OCEA-01, “The Oceans”

Section Assignment on Climate Change
Climate Change Primer Activity - to be done in section

Introduction:
In this class we discussed Greenhouse Gas Emissions and Global Warming. Because there is little background information in the textbook, this section assignment is designed to allow you to review these basic topics.

Activity: In section, you will review and discuss background information on Greenhouse Gas Emissions and Global Warming. Divide yourselves into groups of 3-4 and each group will be assigned one topic from this list:

1. The Greenhouse Effect & its Culprits
2. Scientific Evidence for Global Warming
3. Potential Outcome (future predictions)
4. What the Skeptics don't tell you
5. Kyoto Protocol

Instructions for each group (You have about 20 minutes to do the following):

A. Your group should read through the material assigned to you (see handouts from the TAs).

B. You should then discuss the material, especially anything that you might not understand fully. If your material includes figures, it would be a good idea to discuss what each figure means. Find the TA and ask questions if there is something you don’t understand.

C. Write down a list of key points. This could be an outline of the material, or a few words that help you understand the main point of each figure or graph.

D. Pick one person to present the material. This person will be in charge of sharing what the group has learned to the entire section.

After about 20 minutes, one person from each group will have about 5 – 7 minutes to present the material from the group to the rest of the class. Any student can ask questions.

In case you want to look at this material later, you will easily find the links.

Go to the web site:

http://www.whrc.org/resources/online_publications/warming_earth/
Activity 2: In section At the recent Copenhagen Summit on Climate Change, the US pledged $100 billion to help mitigate the impact of global warming. However, Congress (and the voters) have not agreed to this, and there is a lot of argument about who should pay, and whether it’s really an issue for the US. The attached chart shows what we expect to happen with climate change based on what countries have already agreed to pay (blue), what we haven’t addressed (red) and what the Copenhagen Summit would address (green). If the US agreed to pay all $100B dollars, we could potentially mitigate (avoid) the impacts shown in the red/orange box. The contributions from other countries and the US could mitigate the impacts in the green box (long-term effects) if we paid MORE than $100 billion.

You will divide into two groups. Group A will argue for NOT paying the money, because we are in a financial recession and it would mean more taxes for everyone in the US. Group B will argue for PAYING the money, because if we don’t these changes will occur. Spend about 10 minutes as a group coming up with arguments for/against spending. Then pick 1-2 people to present to the class, and give your arguments as if you were representing the US at the Copenhagen Summit.
Global mean change from pre-industrial temperature (°C)

Water
- More water available in moist tropics and high latitudes
- Decreasing water availability and more drought in mid-latitudes and semi-arid low latitudes
- 0.4-1.7 billion

Ecosystems
- More amphibian extinction
- More coral bleaching
- Most coral bleached
- Increasing species range shifts and wildfire risk
- About 20-30% species at increasingly high risk of extinction
- Widespread coral mortality
- Terrestrial biosphere tends towards a net carbon source, as:
  - -15% of ecosystems affected
  - -40% of ecosystems affected

Food
- Crop productivity
- Low latitudes: decreases for some cereals
- Mid to high latitudes: increases for some cereals
- All cereals decrease
- Decrease in some regions

Coast
- More damage from floods and storms
- Additional people at risk of coastal flooding each year
- 0-3 million
- About 30% loss of coastal wetlands
- 2-15 million

Health
- Increasing burden from malnutrition, diarrhoea, cardiorespiratory disease and infections
- More morbidity and mortality from heat waves, floods and droughts
- Substantial burden on health services
- Leading to reconfiguration of coastlines worldwide and inundation of low-lying areas

Singular events
- Local retreat of ice in Greenland and West Antarctica
- Long-term commitment to several metres of sea level rise due to ice-sheet loss
- Ecosystem changes due to weakening of the meridional overturning circulation

Impacts avoided by financed adaptation

Unavoided impacts

Impacts avoided by current pledges

Global mean annual temperature change relative to 1980-1999 (°C)
Global Warming (Remember to SHOW YOUR WORK)
Take-Home Activities

Activity 1: Carbon Cycle

1. The average concentration of dissolved inorganic carbon (DIC) in the ocean is 0.024 g per kg of seawater. What is the total amount of carbon stored in the ocean as DIC? Give answer in units of grams.

The mass of water in the ocean is $1.365 \times 10^{21}$ kg.

2. The atmosphere contains $7 \times 10^{17}$ g of carbon as carbon dioxide. Does the ocean or the atmosphere hold more carbon?

Carbon moves between the ocean and atmosphere in the form of carbon dioxide. Figure 1 illustrates how the amount of CO$_2$ dissolved in surface seawater varies with temperature. More CO$_2$ dissolves in seawater as it cools. The equation shown in Figure 1 is the equation that describes the line passing through the experimental data. Using this equation, you can calculate how much CO$_2$ can be dissolved in seawater at any particular temperature.

![Solubility of CO$_2$ in Seawater](image)

**Figure 1**: Solubility of CO$_2$ as a function of temperature for surface seawater. The units of solubility are g/kg = "grams of CO2 per kilogram of seawater."
3. Assuming that the average temperature of the ocean is 4°C, how much CO₂ is presently dissolved in the ocean? Give your answer in units of grams (g).

4. How would the storage of CO₂ in the ocean change if the average ocean temperature was to increase to 10°C?

5. If there was less CO₂ stored in the ocean, where do you think much of the rest of the CO₂ would go?

**Activity 2: Greenhouse Gases and Global Warming.**

1. The present atmosphere contains approximately 700 Gtons of carbon in the form of CO₂. [Gton = 10^{15} grams]. Earth’s total recoverable fossil fuel reserves contain at least 4200 Gtons of carbon, mostly in the form of coal. At present, about half the CO₂ produced by fossil fuel burning stays in the atmosphere. The other half dissolves in the ocean or is taken up by the terrestrial biosphere. If this ratio remained constant and we burned up all of our fossil fuels instantaneously, by how much would atmospheric CO₂ concentrations rise? (Express your answer in terms of the new CO₂ level divided by the current one, in other words, by what factor CO₂ in the atmosphere changes).

2. Climate models predict that doubling of the atmospheric CO₂ concentration will cause the mean global temperature to increase by about 4°C. How much would temperature increase as a result of the scenario described in question 1?
3. The actual problem of global warming could be more severe than you just calculated. Forests and soils together contain an additional 2100 Gtons of carbon that might go into the atmosphere if deforestation is not prevented. If one third of the carbon from forests and soils are added to the atmosphere due to deforestation, in addition to all the fossil fuels (question 1), by what factor would atmospheric CO$_2$ rise?

4. How much would temperature increase as a result of the scenario described in question 3?
Activity 3: Sea Level Rise

1. We know that the ocean has warmed a significant amount already. As the ocean warms, it expands and sea level rises. Calculate the change in sea level due to a warming of the oceans of 0.7 °C.

(For this problem, assume that the oceans of the world can be approximated by a basin with totally vertical sides – like a bathtub whose bottom has a constant area. As water warms, its volume increases. Since the bathtub does not increase in size, the water must expand upwards (water level rises = eustatic adjustment). The present (initial) volume of the global ocean can be calculated by multiplying the extent of the area it covers (70% of earth’s surface area), and the average depth (3800m). The final volume of the global ocean after it warms can be calculated by using the thermal heat expansion of water.)

You must carry forward at least 5 digits to right of decimal point to do this problem because the magnitude of the sea level change is so small compared to the dimensions of the ocean.

Here are things that you will need to do this problem:

Radius of earth (r) = 6.37 X 10^6 m
Surface area of earth = 4πr^2
Thermal Heat Expansion = V_{final} = V_{initial} (1 + β ΔT )
   Where V_{final} is the final volume, V_{initial} is the initial volume, β is the volume expansion coefficient, and ΔT is the change in temperature in degrees C.
   β = 0.00021 °C\(^{-1}\) (fractional volume change per degree C)
2. In reality, the ocean basins do not have vertical walls, and in some regions with very gently sloping coasts, sea level rise will cause the coastline to retreat (i.e. coastal flooding will occur). If your beachfront house stands 30m from the coastline, and the coast has a slope of 1°, how much would sea level have to rise before your house would be at the shoreline?

For these problems, you’ll need to use basic trigonometry:
- \( \sin \theta = \frac{\text{opposite}}{\text{hypotenuse}} \)
- \( \cos \theta = \frac{\text{adjacent}}{\text{hypotenuse}} \)
- \( \tan \theta = \frac{\text{opposite}}{\text{adjacent}} \)

3. If the ocean were to warm by 0.7°C, what would happen to your house?