that might accompany global warming. Visible and infrared data are used to assess the health of crops, forests and other forms of vegetative cover. Thermal infrared (IR) is used to determine the temperature of land, clouds and ocean surface.



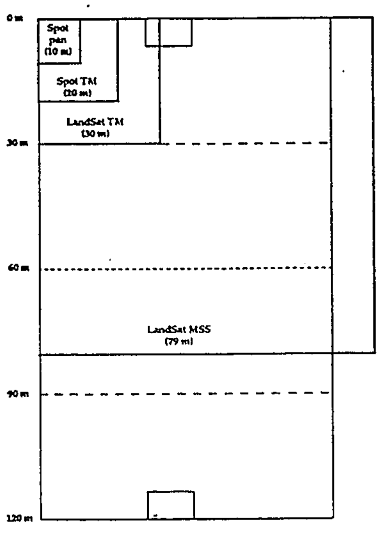
Wavelengths of Electromagnetic Radiation

Satellite images can present data in two different forms; some is photographic; the majority is made of digital data. A *digital image* is produced on a computer and is made up of picture elements called *pixels*, arranged horizontally and vertically on the computer screen. Each pixel in an image corresponds to a particular location on the Earth which is actually a square area of finite dimensions. The pixel represents the smallest area that the particular sensor is able to "see".



How a satellite views the Earth's land cover as a group of equal size units placed on a landscape. Each unit is called a *pixel*.

For every unit in a grid, the satellite sensor will measure the energy being given off by the surface features in that unit. The units are the pixels. The size of each unit, or pixel, will determine the size of the smallest feature on the surface than can be detected, or "resolved". Satellites which measure properties and processes in the oceans and atmosphere usually have large pixels, typically 1000 m (1 km) or larger, since processes here generally do not change much over smaller distances. Land-oriented applications require much higher spatial resolution (10-30 m) because features on land, cultivated fields, roads and rivers, tend to be much smaller than the large-scale features in the atmosphere and ocean. This 1 km or 30 m size is referred to as the *spatial resolution* of the image, or the ability to "see" size, which relates to the size of the pixel. *Course (low) resolution* refers to images made up of larger pixels, while *fine (high) resolution* refers to images made up of smaller pixels. The smaller the pixel, the greater the amount of information recorded by the sensor for the same-sized area on the ground.



A comparison of different spatial resolutions as compared to a typical international football field.

Another important aspect of satellite remote sensing is the *frequency of the coverage*, that is how often the satellite passes over the same location on the Earth's surface. This is largely determined by the orbit in which the satellite is placed. Generally, the higher the orbit, the longer the time required for the satellite to revolve around the Earth. Weather satellites need the most frequent coverage, because of changes occurring on time scales of minutes to hours and are placed in *geosynchronous (geostationary) orbits*, in which the satellite orbits at the same rate as the Earth rotates, and hovers above the same location continuously.

The scientific techniques and technological innovations which have emerged from the past 30 years of analyzing satellite images have fundamentally altered our view of the planet. For many years this technology was restricted to national security, military applications, or to research programs at large academic and commercial institutions. But recently the power of desktop computing and the large number of satellites from other countries have opened this frontier to people everywhere. Now, small colleges and businesses, elementary and secondary schools, land planners, environmental groups and even individuals make use of this technology.

Objective:

- To understand how satellite imagery is used to observe and interpret Earth's atmospheric conditions;
- To evaluate the advantages of different types of satellite images;

Important Terms: Satellite, imagery, geostationary, orbit, rotation, full-disk image, spatial resolution, visible light, digitized data, infrared imagery;

Materials: Videotape of weather report, examples of infrared and visible light images, **Student Activity Sheet**, pencil/pen;

Procedure:

1. Show a videotape of televisions weather coverage to the class.
   - Explain that these examples show how meteorologists can use remote sensing data for weather observations, interpretation and forecasting.
   - Point out that most of the weather coverage on TV is based on data from satellites in orbit more than 35,000 km above the Earth.
   - Ask students to pick out any specific features on the planets that they can identify (clouds, storms, land masses, etc.) and make a list on a sheet of notebook paper.
   - Discuss their findings with the group. Ask for suggestions of what additional types of information they would like to receive from a satellite image and why.

2. Show two different images (slides or transparencies) made with visible light, much like a photograph, but with light and dark areas digitized, or given numerical values.
   - Point out:
     - -the resolution of the image and the time of day that it was made.
     - -that in visible light images, clouds appear white and the ground and water surfaces appear gray or black.
     - - low clouds can usually be distinguished from land surfaces; thunderstorms clouds can usually be seen against lower clouds in late afternoon photos.
     - - visible images can only be produced during daylight hours.

3. Ask students to take detailed notes on the information given by you as well as the observations made of the images you presented.
   - Students should write a paragraph of approximately 250 words describing/ analyzing each image viewed and their criticism of it.

4. Show the two same images shown in #1 but taken in the infrared, rather than visible wavelengths.
   - Point out:
     - - since the Earth is always radiating heat at infrared wavelengths, IR photos can be made at any time of day.
     - - warm land and water surfaces appear dark gray or black;
     - - the cold tops of high clouds appear white, while lower level clouds, which are warmer, appear gray;
     - - in this type of imagery it is difficult to distinguish between features that are nearly the same temperature, for example, low clouds and fog;

5. Repeat the same procedure in # 3. Ask students to compare the two types of images and the advantages of each.

6. Pass out the **Student Activity Sheet #1**.'
   - Ask students to identify and analyze each image.
   - They should be able to tell visible from IR.

7. Students should then go on to complete the **Analysis and Conclusions** sections.

Student Activity Sheet: Satellite Imagery and Remote Sensing- Observing the Earth

Introduction: Beginning in 1957, satellites began carrying instruments to measure conditions in space near the Earth, and as the instrumentation improved, looking back at the Earth itself. Since that time satellite-borne cameras and sensors have charted the Earth's environment: its atmosphere, water, ice, and living organisms, using a technology known as *remote sensing*, the process of making and interpreting measurements of the Earth from space of airborne sensors. The scientific and technological innovations of the past 30 years which have emerged from analyzing satellite imagery have fundamentally altered our view of the planet.

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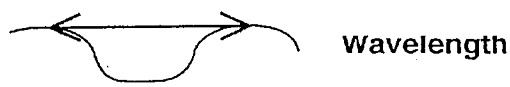

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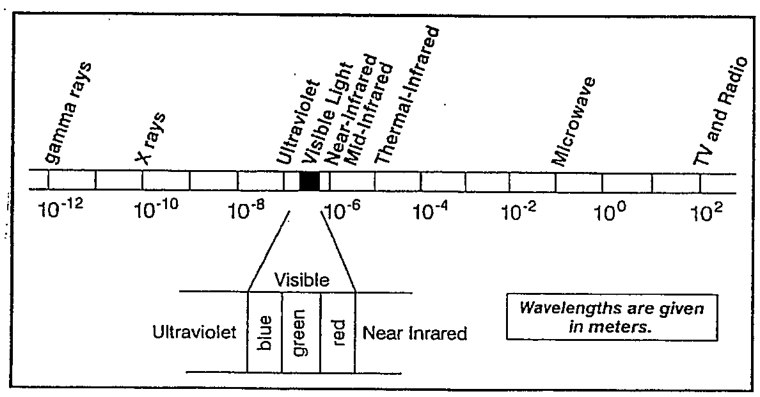

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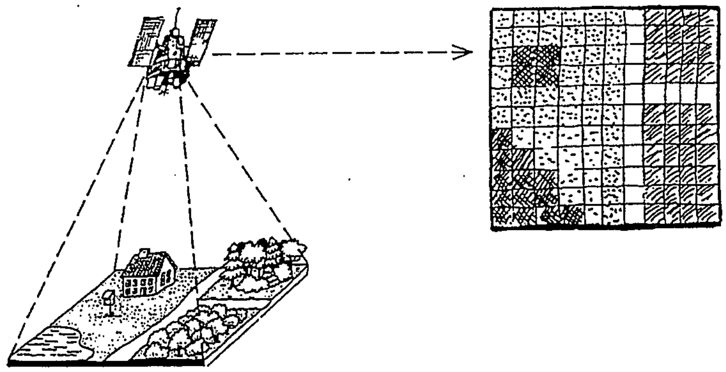

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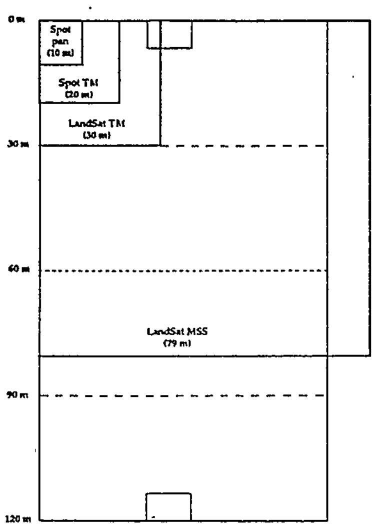

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Procedure:

1. Watch the videotape of televisions weather coverage.

    - Pick out any specific features on the planets that you can identify (clouds, storms, land masses, etc.) and make a list on a sheet of notebook paper.
    - Discuss/ compare your findings with the class.

2. Take notes on the following information:
    - the resolution of the image and the time of day that it was made.
    - in visible light images, clouds appear white and the ground and water surfaces appear gray or black.
    - low clouds can usually be distinguished from land surfaces; thunderstorms clouds can usually be seen against lower clouds in late afternoon photos.
    - visible images can only be produced during daylight hours.

3. Take notes on the information given by your teacher as well as the observations made of the images presented.
    - Write a paragraph of approximately 250 words describing/ analyzing each image viewed and your criticism of it.

4. Look at the images presented that were taken in the infrared, rather than visible wavelengths and take notes on the following information:
    - the Earth is always radiating heat at infrared wavelengths; IR photos can be made at any time of day.
    - warm land and water surfaces appear dark gray or black;
    - the cold tops of high clouds appear white, while lower level clouds, which are warmer, appear gray;
    - in this type of imagery it is difficult to distinguish between features that are nearly the same temperature, for example, low clouds and fog;

5. Repeat what you did in #3. In addition, compare the two types of images (visible and infrared) and the advantages and disadvantages of each.

6. Get a copy of **Student Activity Sheet #1**.
    - Identify and analyze each image.
    - Indicate visible light from IR.
    - Point out any land forms that you can identify, etc.

7. Go on to complete the **Analysis and Conclusions** sections.

Student Activity Sheet #1

Part I: Satellite Imagery Analysis - Carefully observe the various atmospheric conditions shown in the images below. Identify the type of image and write a brief description of what the image portrays.

IMAGE #1:

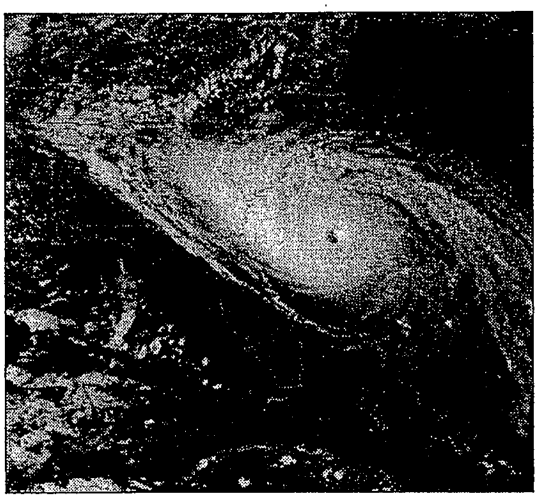
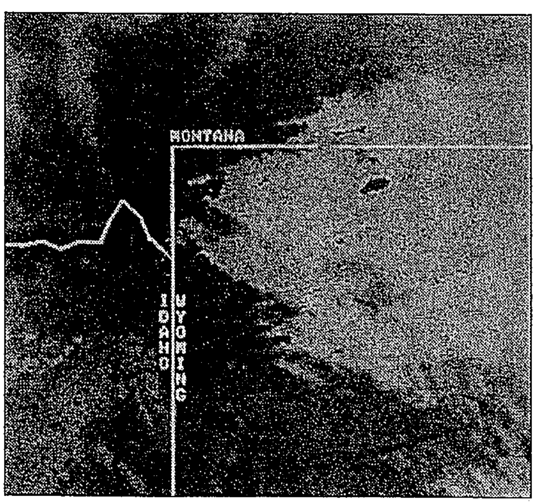


IMAGE #2



Student Activity Sheet #1

IMAGE #3

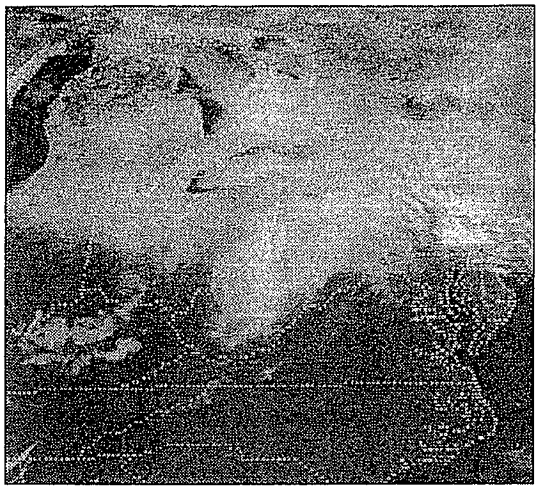


IMAGE #4

Student Activity Sheet #1

IMAGE #5

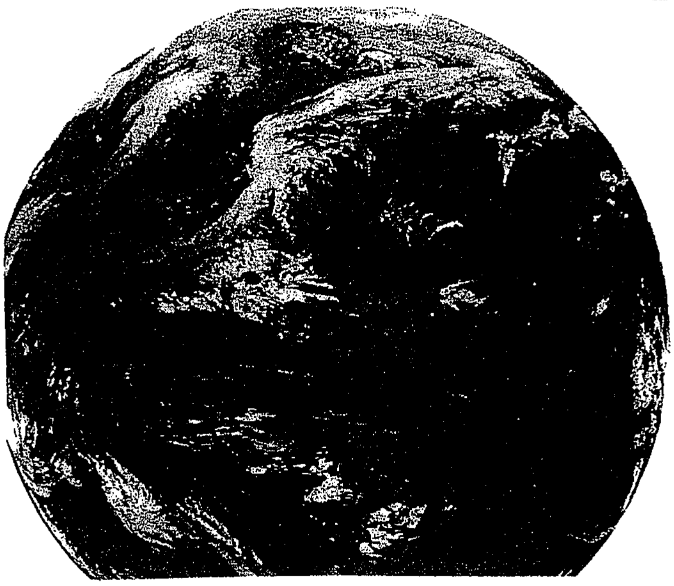


IMAGE #6

Student Activity Sheet #2

Part II: ANALYSIS AND CONCLUSIONS

1. Explain what remote sensing is. ____

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2. Briefly describe how a remote sensor works. ___________________________________

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3. Why is the eye considered a remote sensor? ___________________________________

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4. Refer to the electromagnetic spectrum in the **Introduction**. Briefly compare the properties of infrared and visible wavelengths. ______________________________

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5. What are some advantages / disadvantages of visible light imagery? Of infrared imagery? ____

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6. If you were interested in landcover changes in eastern Colorado, would you want a low resolution or high resolution image? Why? ______________________________

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Student Activity Sheet #2

7. Oceanographers are worried about possible shifts in ocean currents as a result of global warming. What type of images would they want to study? Why?____________

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8. Explain what a *geostationary orbit* is and why they would be useful for weather satellites? ____

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9. Pick an area of land (1 km x 1 km or less) that you are familiar with or a favorite room in your house (5m x 5 m). Create a "mock" satellite image of the area / room on a piece of 8.5 x 11in. paper as if you were the satellite looking down on it. Be as detailed as possible. Use color to enhance the image if you wish, but be sure to create a key explaining the colors and what they mean. Also indicate clearly what the scale of the "image" is that you are creating. Include a written description of the image, including location, time of day, resolution, etc.

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