

**Total points: 100**  
**ATOC 1060-001 Homework #1**

**INSTRUCTIONS: Make sure that you answer all of the questions for maximum credit. Use appropriate units on all numerical answers and answer non-numerical questions with complete sentences. Please write neatly when completing this assignment – if we can't read your answer you will not get credit for it.**

**1. Global Change: Concepts (20pts)**

1a. Write down the three major global environmental changes that are occurring today. (6pts)

The three major global environmental changes that are occurring today are: global warming, ozone depletion, and tropical deforestation. (2 points each)

1b. What is global warming? (2pts) What is greenhouse effect? (2pts)

Global warming is a warming of Earth's atmosphere due to an anthropogenic enhancement of the greenhouse effect.

Greenhouse gases are gases that warm a planet's surface by absorbing outgoing infrared radiation (radiant heat) and reradiating some of it back toward the surface. This process is called the greenhouse effect.

1c. What are the four fundamental components of the Earth system? (4pts)

- i. The atmosphere: A thin layer of gases that surrounds Earth
- ii. The hydrosphere: Composed of various reservoirs of water, including ice
- iii. The biota: Includes all living organism
- iv. The solid Earth: Includes all rocks, including those in both the crust and the mantle.

**Note: 1 point each. The students will get full score as long as they stated the 4 major components. Explanation for each of the component is not required.**

1d. Name four anthropogenic greenhouse gases that are currently increasing in concentration in Earth's atmosphere. (6pts)

- i- Carbon dioxide (CO<sub>2</sub>)
- ii- Freons (CFCs)
- iii- Methane (CH<sub>4</sub>)
- iv- Nitrous oxide, N<sub>2</sub>O

**1.5 point each. The students get full score if they only write down full name.**

## 2. Global change: observational evidence

Figure 1 shows the measurements of atmospheric CO<sub>2</sub> concentrations over the past 1000 years, as determined from ice cores (solid curve) and from direct atmospheric measurements (dashed curve).

2a. Label the “Keeling Curve” and “ice core data” in Figure 1. (4pts) According to figure 1, how much was the CO<sub>2</sub> concentration in 1850 and 1950? (2pts)

The dashed line in figure 1 is known as the “Keeling curve”, and the solid line is from the ice core data.

The students get the full points if they only described in words, or only labeled in the figure.

The CO<sub>2</sub> concentration is about 286ppm in year 1850, and 310ppm in year 1950.  
It had increased by 24ppm from 1850 to 1950.

2b. Based on figure 1, by how much had the Earth’s atmospheric CO<sub>2</sub> concentration increased from 1950 to 2000? (2pts)

The CO<sub>2</sub> concentration is about 310ppm in year 1950, and 371ppm in year 2000.  
It had increased by 61ppm from 1950 to 2000.

For 2a-2b, deduct 1pt for missing one unit. Errors within 5ppm have no point deduction.

2c. Comparing the CO<sub>2</sub> increasing rates that you have obtained from 2a and 2b, during which period CO<sub>2</sub> increased faster, 1850-1950 or 1950-2000? (3pts) What are the main causes for this faster CO<sub>2</sub> increasing rate? (5pts)

Atmospheric CO<sub>2</sub> concentration increases faster during 1950-2000. This faster rate results mainly from the increased combustion of coal, oil and natural gas; and tropical deforestation also contributes.

It’s also ok to say “burning of fossil fuel”. Deduct 1 point if one did not mention “tropical deforestation.”

2d. Figure 1-3 of the textbook also shows a CO<sub>2</sub> increase during 1800-1850. State the major cause of the CO<sub>2</sub> increase during this time period. (4pts)

Deforestation of North America in the 19<sup>th</sup> century contributed to the CO<sub>2</sub> increase during 1800-1850. This is referred to as the “pioneer effect”. [No point deduction if they don’t say “pioneer effect”.]

2e. Figure 2 shows observed anomaly of global average surface temperature since 1861. Negative values indicate temperature below the average and positive values indicate temperature above the average. Based on the mean temperature curve (dark solid line), by how much the temperature had changed from 1861 to 2000? (2pts). Is there a warming or cooling

trend? (3pts) Was the temperature during 1950-1975 below or above the average (2pts)? What was the possible cause for the below or above average temperature during 1950-1975? (3pts)[Accurate to 2 decimal points for numbers.]

Temperature has increased by 0.75C from 1861 to 2000. It is a warming trend. The temperature during 1950-1975 was below the average. Scientists believe that increased aerosols, such as SO<sub>2</sub> in the earth's atmosphere due to heavy industry and volcanic eruption might have reduced solar radiation that reaches the earth's surface, and thus caused the cooling.

2f. What are thought to be the primary causes of the temperature changing trend in figure 2 and why? (10 pts)

The human induced greenhouse gases, such as the increased CO<sub>2</sub> shown in figure 1, are thought to be the primary causes for the warming trend. This is because the increased greenhouse gases enhance the greenhouse effects.

2g. Observations show ozone depletion over the Antarctic region (figure 1-6 and figure 1-7 of the textbook). State how anthropogenic forcing can cause the ozone hole. (10pts) [No point deduction if they don't provide the chemical reaction equation]

Atomic chlorine released from the breakdown of anthropogenic CFCs can react with ozone and produce chlorine monoxide.



Consequently, human-induced CFCs can destroy ozone layer and thus produce the ozone hole.

2h. How does tropical deforestation affect global warming and biodiversity? (8pts)

When the dead tree leaves and branches decay, they release CO<sub>2</sub> to the atmosphere and hence enhance global warming. Tropical deforestation reduces biodiversity (plants and animals).

2i: According to the data shown in Figure 1-10 of the textbook, in the past 800,000 years, how does the Earth's temperature have been changing? (4pts) When is the most recent glacial maximum (the coldest time of the last glacial period)? (3pt) At 350,000 years ago, the Earth was in glacial or interglacial period? (3pt) Our current climate is in glacial or interglacial period? (2pts)

In the past 800,000 years, the Earth's temperature has been going through glacial (cold) and interglacial (warm) cycles, oscillating between cold and warm periods.

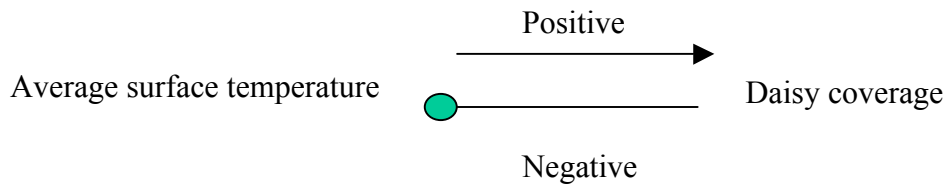
The last glacial maximum is about 21,000 years ago.  
At 350,000 years ago, the Earth was in glacial period.  
Our current climate is in interglacial (warm) period.

### 3. Daisyworld Climate Systems: positive and negative feedbacks

In the Daisyworld climate system, there are mutual influences between average surface temperature of the Earth and the daisy coverage. Assume that an increased surface temperature will increase the daisy coverage.

Draw a schematic diagram (as figure 2-1 panel c of the textbook) showing the feedback loop in responding to a small perturbation - initial increase of the Earth's temperature. In the diagram, use arrows with normal arrowhead to represent positive coupling, and arrows with circular arrowhead to represent negative coupling. (6pts)

The schematic diagram is:



Increased temperature -> increased daisy coverage -> increased albedo -> decreased temperature. [No point deduction if the students only shows the schematic diagram.]

Is the feedback loop you draw in positive or negative? (4pts)

This is a negative feedback loop because the final result of the feedback loop is to damp (reduce) the initial temperature perturbation.