ES 106 Laboratory # 8
CLIMATE CHANGE

Introduction

A majority of observations and studies confirm that Earth's climate is rapidly changing, partly as a result of increases in greenhouse gases caused by human activities.

> **The scientific evidence is now overwhelming: climate change presents very serious risks, and it demands an urgent global response.**
>
> **The scientific evidence points to increasing risks of serious, irreversible impacts from climate change associated with business-as-usual paths for emissions of greenhouse gases.**
>
> **Climate change threatens the basic elements of life for people around the world** -- **access to water, food production, health, and use of land and the environment.** (Stern Review, 30 Oct 2006)

Here are some things everyone should know about climate change.

1. Earth's climate has constantly changed. Earth was warmer than it is now throughout much of the geologic past. Ice Ages have happened, and we may be in an inter-glacial period of one now.

2. Possible causes of climate variation and change that takes place over millions of years include shifting continents, volcanic activity, and mountain building. Most of these changes are explained by the theory of plate tectonics.

3. Glaciers have advanced and retreated many times during the past 2 million years. The last inter-glacial period was about 125,000 years ago, and lasted about 25, 000 years. Irregularities in Earth's orbit changes the amount of solar radiation reaching Earth's surface, and could be the main cause of glacier retreat and advance.

4. Volcanic eruptions can cool the global climate (for relatively short periods of time), and fluctuations in solar output (if large enough) can warm or cool the global climate.

5. Human influences of climate change include greenhouse gases and ozone (both warm the planet), and surface albedo and aerosols (both cool the climate).

6. Direct observations of current climate change include increasing global average air and ocean temperatures, widespread melting of perennial and seasonal snow and ice, and rising global mean sea level. From 1906 to 2005 the global average temperature increased 0.74°C, and the trend over the last 50 years has been 0.16°C per decade. The ocean has been absorbing more than 80% of the heat added to the climate system, warming the ocean to depths of at least 3000 m. In Antarctica and Greenland, the ice sheets are losing mass. Sea level rose at an average rate of 1.8 mm per year from 1961 to 2003, and 3.1 mm per year from 1993 to 2003.

7. The main cause of recent global warming (since about 1950) is increasing amounts of greenhouse gases, especially carbon dioxide. The increase in carbon dioxide is due primarily to fossil fuel consumption, with changes in land use also contributing.

8. During the next 20 years the global average temperature is projected to rise about 0.2°C per decade and sea level is expected to continue rising. During the next 100 years the global average temperature is projected to rise somewhere between 1.1°C and 6.4°C, and sea level is projected to rise somewhere between 0.18 m and 0.59 m. It is virtually certain there will be fewer cold days and nights, and warmer and more frequent hot days. It is very likely that the frequency of heat waves and heavy precipitation events will increase. It is likely that areas affected by droughts, the intensity of tropical cyclones, and the incidence of extreme high seas will increase.

9. The Intergovernmental Panel on Climate Change 2007 report considers a number of different emission scenarios, which tells us that what people do does matter. The most probable temperature increase in the next 100 years is somewhere between 1.8°C and 4.0°C, depending on what people do.

Useful Websites

- http://www.giss.nasa.gov/
- http://www.grida.no/climate/vital/index.htm
- http://www.ipcc.ch/
- http://epa.gov/climatechange/kids/carbon_cycle_version2.html
- http://www.physicalgeography.net/fundamentals/9r.html

Name_____

Lab Day/Time_____

Pre-lab Activities – Complete the before coming to lab.

1. Read chapter 20, in *Earth Science, 14th ed.*, by Tarbuck, et al.
2. Define the following terms:
   A. Greenhouse effect:

   B. General circulation of the atmosphere

   C. Stratosphere

   D. Troposphere

   E. Ozone layer

   F. Carbon cycle

3. What gases are involved in the absorption of solar radiation by the atmosphere?

4. How does the wavelength of incoming solar radiation differ from heat reradiated from Earth's surface?

Part A

1. Briefly explain how greenhouse gases affect Earth's temperature (Heating the Atmosphere: The Greenhouse Effect, p.503-504, Fig. 16.23-16.24, Tarbuck, et al., *Earth Science 14th ed.*).

2. Before the Industrial Revolution carbon dioxide concentration in Earth's atmosphere averaged about 280 ppm (refer to p. 623-625, Figure 20.20 Tarbuck, et al., *Earth Science 14th ed.*) and Earth's average temperature was about 32°C warmer than it would be without greenhouse gases (that is to say that greenhouse warming was 32°C). Today carbon dioxide concentration is about 380 ppm. Calculate how much greenhouse warming would be today if greenhouse warming was *directly proportional* to the carbon dioxide concentration. (If you don't have a "feel" for the Celsius temperature scale, convert the temperatures to Fahrenheit.) Show all of your calculations.

3. Clearly this has not happened. Identify two concepts or ideas that might lead to an explanation of why it hasn't happened --or hasn't happened yet. (Think about Earth System Science, p.26-27 of Tarbuck, et al., *Earth Science 14th ed.*, the concept of inertia from basic physics, and the specific heat of water.)

4. Tarbuck, et al., *Earth Science 14th ed.* (p. 631, Table 20.1) quotes a report published in 2007 by the Intergovernmental Panel on Climate Change (IPCC) that says the global average surface temperature increased by about 0.74°C in the twentieth century. What does the latest data from an American government source say? (HINT: See 'useful websites'.)

Part B

Use the data in Table 1 to plot a graph of Average Global Temperature versus Time. Do this on the graph paper provided in this lab, or enter the data in a spreadsheet program, and use it to make tables and calculations. Remember, the spreadsheet can calculate from numbers, like 1920 and 1930, but not from text entries like 1911-1920 and 1921-1930.

Table 1 Average Global Temperature 1881-2005, by decade
Source: Goddard Institute for Space Studies, NASA

Decade	Degrees C	Degrees F
1881-1890	13.81	56.9
1891-1900	13.71	56.7
1901-1910	13.73	56.7
1911-1920	13.79	56.8
1921-1930	13.92	57.1
1931-1940	14.03	57.3
1941-1950	14.02	57.2
1951-1960	14.00	57.2
1961-1970	13.94	57.1
1971-1980	14.04	57.3
1981-1990	14.29	57.7
1991-2000	14.39	57.9
2001-2005	14.65	58.4

5. Use you graph, or the data in the table, to calculate the following (express your results in degrees Celsius per decade (10 years):

a. average rate of warming from 1901-1910 to 1931-1940

b. average rate of cooling from 1931-1940 to 1961-1970

c. average rate of warming from 1961-1970 to 1991-2000

d. average rate of warming from 1991-2000 to 2001-2005.

6. Describe the rate of warming.

7. Compare your graph to Figure 20.22 on p. 625 of Tarbuck, et al., *Earth Science 14th ed.*).

a. Are they similar?

b. Why does the graph in the book show more variability?

8. While you're looking at Tarbuck, et al., *Earth Science 14th ed.*, check out Figure 20.20 on p. 624 and compare it to Figure 20.22 on p. 625.

a. What do you see?

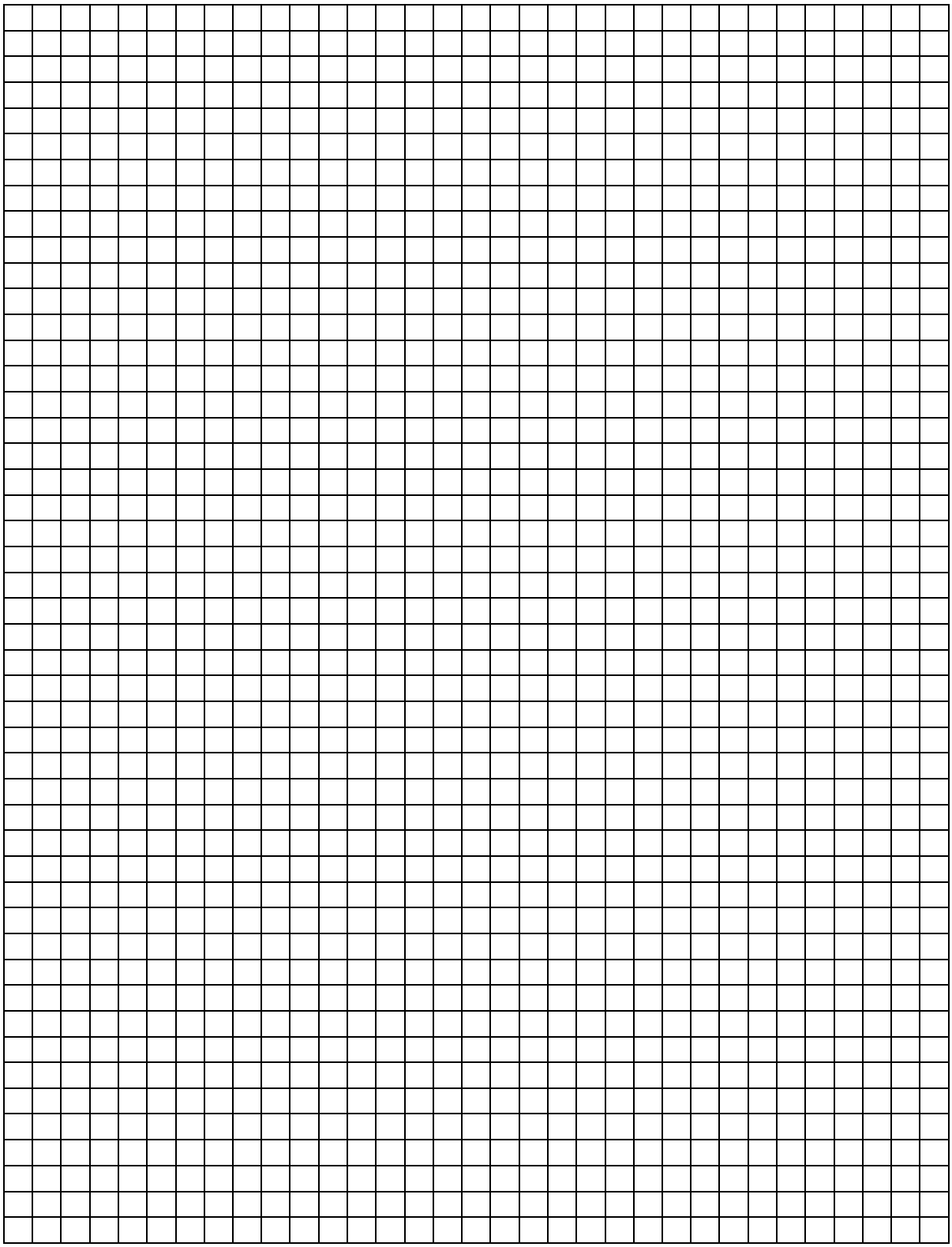
b. Does a correlation prove cause and effect? (We assume you saw a correlation between the two graphs)

c. In this case (carbon dioxide concentration versus average global temperature) does scientific data indicate cause and effect?

9. Plot the data in Table 2 from six locations in the Willamette Valley on one graph. Use colors or symbols to identify location. How do our local temperature trends compare with global temperature trends?

Table 2 Average Temperature 1961-2005, by Decade
Willamette Valley Degrees Fahrenheit
Source: Oregon Climate Service

Decade	Portland Airport	Salem Airport	Eugene Airport	Forest Grove	Dallas	Stayton
1961-1970	53.0	52.0	52.7	53.2	52.1	52.6
1971-1980	53.4	51.8	52.5	52.4	51.8	52.1
1981-1990	54.2	52.4	52.9	52.4	52.2	52.5
1991-2000	54.6	53.5	53.7	53.6	53.1	53.0
2001-2005	54.8	53.3	53.7	53.9	53.5	53.6



Name_____

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POST-LAB ASSESSMENT

1. List five things you can do to reduce the amount of carbon dioxide you release into the atmosphere.

2. What percent of the land surface is presently covered with glaciers?

3. At the present rate of sea level rise, what year will Salem, Oregon (elevation 175 feet) become inundated by the sea?