This protocol is meant to augment a 9th grade Earth Science class, in the atmospheric section of the curriculum.

Weather vs. Climate

In this activity we are going to discuss the difference between weather and climate. To do this, the class is going to take weather data (temperature, relative humidity, pressure, dew point, and precipitation) for a two-week period, or as long as the teacher would like. After the two-week period is up, the students' job is to construct a graph of the data. Then using the Cornell Meteorological station, http://www.nrcc.cornell.edu/climate/ithaca/, the students can graph temperature data as a monthly average for the last two years. In addition students can make a graph showing a yearly average for the last 50 years, using data from the Meteorological Station gathered in the attached Excel spreadsheet as "yearly worksheet". These three graphs are then the centerpiece for a class discussion. In early piloting efforts, the class was divided up into several groups and each group filled out the worksheet. Once they finished, each group presented its answers to the last two questions. From there the rest of the class was spent discussing data analysis, with a focus on time scale and averaging (to examine effects on each graph), and on the difference between weather and climate.

Name: _____   Period:_____
Name: _____
Name: _____
Name: _____
Earth Science Assignment # 22   Due: _____

Graphic Analysis

　　　　Your job today is to work together as a group of scientists and interpret the meaning of the graphs that you constructed last night. One worksheet can be turned in for each group. Each group will present their answers to the class.

1. Does the graph of temperature for the last two weeks show warming, cooling, or no change?

_____

2. Does the graph of temperature for the last two years show warming, cooling, or no change?

_____

3. Do these graphs represent the weather of Ithaca or the climate of Ithaca?

_____

4. Compare your own graphs to the graph of temperature for the last 50 years.

　　What can explain the differences in the graphs?

_____

_____

_____

_____

_____

5. Do you think that the climate in Ithaca is warming? Why or why not?
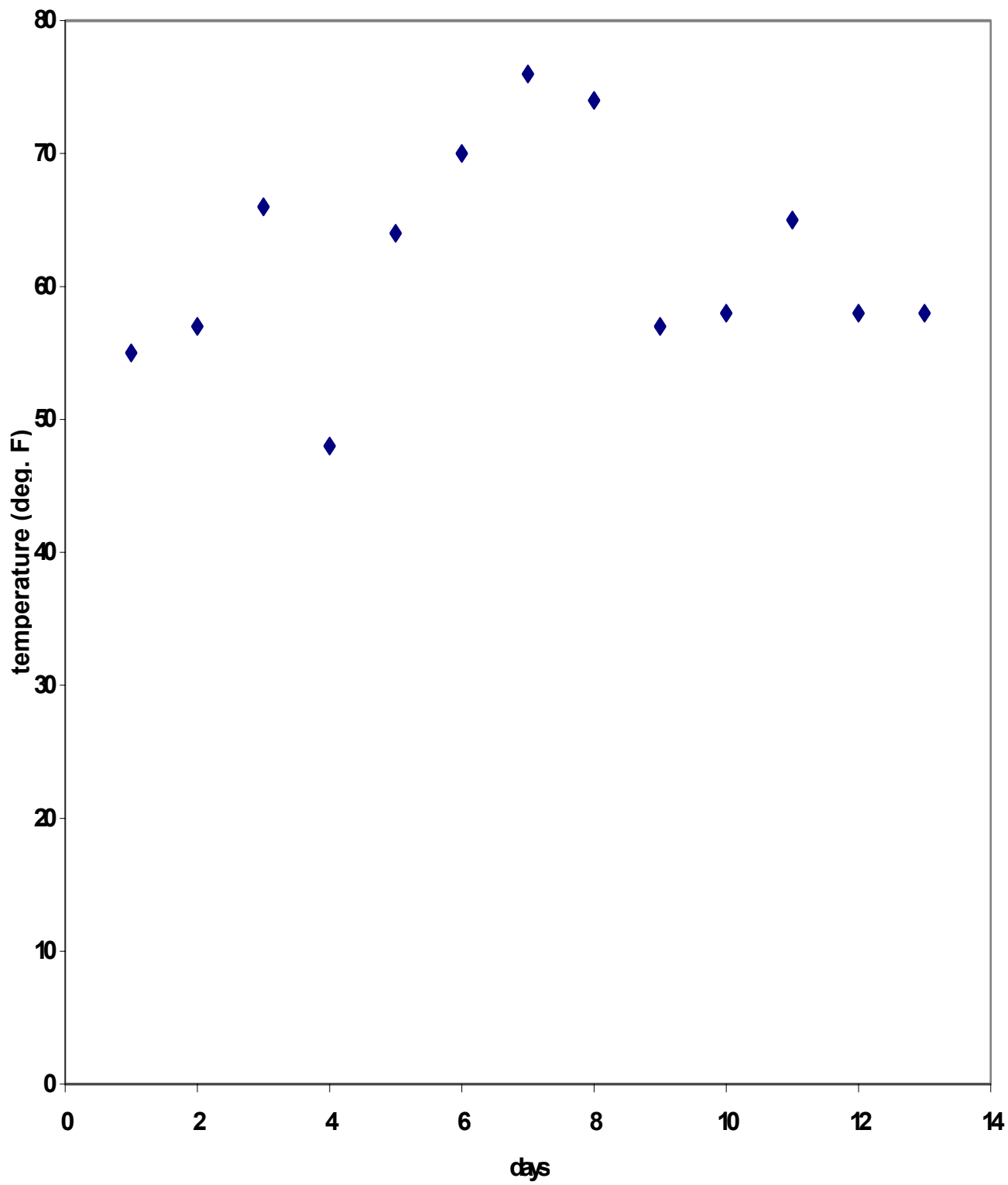
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6. Now what about global warming…do you think that global warming is occurring?

Do you think the Ithaca data give us enough information to draw a sound scientific conclusion about global warming?
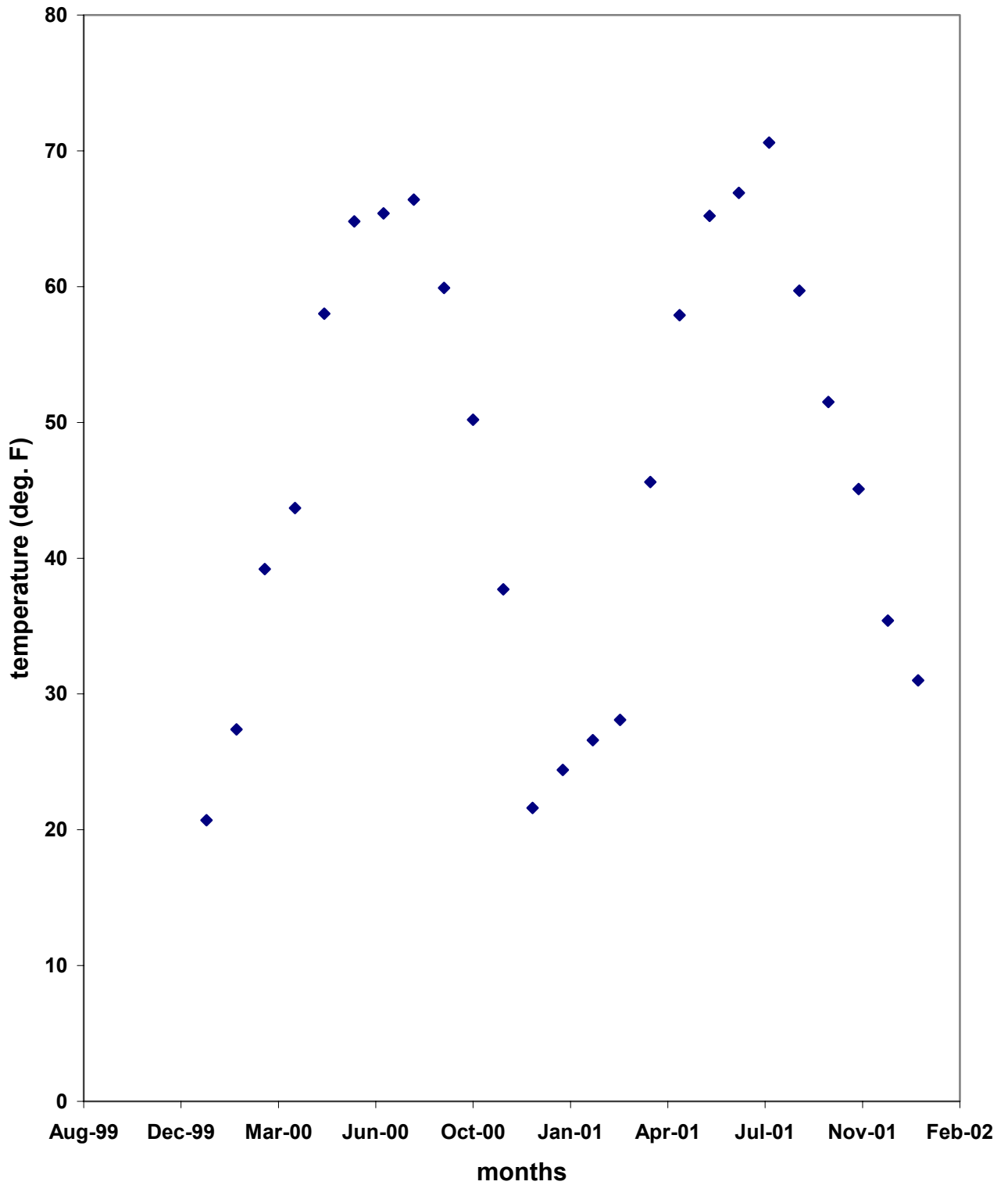
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Ithaca Average Temperature - 1950 - 1996
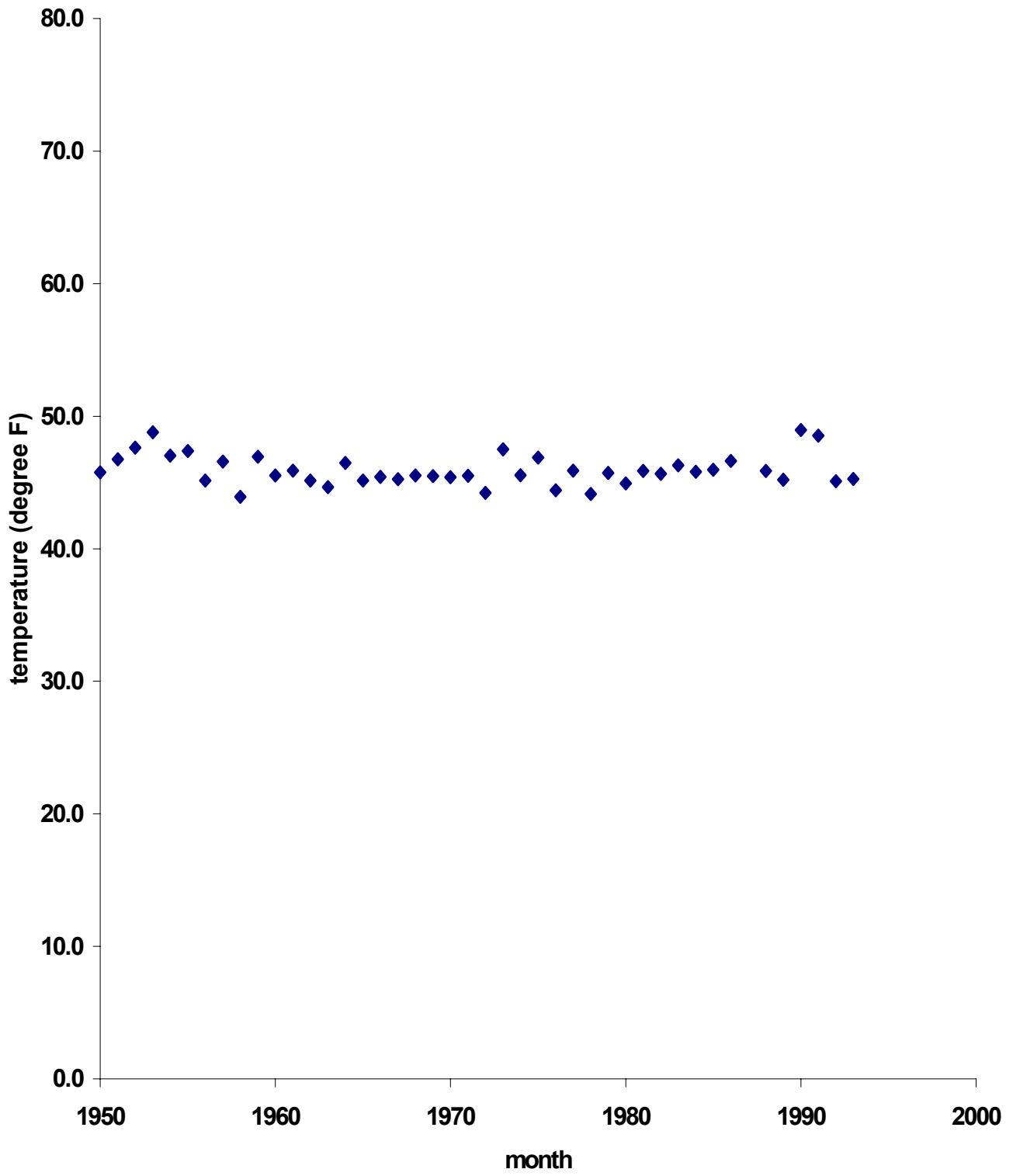
Ithaca average temperature May 2002

Ithaca average temperature 2001-2002

Understanding Changes in CO_2 in the Atmosphere

One important piece in the discussion on climate change is the atmospheric concentration of carbon dioxide. Many people look at data collected from the last century and assume that they provide conclusive proof that climate change is occurring. While an upward trend can be seen from the last 50 years, scientists cannot make such conclusions. They must understand how CO_2 has changed in the past to understand the observations that they currently make and upon which they make further predictions.

In this computer activity, students will use real data sets from the Mauna Loa Atmospheric Observatory, and the Vostok Ice Core to make graphs of CO_2 concentration in order to develop both computer skills and a reference from which to draw conclusions about the issue of climate change.

The following are instructions for downloading the data sets into Excel. To do this method Excel 2000 is needed.

- Go to http://cdiac.esd.ornl.gov/trends/co2/sio-mlo.htm
- Link to Digital Data
- **CTRL-A** (select all)
- Open Notepad (from start menu)
- **CTRL-V** (paste)
- Open Excel
- Under Data
  - Go to Get External Data and Import Text File
  - Select notepad file
  - Choose delimited
  - Click Next>
  - Choose space
  - Click Finish
  - Click OK

Select "Copy" and then "paste special" to transpose the monthly data from each line to get all the data. An easier approach is to graph the annual mean concentration with the year:

- Press the Chart Wizard button on the excel toolbar
- Choose X-Y scatter from menu on the left
- Click Next>

- Go to the Series tab
- Click on the graph symbol to the right of X-values
- Highlight the column with year
- Press Return
- Click on the graph symbol to the right of Y-values
- Highlight the column showing annual mean concentration
- Press Return
- Click Next>
- Go to the Titles tab, and give a name for the chart and each axis
- Go to the Legend tab, and remove the Show Legend mark
- Click Next>
- Now choose to place chart "In A New Sheet"
- Click Finish
- Double click on the axes to change the scale (y-axis should be 300-400)

- Go to http://cdiac.esd.ornl.gov/trends/co2/vostok.htm
- Link to Digital Data
- **CTRL-A** (select all)
- Open Notepad (from start menu)
- **CTRL-V** (paste)
- Open Excel
- Under Data
  - Go to Get External Data and Import Text File
  - Select notepad file
  - Choose delimited
  - Click Next>
  - Choose space
  - Click Finish
  - Click OK

- Highlight the third and fourth columns, corresponding to age of the ice, and concentration
- Press the Chart Wizard button on the excel toolbar
- Choose X-Y scatter from menu on the left
- Click Next>
- Click Next>, again
- Go to the Titles tab, and give a name for the chart and each axis
- Go to the Legend tab, and remove the Show Legend mark
- Click Next>
- Now choose to place chart, In A New Sheet
- Click Finish
- Double click on the axes to change the scale

In addition, the Excel spreadsheet contains the graph and usable data sets under the "Mauna Loa" and "Vostok" tabs.

Greenhouse Gases

According to the National Academy of Sciences, the Earth's surface temperature has risen by about 1 degree Fahrenheit in the past century, with accelerated warming during the past two decades. There is new and stronger evidence that most of the warming over the last 50 years is attributable to human activities. Human activities have altered the chemical composition of the atmosphere through the buildup of greenhouse gases – primarily carbon dioxide, methane, and nitrous oxide. The heat-trapping property of these gases is undisputed although uncertainties exist about exactly how earth's climate responds to them.

Energy from the sun drives the earth's weather and climate, and heats the earth's surface; in turn, the earth radiates energy back into space. Atmospheric greenhouse gases (water vapor, carbon dioxide, and other gases) trap some of the outgoing energy, retaining heat somewhat like the glass panels of a greenhouse.

Without this natural "greenhouse effect," temperatures would be much lower than they are now, and life as known today would not be possible. Instead, thanks to greenhouse gases, the earth's average temperature is a more hospitable 60°F. However, problems may arise when the atmospheric concentration of greenhouse gases increases. Since the beginning of the industrial revolution, atmospheric concentrations of carbon dioxide have increased nearly 30%. These increases have enhanced the heat-trapping capability of the earth's atmosphere.

Why are greenhouse gas concentrations increasing? Scientists generally believe that the combustion of fossil fuels and other human activities are the primary reason for the increased concentration of carbon dioxide. Plant respiration and the decomposition of organic matter release more than 10 times the CO_2 released by human activities; but these releases have generally been in balance during the centuries leading up to the industrial revolution with carbon dioxide absorbed by terrestrial vegetation and the oceans.

What has changed in the last few hundred years is the additional release of carbon dioxide by human activities. Fossil fuels burned to run cars and trucks, heat homes and businesses, and power factories are responsible for about 98% of U.S. carbon dioxide emissions. Increased agriculture, deforestation, landfills, industrial production, and mining also contribute a significant share of emissions. In 1997, the United States emitted

about one-fifth of total global greenhouse gases.

Sea Level Change

With increasing temperatures come higher sea levels. Sea level has risen worldwide approximately 15-20 cm (6-8 inches) in the last century. This happens because the polar ice sheets melt more and more each year with global warming. In addition warm water is less dense than cold water so warm water actually expands to increase the volume of the ocean. Last year a chunk of ice the size of Connecticut broke off from Antarctica. Over 2 billion people live near the coast, so any sea level change could have tremendous impacts. So what do we do with those people and the cities that they inhabit, if global warming continues to raise sea levels?

Read Article on Coastal Response to Climate Change from EOS (American Geophysical

Union) Vol. 82 number 44 Oct. 30, 2001 p.513

Questions:

- What is happening to current sea levels?

- Is the issue of coastal change important? Why or why not?

Computer Exercise

Using what you know about scientific projections of sea levels. Make a map showing the possible change in sea level, and suggest what impact that might have on cities in the US.

- Go to http://atlas.geo.cornell.edu/education/student/web_tools.html#

- Launch the Quest program. This program collects data from immense data sets and may take a minute to load.

- From the Menu

  - Choose Region, and set the map for the United States

  - Choose Topography, and set the sea level to what you think sea level will be in 50-100 years.

  - Click on "Get Map"

  - Print a map out and use this to determine what the possible impact of sea level change would be on the US.

Other possible activities:

Local Indicators of Climate Change

One possible area for classroom research is to start making measurements of things like date of first frost, determining times of bird migration, etc. Bird migration data from the past may be available from the Cornell Ornithological Lab. Use this information to determine if the class can start to draw any conclusions from the data, and talk about what is needed before scientists/students can make any statements about what their observations show them.

Effects on Ecosystems

Jigsaw Activity

Create 4 different stations each with a different ecosystem (e.g., Tropical rain forest, temperate forest, savannah or plain, arctic tundra). At each station include statements about current biodiversity, climate, and human interaction, and possible outcomes from increased temperature on those parameters. Form groups of four, with one group member at each station. Then have each group meet together and teach each other about the major points from their respective station. Finally conclude with a discussion of the importance of biodiversity, and the consequences that climate change could evoke in different areas, particularly your own.

Final discussion:

To bring all this work together, a final class period could model the IPCC, the Intergovernmental Panel on Climate Change. The IPCC is part of the UN and is composed of scientists, economists, politicians, and ethicists from every country. As a group they developed the Kyoto Protocol as a way to deal with carbon dioxide emissions, and climate change. By creating a round table discussion, the students can figure out for themselves the best mitigation strategy. By giving the students a sound background in some of the scientific principles associated with climate change, they will create their own opinions. In the ninth grade Earth Science class I used this in, the students stayed past the bell, because they wanted to finish the conversation. It becomes an effective way to give their science class relevance to current events.