Teacher Sheet 1

PROBLEM SOLVING ACTIVITY: VOLCANOES AND CLIMATE CHANGE

OBJECTIVE: Students will:

- Locate major volcanoes around the world using latitude and longitude; (Activity A)
- Explain how the latitudinal location of volcanic activity may affect global climate conditions; (Activity A)
- Use the V.E.I. to predict the potential of a volcanic eruption to affect climate; (Activity A)
- Examine the dispersal of aerosols through the atmosphere after a volcanic eruption; (Activity B)

ACTIVITY 1: Where and when have recent volcanic eruptions occurred?

Volcanic eruptions are not all the same. They differ in the quantities of dust and ash they produce; some produce just lava. As a result, not every volcanic eruption has the potential to produce significant climate changes. Some of the significant characteristics needed for an eruption to affect global climate include the latitude of the volcano, the season of the year of the eruption, the height of the eruption and the type of gases produced.

MATERIALS:

- ✓ Blank 8.5 x 11" map of the world with latitude and longitude lines;
- ✓ Large wall map of the world
- ✓ Library resources or computer access for information on volcanic eruptions OR the list at the end of this activity.

PROCEDURE:

1. Using **TABLE 1** and the blank map of the world, have students locate each volcano by its latitude and longitude as listed in the table. **(NOTE: The volcanoes listed in TABLE 1 were selected at random. The intent is to give an even distribution of the V.E.I. between the values of 4 and 6.)**

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2. Have students label each volcano with its name, elevation above sea level and the date of the eruption.

3. Direct students to the world map.
   - ✓ Ask if they notice any difference in the amount of volcanic activity recorded in the Northern Hemisphere as compared to the Southern Hemisphere.
   - ✓ What possible explanations do they have for this observation?

4. Climatologists have theorized that only low latitudinal volcanic eruptions between 20 ° N and 20° S can significantly affect global climate conditions.
   - ✓ Ask students to develop a hypothesis for this theory.

5. Have students arrange the data provided in **TABLE 1** in a different way:
   - ✓ Sort the volcanoes by the V.E.I.
   - ✓ Arrange the volcanoes by latitude and longitude and determine if a correlation exists;
   - ✓ Sort the volcanoes by the V.E.I
   - ✓ Arrange by latitude and longitude and investigate for any correlation;
   - ✓ Sort the volcanoes by the V.E.I.
   - ✓ Arrange by data and examine any correlation.

6. Continue this process until all of the variables have been examined in relation to each other.

7. Using the information compiled from **TABLE 1**, students should determine which volcanoes have the greatest effect on global surface temperatures.

8. Some climatologists have criticized the V.E.I. because it does not accurately assess some of the important aspects of a volcanic eruption.
   - ✓ Have students determine what characteristics of an eruption the V.E.I. does not take into account when considering climate change.

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ACTIVITY 2: How are aerosols dispersed through the atmosphere after a volcanic eruption?

Studies have shown that the explosivity of an eruption and the amount of ash injected into the stratosphere are not the main factors in causing a change in Earth's climate. Instead, scientists have concluded that the most significant impacts from large explosive eruptions come from the conversion of sulfur dioxide (SO_2) to sulfuric acid (H_2SO_4), which condenses rapidly in the stratosphere to form fine sulfate ***aerosols***. The aerosols increase the reflection of radiation from the Sun back into space and thus cool the Earth's lower atmosphere or troposphere; however, they also absorb heat radiated up from the Earth, thereby warming the stratosphere.

The eruption of El Chichón, Mexico, in 1982 conclusively demonstrated that this idea was correct. The explosive eruption injected at least 8 Mt of sulfur aerosols into the atmosphere, and it was followed by a measureable cooling of parts of the Earth's surface and a warming of the upper atmosphere. A similar-sized eruption at Mount St. Helens in 1980, however, injected only about 1 Mt of sulfur aerosols into the stratosphere. The eruption of Mount St. Helens injected much less sulfur into the atmosphere--it did not result in a noticeable cooling of the Earth's surface. Satellite measurement made it possible to measure these differences in the eruption clouds. Such direct measurements of the eruption clouds combined with surface temperatures made it possible to study the connection between volcanic sulfur aerosols (instead of ash) and temporary changes in the world's climate after some volcanic eruptions.

Atmospheric scientists study the effects of volcanic eruptions using ***lidar***, a type of radar that uses pulses of laser light instead of pulses of radio waves. The short pulses of light bounce off particles, molecules and even insects in the atmosphere. Some of the scattered light returns to its source. Measuring the amount of time it takes for the scattered laser light to return allows us to calculate the distance to the object (in this case, aerosols). The light that returns to the source is called ***backscatter***. The amount of backscatter indicates the amount of sulfuric acid aerosols in the atmosphere.

Teacher Sheet 4

MATERIALS:

- ✓ **Student Activity Sheets**
- ✓ Ruler
- ✓ Pencil/colored pencils
- ✓ Computer with Excel if possible

PROCEDURE: Instruct students to complete the following:

1. Number the horizontal axis of the graph from 0 to 3600, by hundreds;

2. Number the vertical axis from 0-30, by ones;

3. Using the data provided, plot the data points corresponding to the units if backscatter for each time period.
   - ✓ Connect the points with a smooth line.
   - ✓ Use a different colored pencil for each time period.

4. Draw a horizontal dashed lined across the graph at 10 km.
   - ✓ Labe the area beneath the line "Troposphere."

5. Draw a horizontal dashed line across the graph at 11km.
   - ✓ Label the area beneath the line "Tropopause."
   - ✓ Label the upper part of the graph "Stratosphere."

6. Print a title at the top of the page.

7. Place a color coded legend on your graph in the space provided.

8. Complete the questions in the **ANALYSIS** section and the activity in the **CONCLUSIONS** section.