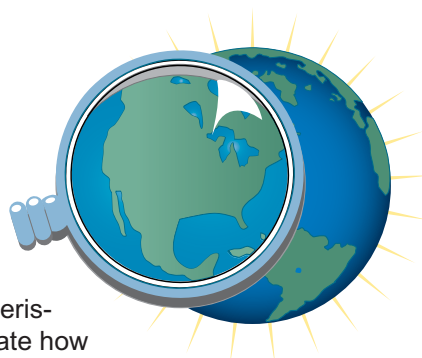




What can satellites tell us about Earth?



Investigation Overview

Students learn to identify basic characteristics of satellite images. They demonstrate how satellite signals are connected to images and explore the ways in which different scientists use such images.

Time required: Two 45-minute sessions

Materials/Resources

Crayons

- Log 1: Morro Bay, California: Which is the satellite image? (transparency)
- Log 2: What is this satellite doing? (transparency)
- Log 3: How do satellites work? (transparency and one copy for each student)
- Log 4: How are satellite images like puzzles? (one copy for each pair of students)
- Log 5: Who uses satellite images and for what purpose? (one copy for each group of four students)
- Log 6: How do satellite images help predict hurricanes? (transparency)
- Log 7: How do images of flooding help us learn about Earth? (transparency)
- Log 8: How do images of volcanoes help us study Earth? (transparency)

Content Preview

Remote sensing is the science of observing, identifying, and measuring objects and regions without direct contact. An aerial photo and a remotely sensed satellite image are two perspectives “from above.” Sensors are mounted on satellites that orbit Earth. Sensor signals are processed to produce a satellite image. Views of large areas are produced by overlapping remotely sensed images, a technique known as mosaicing (making a mosaic). A pixel is the smallest unit in an aerial photo or remotely sensed image, and refers to the area on the ground from which the satellite acquires a single measurement. A remotely sensed digital image is made up of millions of pixels. Many types of scientists use remote sensing and satellite images in their research.

Classroom Procedures

Beginning the Investigation

1. Show the students a transparency of **Log 1**. Explain that both show Morro Bay, California. Discuss the differences between the two and have them answer the Log questions. Guide the students to discover the difference in scale.

Geography Standards

Standard 1: The World in Spatial Terms

How to use maps and other geographic representations, tools, and technologies to acquire, process, and report information from a spatial perspective

- Identify and describe the characteristics and purposes of geographic representations, tools, and technologies.

Geography Skills

Skill Set 4: Analyzing Geographic Information

- Use texts, photographs, and documents to observe and interpret geographic trends and relationships.

- The satellite image (**Figure 2**) shows a much larger area since the satellite was at a higher altitude than the airplane from which the photo was taken. The satellite was directly overhead (oblique view), while the airplane view was at an angle (though cameras mounted on airplanes can also take photographs from directly overhead).
 - The satellite image appears to be made of small squares. These are called pixels. Tell the students that they will soon learn why this is so.
 - Explain that during this investigation students will learn how a satellite creates images, and how these satellite images are used to study Earth.
2. On the board write “remote sensing” and ask students if anyone has heard of this term. Ask one student to read a few sentences from a book. Tell the class that this student is using remote sensing. Ask how can this be? Explain that this student is gathering information about something from a distance and that this is a form of remote sensing. Explain that the brain gathers information from a book by analyzing and interpreting reflected light. Explain that remote sensing is a way of gathering information without touching the source of the information, from as close as a book or from as far away as a satellite in orbit.

Developing the Investigation

3. Ask students what they know about satellites. Explain that a satellite is a small body, natural or artificial, that revolves around a larger astronomical object. The Moon is Earth’s natural satellite. There are many kinds of artificial satellites that serve different purposes. Some help communication by transmitting signals from telephones and computers. NASA’s satellites carry sensors that observe Earth to better understand the environment. These satellite sensors gather information about weather, landforms, oceans, vegetation, land use, and other things. The information is transmitted to computers on Earth. Information gathered by satellites is displayed as pictures or “images.”
4. If an Internet connection is available, show the class the animation of how one satellite scans Earth. <http://earthobservatory.nasa.gov/Library/AM1/anim/am_godview.mov> or <http://earthobservatory.nasa.gov/Library/AM1/anim/swath_modis.mov> Have students note that as Earth rotates, the satellite observes a new swath of Earth surface.
5. How do satellites send images from space? Tell students that they are going to draw a picture to simulate how satellites send images from space to computers. Give each student a copy of **Log 3** and display a transparency of **Log 3**.

Tell students that you are the “sender” in the satellite and each of them is a “receiver” in a computer at a ground station that communicates with the satellite. They will draw a picture by interpreting the signals you send them. This is remote sensing!

Tell the students that the squares on the Log are called pixels. Each pixel must be completely filled in with their pencils or left completely empty. Tell them that when you say “0,” the pixel is to be left empty and when you say “1” the pixel is to be completely filled in. Read the “digital code” to the receivers, the students. Fill in the first few pixels on the transparency to help them get started.

1A - 1	1B - 0	1C - 0	1D - 0	1E - 0	1F - 0	1G - 0	1H - 1
2A - 0	2B - 1	2C - 0	2D - 0	2E - 0	2F - 0	2G - 1	2H - 0
3A - 0	3B - 0	3C - 1	3D - 0	3E - 0	3F - 1	3G - 0	3H - 0
4A - 0	4B - 0	4C - 1	4D - 0	4E - 0	4F - 1	4G - 0	4H - 0
5A - 0	5B - 0	5C - 0	5D - 1	5E - 1	5F - 0	5G - 0	5H - 0
6A - 0	6B - 0	6C - 0	6D - 1	6E - 1	6F - 0	6G - 0	6H - 0
7A - 0	7B - 0	7C - 0	7D - 1	7E - 1	7F - 0	7G - 0	7H - 0
8A - 0	8B - 0	8C - 0	8D - 1	8E - 1	8F - 0	8G - 0	8H - 0

6. Color the pixels according to the directions. Share the finished products. The pictures should all look the same. Help students figure out that they have made an image of part of a river, where two tributaries meet. It may be difficult for them to interpret the image because the pixels distort the paths of the rivers but this distortion is an important concept. Explain that pixels can be smaller or larger and speculate with the class whether their images would look more like actual river paths if the pixels were much smaller. (*Yes, the smaller the pixels the more realistic the image.*)
7. **Putting the pieces together.** Tell students that computers create very many small images that must be put together into larger images. To make sure there are no gaps, each image shows part of the previous image. Explain that only by overlapping the images can we get a clear picture of a

larger area. This larger image is called a mosaic. Ask students if they know another meaning for the word mosaic and lead them to discover that the connotation of small pieces fitting together makes this an appropriate term for these pieced-together satellite images.

8. Divide the students into pairs and give each pair a copy of **Log 4**. Ask them if they can identify one part of each image that also appears in the other image. (*The bottom of the first image and the top of the second image.*) Tell students to cut out each of the boxes and overlap them to make a mosaic. Point out that these images are composed of very small squares (pixels).

Concluding the Investigation

9. Who uses satellite images and how do they use them? Divide students into groups of four and ask them to make a list of ways that satellite images can be used to study Earth. Next, give each group **Log 5**. Tell students to cut out the boxes, read and discuss the information, and paste the box in the bubble that matches the drawing. Discuss the answers with students. Geographers do all of these tasks.
10. Now show students each of the transparencies listed below, one at a time.
 - Log 6:** How do satellite images help predict hurricanes?
 - Log 7:** How do images of flooding help us learn about Earth?
 - Log 8:** How do images of volcanoes help us study Earth?

Discuss each transparency using the following questions:

- Describe what you see in the image.
- Who might use an image like this one and how could it be used? Identify the person in **Log 5** who would use each image.

Background

Remote sensing involves the detection and measurement of radiation of different wavelengths reflected or emitted from distant objects or materials. The difference in reflection allows objects to be identified and categorized by class, type, substance, and spatial distribution. A pixel represents an area on an image that is a measure of the sensor's ability to see objects of different sizes. For example, for a sensor with a resolution of 15 meters, each pixel represents an area of 15 meters by 15 meters. Satellites are particularly effective remote sensors because they can cover the entire globe every few days. Scientists use computers to analyze the information gathered by satellites for

many purposes, including to make predictions. Satellites orbit Earth, many greater than 480 kilometers above the ground. Such orbits allow satellites to observe all of Earth's features: land, plant life, oceans, lakes, rivers, clouds, and polar ice.

Evaluation/Key

*Log 1: Morro Bay, California

Which one is a satellite image?

1 is an aerial photograph of Morro Bay, California

2 is a satellite image of Morro Bay, California

How can you tell?

1. The satellite image shows a vertical view from a greater distance.
2. You can see the pixels in the image.

*Log 3: How do satellites work? (River)

1	0	0	0	0	0	0	1
0	1	0	0	0	0	1	0
0	0	1	0	0	1	0	0
0	0	1	0	0	1	0	0
0	0	0	1	1	0	0	0
0	0	0	1	1	0	0	0
0	0	0	1	1	0	0	0
0	0	0	1	1	0	0	0

*Log 4: How are satellite images like puzzles?



***Log 5: Who uses satellite images and for what purpose?**

- | | |
|------------------|------------------|
| A. hydrologist | D. volcanologist |
| B. meteorologist | E. planetologist |
| C. oceanographer | F. glaciologist |

***Log 6: How do satellite images help predict hurricanes?**

- Describe what you see in the image. (*South-eastern part of the United States and hurricane clouds.*)
- Who might use an image like this one and how would it be helpful? (*Meteorologists; help forecast hurricanes and give people advance notice so they can prepare for them. Satellite images over time show direction and speed of the hurricane.*)

***Log 7: How do images of flooding help us learn about Earth?**

- Describe what you see in the image. (*Flooding of the Missouri River. Locate the Missouri on a map.*)
- Who might use an image like this one and how would it be helpful? (*Meteorologists; warn people of storms and resulting flooding. Hydrologists; study changes in the river and what happens to vegetation, animals, and fish who inhabit the river during floods.*)

***Log 8: How do images of volcanoes help us study Earth?**

- Describe what you see in the image. (*Mount St. Helens, other volcanoes, craters, vegetation.*)
- Who might use an image like this one and how would it be helpful? (*Volcanologists; see changes to a region over time and to study changes in climate as a result of it.*)

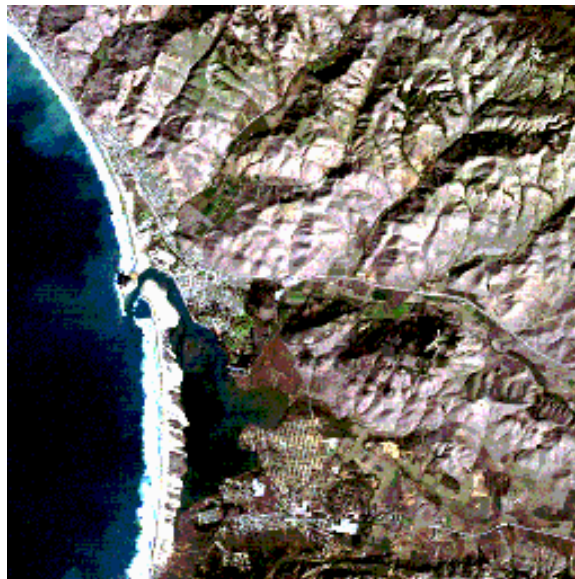
References

"Echo the Bat." Lesson 4—How do satellites work?
<<http://imagers.gsfc.nasa.gov/color/>>



Module 1, Investigation 3: Log 1

Morro Bay, California: Which is the satellite image?



Number _____ is a satellite image.

How can you tell? Give two reasons.

1) _____

2) _____



Module 1, Investigation 3: Log 2

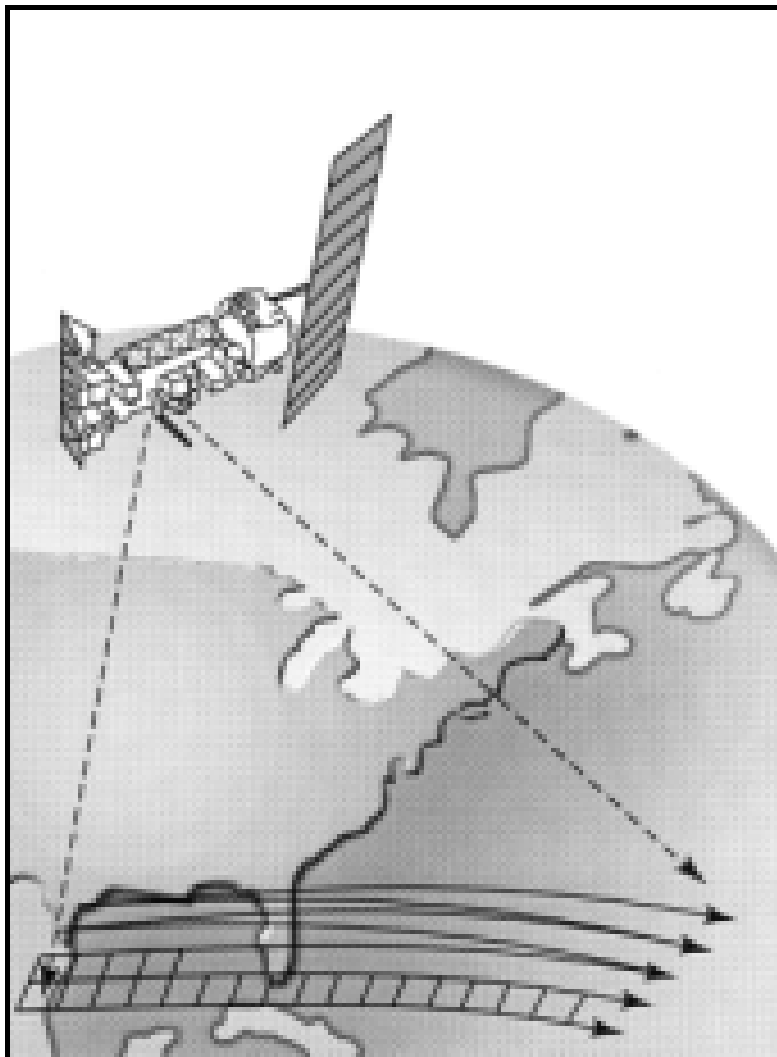
What is this satellite doing?

Satellites orbit Earth while Earth rotates. The sensors on the satellite observe and collect information from a strip or swath of Earth's surface.

Color the first swath red and label it 1.

Color the second swath green and label it 2.

Continue for the next two orbits.





Module 1, Investigation 3: Log 3

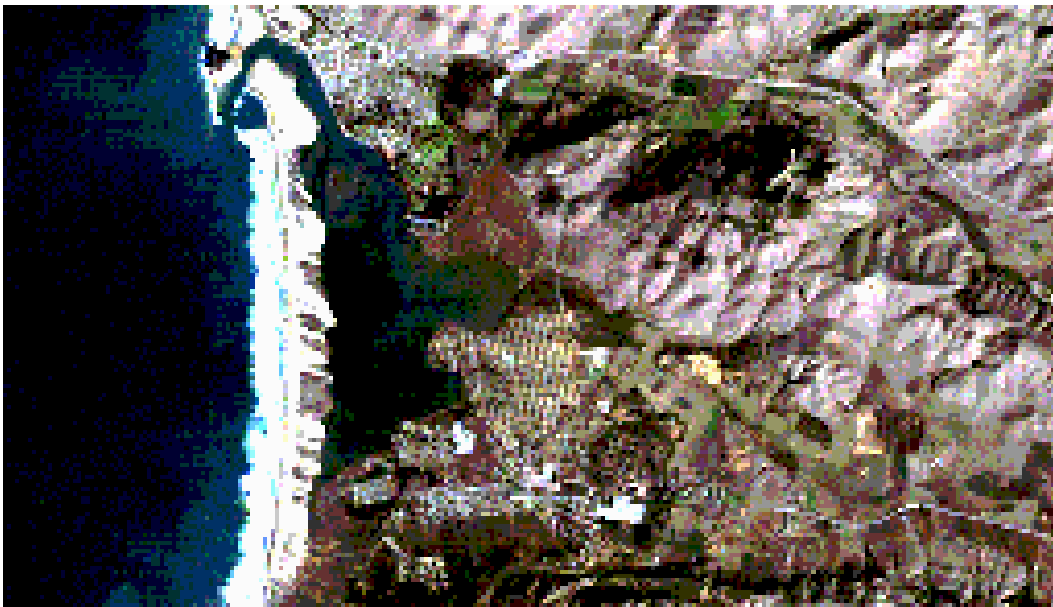
How do satellites work?

	A	B	C	D	E	F	G	H
1								
2								
3								
4								
5								
6								
7								
8								



Module 1, Investigation 3: Log 4

How are satellite images like puzzles?





Module 1, Investigation 3: Log 5

Who uses satellite images and for what purpose?

Name _____ Date _____

A



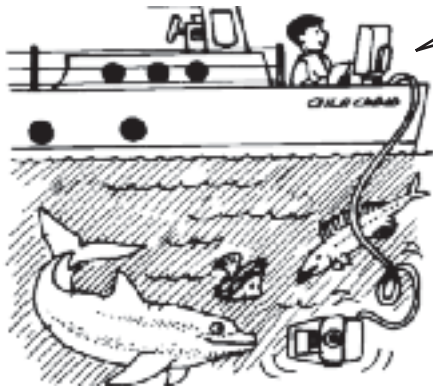
B





Module 1, Investigation 3: Log 5

Who uses satellite images and for what purpose?



C



D



Module 1, Investigation 3: Log 5

Who uses satellite images and for what purpose?

E



F





Module 1, Investigation 3: Log 5

Who uses satellite images and for what purpose?

Directions: Cut out the boxes, read and discuss the information in each box, and paste the box in the bubble that matches the drawing.

Volcanologist: I study volcanoes. I use satellite images to find out where winds carry volcanic ash.

Oceanographer: I study oceans and how they change. I make observations from ships, airplanes, and satellites and use images to measure changes in shorelines and ocean currents.

Meteorologist: I predict the weather by gathering information about the atmosphere from satellite images and ground measurements. You can see meteorologists on television news programs.

Hydrologist: I study water. I study where water goes, what elements it contains, and whether its chemistry has changed. I use satellite images to measure flooding.

Glaciologist: I study glaciers in the Arctic and Antarctic as well as those formed in the tallest mountains. I study temperatures, snow accumulation, and deep ice cores to understand what is happening to the glaciers. I can use satellite images to determine how fast glaciers move.

Planetologist: I study planets other than Earth. When I study planets like Mars, which has very little water compared to Earth, I can learn more about what could happen to our planet if it becomes drier. The only way I can study Mars is by observing the planet with large telescopes and using satellite images. The satellites we have sent to orbit around Mars send us detailed information about the planet.



Module 1, Investigation 3: Log 6

How do satellite images help predict hurricanes?

Predicting Hurricane Intensity Far from Land



Source: <http://svs.gsfc.nasa.gov/imagewall/hurricanes/bonnieir.jpg>

Which of the people in Log 5 would use this image? _____



Module 1, Investigation 3: Log 7

How do images of flooding help us learn about Earth?

Flooding in the Missouri River



Source: http://svs.gsfc.nasa.gov/imagewall/LandSat/missouri_flood.html

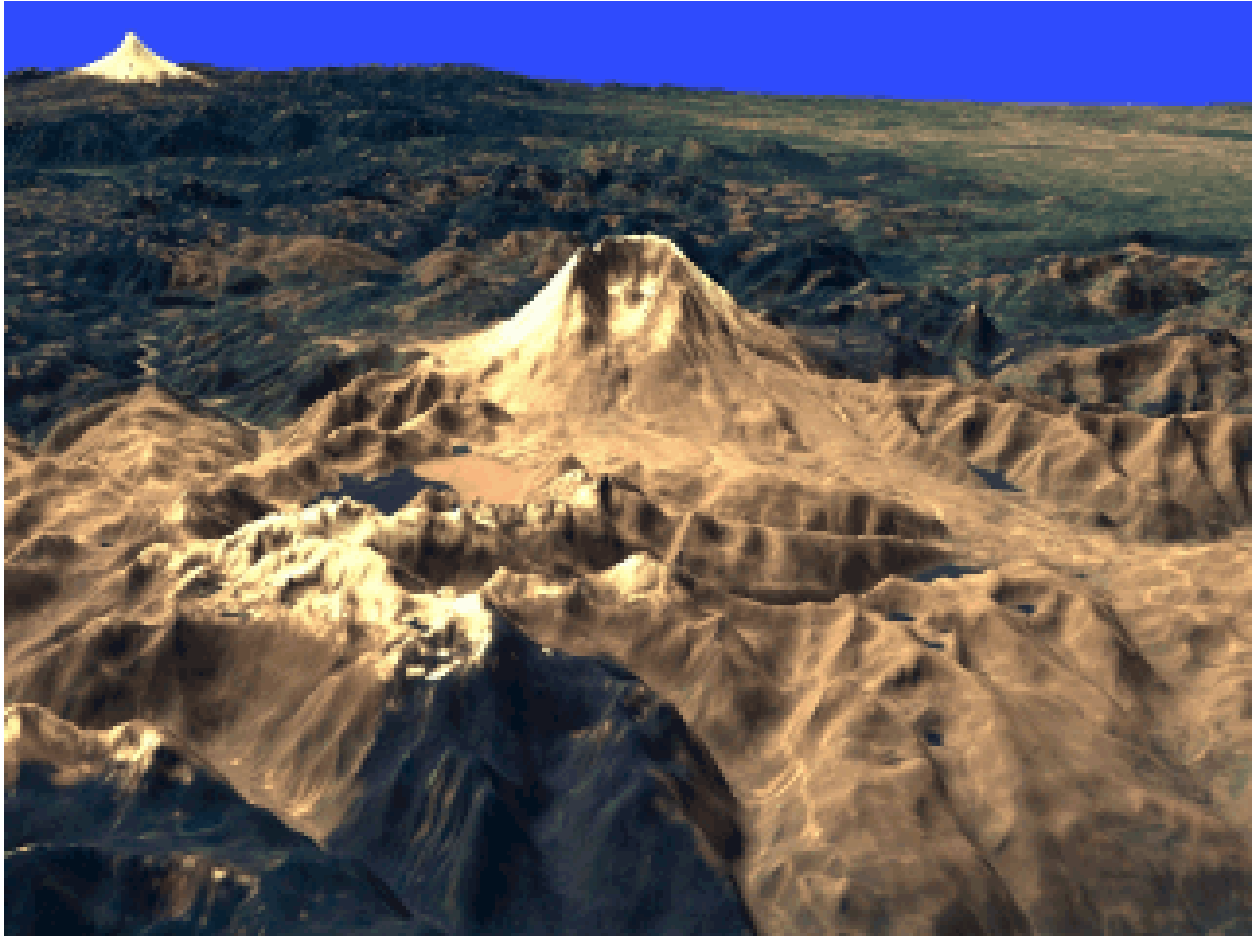
Which of the people in Log 5 would use this image? _____



Module 1, Investigation 3: Log 8

How do images of volcanoes help us study Earth?

Mt. St. Helens



Source: http://svs.gsfc.nasa.gov/imagewall/LandSat/mt_st_helens.html

Which of the people in Log 5 would use this image? _____