Global Warming

Category

Mathematics, Technology, Science

Real World Connection

Climate, Future Planning, Research

Materials

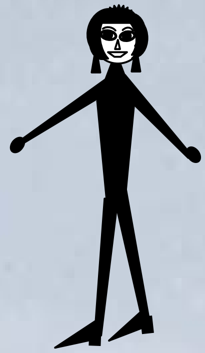
NOAA Paleontology: Vostok Antarctica Ice Core Data, Graph Paper (Both Included)

Problem Question

Is our global climate warming?

Prior Knowledge What I Know	Conclusion What I Learned
Based on your prior knowledge, answer the problem question to the best of your ability.	*Answer the problem question after completing the activity.*

Background



Should I bundle up to face the cold? Will today be sweltering hot? Maybe the temperature will be just right?

In an attempt to anticipate temperature changes and to ensure our personal comfort, people around the globe keep temperature records. The earliest records of temperature made by thermometers date back to the late 1700's in Europe. Over time, thermometers were improved and a network of temperature collection stations developed world-wide. Today, we have satellite-derived temperatures as well as ground based temperatures.

Before people had thermometers, indeed before any temperatures were recorded, Earth itself, kept temperature records. Secure in its "deep freeze" and sequestered over time, records of past temperature, precipitation, atmospheric gases, and other matter can be found stored in ice.

To reveal these clues to the past, researchers drill into the ice -- glaciers and ice caps -- and remove cylinder shaped samples of ice called ice cores. The first and deepest ice core drilling occurred at Vostok, a research station located in Antarctica. From the Vostok ice core samples and other ice core drillings, researchers can determine temperature and the amount of trace gases in Earth's atmosphere dating back over 400,000 years ago.

Drilling to remove an ice core

Sawing the ice core into pieces that can be easily moved

The Carbon Cycle

A natural cycle whereby plants take in CO_2 and give off oxygen (O_2), and animals reverse this process by taking in O_2 and emitting CO_2. In addition, some CO_2 dissolves in seawater where it is used by plants during photosynthesis, and by other seawater organisms to produce calcium carbonate ($CaCO_3$) shells.

Why should we invade the depths of Earth's frozen interior?

Investigating Earth's air temperature and the amount of carbon dioxide in the atmosphere over a long time period helps us to better understand Earth's carbon cycle. As a natural process, the carbon cycle helps to control the amount of CO_2 in the atmosphere. (See "The Carbon Cycle" activities).

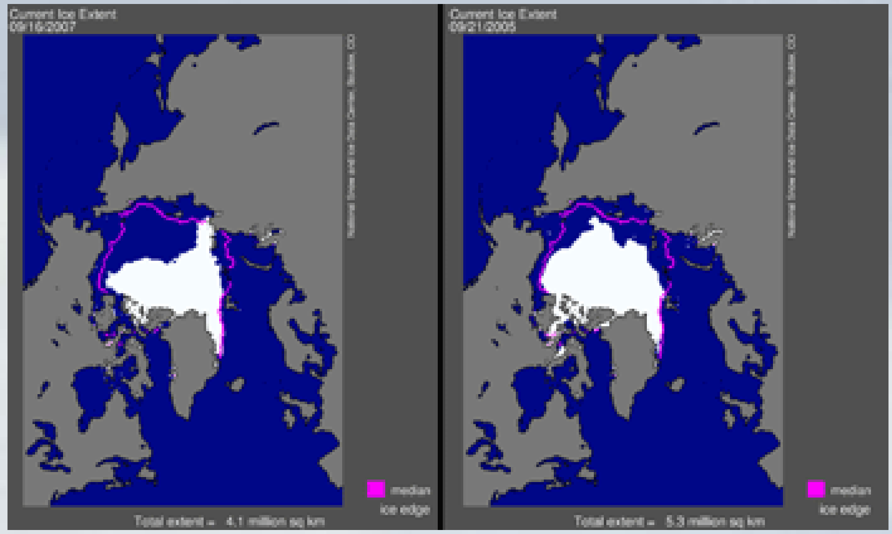
Over time, especially since the Industrial Revolution began (1750), the carbon cycle has been complicated by human activity. With increasing numbers, we drive automobiles, heat or cool buildings, and produce consumer goods – increasing the amount of CO_2 in the atmosphere and upsetting the carbon cycle.

What are "fossil fuels"?

Coal, oil, natural gas!

Fossil fuels are formed from the decay of plants and animals deep underground for millions of years. As the coal, oil or natural gas burns, energy that had been stored is released. In the U.S. fossil fuels provide close to two-thirds of our electricity, and all of our transportation fuels.

Sea ice extent for September 16, 2007 (left), compared to previous record low (right). The thin line around the ice shows the mean (average based on the period between 1980 – 2000) ice extent.



To understand global warming – its causes and implications for the future -- we need to unravel the intricate relationship between humans and the carbon cycle. Analyzing the link between atmospheric temperature and CO_2 concentration in the past is one step toward understanding of the present and predicting our future climate.

Definitions

Temperature anomaly – temperature change from normal for this data set (-56 degrees C)
Paleoclimate – climate in past ages
Ice extent – the distance or area (or volume) over which ice is located

Procedure

Using data from the NOAA National Climatic Data Center (Vostok Ice Core Data for 420,000 Years), follow the directions that follow.

1. In the space provided in Table 9-1, round off the CO_2 concentration to the nearest whole number.
2. In the space provided in Table 9-1, round off the temperature anomaly to the nearest tenth.
3. Number the x-axis of Figure 9-1 from zero to 400,000, from right to left, counting by 10,000's. Label the axis.
4. On the y-axis located on the left hand side of Figure 9-1, number the parts per million for the CO_2 concentration. Begin with 160 at the lower end and number up to 310 ppm, counting by 10's. Label the axis.
5. On the y-axis located on the right hand side of Figure 9-1, number the temperature anomaly. Begin with –9.0 at the lower end and number up to 2.0, counting by five tenths (0.5) of a degree Celsius. Label the axis.
6. Using different colored pencils or different line shapes, plot the points for CO_2 concentration and temperature anomaly.
7. Write a title for your graph.

Thousands of Years Before Present	CO_2 Concentration (ppm)	CO_2 Concentration Rounded to Nearest Whole Number	Temperature Anomaly (Degrees C)	Temperature Anomaly (Degrees C) Rounded to Nearest Tenth Degree
2.34	284.7		-0.00	
10	261.6		-0.28	
20	189.2		-7.62	
30	205.4		-7.95	
40	209.1		-6.91	
50	190.4		-5.18	
60	210.4		-6.53	
70	227.4		-7.84	
80	221.8		-3.66	
90	208.0		-4.69	
100	225.9		-3.45	
110	245.7		-5.53	
120	265.2		-0.86	
130	263.4		+1.47	
140	192.3		-8.99	
150	191.9		-7.34	
160	204.4		-6.25	
170	197.9		-7.01	
180	213.2		-6.34	
190	231.4		-6.49	
200	242.6		-2.68	
210	244.6		-3.07	
220	212.2		-4.31	
230	245.2		-6.15	
240	230.4		-2.12	
250	203.9		-6.52	
260	184.7		-8.30	
270	231.4		-5.95	
280	207.7		-6.17	
290	240.2		-6.00	
300	241.9		-3.08	
310	256.3		-3.32	
320	271.8		-0.12	
330	234.2		-4.90	
340	220.4		-7.44	
350	193.0		-7.64	
360	206.4		-5.80	
370	229.7		-5.42	
380	245.9		-4.88	
390	255.2		-5.34	
400	278.0		-1.64	

Table 9-1. Carbon Dioxide Concentration and Temperature Anomaly Data.

Title:

Figure 9-1. Carbon Dioxide Concentration and Temperature Anomaly Plot Template

Questions

1. What pattern(s) on the graphs do you notice?

2. How many peaks (top) can you identify? How many troughs (bottom)?

3. What is the approximate number of years in one complete cycle? (Hint: A cycle is the time between two peaks or between two troughs.)

4. Do peaks or troughs represent glacial (cold) periods? How do you know?

5. Use your graph (Figure 9-1) and data table (Table 9-1) to fill in Table 9-2. Follow the directions in each column and row of Table 9-2 and fill in where you see a question mark(?). To help you get started, parts of Table 9-2 are completed for you in ***bold italics***.

CO_2 Concentration and Temperature Rate of Change (50,000 – 2000 Years Before Present [BP])

Category / Data Parameter	Beginning Year	Ending Year	Difference in Time Between Beginning and Ending Year	For the Beginning Year	For the Ending Year	Difference Between Beginning and Ending Year = Change	Difference Divided by Mathematical Time Range = Rate of Change
Carbon Dioxide Concentration (CO_2 – ppm)	***50,000 BP***	***2000 BP***	? ____________	CO_2 Concent. is ? _________	***CO_2 Concent. is 285.0 ppm***	CO_2 Change is ? ____________	CO_2 Rate of Change is ? ____________
Temperature Anomaly (Degrees C)	***50,000 BP***	***2000 BP***	? ____________	Temp. Anomaly is ? _________	***Temp. Anomaly is -0.45 °C***	Temperature Anomaly Change is ? ____________	Temperature Anomaly Rate of Change is ? ____________

Table 9-2. CO2 Concentration and Temperature Rate of Change – I.

6. Use your graph (Figure 9-1) and data table (Table 9-1) to fill in Table 9-3. Follow the directions in each column and row of Table 9-3 and fill in where you see a question mark(?). To help you get started, parts of Table 9-3 are completed for you in ***bold italics***.

CO_2 Concentration and Temperature Rate of Change (1880 to Present)							
Category / Data Parameter	Beginning Year	Ending Year	Difference Between Beginning and Ending Year	For the Beginning Year	For the Ending Year	Difference Between Beginning and Ending Year = Change	Difference Divided by Mathematical Time Range = Rate of Change
Carbon Dioxide Concentration (CO_2 – ppm)	***1880***	***Present (2000)***	? ____________	***CO_2 Concent. is 291.0 ppm***	***CO_2 Concent. is 370.0 ppm***	CO_2 Change is ? ____________	CO_2 Rate of Change is ? ____________
Temperature Anomaly (Degrees C)	***1880***	***Present (2000)***	? ____________	***Temp. Anomaly Is -0.51^o C***	***Temp. Anomaly is $+0.36^o$ C***	Temperature Anomaly Change is ? ____________	Temperature Anomaly Rate of Change is ? ____________

Table 9-3. CO2 Concentration and Temperature Rate of Change - II

7. What is the mathematic time range in Table 9-2? Table 9-3?

8. Does Table 9-2 or Table 9-3, both tables, or neither table show a warming trend? Explain.

9. What trend, upward or downward, are we currently experiencing?

10. What is the change in the temperature anomaly between 1880 and 2000?

11. In 1971, the globally averaged CO_2 concentration was approximately 330 ppm. If the current CO_2 concentration is about 384 ppm, calculate the amount of increase per year.

12. What is happening to the rate of change for CO_2 concentration and temperature anomaly over time?

Challenge: Use the Internet to answer the following question.

13. What factors other than CO_2 concentration might affect global temperature?
(Hint: Use your web browser to search for **"climate forcing"**.

FYI (Courtesy of NOAA)

Why are temperature anomalies used instead of the absolute temperatures that we ordinarily use? An analogy using human body temperatures might help to explain why anomalies are useful. The "average" human body temperature is about 98.6 deg. F. But some people have lower normal temperatures than others. For someone with a normal body temperature of 98.0 deg. F., a temperature reading of 98.6 deg. would indicate a fever. The use of 98.6 deg. alone would not indicate this condition to most people but the use of an anomaly or departure from the normal body temperature for this person (+0.6 deg. F) would indicate the feverish condition.