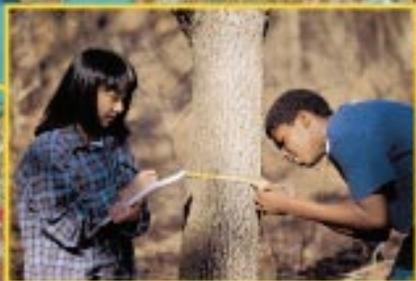


# Reflections on Earth

## *Exploring Planet Earth from Space*



Smithsonian

*"Reflections on Earth: Exploring Planet Earth from Space"*  
program is made possible by support from Honda.

# *Reflections on Earth: Exploring Planet Earth from Space*

*Reflections on Earth* supports the nation's teachers and students in using space technology as a tool to study Earth and the environment.

*Reflections on Earth* combines environmental studies, scientific research, and remote sensing technology to develop a better understanding of the natural processes found on Earth.

*Reflections on Earth* brings current research to teachers and students across the country by providing instructional materials and teacher workshops.

## **INSTRUCTIONAL MATERIALS**

### **Reflections on Earth Teaching Poster**

In this introduction to remote sensing, students use satellite images to investigate changes over time and then use scale to calculate distance and area.

### **Reflections on Earth: Biodiversity and Remote Sensing Teacher's Guide**

With lessons for the classroom and field studies, students learn to measure and monitor forest biodiversity on a local, regional, and global scale.

### **Reflections on Earth: Earth Science and Remote Sensing Teacher's Guide**

With lessons that apply current research techniques, students learn to interpret images and data to monitor Earth processes.



Smithsonian  
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## **TEACHER WORKSHOPS**

- ★ Week-long workshops are offered during the summer for middle and high school teachers.
- ★ Travel expenses, housing and meals are provided.
- ★ Participants are chosen by an application process.
- ★ Workshop topics are offered alternate years.

### **Forest Biodiversity and Remote Sensing (Beginning Summer 1999)**

Work with Smithsonian scientists to learn how to establish and monitor a forest biodiversity plot using protocols developed for the Smithsonian Biodiversity Monitoring Program. Use remote sensing data and images to analyze regional and global trends. Work with educators to adapt research techniques for your classroom.

### **Earth Science and Remote Sensing (Beginning Summer 2000)**

Work with Smithsonian scientists to learn research techniques used to monitor large-scale environmental processes. Use remote sensing data and images to study Earth's surface and analyze changes over time. Work with educators to adapt research techniques for your classroom.

*Reflections on Earth: Exploring Planet Earth from Space* program is a collaborative effort of the educators and researchers at the Smithsonian Institution. The Center for Earth and Planetary Studies and Educational Services at the National Air and Space Museum are working with the National Zoological Park's Conservation and Research Center and the Smithsonian Institution's Monitoring and Assessment of Biodiversity Program.

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# Introduction to Remote Sensing

## OVERVIEW

Students examine and describe a satellite image of Earth. By observing a magnified part of this image, they contrast the appearance of surface features shown at different scales. Then they calculate distances and estimate an area from the scale of the magnified images. They discuss how images made at different times show change on Earth's surface.

## EDUCATION STANDARDS ADDRESSED IN THIS ACTIVITY

### National Science Education Standards

#### *Unifying Concepts and Processes*

- ★ Systems, Order, and Organization
- ★ Evidence, Models, and Explanation
- ★ Constancy, Change, and Measurement

#### *Abilities Necessary to Do Scientific Inquiry*

- ★ Conduct Scientific Investigations

#### *Understandings about Scientific Inquiry*

- ★ Scientists rely on technology to enhance the gathering and manipulation of data

### National Council for Geography Education Standards

#### *The World in Spatial Terms*

- ★ Maps and other geographic tools for information in a spatial perspective

#### *Environment and Society*

- ★ Human actions modify physical environment

#### *Skills*

- ★ Acquiring geographic information
- ★ Analyzing geographic information

## OBJECTIVES

- ★ Describe a false-color image of Earth
- ★ Contrast images at different scales
- ★ Calculate distances from the scale of an image
- ★ Describe how scientists use satellite images to investigate changes on Earth

**Grade Level:** 7 through 12

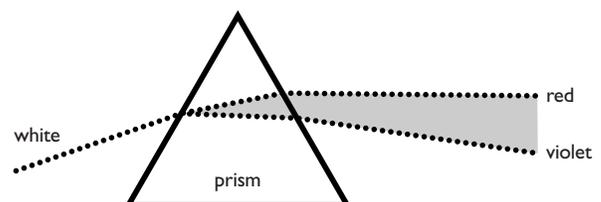
**Time Required:** a 55-minute class period

## BACKGROUND INFORMATION

Standing on the ground, a scientist can observe the landscape and create a map that shows the characteristics of that particular place. But many scientists ask questions that require observation of very large regions or of the whole planet. How has the total amount of plant material changed over time? How have deserts changed? How has urbanization changed nearby waterways? To find the answers, scientists often study satellite images taken in orbit and then transmitted to Earth, a process called *remote sensing*.

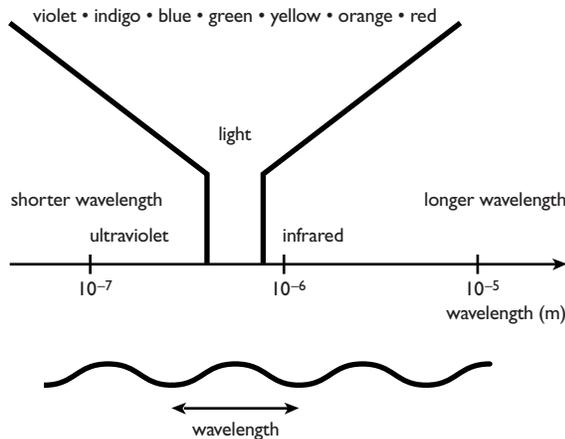
We see Earth in reflected sunlight. Light is electromagnetic waves, and the different wavelengths of light correspond to the different colors that our eyes and brain create through vision. The colors in sunlight appear when a prism spreads out the light (see Fig. 1) or when water droplets in air make a rainbow. In addition to visible light, the Sun also gives off

**FIGURE 1**



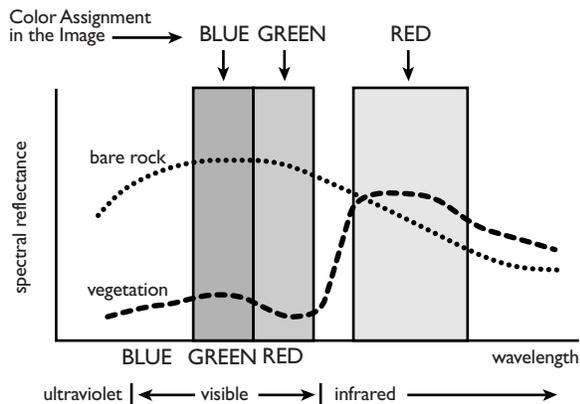
considerable energy as ultraviolet light and infrared light, and Figure 2 shows this part of the electromagnetic spectrum.

**FIGURE 2**



Earth’s atmosphere absorbs most of the ultraviolet energy, but the infrared energy reaches the surface and reflects back toward space, along with much of the visible light. The amount of energy reflected depends on the wavelength of the radiation: Red light has a longer wavelength than blue light, and infrared radiation has a longer wavelength than red light (see Fig. 2). The amount reflected at different wavelengths—in scientific terms, the *spectral reflectance*—provides a wealth of information about Earth’s surface, including geology, hydrology, urbanization, and vegetation. A spectral reflectance measured by the Landsat satellite is shown schematically in Figure 3. Note the difference in reflectance between vegetation and rock. Moreover, the way vegetation reflects infrared energy depends on the size of

**FIGURE 3**



the plant cells and the thickness of the cell walls, so that the reflected radiation provides a “signature” for the type of vegetation present.

To highlight different features of Earth, scientists combine images made in several broad wavelength bands (see Fig. 3). To create the composite image, colors are assigned to each wavelength band (see Table 1 and Fig. 3), and the result is called *false-color*.

The more radiation reflected, the brighter the corresponding color in the image, and these colors are combined by addition, as in a computer monitor or color TV, to produce the image.

A satellite image is composed of square units called *pixels*. The brightness of each pixel is specified by a number between 0 and 255, and these numbers are transmitted by radio to an Earth station, so that the image can be reassembled and studied. To see individual pixels, look at Figure 4, which shows a magnification of a Landsat image of Washington Dulles International Airport.

**TABLE 1**

**False-Color Assignment**

<b>Reflected radiation</b>	<b>Color shown on image</b>
Near infrared	Red
What we see as red	Green
What we see as green	Blue

The pixel size (30 meters square for Landsat images) limits the fineness of the detail, which is called the *resolution*. For instance, surface features smaller than 30 m square would fit within a single pixel and could not be observed. The smaller the pixel size, the finer the detail that can be seen, and the higher the resolution.

Suppose a scientist hypothesizes that a shade of red in an image indicates the presence of a certain type of vegetation on the ground. To test this idea, the scientist selects an area that has been imaged in this shade of red and then visits the area to observe the vegetation directly. This process, called *ground-truthing*, is an essential part of remote sensing. If ground-truthing proves the correspondence correct in a few areas, the scientist can apply it to identify different types of surface features in other areas as well.

**FIGURE 4**



### VOCABULARY

- ★ image
- ★ infrared
- ★ light
- ★ radiation
- ★ scale
- ★ visible
- ★ wavelength

### MATERIALS

#### For each group:

- ★ copies of blackline masters:
  - Dulles Airport and Mount St. Helens
- ★ magnifier
- ★ metric ruler
- ★ calculator (optional)

#### For the class:

- ★ poster
- ★ map of United States

### PREPARATION

Set up the poster where the whole class can see it. Consider having small groups of students view the poster with the help of magnifiers before beginning the activity. Make a copy of each blackline master for every student.

### PROCEDURE

1. Ask students to imagine they have taken a photograph of Earth from a spaceship. What might they learn about Earth from that image? (For instance, they could learn about weather, vegetation, mountain ranges, and bodies of water.)
2. Show the students the poster. Show them a map of the United States and identify the area shown in the poster image (Maryland and Virginia, near the Chesapeake Bay, Washington, D.C., and Baltimore). Sketch on the board the map shown in “Background Information,” or copy this map onto acetate to make an overhead transparency. Ask students to look closely at the poster, with both the naked eye and a magnifier, and record their observations. Have them discuss what they see.
3. Ask if the poster shows the true colors of Earth’s surface. (No. On Earth, land is mostly green, brown, and gray; water is blue or brown.) Explain that the colors were selected by scientists to show how different parts of Earth’s surface reflect radiation with different wavelengths. Explain as much about visible and infrared radiation, and as much about the false-color process, as your students can understand. (See “Background Information.”)
4. Ask students how they could find out what each color indicates. (On the ground, investigate a small area and relate the observations to how the same area is shown in the poster image.) Explain that this process is called ground-truthing.
5. Hand out to every student one copy of the blackline master for Dulles Airport. Point out the airport near the left edge of the poster, just to the west of Washington, D.C. Explain that the solid white areas on the image are probably buildings or streets. Discuss each question, have each student write the answers, and then discuss them with the

class. The answers are provided below. Notice that the answer to Question 2 is given to only two significant figures (2.9 km instead of 2.94 km). Because of the uncertainty in locating each end of the runway, it is difficult to measure the length to even the nearest millimeter. Reporting the result as 2.94 km would imply an accuracy that is much too great.

- Hand out to every student one copy of the blackline master for Mount St. Helens. Point to the state of Washington on a U.S. map to show the vicinity of this mountain. Explain that in the image on the left (the white area toward the lower left of the image) is the snow cover on the mountain; in the image on the right, the white area is ash from the eruption of the volcano. In fact, the gray area to the northwest of the mountain is also ash. If you have a copy of *Looking at Earth*, pass it around so your students can see these images in color on pages 168 and 169. As before, discuss each question, have each student write the answers, and then discuss their answers. Encourage the students to approximate the large white area to the northeast of the volcano by a rectangle, convert the sides to kilometers, and then find the area by multiplying the length times the width.

## ABOUT THE POSTER

- ★ **Satellite:** Landsat 5 Thematic Mapper, launched in 1985
- ★ **Orbit:** near-polar, with altitude of 700 km
- ★ **Pixel size:** 30 m x 30 m
- ★ **Scale:** 1 cm = 1.9 km
- ★ **Wavelength bands:** two in the visible, one in the near infrared
- ★ **Date of image:** November 1997

*The entire poster image was created on a single pass of the satellite.*

### ★ Interpreting Colors:

*Urban areas:* shades of light blue

*Forests:* shades of dark green and brown

*Grassland and cultivated land:* shades of pink to light green

*Water:* dark blue and black, with light tones in water indicating sediment

Figure 5 shows a map of the poster area.

**FIGURE 5**



*Map of the Middle Atlantic Coastal States with the Poster Area in a Box.*

## REFLECTION AND DISCUSSION

When students are finished with the blackline masters, ask what other changes could be investigated with satellite images (for instance, the decrease in the size of the rain forests, the change in the size of deserts, the appearance of new volcanic islands, or the growth of a city). Also, ask over what times these changes could occur (days for a volcano, years or decades for rain forests, deserts, or cities).

### Answers to Questions on the Blackline Masters

#### *Dulles International Airport*

1. The image on the sheet shows far more detail, such as the diagonal stripes on the runways.
2. The length of the shortest runway, which runs approximately northwest to southeast, is about 2.1 cm on the image. Since each centimeter represents 1.4 km, the length of the actual runway is  $2.1 \text{ cm} \times 1.4 \text{ km/cm} = 2.9 \text{ km}$ .
3. In the image taken in 1997, five years after the earlier image, there are more white areas around the airport, and the middle of the airport, between the two north-south runways, has filled in with white as well.
4. Buildings and parking lots have replaced grass and trees.

#### *Mount St. Helens*

1. Most of the landscape was covered with ash.
2. The ash-covered area is about 3.5 cm across on the image. Since  $1 \text{ cm} = 4.8 \text{ km}$ , the actual distance across is  $3.5 \text{ cm} \times 4.8 \text{ km/cm} = 17 \text{ km}$ .
3. The area is about  $17 \text{ km} \times 17 \text{ km}$  or  $290 \text{ km}^2$ .

## CURRICULUM CONNECTIONS

- ★ Mathematics: measuring distance; changing scale
- ★ Language Arts: creative writing; descriptive writing

## EXTENSIONS

1. Ask students to write a key that describes the appearance on the poster image of different features, such as urban areas, water, mountains, and cultivated fields.
2. Have students imagine that they could zoom in on an image of a new volcano near a town. Have the students make up a story based on what they saw.
3. Discuss with the students the difference in scale on the poster and the blackline master images.

## RESOURCES FOR TEACHERS

### Books

Engle, F., and Strain, P. *Looking at Earth* (Atlanta, Turner Publishing, Inc., 1992).

English, A., and Jones, T. *Mission: Earth: Voyage to the Home Planet* (New York, Scholastic Press, 1996).

### Web Sites

For information about Washington Dulles International Airport, see <http://www.metwashairports.com/Dulles/history.html>

For various definitions of remote sensing, see <http://www.itc.nl/~bakker/rsdef.html>

For an overview of how satellite images are made, see <http://www.geo.mtu.edu/rs>

For more information about Mount St. Helens, see <http://volcano.und.nodak.edu/vwdocs/msh/msh.html>

To see images of change in the Washington, D.C. area, see [www.nasm.edu/ceps/research/wash/washdc.html](http://www.nasm.edu/ceps/research/wash/washdc.html)

# *Washington Dulles International Airport 1982 and 1997*

↑  
N



1982

↑  
N



1997

1. How is the image of the airport on this sheet different from the image of the airport on the poster?
2. The scale of these images of Dulles Airport is 1 cm = 1.4 km. What is the length, in kilometers, of the shortest runway at Dulles?
3. Look at the area around the airport in both images on this sheet. How is this area different in the two images?
4. What do these two images tell you about the way the use of land has changed?

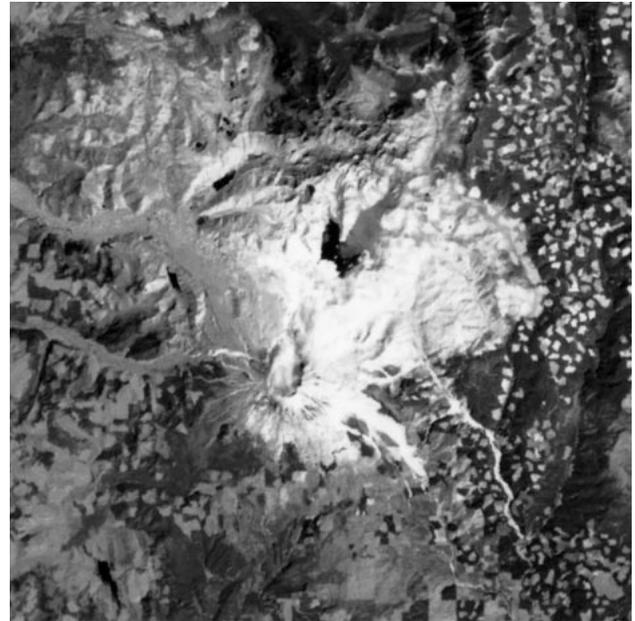
# *Mount St. Helens, Before and After the Eruption in 1980*

↑  
N



**BEFORE THE 1980 ERUPTION**

↑  
N



**SHORTLY AFTER THE 1980 ERUPTION**

The white area in the image on the left shows the part of Mount St. Helens that is covered by snow. The white area in the image on the right shows the part of the landscape that is covered by ash from the explosion of the volcano.

1. How did the landscape near Mount St. Helens change when the volcano exploded?
2. The scale of these images is  $1 \text{ cm} = 4.8 \text{ km}$ . About how far across, in kilometers, was the area covered by ash?
3. About what area, in square kilometers, was covered by ash? Show how you found your answer.

# Request Form

## PLEASE SEND ME

- Reflections on Earth* Teaching Poster
- Reflections on Earth: Biodiversity and Remote Sensing*  
(available Fall 1999)
- Reflections on Earth: Earth Science and Remote Sensing*  
(available Fall 2000)
- Teacher workshop application

NAME

ADDRESS

CITY

STATE

ZIP

( )

E-MAIL

PHONE

GRADE(S)

SUBJECTS(S) TAUGHT

SCHOOL DISTRICT

## MAIL OR FAX THIS FORM TO

Reflections on Earth  
Smithsonian National Air and Space Museum  
Washington, DC 20560-0305  
Fax number: (202) 633-8928

*Application and instructional materials are available from our web site at <http://www.nasm.edu/ceps/reflect>*

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