



Dark Skies: Volcanic Contribution to Climate Change

Unit: Little Ice Age
Lesson: 8

Materials & Preparation

Time:

- Preparation: 30 minutes
- Teaching: Two, 45-minute, class periods

Materials for the Teacher:

- Dark Skies PowerPoint presentation (or overhead transparencies) (*see Advanced Preparation section, p.2)
- Computer projector (or overhead projector)

Materials for the Class:

- Colored pencils
- Flashlights
- Tracing paper

Materials for Individual Students:

- Pencil
- Student Page #1: *Changes in the Landscape, Changes in the Atmosphere*
- Student Page #2: *Volcanic Eruption, Climate Disruption*

National Science Standards

- Earth and Space Science: Content Standard D
- Science in Personal and Social Perspectives: Content Standard F

Colorado Science Standards

- Science: 4.1c, 4.2, 6e

Learning Goals

Students will

- Understand that climate change can result from natural events.
- Understand that volcanic eruptions contribute to the chemical composition of the atmosphere.
- Understand that large volcanic events impact local AND global environments as well as climate.
- Illustrate the effects of a volcanic eruption on the appearance and composition of the atmosphere.

What Students Do in this Lesson

In this activity students learn how volcanic eruptions affect global climate. To begin, students listen to first-hand accounts of the effects of a large volcanic eruption and then illustrate their understanding of the effects upon the landscape and the atmosphere. Next, students are introduced to the effects a major volcanic eruption had on the atmosphere through the use of recent and historical images. Students model the reduction in light to Earth's surface using simple tools. Student learning about atmospheric change due to eruptions. Climate impacts of eruptions are assessed with a simple graphing activity.

Key Concepts

- Natural events can change the climate.
- Small particles of debris produced by large volcanic eruptions collect in the atmosphere
- Some of this material can be distributed globally and remain in the atmosphere for up to several years.
- Volcanic debris in the atmosphere reduces the amount of sunlight reaching the surface of Earth.
- The reduction in light results in lower annual temperatures near Earth's surface.
- Low annual temperatures persist as long as the volcanic debris (aerosols) remain in the atmosphere.



Dark Skies: Volcanic Contribution to Climate Change

Advanced Preparation

- Review and practice the Dark Skies PowerPoint presentation available at: http://www.eo.ucar.edu/Dark_Skies_2.ppt
- Copy Student Page 1 (*Changes in the Landscape, Changes in the Atmosphere*) and Student Page 2 (*Volcanic Eruption, Climate Disruption*) for each student.
- Obtain drawing materials such as colored pencils and extra paper.

Introducing the Lesson

- Explain that in this lesson, students will explore the relationship between volcanoes, the atmosphere and climate.
- Show an image of a massive volcanic eruption (see examples on page 6 of this lesson or in the Dark Skies presentation). Ask students to identify the image. Is this process natural? (The answer is yes, however some students may confuse the eruption with a nuclear explosion.)
- Read the following quote describing what it was like to be in Olongapo City, relatively close to Mt. Pinatubo when it erupted in 1991.

"I was only 14 when it happened. But I remember that there was no sun for several days. The sky was either red or black. The ground was shaking all the time for days from the aftershocks. It was raining ashes and we had to wear a mask when we go outside. We also stayed inside the base for three days."
(<http://forums.about.com/n/pfx/forum.aspx?nav=messages&tsn=3&tid=1491&webtag=ab-geography>)

- Ask students to describe what occurs during a volcanic eruption and what materials are forced out of the volcano. Student's answers may include rocks, ash, and smoke.
- Draw student attention to the vast amounts of ash and gas that are forced into the atmosphere. Ask students to consider where that material goes and what effects it might have upon the planet.
- Read the following quote describing how the atmosphere appeared different in Baton Rouge, LA, a location very far from Mt. Pinatubo around the time of the eruption.

"I was playing city little league baseball that summer, and I remember during our evening games, the sun would be so beautiful—more reddish than usual. During our playoffs, I can remember how the sky had a sort of wierd tint to it. That was maybe a few weeks after the eruption or so. If it was a partly cloudy day, the clouds would be a purplish-gray color."

(<http://forums.about.com/n/pfx/forum.aspx?nav=messages&tsn=2&tid=1491&webtag=ab-geography>)

- Create a list of the various changes students predict for the landscape and atmosphere over time after an eruption.

Facilitating the Lesson

1. Distribute and review the Student Page, *Changes in the Landscape, Changes in the Atmosphere*.
2. Ask students to draw what they think the landscape near a volcano looks like during and after an eruption.
3. Explain to students that they should use their imaginations to draw what the atmosphere surrounding the Earth looks like before, during, and after an eruption.
4. Allow students to brainstorm their ideas at this stage of the lesson.
5. Ask volunteers to share their drawings with the class and explain what they believe happens to the landscape and atmosphere during and following a volcanic eruption. (Alternatively, have each student tape her/his drawing to the wall, and allow students to circulate around the room to view each picture as if in a museum.
6. Use student sharing to discuss the various predictions they made about the changes to the landscape and the



Dark Skies: Volcanic Contribution to Climate Change

distribution of volcanic material throughout the atmosphere.

7. Create a list of the various changes students predict for the landscape and atmosphere over time.

Presenting the Slide Show

- The PowerPoint presentation (available at: http://www.eo.ucar.edu/Dark_Skies_2.ppt) provides images, information, and anecdotes about changes in the landscape and atmosphere that can result from a massive volcanic eruption. While volcanic eruptions drastically change the local environment, the far reaching effects on the atmosphere and climate should be emphasized.
- Facilitate the presentation and encourage student questions and observations.
- Following the presentation, ask students what they would change if they were to revise their original drawings on the *Changes in the Landscape, Changes in the Atmosphere* Student Page.

Modeling the Reduction of Light

Explain to students that they will try to model the reduction of light reaching Earth following a volcanic eruption. Explain that the flashlight represents the Sun, the white surface represents the surface of the Earth, and the translucent sheet of paper represents the dust layer produced by a volcanic eruption that blocks incoming light. Alternatively, you may want to do this as a demonstration.

- Using the overhead projector or a flashlight, project a beam of light onto a white surface.
- Using a light meter (or visual assessment) record the amount of light reaching the surface.
- Next, place a sheet of translucent (tracing paper) between the light and the surface.
- Measure or note the change in the intensity of light reaching the white surface.

Assessment

- Hand out the Student Page *Volcanic Eruption, Climate Disruption* to each student.
- Explain the illustrations at the top that show what the Sun looked like before, during, and at several times after an eruption.
- Explain the axes of the graphs and the student directions.
- Ask students to draw a graph of the relative amount of ash in the atmosphere based on the illustrations of the Sun. (Answer: Large amount of ash right after the eruption and then amount of ash decreases gradually over time.)
- Ask students to predict how this amount of ash (and the change in ash through time) would affect temperature at the Earth's surface.
- Summarize results as a class. (Answer: Temperature curve should be the inverse of the ash curve - i.e., when the ash amount is greatest, temperature is lowest, when the ash amount is lower, the temperature is higher.)

Extensions or Homework

- Create a set of images that show the sequence of events, in the Earth's atmosphere during and after a volcanic eruption. Randomize the images and have students organize them into a correct sequence.
- Create a hypothesis about how volcanic eruptions impact the Earth system (biosphere, hydrosphere, geosphere).
- Students investigate what causes volcanoes and where volcanoes are located in their country or state.



Dark Skies: Volcanic Contribution to Climate Change

Background Information

Scientists who specialize in the study of climate (climatologists) have identified three major contributors to climate change: the solar cycle, extreme or persistent volcanic eruptions, and the release of gases into the atmosphere as by-products of human energy consumption. In this lesson, students learn about volcanic contributions to climate change.

Volcanoes have a significant long and short term effect on the global climate and environment. Over time, they influence the chemical composition of the atmosphere. Short term effects include local devastation and a measurable decrease in the global temperature. Ash and gas produced by volcanic eruptions may spread throughout the globe in a matter of weeks. Gases rich in sulfur combine with water vapor to form sulfuric aerosols that remain in the atmosphere for up to several years following an eruption. These small droplets form a cloud layer that blocks light from the Sun, reducing the amount of energy reaching Earth. In addition, the aerosols absorb energy radiated from the surface of Earth. This process, known as “radiative forcing,” persists for several years and results in surface temperatures that are cooler in the summer and warmer in the winter.

Once aerosols enter the stratosphere, they absorb energy radiating from the Earth, causing this layer of the atmosphere to warm. A warmer stratosphere leads to changes in winter conditions across the Northern Hemisphere. High pressure systems that form over the North Pole send cold air and storms to lower latitudes. This weather pattern is known as the “negative phase” of the Arctic Oscillation. From the early 1900’s through the 1970’s the Arctic Oscillation alternated between a negative and a positive phase; the positive phase having characteristics opposite of the negative phase. During the positive phase, high latitude locales such as Alaska, Scotland and Scandinavia have wetter weather while the western United States and the Mediterranean have drier weather, the eastern United States is warmer than usual while Greenland and Newfoundland are cooler than usual. Since approximately 1970, the positive phase has dominated, leading scientists to believe that human emissions of gases have changed the natural pattern of atmospheric circulation, and thus, the weather for the Northern Hemisphere.

Massive volcanic eruptions capable of changing global climate occur infrequently. In order to assess the relative size of eruptions, the Volcanic Eruptive Index (VEI) was developed in the

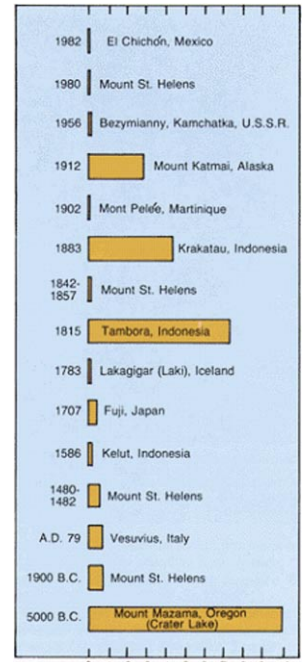
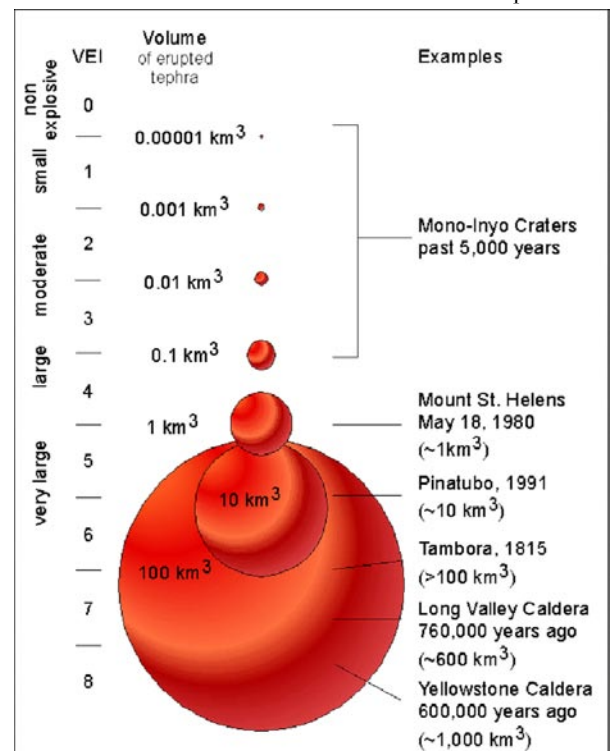
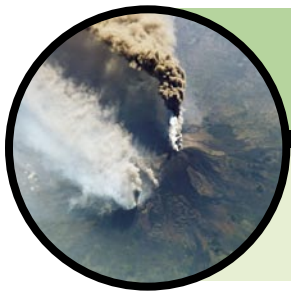


Figure 1: (above) Size of volcanic eruptions on a VEI scale of 0 to 10. Figure 2 (below) Volcanic eruptions on the VEI with volume emphasized.





Dark Skies: Volcanic Contribution to Climate Change

early 1980's. The scale, like the Richter Scale used to measure earthquakes, is logarithmic. Thus, a volcanic event that measures 3 on the scale is ten times more explosive than an event measuring 2. Single volcanic explosions that change global climate generally measure greater than 5 on the VEI scale. These explosions generate millions of tons of debris that catapult into the upper tropopause and lower stratosphere. According to the USGS, "the record of volcanic eruptions in the past 10,000 years maintained by the Global Volcanism Program of the Smithsonian Institution shows that there have been 4 eruptions with a VEI of 7, 39 of VEI 6, and 84 of VEI 5..." More important to climate change than the ash and particulates produced by an explosion, is the amount of sulfur dioxide that is generated. Scientists have yet to determine the primary source of this sulfur. Also, each eruption releases varying amounts of sulfur depending upon the chemical composition of the magma.

The two figures on page 4 compare the relative sizes of several recent and historical eruptions. From these figures we learn that the 1980 eruption of Mt. St. Helen's was quite small in comparison to the massive eruptions of Krakatau in 1883 and Tambora in 1815. To estimate the size of historical explosions, geologists measure the depth of ash layers produced and their global distribution. Understanding and predicting the effects of eruptions help us to anticipate changes to the atmosphere, climate change, and the effects of human energy consumption which releases similar gas by-products into the atmosphere.

Additional Resources

- NASA Earth Observatory: <http://earthobservatory.nasa.gov/>
- Earth Observatory: Volcanoes & Climate Change: <http://earthobservatory.nasa.gov/Study/Volcano/>
- Mt. Pinatubo Eruption: <http://www.gsfc.nasa.gov/gsf/earth/pinatuboimages.htm>
- Volcanoes and Climate Effects of Aerosols: http://eosps0.gsfc.nasa.gov/science_plan/Ch8.pdf
- USGS Cascade Volcano Observatory: <http://vulcan.wr.usgs.gov/>
- National Snow and Ice Data Center, The Arctic Oscillation
http://nsidc.org/arcticmet/patterns/arctic_oscillation.html



Dark Skies: Volcanic Contribution to Climate Change

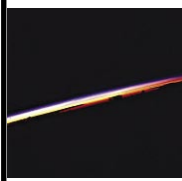
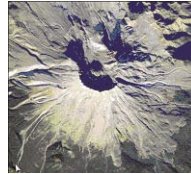


Image of the atmosphere in pristine condition taken by NASA astronauts.
Source: <http://eol.jsc.nasa.gov/scripts/sseop/photo.pl?mission=STS41D&roll=32&frame=14>



Mt. St. Helen's, WA, photographed from the International Space Station following the 1980 eruption.
Source: <http://eol.jsc.nasa.gov/debrief/Iss005/topFiles/ISS005-E-18511.htm>

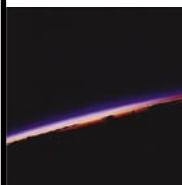
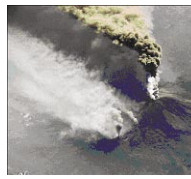


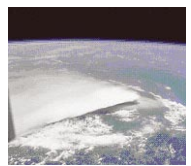
Image of the atmosphere following a volcanic eruption and the formation of an aerosol layer as photographed by NASA astronauts.
Source: <http://eol.jsc.nasa.gov/scripts/sseop/photo.pl?mission=STS41D&roll=32&frame=14>



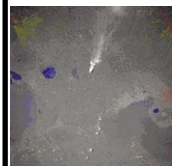
The eruption of Mt. Etna, Sicily, as photographed from the International Space Station.
Source: <http://eol.jsc.nasa.gov/debrief/Iss005/topFiles/ISS005-E-19024.htm>



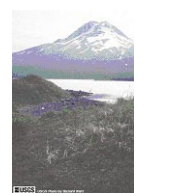
Photograph of a pristine atmosphere.
Source: <http://eol.jsc.nasa.gov/debrief/Sts109/topFiles/STS109-345-32.htm>



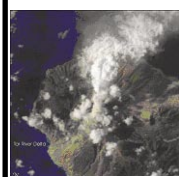
The Rabaul eruption plume, New Britain Island September 1994 photographed from the space shuttle.
Source: <http://eol.jsc.nasa.gov/sseop/EFS/photoinfo.pl?PHOTO=STS064-40-10>



A plume of volcanic ash from the volcano, Masaya, in Nicaragua, swept by the wind.
Source: <http://eol.jsc.nasa.gov/sseop/EFS/photoinfo.pl?PHOTO=STS51A-32-64>



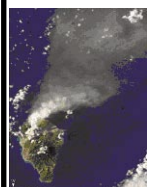
Dormant volcano Augustine in Alaska.
Source: <http://vulcan.wr.usgs.gov/Volcanoes/Ecuador/images.html>



Ash and steam, Soufriere Hills Volcano, Montserrat photographed from the International Space Station.
Source: <http://eol.jsc.nasa.gov/debrief/Iss004/topFiles/ISS004-E-8972.htm>



Dormant volcano Cotopaxi located in Ecuador with a global positioning system in the foreground.
Source: <http://vulcan.wr.usgs.gov/Volcanoes/Ecuador/images.html>



Ash and steam, Soufriere Hills Volcano, Montserrat as photographed from the International Space Station.
Source: <http://eol.jsc.nasa.gov/debrief/Iss004/topFiles/ISS004-E-8973.htm>



Geologists monitoring gas emissions on Mt. St. Helen's, Washington
Source: <http://vulcan.wr.usgs.gov/Photo/Monitoring/Emissions/images.html>

Information about images from Dark Skies presentation.




Dark Skies:
Student Page #1

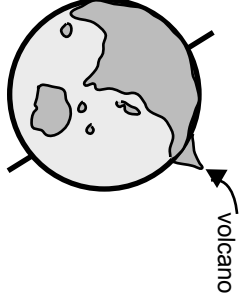

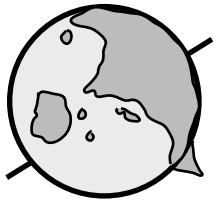
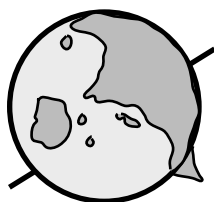
Name _____
Date _____ Class _____

Changes in the Landscape, Changes in the Atmosphere

Draw a view of the landscape near the volcano at different times after an eruption.

			
Before the eruption	During the eruption	Three weeks after the eruption	One year after the eruption

Draw a view of the Earth's atmosphere, as seen from space, before, during, and after the volcanic eruption. (Notes: Earth and volcano are not to scale. The rotation axis is shown with dark lines.)

			
Before the eruption	During the eruption	Three weeks after the eruption	One year after the eruption



Dark Skies:
Student Page #2

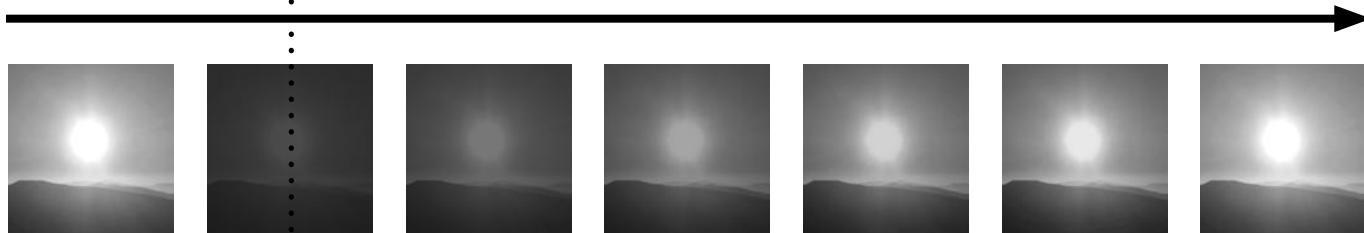
Name _____
Date _____ Class _____

Volcanic Eruption, Climate Disruption

How does a large volcanic eruption affect the atmosphere? How does debris in the atmosphere affect temperature on our planet? Create graphs below to estimate the change to the atmosphere and temperature. Use the illustrations of the Sun to estimate the amount of debris in the atmosphere.

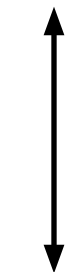
Eruption
Occurs

TIMELINE



Amount of volcanic debris in atmosphere

More
Debris



Less
Debris

Time

Temperature at the Earth surface

Warmer



Cooler

Time