My NASA Data - Lesson Plans

Using Aerosol Data to Find Evidence of Volcanic Activity

Overview

Students will use NASA satellite data of aerosol optical depth and sulfur dioxide as a tool to find evidence of volcanic activity at Kilauea, HI.

Learning Objectives

- Analyze data to find evidence of volcanic activity
- Analyze more than one data source for evidence of activity
- Make a claim based on evidence of how aerosols and sulfur dioxide data are related
- Share your findings with others

Why Does NASA Study This Phenomenon?

NASA Getting the Big Picture

NASA uses satellites for many different purposes. Watch Getting the Big Picture, (https://youtu.be/rA_VCLzvbvM) for general information.

Video: NASA | Getting the Big Picture

Video

NASA | Getting the Big Picture | https://www.youtube.com/watch?v=rA_VCLzvbvM | Source: NASA Goddard

About the NASA Disasters Program

The Disasters Applications area promotes the use of Earth observations to improve prediction of, preparation for, response to, and recovery from natural and technological disasters. Disaster applications and applied research on natural hazards support emergency preparedness leaders in developing mitigation approaches, such as early warning systems, and providing information and maps to disaster response and recovery teams. Source: NASA Applied Sciences

Essential Questions

How can satellite data be used to detect and monitor volcanic activity?

Materials Required

Teacher Slide:

- Using Aerosol Data to Find Evidence of Volcanic Activity - (Google Slide Version, PPT Version)

Per Group:

- ***Group A: Sulfur Dioxide Group***
  - Monthly SO_2 Images and Ten Year SO_2 Graph for Students
    - **Interactive (editable) Version:**
      - Monthly SO2 Images for Students and 10 Year Sulfur Dioxide Graph Student Sheet
    - **PDF version:**
      - Monthly SO2 Images for Students
      - 10 Year SO2 Graph Student Sheet
- ***Group B - Aerosol Group***
  - Monthly Aerosol Images and Ten Year Aerosol Graph for Students
    - **Interactive (editable) Version:**
      - Monthly Aerosol Images Student Sheet and 10 yr Aerosols Graph Student Sheet
    - **PDF version:**
      - Monthly Aerosol Images for Students
      - 10 Year Aerosol Graph Student Sheet

Per Student:

- **Student Sheet**
  - (Google Doc version, DOC version)

Optional:

- Are you interested in scaffolding data analysis for your students? Do you have students in your class who require differentiation?
  - If so, consider using the Data Literacy Cube and Question Sheets. The question sheets are available to Google Forms. See the Data Literacy Cube Guide and related resources for graphs and maps.
  - To use the Data Literacy Cube and questions sheets with this activity, each group will require the following:
    - Data Literacy Cube (or die)
    - Map Question Sheet (at the student's level)
    - Graph Question Sheet (at the student's level)
    - Loose Leaf Paper & Pencil Per Student

NOTE: **Virtual Teachers**: Make a copy of the  Google Form of your choice so that you may assign it directly from your Google Drive into your Learning Management System (e.g., Google Classroom, Canvas, Schoology, etc.). Do you need help incorporating these Google Forms into your Learning Management System? If so, read this  **Guide to Using Google Forms with My NASA Data**.

Technology Requirements

- Internet Required
- One-to-a-Group
- Teacher computer/projector only

Teacher Background Information

NASA Monitoring of Sulfur Dioxide from Space

Sulfur dioxide is a colorless gas with a pungent odor that irritates skin and the tissues and mucous membranes of the eyes, nose, and throat. SO_2 emissions can cause acid rain and air pollution downwind of a volcano—at K?lauea volcano in Hawaii, high concentrations of sulfur dioxide produce volcanic smog (VOG) causing persistent health problems for downwind populations. During very large eruptions, SO_2 can be injected to altitudes of greater than 10km into the stratosphere. Here, SO_2 is converted to sulfate aerosols which reflect sunlight and therefore have a cooling effect on the Earth's climate. They also have a role in ozone depletion, as many of the reactions that destroy ozone occur on the surface of such aerosols.

Volcanic Smog (vog) is produced from sulfur dioxide gas and is a hazard in Hawaii. Scientists monitor sulfur dioxide emission rates at Kilauea volcano. This image show gasses from the Halema'uma'u crater, located in the summit caldera of Kilauea.

Source 1: NASA Monitoring of Sulfur Dioxide Emissions from Space

Source 2: USGS

Aerosol Remote Sensing and Modeling

The Climate and Radiation Lab (CRL) has a very active group studying the climate and health impacts of airborne particles ("*aerosols"*). Aerosol particles reflect sunlight, which tends to cool surfaces locally. Some also absorb sunlight, warming and stabilizing the ambient atmosphere while still cooling the surface below, sometimes suppressing cloud formation, and even affecting large-scale atmospheric circulation. In addition, aerosols are essential participants in the formation of cloud droplets and ice crystals, functioning as the collectors of water vapor molecules during the initial stages of cloud development. Particle abundance and properties affect the brightness, thickness, and possibly lifetimes of clouds and ultimately, precipitation and the terrestrial water cycle. And in significant near-surface concentrations, they are pollutants, reducing visibility and raising health risks for those exposed.

Airborne particles originate from a great variety of sources, such as wildfires, volcanoes, exposed soils and desert sands, breaking waves, natural biological activity, agricultural burning, cement production, and wood, dung, and fossil fuel combustion. The particles having the largest direct environmental impact are sub-visible, ranging in size from about a hundredth to a few tenths the diameter of a human hair (about 0.1 to 10 microns). They typically remain in the atmosphere from several days to a week or more, and some travel great distances before returning to the Earth's surface via gravitational settling or washout by precipitation. As such, they can affect regions thousands of kilometers from their sources: Dust from the Sahara Desert, transported across the Atlantic Ocean, supplies iron to the underlying ocean surface waters, occasionally limits visibility in Florida and the Caribbean, and possibly fertilizes the Amazon basin. Pollution and dust from East Asia sometimes reach North America, and smoke from summertime fires in Siberia, northern Canada, and Alaska darken snow surfaces in the Arctic.

The global scope of aerosol environmental influences makes satellite remote sensing a key tool for the study of these particles. Desert dust storms, wildfire smoke, and volcanic ash plumes, and urban pollution palls on hot, cloud-free summer days are among the most dramatic manifestations of aerosol particles visible in satellite imagery.

Prerequisites Student Knowledge

- Basic understanding of aerosols or particles found in the atmosphere.

Student Misconception

- All types of pollution cause global warming (aerosols, acid rain) (Source LASP, University of Colorado)
- Gas makes things lighter. Air has no weight, color or odor and is in effect invisible and inconsequential. (Source: Ohio State University)

Procedure

Engage Prior Knowledge

Pose the following questions to students:

1. What are some of the effects of volcanic activity?
2. How are volcanoes found in the geosphere related to the atmosphere?

3. How can volcanoes be hazardous to living things in the atmosphere?

Discuss these for a few minutes with students. If students identify volcanic emissions of gases into the Atmosphere, shift the discussion to aerosols and sulfur dioxide and provide background information. If they do not bring up volcanic emissions, tell the students that among other volcanic hazards, emissions gases and particles which enter into the air are also serious hazards.

Build Background (if needed)

If students are unfamiliar with aerosols, show students the NASA: My Name is Aerosol (https://youtu.be/4eh6IKahbok).

Video: NASA's Earth Minute: My Name is Aerosol

Video

NASA's Earth Minute: My Name is Aerosol | https://www.youtube.com/watch?v=4eh6IKahbok | Source: NASA Climate Change

1. Discuss the following questions with the students.
    1. Identify different sources of aerosols.
    2. What are the effects of aerosols?
    3. How does NASA study them?
    4. Why does NASA study them?
2. Ask the following question. If there are so many different sources of aerosols, how can we know that the aerosols we are seeing in data are from a volcano?

Begin Exploration

1. Show the NASA video: *Fire, Ice, and Safer Skies: NASA Satellites Track Volcanic Clouds* (https://youtu.be/TP4vzFojewU), which describes hazards of volcanic emissions.

Video: Fire, Ice, and Safer Skies: NASA Satellites Track Volcanic Clouds

Video

Fire, Ice, and Safer Skies: NASA Satellites Track Volcanic Clouds | https://www.youtube.com/watch?v=TP4vzFojewU&t=3s | Source: NASA

- Have students identify the answers to the following questions.

    1. What are some things you observed in the video?
    2. What is a way in which satellites can help NASA scientists when observing sulfur dioxide?
    3. How does this information help pilots?

1. Review student answers.
2. Have a general discussion around the following topics:

    1. What are some things you observed in the video?
    2. What is a way in which satellites can help NASA scientists when observing sulfur dioxide?
    3. How does this information help pilots?
3. Present the following question to students: "If there are so many different sources of aerosols, how can we know that aerosols we are seeing in data are from a volcano?" Tell students that they will analyze data from Kilauea in Hawaii to help answer this question.
4. Describe Kilauea and set the stage for this data analysis activity. K?lauea is one of the most active volcanoes in the world; it is located in the Hawaiian Islands and is one of the youngest volcanoes in the island chain. Show elements of the 2018 K?lauea Eruption and Summit

Collapse video (https://youtu.be/Jp1DhVLe2NQ) by the National Park Service garner excitement.

Video: 2018 K?lauea Eruption and Summit Collapse

Video

2018 K?lauea Eruption and Summit Collapse | https://www.youtube.com/watch?v=Jp1DhVLe2NQ | Source: U.S. National Park Service

Analyze Data

1. Students will work in groups to analyze data obtained in the months around a major eruption of Kilauea.
    - Show students the video, Kilauea Close Up (Eruption vs Sulfur Dioxide Concentrations, (https://youtu.be/XOlVliTOVHA) of sulfur dioxide in the spring of 2008. The color bar shows the concentration of SO2 in the air column. Identify with students the color associated with high vs. low values. The units of these measurements is Dobson Units (DU; 1 DU equals = 2.69 × 10^16 molecules cm^?2).

Video: Kilauea Close Up (Eruption vs Sulfur Dioxide Concentrations)

Video

Kilauea Close Up (Eruption vs Sulfur Dioxide Concentrations) | https://www.youtube.com/watch?v=XOlVliTOVHA | Source: NASA Goddard

1. Have students answer the following questions.

    1. Was there any noticeable change? If so, when?
    2. To what degree did the data values change?

Digging Deeper

1. Distribute the **Monthly SO_2 Images for Students** to half of the class (Group A) and the **Monthly Aerosols for Students** to Group B, the remaining students. Have students analyze the data for each month and look for patterns.

    1. How do the data change?
    2. What is the rate of change in the data from month to month?
    3. What patterns do you observe in the way that the data change over time?
2. Consider using the Map Question Sheet and Data Literacy Cube to engage students to go deeper into their data. For example, students may select the map showing the greatest change. Have students use the cube and question guide for aerosols and SO_2 values for June 2018. They will need a separate sheet of paper to write on.
3. Students will then analyze the graph showing one decade (2008-2018) of values for their variable (Group A: **Ten Year SO_2 Graph Student Sheet** and Group B: **Ten Year Aerosol Graph Student Sheet**.
    - Students may use Graph Cube Questions and Cube to analyze these data. Have students discuss their graph with the group.

        1. Does this graph agree with the images for the same variable?
        2. What was the trend over the course of a year? decade?
        3. Was there any noticeable change? What might have caused this?
        4. How is the rate of change changing over time? Is this to be expected in the future?
4. Now have students switch the graph with the opposite group. Compare the graphs with one another.

1. What are the similarities and differences among the aerosol and SO_2 graphs?
2. What patterns do you see?
3. How might have the volcanic activity caused the pattern you observe?

    1. How do you know that the volcano caused the change in aerosol or SO_2?
    2. Does the fact that the data showed _____ always happens (after/whenever) _____ occurs mean that _____ causes _____? Why/why not?
    3. What would you predict would happen if the volcanic activity would decrease. How would this affect SO_2 values? aerosol values?

Make a Claim and Support With Evidence

1. Have students make a claim using SO_2 data in relation to aerosols, volcanic eruptions, and safety.
2. What evidence do you have to support this claim?

Close the Lesson

1. Students should share out their claims and evidence with the class. Initiate discussion in cases where their observations are different.
2. Engage students in the process of going deeper in their observations during these times. Initiate a discussion about the importance of using evidence to support claims.