Assignment Discovery Online Curriculum

Lesson title:
Reading Satellite Images

Grade level:
6-8, with adaptation for older students

Subject areas:
Earth Science, Physical Science

Duration:
One to two class periods

Objectives:
Students will
1. Understand how satellite images are made by active, passive, and remote sensing instruments.
2. Understand that analyzing satellite images reveal features and events that would be impossible to detect with other means of analysis.

Materials:

The class will need the following:
- Computer with Internet access (optional but very helpful)
- Three digital satellite images:
  Image one: http://asterweb.jpl.nasa.gov/gallery/images/usu2.jpg
  Image two: http://asterweb.jpl.nasa.gov/gallery/images/college.jpg
  Image three:
  http://seawifs.gsfc.nasa.gov/SEAWIFS/IMAGES/SEAWIFS/S1998156182955.L1A_HNAV.MexicanFires.jpg

  If classroom Internet access is not available, color copies of the images may be used.
- Maps/atlases with longitude and latitude markings

Each student will need the following:
- Pencils
- Rulers
- One copy of Classroom Activity Sheet: Analyzing Satellite Images
- One copy of Take Home Activity Sheet: Tracking Weather with Satellite Images

This lesson plan could be enhanced by purchasing a copy of the documentary *Satellite Technology*. This documentary airs on the Discovery Channel March 1, April 5, May 10, and June 14.

Procedures:

1. Begin the lesson by asking students if they know what the term “artificial satellite” means. Write down their ideas and tell them that one possible definition is “a human-built object that orbits a planet, such as Earth, and performs a specific task by receiving and transmitting signals. The six main types of artificial satellite are listed below:

   - Scientific research—used to map sea surface temperatures
   - Weather—provides ongoing weather data
   - Communications—used to track the satellite system
   - Navigation—the Global Positioning System (GPS)
   - Earth observation—used to map surface features such as land use
   - Military—provides secure communications for the military

2. Ask students to describe how they think satellite images are made. Address any errors, such as the misconception that satellites take photographs on film that are then collected and developed. Explain that satellites use *remote sensing* instruments to collect data, which are transmitted from the satellite to the ground as radar or microwave signals. Some satellites have *active instruments*, which send out a signal and record the “echo” when it bounces back up to the satellite similar to the way a submarine uses sonar to map the ocean floor. Other satellites use only *passive instruments* that don’t emit signals but instead collect radiation emitted or reflected from Earth.

   Point out that raw satellite data are just sets of numbers registered by digital equipment; by itself; raw data do not make an image. Converting raw data into an image requires computer software that converts ranges of radiation values into colors we can see.

3. Divide the class into groups of three or four and tell each group that they will be analyzing three satellite images. If groups have Internet access, they can view the images directly on a computer monitor. Otherwise, each group should have a color copy of each image.) Distribute the Classroom Activity Sheet: Analyzing Satellite Images. Tell students that their goal is to work together to complete the questions on the sheet. The three satellite images can be found at:

   Image 1: http://asterweb.jpl.nasa.gov/gallery/images/usu2.jpg
   Image 2: http://asterweb.jpl.nasa.gov/gallery/images/college.jpg
   Image:
   http://seawifs.gsfc.nasa.gov/SEAWIFS/IMAGES/SEAWIFS/S1998156182955.L1A_HNAV.MexicanFires.jpg

4. After students have completed their analyses, have a class discussion on the results. Have representatives from each group share their results and explain how they reached their conclusions. Suggested answers for the questions on the Classroom Activity Sheet follow:

Image 1: Volcanic Eruption

1. Japan; *Bonus*: Mt. Usu
2. Lake Toya, a volcanic caldera.
3. The three dark streaks are ash deposits from the eruption of Mt. Usu.
4. In six months, the ash trails will no longer be visible. Some snow will remain, but it will not be as extensive. If the volcano erupts again, it may create more ash plumes, and the crater may widen.

Image 2: Glacier Movement

1. United States; *Bonus*: College Fjord, Alaska
2. Harvard Glacier is growing into the fjord. The boundary line between the glacier and water is well defined and appears to have some accumulation. Yale Glacier is receding from the fjord. Vegetation appears to be growing in areas scraped by the glacier.
3. Harvard Glacier is producing the most icebergs.
4. The largest concentrations of vegetation are along the fjord walls.

Image 3: Fire

1. Mexico and Guatemala; *Bonus*: Gulf of Mexico
2. Roughly from south to north
3. The southern United States and Mexico would be affected directly. Depending on prevailing winds, countries south of the fires, such as Honduras and Nicaragua, could be affected, too.
4. A radar image of this region would reveal topographic features but no atmospheric phenomena, such as smoke. Radar also would not reveal hotspots on the ground; infrared instruments are required to seetemperature variations.

5. Distribute the Take Home Activity Sheet: Tracking Weather with Satellite Images. Encourage students to chart cloud coverage for the region of their choice for a week. When the worksheets are complete, you may wish to have students share some of their results with the class.

Adaptation for older students:

After analyzing the images, have older students continue working in groups to conduct research and develop an original satellite operations plan. Each group should first come to a consensus on the purpose of their satellite. Possibilities include but are not limited to urban growth assessment, pollution monitoring, flood detection, navigation, or telecommunications. After deciding on the goal of the satellite, each group should draft an orbital operations plan addressing the following: type of orbit (polar, equatorial, or geosynchronous), geographic coverage areas, mission duration, types of remote sensing instruments employed, and post-mission strategy (i.e., what to do with the satellite when its mission is complete). Instrument descriptions should include the range of radiation detected and/or transmitted. The plan should include provisions for ground tracking, data stations, and optional relay satellites. When the plans are complete, have each group present their ideas to the class.

Questions:

1. Describe the most important benefits of satellites and satellite imagery. Are images from space always helpful? What are the limitations of satellite images?

2. How do satellites collect data? How can some of these data be converted into useful images?

3. Explain the differences between satellite orbits. How does the orbit of a satellite affect what it can observe?

4. Satellites can operate for several years, but eventually the hardware will stop working. Should satellites that break down be repaired in orbit, brought back to Earth to be repaired or recycled, or abandoned? What potential hazards might be associated with each case?

5. In 1957, the Soviet Union launched Sputnik 1, the first artificial satellite. Its launch caused widespread fear that the Soviets would control space exploration and use their power to spy on the rest of the world. In truth, Sputnik sent only a feeble tracking signal. Today, spy satellites are used daily by the United States and other countries. What are the advantages and disadvantages of satellite surveillance?

6. Describe how a satellite image of 20 square miles around your home might look. How might it change over time?

Evaluation:

Use the following three-point rubric to evaluate students' work during this lesson. Students should be evaluated on how successfully they worked in groups, whether they were able to read the satellite images, and whether they were able to answer the questions successfully.

Three points: All questions answered thoroughly; group displayed cooperation and communicated effectively

Two points: Most questions answered; group was somewhat effective at cooperating and communicating with each other

One point: At most, half the questions were answered; group cooperation and communication was somewhat ineffective

Add a point for each correctly answered bonus question on the Classroom Activity Sheet. Answers are listed below:
Bonus question 1: Mt. Uzu, Japan
Bonus question 2: College Fjord, Alaska in Prince William Sound
Bonus question 3: Gulf of Mexico

Extensions:

Demonstrating String Orbits

Help students understand how the orbit of a satellite affects what it can observe by performing some or all of these simple demonstrations showing three kinds of satellite orbits—*geosynchronous*, *equatorial*, and *polar*.

> *Geosynchronous orbit*. Use a globe or basketball to represent Earth and some string or yarn to represent the ground path of an orbit. Select two volunteers: one to choose a location to view and a second to hold the globe and rotate it slowly eastward. In order to keep the location in constant view, the first volunteer will need to orbit the globe as it spins. Explain that satellites whose orbits keep them over the same ground position are in synch with Earth's rotation, so they are called geosychronous satellites. Ask the class how long such a satellite would take to orbit Earth (answer: 24 hours). Note: Geosychronous orbits are located about 22,000 miles above the ground, giving them a great view of large areas; because they remain over the same ground position, they provide 24-hour coverage.
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> *Equatorial orbit.* Ask volunteers to use yarn to demonstrate the ground path of a satellite orbiting over the equator. For each orbit, the yarn should encircle the globe once completely. Explain that some satellites in equatorial orbits only take 90 minutes to circle Earth. Ask the class how many times the yarn would wrap around the globe in one 24-hour rotation of the globe if the *orbital period* of the satellite was 90 minutes (answer: 24 hours at 1.5 hours = 16 times).
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> *Polar orbit.* To demonstrate the ground path of a polar orbit, volunteers should stretch the yarn from the top side at the north pole to the bottom side at the south pole. They should continue stretching the yarn underneath the globe and up the other side, returning to the north pole as the globe rotates. This may take some practice. To keep the yarn from slipping off, the volunteers may need to affix the yarn to the north pole with a piece of tape. As the volunteers continue through several globe spins, the class should begin to see that, over time, a satellite with a polar orbit will cover the entire Earth.

Radar Altimetry with a Shoebox

Satellite radar works by emitting a signal to the ground and measuring the time it takes to return to the satellite. The measurements allow scientists to calculate the altitude of surface features on the ground regardless of the amount of cloud cover. Have students work in groups to prepare a mini-landscape in a shoebox. They should distribute some sand, rocks, and dirt in the bottom of the shoebox and tape the lid on securely. When ready, groups should exchange boxes (carefully, without shifting the landscape), with instructions to take measurements of the landscape and produce a map of it without actually opening the box.

Using a ruler and pencil, each group should draw a pattern on the top of the box indicating where they will poke small holes to take measurements. These holes are called data points. The holes should be evenly spaced, and the pattern should include enough holes to get an accurate reading of the content of the box. A grid works well, but students may select any configuration they think will provide accurate readings. After the box top is marked, each hole should be carefully poked to allow only a thin dowel rod to pass through (long drinking straws can be used instead of dowels). To take a measurement, students should insert the dowel just until it meets resistance, being careful not to press down too hard. At that point, students should make a mark on the dowel, remove it from the box, and measure the length from the mark to the end of the dowel to get a distance reading from the box top to the landscape. Note: Taller features will yield shorter measurements, so this measurement will need to be subtracted from the total height of the box to reveal the actual height of the landscape.

Once all the measurements have been made, each group should produce a topographic map showing the data points and connecting points with the same measurements. This would allow the map to reveal surface features. Maps can be color-coded to bring out contrasting features in the landscape. After the maps are completed, each group should open their box lid and compare the map to the real thing. As a class, discuss sources of error and explain what adjustments could be made to increase the accuracy of the measurements.

Suggested Readings:

Satellites
Mary Virginia Fox.
Benchmark Books, 1996.
This book is a brief overview of the history of satellite technology. It contains an explanation of how satellites function and descriptions of the varieties of ways they can be used, from enhancing world-wide communication to mapping natural resource distribution.

America From Space
Thomas B. Allen. Firefly Books, 1998.
This book is primarily a series of spectacular computer-generated images of America obtained from satellite-sensing systems. Each image is accompanied by a caption that explains how the image has been computer-enhanced to reveal nature's secrets and human influence on the environment. In addition, the book provides a brief description of the types of remote sensing satellites in use today and how each one works.

Educator's Guide to Spotting Satellites
A classroom guide to satellites and their location.
http://learn.jpl.nasa.gov/spotsat.htm

How Satellites Work: Teacher Resources
Includes the following topics: What is a satellite? How does a satellite work? How does a satellite stay in orbit?
http://octopus.gma.org/surfing/satellites/index.html

Learning Without Touching (Remote Sensing)
A NASA -maintained web site that includes information about satellites.
http://observe.ivv.nasa.gov/nasa/exhibits/learning/learning_0.html

Remote Sensing Data and Information
An archive of satellite instruments, images, projects, and data.
http://rsd.gsfc.nasa.gov/rsd/RemoteSensing.html

WhaleNet's Satellite Tagging Observation Program
Students and educators work in conjunction with international research organizations, using advanced satellite technology and telecommunications to monitor and research the actual migration patterns and movements of selected species of whales and marine animals.
http://whale.wheelock.edu/whalenet-stuff/stop.html

Vocabulary:

equatorial
Definition: Being in the plane of the equator.
Context: Satellites in an equatorial orbit take only 90 minutes to move around Earth, considerably less time than the 24 hours taken by geosynchronous satellites.

geosychronous
Definition: An orbit requiring a velocity such that a satellite appears to stay in a fixed position with respect to Earth.
Context: The geosynchronous orbital period is 24 hours.

infrared
Definition: Radiation that has a lower energy than that of visible light and is just beyond the red portion of the spectrum.
Context: The SeaWiFS satellite measures infrared energy, which provides data on sea surface temperatures.

orbital period
Definition: The amount of time it takes a satellite to travel all the way around a planet.
Context: The orbital period of a satellite can be adjusted by changing the satellite's altitude. The lower the orbit, the faster it must travel to maintain its orbit.

polar orbit
Definition: Passing over a planet's north and south poles.
Context: A satellite with a polar orbit passing from the north pole to the south pole will, over time, cover the entire Earth.

remote sensing
Definition: The act of detecting objects from a distance.
Context: Satellites use remote sensing instruments to track levels of ozone in the upper atmosphere.

wavelength
Definition: The distance from any one point to the next point of a corresponding phase (crest-to-crest, for example) in a wave. In the spectrum, shorter wavelengths have the more energy than longer wavelengths.
Context: While most visible light passes easily through the atmosphere, most ultraviolet light has just the right wavelength to be absorbed by high-altitude ozone.

Academic Standards:

Grade level:
6-8
Subject area:
Earth and Space Science
Standard:
Understands basic features of Earth.
Benchmark:
Knows factors that can impact the Earth's climate (e.g., changes in the composition of the atmosphere; changes in ocean temperature; geological shifts such as meteor impacts, the advance or retreat of glaciers, or a series of volcanic eruptions).

Grade level:
6-8
Subject area:
Geography
Standard:
Knows the physical processes that shape patterns on Earth's surface.
Benchmark:
Knows the major processes that shape patterns in the physical environment (e.g., the erosion agents, such as water and ice, earthquakes and volcanic activity, the ocean circulation system).

Grade level:
6-8
Subject area:
Technology
Standard:
Understands the relationships among science, technology, society, and the individual.

Benchmark:
Knows that technology and science are reciprocal (e.g., technology drives science, as it provides the means to access outer space and remote locations, collect and treat samples, collect, measure, store, and compute data, and communicate information; science drives technology, as it provides principles for better instrumentation and techniques and the means to address questions that demand more sophisticated instruments).

Credit
Chuck Crabtree, former math and aerospace science teacher.

Name: ____________________

Analyzing Satellite Images

Use the information provided to answer the questions about each satellite image. You will need an atlas or globe to determine the location of features on the satellite images.
To answer some of the questions, you will need to use the Internet links provided to view the full color image.

Using the latitude and longitude and an atlas, name the country over which this image was taken.

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Bonus: Name the volcano:

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What is the largest feature in this image?

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What might the three dark streaks in the image be? What could have caused them?

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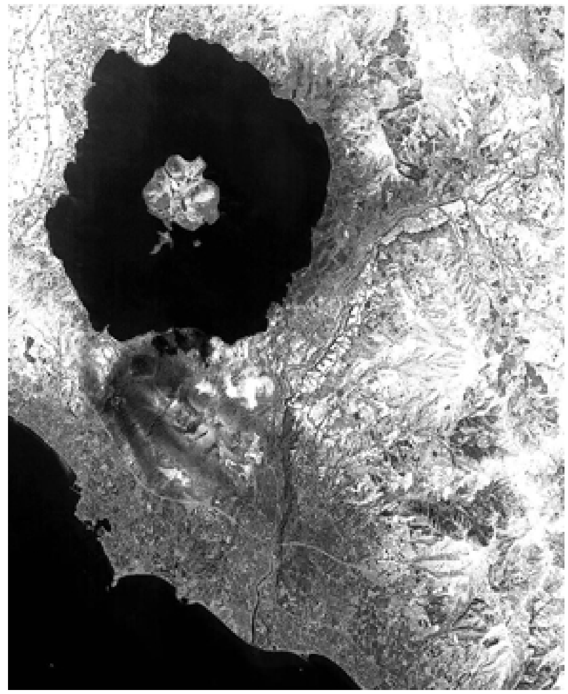

Image 1: Volcanic Eruption
Link: http://asterweb.jpl.nasa.gov/gallery/images/usu2.jpg
Date: April 3, 2000
Location: latitude 42.53° N, longitude 140.83° E
Instrument wavelength: Infrared
Image coverage: 18 km (13 miles) by 22 km (15 miles)
Satellite: TERRA (instrument: ASTER - Advanced Spaceborne Thermal Emission and Reflection Radiometer)
Orbit type: Polar
Credit: NASA/GSFC/MITI/ERSDAC/JAROS and U.S./Japan ASTER Science Team

How might this region look in a satellite image taken six months later?

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Continued

Name: ____________________

Analyzing Satellite Images

To answer some of the questions, you will need to use the Internet links provided to view the full color image.

Image 2: Glacier Movement
Link: http://asterweb.jpl.nasa.gov/gallery/images/college.jpg
Date: June 24, 2000
Location: latitude 61° 15' 25" N, longitude 147° 37' 12" W
Instrument wavelength: Infrared
Image coverage: 20 by 24 km (12 by 15 miles)
Satellite: TERRA (instrument: ASTER)
Orbit type: Polar
Credit: NASA/GSFC/MITI/ERSDAC/JAROS, and U.S./Japan ASTER Science Team

Using an atlas and the latitude and longitude readings, name the country over which this image was taken.

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Bonus: This image covers a portion of a fjord, a narrow inlet with steep cliffs. What is the name of the fjord?

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This image clearly shows two prominent glaciers. Harvard Glacier is the large glacier on the left and Yale is on the right. Snow and ice appear white and blue, and water appears dark because it reflects the least amount of infrared energy. Examine the areas where Harvard and Yale Glaciers touch the water. Which of these two glaciers appears to be shrinking and which one is growing into the fjord?

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Icebergs that have broken away from glaciers can be seen as white dots in the water. Which glacier appears to be producing the most icebergs?

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Where are the largest concentrations of vegetation (shown in red on screen)?

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Continued

Name: ____________________

Analyzing Satellite Images

To answer some of the questions, you will need to use the Internet links provided to view the full color image.

Using an atlas and the latitude and longitude readings, name the two countries over which this image was taken.

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Bonus: Name the body of water in the upper part of the image.

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What is the apparent wind direction? (The top of the image is north.)

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What areas of the world might be directly affected by the smoke from these fires?

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Image 3: Fires
Link: http://seawifs.gsfc.nasa.gov/SEAWIFS/IMAGES/SEAWIFS/S1998156182955.L1A_HNAV.MexicanFires.jpg
Date: June 5, 1998
Location: latitude ~18° to 20° N, longitude ~90° to 100° W
Instrument wavelength: Infrared. *Note:* the true-color effect of this image is accomplished by combining several gray-scale infrared images and converting certain wavelength ranges to red, green, or blue.
Satellite: SeaWiFS
Orbit type: Polar
Credit: Provided by the SeaWiFS Project, NASA/Goddard Space Flight Center, and ORBIMAGE

How might this image be different if it had used radar imagery rather than infrared technology? Would the smoke and fires still be visible?

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Take-Home Activity Sheet: **Reading Satellite Images** Name: ____________________

Tracking Weather Satellite Images

Use this sheet to track major weather conditions for five days using satellite images from television and newspaper reports or online at http://weather.com. Each of the five boxes below will represent a snapshot of weather for that day. By charting the weather over several days, you will be able to identify major patterns and possibly forecast weather events before they happen.

1. Choose a region (such as the southeastern United States). Trace a map of this region in each of the five boxes.
2. Each day for a week, find a weather satellite image of this region. (Each image should have been taken at roughly the same time of day.)
3. On your map of the region for that day, draw cloud patterns you've been able to detect from the satellite images. If directions of movement can be determined, draw indicative arrows.
4. At the end of the week, look at your five maps. Do any patterns emerge? Write a paragraph describing how cloud cover patterns change from day to day.

Monday	**Tuesday**	**Wednesday**
Thursday	**Friday**	**Additional Observations**