Climate Change: Ice Cores and Other Evidence

EPSCoR Nevada Education Project
Grade Level – Middle and High School

Purpose: In order to gain a better understanding of past climates, students will create and analyze ice cores.

Background: Ice cores contain an abundance of climate information --more so than any other natural recorder of climate such as tree rings or sediment layers. Although their record is short (in geologic terms), it can be highly detailed. An ice core from the right site can contain an uninterrupted, detailed climate record extending back hundreds of thousands of years. This record can include temperature, precipitation , chemistry and gas composition of the lower atmosphere, volcanic eruptions, solar variability, sea-surface productivity and a variety of other climate indicators. It is the simultaneity of these properties recorded in the ice that makes ice cores such a powerful tool in paleoclimate research. (National Ice Core Laboratories web site: http://nicl.usgs.gov/). This activity was adapted from T.E.A. Classroom Activities (2008) for use in the 2011 EPSCoR Northern Nevada Summer Global Climate Change Science Institute for Washoe County Science Educators at University of Nevada, Reno.

Objectives: Students will be able to:

1. Create an ice core for a particular climate zone;
2. Analyze and compare ice core data;
3. Translate (infer) the ice core analysis to create a mental picture of the environment at different time periods in the ice core;
4. Write a summary of the change over time regarding the climate/environment that one particular ice core depicts.

Overview

Students investigate climate changes going back thousands of years by graphing and analyzing ice core data from Greenland and Antarctica. They use information about natural and human-caused changes in the atmosphere to formulate predictions about the Earth's climate.

Students will:

- create a graph.
- explain the pattern of data on a graph.

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- make predictions that go beyond the data.
- analyze and discuss the relationships among data on different graphs.
- explain how ice cores provide information about Earth's past atmosphere and climate.
- describe how natural and human-related (anthropogenic) factors can affect climate.

Procedures

1. Assign each group of students an anonymous ice core location, only latitude/longitude is given as a clue to its identity. The ice cores have temperature and CO_2 (or any other greenhouse gas, if CO_2 is unavailable) data available from 18,000-7000 years ago obtained from the NOAA Paleoclimatology website (more info) .
2. The data (CO_2 and temperature) will be given to the students in an Excel spreadsheet at the beginning of the lab and the students must make a graphical representation of the data to analyze and interpret.
3. The students also will use the NOAA website and the latitude/longitude that was given to determine where their core is from and when it was collected.
4. The students will then present all of their data and interpretations to the class.
5. After the presentations, the groups will use data from the Carbon Dioxide Information Analysis Center to make a graphical representation of the current available atmospheric CO_2 concentrations nearest to their specific location and will compare it to the past levels found in ice cores.
6. Students will answer several questions in writing throughout the lab.

Goals

Students should be able to do the following:

- Understand the link between CO_2 (or greenhouse gases) and temperature
- Be able to work with real data
- Be confident in searching the NOAA website
- Create graphs in Excel
- Perform qualitative analysis and interpretation of the ice core data

Assessment

The assessment will be done on the questions answered by each group throughout the lab.

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1. What correlation did you find between temperature and CO_2 from the ice core data?
2. What fluctuations did you see in your core?
3. How did your data compare with the other groups' data?
4. What are the implications on future temperatures based on the current CO2 levels seen in your ice core data?

National Standards

Content Standard K-12: Unifying Concepts & Processes

Content Standards 5-8: A, B, D ,F, G

Content Standards 9-12: A, D, F, G

Nevada Standards:

N.12.A.2 Students know tables, charts, illustrations and graphs can be used in making arguments and claims in oral and written presentations.

N.12.B.4 Students know scientific knowledge builds on previous information.

L.12.C.2 Students know how changes in an ecosystem can affect biodiversity and biodiversitys contribution to an ecosystem's stability.

E.12.A.2 Students know the composition of Earth's atmosphere has changed in the past and is changing today.

E.12.C Students understand evidence for processes that take place on a geologic time scale

Pre-activity set-up

Teacher should be familiar with the following concepts (see resource links):

- ✓ Ice sheets - large masses of ice thousands of meters thick that cover most of Greenland and Antarctica; form from accumulated snowfall over thousands of years
- ✓ Ice cores - samples extracted from ice sheets; contain traces of air, chemicals, and dust

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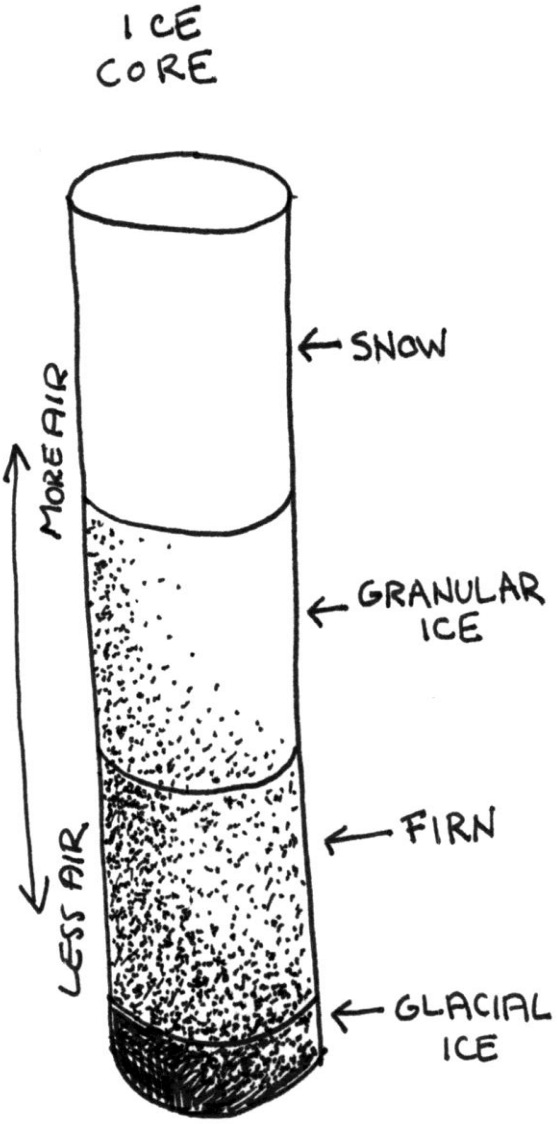
- ✓ Greenhouse effect - the trapping of heat in the atmosphere by carbon dioxide, water vapor, and other gases
- ✓ Global warming - the potential warming of the atmosphere resulting from increases in greenhouse gases due to human activities
- ✓ Students should be familiar with the following concepts:
- ✓ Climate - the average pattern of temperature and precipitation
- ✓ Atmosphere - the layer of gases surrounding the Earth; mostly nitrogen and oxygen with small amounts of carbon dioxide and other gases

Materials

- world map or globe

Each small group of 3 - 4 students will need:

- graph paper - 2 sheets
- poster paper - 1 sheet
- copies and/or transparencies of the graph template - 1 sheet
- ice core data set - 1 copy
- graph of recent data
- markers
- colored modeling clay - small block
- clear plastic straw (fast food variety)



Lesson Duration

Approximately one week ~ 4 to 5 hours of class time

1. Engagement and Exploration Modeling ice sheets and cores with clay and straws - 30 minutes

2. Explanation Students write and draw what they learned - 15 minutes

3. Elaboration

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a. Graphing and analyzing ice core data Making predictions about recent trends - 1 to 2 hours
b. Group presentations of graphs and predictions Discussion of the relationships between different sets of data - 1 hour
c. Investigation of recent climate data - 30 minutes

4. Exchange Discussion of human-caused changes in the atmosphere and their effects on the Earth's climate - 30 minutes to 1 hour

Engagement and Exploration *(Student Inquiry Activity)*

1. Organize the class into groups of 3 to 4 students. Distribute a small brick of clay to each group and instruct them to divide it among group members. Have students flatten the clay into a thin layer.

2. Explain that layers of clay will represent annual layers of snowfall in cold, polar regions.

3. Have students come up in turn and place their clay on a flat surface. (You may choose to do the demonstration on a map or globe.) Each layer should be placed on top of the previous layers.

4. Explain that constructing the mound of clay simulates the formation of an ice sheet from accumulated snowfall over thousands of years.

5. Explain that the deep layers in the ice sheet contain information about the atmosphere and climate from long ago. Ask how scientists might be able to access that information. Explain that we are going to use straws to simulate the drilling and removal of ice cores.

6. Give each group a clear, plastic straw. Have each group simulate the recovery of an ice core. By pressing the straw straight down through all layers of the clay and carefully pulling it out they should obtain a core with visible layering.

7. Discuss which parts of the core represent the youngest and oldest layers of ice. Ask students to describe any differences they see in the layers. Have students speculate on why actual ice layers may have different properties, appearance, or thickness.

8. Display and describe ice core images.

Explanation

Have each student write and/or draw in response to the following questions:

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- What are ice sheets and how do they form?
- What are ice cores and what might they be used for?

Elaboration *(Polar Applications)*

Each group is now a science team responsible some actual ice core data. Their task is to graph, analyze, and report on their particular set of data. The information comes from the GISP2 ice core from Greenland and the Vostok core from Antarctica. You might want to have students find these locations on a map or globe. Both cores extended down a few thousand meters into the ice sheet providing information dating back over 100,000 years BP (before the present). Some data sets indicate the amount of different chemicals (methane, carbon dioxide, sulfate, nitrous oxide) that were present in the atmosphere. Data is also provided on past temperatures, determined by measuring the ratio of oxygen isotopes in the ice. The data represents natural changes in Earth's atmosphere and climate.

Provide each team with one set of data. More than one team may get the same data. You may choose to have each group produce their graph on a large piece of poster paper (lined or grid paper works best). This will allow them to display their graphs for presentation and comparison of the data. You may want them to use the graph template either on a transparency or on paper that can be made into a transparency later. Transparencies will allow you to overlay graphs from different teams for easy comparison.

After finishing the graph, each team should discuss and record the following:

- description of the data including any trends, patterns or cycles they might discern. They should share the unit of measurement (e.g. ppbV - parts per billion of volume) and the magnitude of any changes
- prediction and rationale for what they expect the data might look like from the last point on their graph up to the present

· Have each team give their presentation to the class. These should include:

- displaying the graph
- presenting the analysis
- sharing the prediction and rationale

Challenge the class to find any relationships between the data on different graphs. They might look for:

- similar patterns of temperature between the Greenland and Antarctic cores.

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- a relationship between temperature and levels of greenhouse gases (carbon dioxide, methane, nitrous oxide).
- a negative relationship between temperature and sulfate levels. Discuss the meaning or potential reasons for these relationships.

Distribute and/or display the graphs that show recent data for gases and temperature. The rapid increases in some gases over the last couple centuries are examples of anthropogenic effects linked to human activities. Have each team record a description of the data and an evaluation of their prediction. These may be shared with the class.

Exchange (*Students Draw Conclusions*)

Have the class share their thoughts about the recent data. The following questions can be used to guide the discussion:

- How have human activities resulted in the rapid rise in the levels of these gases?
- How has the Earth's temperature changed over the last 1000 years? 140 years?
- Have increased greenhouse gases caused temperature levels to increase?
- How might sulfate in the atmosphere affect climate?
- What natural factors may affect the future climate?
- What effect might climate change have on our lives and those of future generations?
- Should we do anything about the possibility of global warming?

Evaluation

Students may be evaluated based on:

- Participation in group activities and class discussions
- Quality of the graph produced
- Presentation of the data with a logical analysis and reasonable prediction
- Written or oral explanation of how ice cores are used to learn about climate
- Written or oral description of how natural and human factors affect climate

References

Malnor, C.L. (2008). A Teacher's Guide to How We Know What We Know About Our Changing Climate: Lessons, Resources, and Guidelines About Global Warming. DAWN Publications.

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