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## **My NASA Data - Lesson Plans**

### **Mount Saint Helens Volcano**



*This photograph shows an eruption of Mount St. Helens in Washington in July 1980. This eruption sent ash 6 to 11 miles (10-18 kilometers) into the air, and was visible in Seattle, Washington, 100 miles (160 kilometers) to the north. Credit: Mike Doukas, USGS*

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## Overview

This investigation provides an overview of the local effects of volcanism. Students categorize causes, effects, and responses to volcanic hazards by focusing on the interdependence of all Earth systems. Using various remotely-sensed images, students observe the visible effects of the eruption of Mount St. Helens in 1980 over time. Based on these observations, students identify a buffer zone to designate safer locations for development.

This lesson has been adapted from the NASA Mission Geography module; *most of the content is the same.*

[“How Close Is Safe: Buffer Zone Development.”](#) *Mission Geography*, Mission Geography/NASA.

## Learning Objectives

- Categorize the impacts of volcanism on the different spheres of the Earth system
- Suggest ways humans can prepare for and adapt to volcanoes of Earth’s physical system

## Essential Questions

Where should a buffer zone be established around Mount St. Helens?

## Materials Required

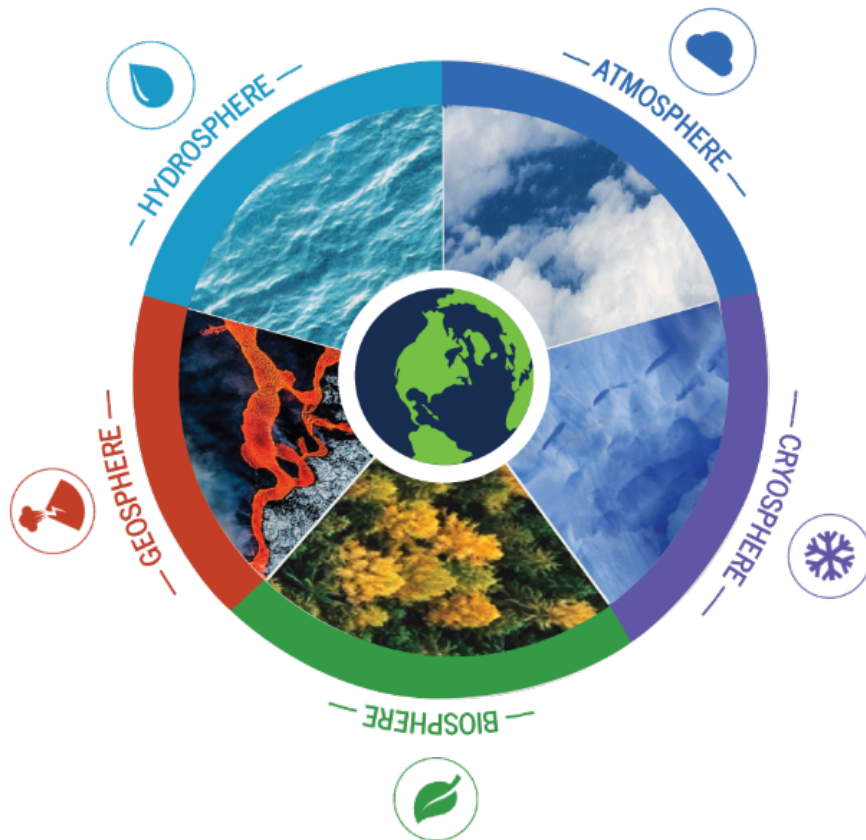
All master copies can be found in the Student Sheets Document

- Log 1, Briefing, and Log 2 (one copy per student)
- One set of Cause and Effect Statements, cut into strips (per group)
- Poster paper for categorization (per group)
- Student Sheets Images (one copy per group)
  - Figure 1: Mount St. Helens, March 1980, before the eruption
  - Figure 2: Mount St. Helens, June 1980, after the eruption
  - Figure 3: Aerial photograph of 1980 damage to Mount St. Helens
  - Figure 4: Mount St. Helens in 1999
  - Figure 5: Mount St. Helens hazards map
- Blank overhead transparency (one per group)
- Five different colors of transparency markers
- Masking tape

## Technology Requirements

- Standalone Lesson (no technology required)

## Teacher Background Information



Geographers conceptualize the Earth in terms of physical systems (the lithosphere which is also known as the geosphere, the biosphere, the hydrosphere, and the atmosphere) and human systems that are unified in a single, highly-interconnected system. Changes in one system lead to changes in other systems, with an impact on a variety of scales, from local to regional to global. Volcanoes provide an outstanding opportunity to highlight the relationships between human and physical systems and how humans deal with natural hazards.

Volcanoes are dangerous, but they are also very important to humans. Volcanic eruptions contribute substantially to soil fertility. In the Andes, many people live on the flanks or at the foot of active composite volcanoes, largely because of the fertility of the volcanic deposits. The same is true in the Philippines where residents near active volcanoes like Mount Mayon and Mount Taal regularly move away during eruptions, only to move right back when the danger subsides. These two cases present good examples of how people learn to live and adapt to hazardous environments.

Mount St. Helens is one of many composite (stratovolcano) volcanoes in the Cascade Range of the Northwest United States. Mount St. Helens has been one of the most active volcanoes in the Pacific Northwest, although before the eruption in May 1980, it had been dormant since 1857.

More detailed information about the Cascade Range, Mount St. Helens, and the 1980 eruption can be found at the [USGS/Cascade Volcano Observatory web site](#).

## Formation, Location and Examples of Different Volcano Types

	Shield	Composite/ Stratovolcanoes	Cinder Cone
Formation/ Location	Massive fluid lava flows and slowly builds up a gently sloping volcanic shape.	Built from both explosive eruptions and quieter eruptions. Layers of tephra (ash, cinders, and other material blown into the air) alternate with layers of lava to create steep-sided often symmetrical cones.	Made primarily from explosive eruptions of lava. Blown into the air, the erupting lava breaks apart into the small fragments known as cinders. The fallen cinders accumulate into a cone around the volcano's central vent (the "hole in the ground" from which the lava emerged).
Location	Primarily located along tectonic spreading centers or at "hot spots."	Stratovolcanoes are located primarily along tectonic subduction zones, where two plates slowly collide.	Not associated with any particular tectonic activity. Some are found near current tectonic boundaries, and others are near old boundaries.
Examples	Kilauea, Mauna Loa (Hawaii)	Mount Fuji (Japan), Mount St. Helens (Washington)	Sunset Crater (Arizona), Capulin Mountain (New Mexico)

### Prerequisites Student Knowledge

- Students should be familiar with basic structure of Earth's interior.
- Students should know what the spheres of Earth represent in order to classify effects on the spheres. This includes the atmosphere, biosphere, hydrosphere and lithosphere.

### Student Misconception

- Volcanoes are randomly located across the earth's surface.
- Volcanoes are found only on land.
- Volcanoes are found only in hot climates.
- All volcanoes erupt violently.
- Volcanoes only erupt straight up through the top vent.
- If a volcano doesn't erupt for a hundred years, it's extinct.
- If a volcano does not produce lava, it is not dangerous.

Source: [Beyond Penguins and Polar Bears: Common Misconceptions about Weathering, Erosion, Volcanoes and Earthquakes](#)

### Procedure



## Beginning the Investigation

1. Explain that the purpose of the module is to investigate the effects of volcanoes. Geographers are interested in learning about changes caused by volcanoes at different scales, from the local (immediately adjacent to volcanoes) to the global (world atmospheric conditions affected by volcanic eruptions). Give students time to discuss what they already know about volcanoes

### Module 1, Investigation 1: Log 1

#### How close is safe? Buffer zone development

**Background**

Volcanoes are like good news, bad news jokes. The good news is that they offer humans benefits such as rich soil. The bad news is that they are very destructive when they erupt. Because of this contradiction between productivity and destruction, areas around volcanoes need to be evaluated for safety. Creating a safety zone around a volcano helps to minimize a volcano's effect on humans. Creating a safety or buffer zone, however, requires information about the extent of previous eruptions compared to human settlement patterns. In this investigation you use data at different scales to study the impact of volcanic eruptions on the environment and its inhabitants in order to establish a buffer zone.

**Objectives:** In this investigation, you

- categorize the causes and effects of volcanic eruptions and human responses to them,
- measure the extent of damage of the Mount St. Helens 1980 eruption, and
- analyze images of a volcano to suggest a settlement buffer zone.

**Procedures for the Investigation:**

1. Read the account of the Mount St. Helens 1980 eruption.
2. Define the following elements of Earth's physical systems:
  - hydrosphere: \_\_\_\_\_
  - lithosphere: \_\_\_\_\_
  - atmosphere: \_\_\_\_\_
  - biosphere: \_\_\_\_\_
3. Categorizing causes, effects, and responses
  - Organize the Cause and Effect Statements into three categories. List the strip numbers under each category title.

Causes	Effects	Human Responses

Divide the strips into more specific categories using the headings on Log 2. Cause and effect organizer. Be prepared to explain your choices.

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and their local-to-global effects.

2. Distribute **Log 1** and have students read the background and objectives. Distribute the **Briefing** and have students read the narrative account of Mount St. Helens' 1980 eruption. You may ask students to take turns reading this dramatic story in a "reader's theater."

### Module 1, Investigation 1: Briefing

#### Narrative of Mount St. Helens 1980 eruption

**A Slumbering Volcanic Giant**

Mount St. Helens was once one of the most beautiful mountains in the entire Cascade Range of the American Northwest. In 1805, William Clark in the Lewis and Clark expedition described Mount St. Helens as "perhaps the greatest pinnacle in America."

The serenity of the mountain and its surroundings was misleading. One of the Indian names for Mount St. Helens was "The mountain." Local Indians were reluctant to approach the mountain despite the abundant game in the area.

To the experienced observer, the cone shape and composition of rocks on the mountain boldly proclaimed Mount St. Helens' true nature—it was a volcano. Lava flows and multiple layers of ash (powdered volcanic rock) lay everywhere under the carpet of trees—abundant evidence of many prior eruptions. Volcanic deposits had reshaped the region around the mountain. Even beautiful Spirit Lake was a volcanic accident created by a giant mudflow that rolled down the mountain 5,000 years ago and backed up a stream.

Mount St. Helens was active between 1832 and 1857 during the early settlement of the area by Easterners. But the eruptions were small, and the mountain then "slept off" for the next century. Small settlements became towns, and towns became cities like Portland and Seattle. These new neighbors of Mount St. Helens knew the mountain only as a sleeping giant. Its violent past was largely ignored.

**The Awakening**

The quiet ended abruptly in March 1980, with a series of steam explosions and bursts of ash. The following story of the eruption of Mount St. Helens illustrates the potential dangers of an eruption from Mount Rainier—a volcano about 120 kilometers southwest of Seattle, Washington.

During the months following the initial outbursts, volcanologists and seismologists watched the mountain closely. Small earthquakes accompanied the bursts and indicated the movement of fresh lava into the heart of the mountain. Enormous cracks appeared in the summit and sides of the mountain,

and the entire northern face expanded outward some 137 meters. Locals perceived this initial activity as minor, so in spite of warnings and the designation of the mountain and its surroundings as a dangerous "Red Zone," tourists flocked to the area to get a close view of the fireworks. Residents were strongly advised to move away, but some refused to go. Likewise, logging companies working in the area refused to shut down, claiming to "know the mountain." Volcanologists established several camps around the mountain to monitor its activity. Some of the camps had to be dangerously close to the mountain to provide the necessary data. The scientists who manned the camps in shifts knew they were at risk.

**The Main Eruption**

On May 18, a quiet Sunday morning, a few observers were at their stations, watching Mount St. Helens. Tourists and loggers were also nearby. At 8:32 a.m. a small aircraft with two geologists aboard flew directly over the central cone.

Eleven seconds later, a strong earthquake shook Mount St. Helens. The whole north face of the mountain broke free and slid downward as a giant rock avalanche. In seconds, pressure in the mass of hot lava inside the mountain dropped, water that had been dissolved in the lava turned into superheated steam, fragmenting the lava into a fine powder ash. This mass of superheated steam and ash blasted upward and outward over the top of the avalanche, roaring to the north and west at speeds reaching hundreds of miles an hour. The pilot of the small aircraft narrowly avoided disaster by pulling the plane into a steep dive to gain speed and turning sharply south, away from the expanding ash cloud.

Every living thing within about 16 kilometers of the volcano on the north side—tree or bush, human or animal, scientist or layman—was destroyed. Some of the people took a few quick pictures. Then, realizing their situation, most ran or tried to drive away from the approaching cloud of dust and steam. The near-supersonic blast of rock, ash, and hot gas engulfed the area with enough force to uproot trees. The temperature within the cloud reached 250°C (500°F), more than enough to start fires or burn exposed skin. The rock avalanche

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3. NASA monitors volcanoes because of their significant effect on people and the environment.


Introduce or review the following terms used to describe the environment in Earth-systems terms:

- Hydrosphere: Earth system dealing with water (hydro-), including surface water systems (lakes, rivers, oceans) and frozen water (glaciers, polar ice caps) as well as water beneath the surface of Earth (aquifers, groundwater, etc.)
- Lithosphere (AKA Geosphere): Earth system dealing with land (soil, rocks, etc.)
- Atmosphere: Earth system dealing with air
- Biosphere: Earth system dealing with plant and animal life (flora and fauna)
- Have students record definitions in the Log.

4. Divide the class into groups of 3-5 and distribute the Cause and Effect Statements, cut into strips, one set per group.

- Review the statements with students to make sure they understand the vocabulary.
- Ask students to organize the strips into three groups: Causes, Effects, and Human Responses
- Some statements may require a fine distinction between “cause” and “effect”; develop working definitions as a class if necessary. (Suggested definitions: Cause—incidents that lead up to or are related to the actual eruption event. Effect—incidents that result from the actual eruption event).
- Students complete Item 3 in the Log.

5. Using large sheets of poster paper and tape, have students classify the statements again, this time into more specific categories shown in **Log 2: Cause and effect organizer**.

 <b>Module 1, Investigation 1: Log 2</b> Cause and effect organizer		
Causes	Effects	Human Responses
Structure of the Volcano	Effects on the Lithosphere	Clean-Up Efforts
	Effects on the Hydrosphere	
	Effects on the Biosphere	Responses to Environmental Hazards
The Eruption Event	Effects on the Atmosphere	Monitoring Efforts
	Effects on Human Activities	

Be sure that all students understand the categories. Discuss the types of cues they would use to determine a statement’s classification. For example, students should identify that statements dealing with the plant and animal life of the area would be placed under “Effects on the Biosphere.”

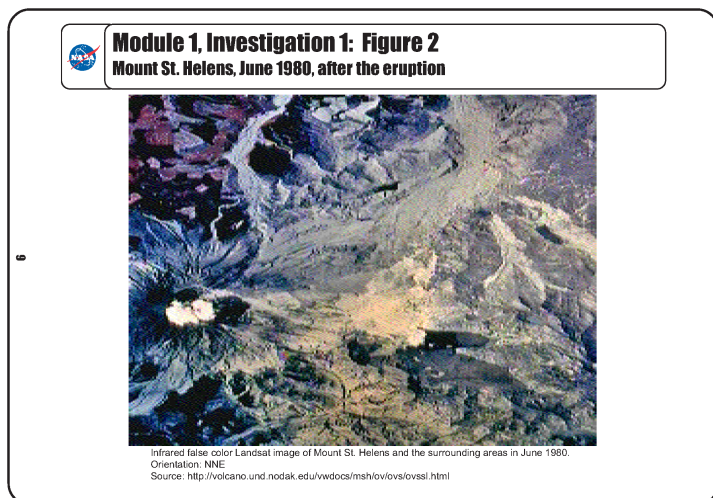
- Students record their categorizations on **Log 2**.
- Ask selected groups to share their classifications with the class. If groups disagree about a statement’s classification, allow them to explain their underlying thought process. Use points of disagreement to reinforce the concept that Earth systems function interdependently, so it is sometimes difficult to determine which “-sphere” is being affected.

6. Debrief this activity by highlighting that effects and consequences such as the ones listed require considerable lengths of recovery time after an eruption. How people prepare for and respond to volcanic eruptions is vital to the safety and productivity of an area. Explain that NASA images show the extent of damage after an eruption and provide data useful to lessen

the human impacts of possible future eruptions.

## Developing the Investigation

1. Distribute **Figure 1: Mount St. Helens, March 1980, before the eruption** to each group. Explain that this is a false-color Landsat image, which means that the colors on the image are not the same as would appear to the human eye. In this image, vegetation is red.

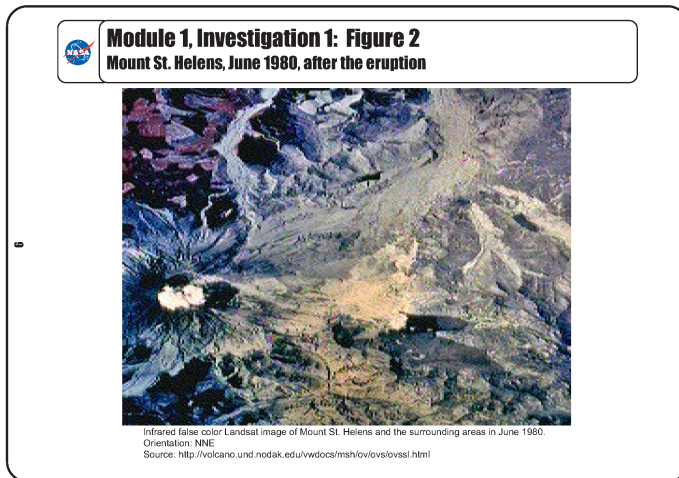


2. Guide students in interpreting the image using the following questions:
  - What features would you look for in order to identify a river? (Look for meanders or curves in a line.)
  - How would you identify the location of the volcano's peak? (Look for dark gray or black areas surrounded by little vegetation. These represent snow and glaciers that are on top of the volcano.)
  - How would you find areas of vegetation? (Look for red areas since this is a false-color image and living vegetation is reddish.)
  - Why might some areas of vegetation have straight boundaries? (They are probably boundaries for agricultural land or some other managed landscape.)
  - Have students complete item 4 in the Log.
3. Ask students to review the Cause and Effect Statements they organized earlier in the investigation. Have them record in their log three things that they would expect to be able to observe in a false-color image taken after an eruption. Allow students to discuss their predictions with the class. They should mention things like:
  - less red color because much of the vegetation was killed by the blast
  - changes in the course of rivers or the development of new lakes as debris obstructed the flow
  - of rivers
  - changes in the shape of the volcano due to landslides
4. Distribute a blank overhead transparency and transparency marker to each group. Instruct students to mark the corners of **Figure 1** on the transparency to aid in lining up other images later.
5. Ask students to locate the summit of the volcano (in the lower-left area of the image) and then trace the extent of the volcano. Students should create a key at the bottom of the transparency for each color used throughout the investigation.
6. Explain the concept of a buffer. A buffer provides an area to absorb the negative consequences of physical or human activities. For example, tree buffers can serve to protect



a neighborhood from highway traffic and noise, while an uninhabited buffer area can protect people from some dangers of natural hazards. In a different colored transparency marker, ask students to sketch the area they think should be the buffer zone for safety around Mount St. Helens.

7. Distribute **Figure 2: Mount St. Helens, June 1980, after the eruption.**



- Instruct students to compare this figure to **Figure 1**.
  - Have students discuss their reactions to the changes from **Figure 1** to **Figure 2**. In what ways was the environment disturbed and disrupted by the eruption? In what ways was vegetation altered? The flow of rivers? Students should check to see the changes they predicted. Were their predictions accurate?
  - Have students place the transparency on **Figure 2**, lining up the corner marks.
  - In another color, have students trace the boundary of the extent of the disruption and devastation brought on by the eruption. Ask how effective their buffer would have been for this particular eruption.
8. Have students review the Cause and Effect Statements again to imagine what the area in this image would look like at ground level. Then, display **Figure 3: Aerial photograph of 1980 damage to Mount St. Helens** to illustrate what the land looked like after the eruption.



**Module 1, Investigation 1: Figure 3**  
**Aerial photograph of 1980 damage to Mount St. Helens**



Mount St. Helens' 1980 eruption triggered massive debris flows down the north face of the volcano as seen in this photograph.

Source: Cascade Volcano Observatory by Thomas Casadevall [http://denali.gsfc.nasa.gov/research/volc2/volc\\_top.html](http://denali.gsfc.nasa.gov/research/volc2/volc_top.html)

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9. Ask students to formulate a hypothesis about the present environment around Mount St.



**Module 1, Investigation 1: Figure 4**  
**Mount St. Helens in December 1999**



True color Landsat image of Mount St. Helens in 1999. Some areas have yet to rebound from the 1980 eruption.  
 Key: green = forest  
 white = snow and glaciers  
 grey = areas destroyed by 1980 debris flow which have not recovered  
 Orientation: NNE  
 Source: [http://volcano.und.nodak.edu/vwdocs/volc\\_images/img\\_st\\_helens.html](http://volcano.und.nodak.edu/vwdocs/volc_images/img_st_helens.html)

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Helens. What would it look like today?

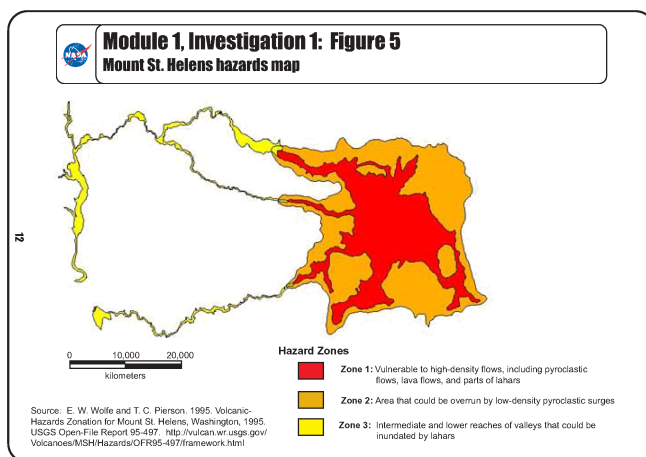
Using a new color transparency marker, have students draw in with dashed lines how much of the area they think probably still shows effects of the 1980 eruption today.

10. Distribute **Figure 4: Mount St. Helens in December 1999**. Students need to line this image up with the lower right corner of their transparency. Explain that instead of vegetation appearing red, in a true-color image vegetation looks green like it does in the real world. Ask students to compare this image with the previous two. How has the local environment changed? Ensure that students notice the vegetation regrowth in some areas. Where has regrowth occurred, and where has it not? Have students look for patterns and explanations for the areas of regrowth. (Explanations could include: The impact was more severe and lasting in the direction of the blast. The area directly adjacent to the volcano was slowest to grow vegetation. Areas along the river and surrounding Spirit Lake have begun to recover vegetation.)

- Using a different color marker, ask students to draw a second safe buffer zone around the volcano applying this new information. Students should record their justification for the boundary by stating which effects are being addressed by their new buffer zone.

## Concluding the Investigation

- Compare the second buffer zone to the buffer they drew originally. Ask how many groups made their second buffer zone bigger. Students may assume that the next eruption will affect the same area, which would not necessarily be the case. Ask what other information students or scientists would need to create a buffer zone that took this possibility into account.
- Remind students that scientists are constantly monitoring changes with volcanoes, hoping that new information will help the area be safer and more prepared for potential eruptions. Using data from several different years allows people to make wiser decisions. If students changed their buffer zone, they understand the need to respond to additional information about dangers.
- Circulate **Figure 5: Mount St. Helen's hazards map** for students to compare their second buffer zone area with the hazard areas identified by the U.S.



Geological Survey.

- Ask students to review the Cause and Effect Statements they used at the beginning of the investigation. Have them identify which effects may have been less of a problem if there had been a sufficient buffer zone in place before the 1980 eruption of Mount St. Helens. Have students record their answers in their Log. Provide time for whole group discussion of the possible effects and limitations of buffer zones.

## Related NASA Resources

- [Earth Observation System Volcanology Homepage](#), provides comparative information on a variety of volcanoes under study. Includes eruption data as well as satellite and aerial images of each.

## Related Resources

- [Links to information about Mount St. Helens](#). Includes details of the 1980 eruption, maps and graphics of the Cascades Volcanoes, monitoring efforts, and more.
- [Summary of the 1980 eruption event](#), including measurements and extent of damage
- [MtStHelens Landsat progression](#) of images with additional pictures of selected sites
- [Alaskan Volcano Observatory](#), outstanding images and text about all volcanoes in Alaska, the

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Aleutian Islands, and Kamchatka Peninsula. Regional and local maps. Images of volcanoes, their eruptions, and the effects on the nearby human populations

## **Extensions**

At the completion of the unit, students may be given the assignment of preparing a brief to an international organization in which they must address this statement:

Roughly 28 percent of Earth's surface and over half of its population are directly affected by volcanism. Volcanism has wide effects on world rainfall, temperature, and other atmospheric conditions. Summarize the potential effects of volcanism on the world population based on the material studied in this module. Suggest ways humans can prepare for and adapt to this dynamic aspect of Earth's physical system.