Volcanic Plumes: Beautiful yet Deadly

** Created by Kyle N. Hoffman, Geology, Linn-Mar High School, Marion Iowa. 2009*

Teacher Notes

Objectives:

- Students will demonstrate an understanding of the hazards of volcanic eruptions
- Students will demonstrate an understanding of volcanic ash plumes and their trajectory
- Students will demonstrate an understanding of the connections between geologic processes and meteorological processes

Standards:

Science as Inquiry:

1. Identifies questions and concepts that guide scientific investigations
3. Uses technology and mathematics to improve investigations and communications
4. Formulates and revises scientific explanations and models using logic and evidence
5. Recognizes and analyzes alternative explanations and models
6. Communicates and defends a scientific argument

Earth and Space:

1. Understands and applies knowledge of Geochemical cycles

Physical Science:

2. Understands and applies knowledge of chemical reactions
6. Understands and applies knowledge of interactions of energy and matter

Essential Questions:

1. What are the health concerns with volcanic eruptions?
2. What are the main pollutants and chemicals during a volcanic eruption?
3. What are the environmental concerns with volcanic eruptions?

Teacher Notes:

This is an earth systems approach to the air quality unit. This will be a multiple day assignment that will need to be mainly done in the computer lab. Within the unit, the students have already learned about the general chemical make-up of volcanic eruptions. Here is a reminder of the main ideas:

- Water vapor makes up about 90% of the gases released during eruptions. The other common volcanic gases are carbon dioxide, sulfur dioxide, hydrogen sulfide, hydrogen, and fluorine. As for the environmental and health concerns, the following are of most concern:
    - Sulfur dioxide gas can react with water droplets in the atmosphere to create acid rain, which causes corrosion and harms vegetation. This can also damage aquatic life if

the acid rain falls in waterways or if the sulfur dioxide gas comes in direct contact with the bodies of water.

- Carbon dioxide is heavier than air and can be trapped in low areas in concentrations that are deadly to people and animals.

- Fluorine, which in high concentrations is toxic, can be absorbed onto volcanic ash particles that later fall to the ground. The fluorine on the particles can poison livestock grazing on ash-coated grass and also contaminate domestic water supplies. (http://pubs.usgs.gov/fs/fs002-97/)

Using the HYSPLIT, the students will be creating two types of forecasts: 1) volcanic ash cloud and 2) possible SO_2 and CO_2 emissions traces.

Engage:

Put up the below overhead/screen projection (it is located after the rubric in the teacher's notes). They will need to observe the satellite image for a few minutes. In their comp. book, students need to describe exactly what they see. Remember, substance is more important than getting the right answer. They will need to discuss their answer with their partner. The small group will need to create a new, stronger thought and rewrite their earlier conclusion. There will be a whole class discussion following this. In doing so, the class will compile a list of ideas and conclusion to help guide the discussion.

Explore:

In the computer lab, the students will be researching active/dormant, American/Canadian volcanoes and their potential ash fallout paths. In the lab, go to http://www.arl.noaa.gov/HYSPLIT.php . Click on the HYSPLIT for Volcanic Ash link. Next, click on the Run HYSPLIT model (volcanic ash) link, and then click on the Compute volcanic ash concentrations link. Under the -------Forecast Data------- drop bar, click on the GFS (0-84h, Global) and hit next. Now, choose a volcano. Your only requirements are that your volcano needs to be found in the continental United States, Canada, Alaska (Aleutian Islands) or Hawaii. On the next page, set the day as if it was two days ago, set the time at 12 (if you can), set the Total Run Time (hours) to 48h and keep the rest the same. Click on Request Dispersion Run bottom. Under the results, they can choose on the following options (0, 1, 2, and 3). Have the students print their forecasts for each result (1, 2, and 3).

Have them go back to http://www.arl.noaa.gov/HYSPLIT.php and now click on Run HYSPLIT with archived data. They will need to click on Compute trajectories link. Now, have them click on GDAS (global, 2005-present) link, then the current7days link. They will need to only have one trajectory starting location. Using the coordinates from their previous model, they will need to plug in the appropriate latitude and longitude numbers. On this page, they will need to put in the same date and time as the previous model, the Total run time (hours) should be at 48h, their start height should be the same as the elevation as their volcano. Have them change the Label Interval to 24 hours, Zoom factor to zero (far), Graphic size to 120 and GIS output to Google Earth. Click on the Request trajectory bottom to run the model. They will need to print this model too.

Now go to Google Maps. Here, they will need at least two maps. The first set of maps needs to follow the line of trajectory that the models showed, the other map needs to have both their volcano and their hometown included. All of these maps need to be printed.

Elaborate:

Back in the classroom the students will need to put together all of the models, maps and knowledge of volcanic eruptions and put together a damage report that follows the line of trajectory the models gave them. They are to focus on the SO_2 and CO_2 pollutants and their potential damage to the populated areas along the trajectory path. To determine the amount of SO_2 and CO_2 in the eruption, they will need to research their chosen volcano and find the following: eruptive history, chamber size (if available), chemical make-up (in terms of SO_2), mineral deposits, magma type (felsic or mafic). Most can be found on the USGS website. They need to describe the processes that SO_2 and CO_2 can form into and what kind of damage they can do both environmentally and health wise. Using their trajectories, they need to interrupt the dispersion of the ash cloud over the 48 hours period and make an additional 24 hour prediction of that cloud. Finally, they will create an evacuation plan for the populated areas that could receive the worse damage from the eruption. They would need to check the EPA website and local state websites to check if their plan correlates with these agency's evacuation plans. They will also need to create a cleanup plan for the areas affected the most and also check with EPA and local state websites, just as with the evacuation plans.

Extension:

We will then use the following website http://www.hpc.ncep.noaa.gov/dailywxmap/index.html and look at upper atmospheric wind patterns at different times of the year. They will need to write some quick observations on how wind patterns could change the trajectory and explain why and how these eruptions could be different due to the winds.

Evaluation:

	5	3	2	1
Trajectory Models	Both Volcanic Ash and Trajectory Models are accurate with each other	One or two data do not match up with both models	More then two data do not match up with both models	All data of the models are inaccurate with each other
Trajectory Maps (x2)	All maps are present and accurately line with the trajectory models	One or two of the maps do not line up with models and all maps are present	More then two maps do not line up with models and some maps are missing	None of the maps line up with the models and more then 4 maps are missing
Damage Report (x2)	All aspects are included and accurate	All aspects are included but there are some inaccurate conclusions	Missing one or two aspects and some inaccurate conclusions	Over two aspects missing and more then three inaccurate conclusions
Evacuation Plan	Well developed	Somewhat developed	Not well developed	Not well developed and not realistic
Clean-Up Plan	Well developed	Somewhat developed	Not well developed	Not well developed and not realistic
Grammar	No spelling or grammar mistakes	1-3 spelling or grammar mistakes	4-6 spelling or grammar mistakes	Over 7 spelling or grammar mistakes

Take a moment to observe the picture.

Now, describe what you are looking at in your journal.

Remember; focus more on your explanation than having the right answer (if there is one).

Think about the following, and then write a response:

What if there was a major city under this cloud? What kind of concerns would there be, if any? Think in terms of environmental and health.

Be ready to share your thoughts with the class

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Purpose:

Your goal to create a trajectory path of a volcanic eruption in the United States and show it's affect on both the environment and human health. You will be using several programs to create your scenario, including HYSPLIT and Google Maps. With your trajectory you will put together a damage report, evacuation and cleanup plans with this zone.

Essential Questions:

1. What are the health concerns with volcanic eruptions?
2. What are the main pollutants and chemicals during a volcanic eruption?
3. What are the environmental concerns with volcanic eruptions?

Exploration:

Step 1:

In the computer lab you will need to follow the following steps:

- Go to http://www.arl.noaa.gov/HYSPLIT.php
- Click on the HYSPLIT for Volcanic Ash link.
- Next, click on the Run HYSPLIT model (volcanic ash) link
- Click on the Compute volcanic ash concentrations link.
- Under the -------Forecast Data------- drop bar, click on the GFS (0-84h, Global) and hit next.
- Now, choose a volcano.
    - Your only requirements are that your volcano needs to be found in the continental United States, Canada, Alaska (Aleutian Islands) or Hawaii'.
- On the next page, set the day as if it was two days ago,
    - Set the time to your choice
    - Set the Total Run Time (hours) to 48h and keep the rest the same
- Click on Request Dispersion Run bottom.
    - Under the results, choose on the following options (0, 1, 2, and 3) from the .gif drop box
        - You will have to do a model for options (1, 2, and 3)
- Print your forecast for each result (1, 2, and 3). This will have to be done one at a time.

Next,

- Go back to http://www.arl.noaa.gov/HYSPLIT.php
- And now click on Run HYSPLIT with archived data
- Click on Compute trajectories link.
- Click on GDAS (global, 2005-present) link
- Then the current7days link.
    - You will need to only have one trajectory starting location.
- Using the coordinates from your previous model, you will need to plug in the appropriate latitude and longitude numbers. On this page, you will need to put in the same date and time as the previous model, the Total run time (hours) should be at 48h, your start height should be the same as the elevation as their volcano (convert feet to meters).

    - Change the Zoom factor to zero (far) and the Graphic size to 120
- Click on the Request trajectory bottom to run the model.
- You will need to print this model too.

Next,
- Go to Google Maps.
    - Here, you will need at least two maps.
- The first set of maps needs to follow the line of trajectory that the models showed
- The other map needs to have both your volcano and your hometown included
    - When your map is set, select the print screen bottom. Open up Print from the Start Menu and paste your screen here. You will need to cut out the map you want, open a new Print and paste it here. Using the tools bar, create a line of trajectory, using your models you have already printed. Each map section you have needs to have this done.
- All of these maps need to be printed.

Step 2:
Back in the room and out of class;

You will be creating a damage report for a zone within your plume trajectory. These reports need to focus on the SO_2 and CO_2 content for the ash cloud. You need to figure out where, why and how SO_2 may form into H_2SO_4. Make sure to thoroughly explain the process this chemical change will have on the atmosphere. Explain what kind of environmental and health hazards could occur and what the overall damage could be (don't forget to talk about where it may take place). For accuracy, use the USGS website to find the following of your volcano:
- chamber size (if available)
- eruptive history
- chemical make-up (in terms of SO_2)
- mineral deposits
- magma type (felsic or mafic)

This will help you determine the amount of SO_2 that would be present during the eruption.

Next you need to create an evacuation and a cleanup plan for your zone of fallout. Be creative! But make sure you are realistic with your plans. After you have created both, check the EPA, FEMA and local state websites to check if your plans are in compliance with the actual plans. Write a brief statement at the end of each of your plans summarizing what would actually work and not work according the governments. Explain why.

Step 3:

Finally, back in the computer lab, you will go to http://www.hpc.ncep.noaa.gov/dailywxmap/index.html. Here you will need to find maps of upper atmospheric winds from all of the four seasons. Looking at your current season first, explain the correlation between your ash plume and wind patterns for that day. Next, compare and contrast your season with the other three. Make observations about how different (if at all) your ash plume would be if your volcano erupted during a different time of the year. How would this affect your damage report and plans you have created? Seeing these differences, what changes should be made to your report and plans? Why?

Further Inquiry (if time permits):

Using HYSPLIT again, repeat the processes you used before (all the same data) to recreate your ash plume and trajectory. This time, use the other databases. Explain the differences (if any). Is there something wrong with the other databases? Is using the other databases good or bad for helping to predict ash cloud fallout and hazards involved? Explain. Also, run a few dispersion models. How can this help us? Why?

Project Timeline:

- two days in the computer to gather your information
- one day in class to put data together
- final work will be due 4 days later (out of class work time)

Final Work:

To be handed in (40 points):

- trajectory model and the three ash cloud fallout models
- Damage Reports (minimum of 4 pages)
- Evacuation Plan (minimum of 2 pages)
- Cleanup Plan (minimum of 2 pages)

To be done in your composition notebook (30 points):

- observations on seasonal changes (thoroughly done and all questions answered)
- comparison with other databases (thoroughly done and all questions answered)

Total Points: 70 points

Volcanic Plumes: Beautiful yet Deadly Rubric

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