Atmospheric Controls of Surface Temperature

WHAT YOU SHOULD LEARN IN THIS EXERCISE:

- **How the greenhouse effect influences the global mean surface temperature.**
- **How cloud cover affects the global mean surface temperature.**
- **How cloud albedo affects the global mean surface temperature.**

WHAT YOU NEED TO DO IN THE COMPUTER LAB:

1. Create a folder on your desktop entitled "TempControls." You should save all of the plots and data for today's exercise in this folder.
2. Open the program:
   (a) Go to the Hands-On Meteorology page via Blackboard | External Links
   (b) Choose "ATMOS 100"
   (c) Open the program link to "Controls of Temperature"
3. Open a notepad to record your answers. Select the "Graphing Tool" button. In the Graphing Tool window click "Notepad."
4. Work through parts A, B, C and D.

You will vary four different quantities during today's exercise:

% of Greenhouse Gases: This is the percentage of greenhouse gases present in the atmosphere as a percent of normal concentrations. For example, 100% means that there is the same amount of greenhouse gases as in the current atmosphere. 0% means there are no greenhouse gases and 200% means there are twice as many.

Cloud Cover %: This is the percentage of the Earth that is covered by clouds. For example, 0% means no clouds and 100% means the entire planet is covered with clouds. On average 30% of the earth is covered by clouds at any given time.

Cloud Albedo: This is the globally averaged albedo associated with the clouds. It has a range of 30-50% for thin clouds and 60-90% for thick clouds.

Ground Albedo: This is the globally averaged albedo of Earth's surface. The range can vary from 0 to 100%.

PART A: GREENHOUSE EFFECT

This part of the exercise explores the effect of greenhouse gases on the global mean surface temperature of the Earth. Recall that the amount of greenhouse gases (*selective absorbers*) and clouds controls the greenhouse effect.

Answer the following questions:

A1. Slide the "% of Greenhouse Gases" to 0%. Set the "Cloud Cover %" to 60%, the "Cloud Albedo" to 65%, and the "Ground Albedo" to 25%. Record the Global Mean Surface

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Temperature on your notepad (accessible through the Graphing Tool). Be sure to include the question number and temperature units.

A2. Slide the "% of Greenhouse Gases" to 100%. Leave all other slider bars the same. Record the Global Mean Surface Temperature.

A3. Slide the "% of Greenhouse Gases" to 200%. Leave all other slider bars the same. Record the Global Mean Surface Temperature.

A4. Now you will create and save a graph depicting temperature change as a function of percent of greenhouse gases.
   a. In the Graphing Tool window choose:
      X-axis: GH gas
      Y-axis: Temp C (not the Temp K)
   b. Save the graph in the folder you created on the Desktop.

A5. Save your notepad data, but do not close it. Choose "File" and "Save As" from the menu.

PART B: EFFECT OF CLOUDS

This part of the exercise explores the role that clouds play on the global mean surface temperature of the Earth.

Answer the following questions:

B1. Set "% of Greenhouse Gases" to 100%, "Cloud Albedo" to 65%, and "Ground Albedo" to 25%. Slide "Cloud Cover %" to 0%. Record the Global Mean Surface Temperature on your notepad. (Include question number and units.)

B2. Slide the "Cloud Cover %" to 50%. Leave all other slider bars the same. Record the Global Mean Surface Temperature.

B3. Slide the "Cloud Cover %" to 100%. Leave all other slider bars the same. Record the Global Mean Surface Temperature.

B4. Create and save a graph depicting temperature change as a function of Cloud Cover %. (see next page)
   a. In the Graphing Tool window choose:
      X-axis: Cloud %
      Y-axis: Temp C
   b. Save the graph in your folder on the Desktop

B5. Save the data in your notepad. (Choose "File" and "Save.")

PART C: EFFECT OF CLOUD ALBEDO

Now examine the effect of cloud albedo on global mean surface temperature. Cloud albedo can range from 30% to 90% depending on how thick the clouds are. Thin clouds have an albedo of 30% to 50%, while thick clouds have an albedo from 60% to 90%.

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Answer the following questions:

C1. Set "% of Greenhouse Gases" to 100% and "Cloud Cover %" to 60%, and Ground Albedo to 25%. Slide the "Cloud Albedo" to 30%. Record the Global Mean Surface Temperature in your notepad. (Include question number and units.)

C2. Slide the "Cloud Albedo" to 50%. Leave all other slider bars set the same. Record the Global Mean Surface Temperature in your notepad.

C3. Slide the "Cloud Albedo" to 90%. Leave all other variables the same. Record the Global Mean Surface Temperature.

C4. Create and save a graph depicting temperature change as a function of Cloud Albedo.

a. In the Graphing Tool window choose:
   X-axis = Cld Alb.
   Y-axis = Temp C
b. Save the graph as you did above.

C5. Save your notepad data.

PART D: EFFECT OF GROUND ALBEDO

Now examine the effect of ground albedo on global mean surface temperature. Ground can range from near 0% to 98% depending on surface conditions.

Answer the following questions:

D1. Set "% of Greenhouse Gases" to 100% and "Cloud Cover %" to 60%, and Cloud Albedo to 65%. Slide the "Ground Albedo" to 5%. Record the Global Mean Surface Temperature in your notepad. (Include question number and units.)

D2. Slide the "Ground Albedo" to 25%. Leave all other slider bars set the same. Record the Global Mean Surface Temperature in your notepad.

D3. Slide the "Ground Albedo" to 60%. Leave all other variables the same. Record the Global Mean Surface Temperature.

D4. Create and save a graph depicting temperature change as a function of Ground Albedo.

c. In the Graphing Tool window choose:
   X-axis = Grnd. Alb.
   Y-axis = Temp C
d. Save the graph as you did above.

D5. Save your notepad data.

The rest of the exercise you can work on at home.

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PART E: QUESTIONS FOR THOUGHT

WHAT YOU NEED TO TURN IN:
Please organize the following materials in the order they are listed, staple, and turn in.

- Cover page with your name, the date, title of exercise: "Controls of Surface Temperature," and your section number and instructor.
- Printed data file that contains your answers to the questions in parts A through D (see #1 below).
- The four graphs you created in class (see #2 below)
- The answers to questions 3 – 8 below (part E).

Note: Your answers should be typed. This will provide you with a backup copy of your assignment and prevent any misinterpretation by the TA grading the assignment.

Complete the following:

1. Open the data file that contains your answers to the questions in parts A through D and convert your temperatures to degrees Fahrenheit. Type the Fahrenheit value next to the value you recorded. Be sure to indicate units. (Your final file with contain both units.)

2. Print out the four graphs you created (listed below). Attach these graphs to your Extended Exercise write-up.
   - % Greenhouse Gases vs. Global Mean Surface Temperature
   - Cloud Cover vs. Global Mean Surface Temperature
   - Cloud Albedo vs. Global Mean Surface Temperature
   - Ground Albedo vs. Global Mean Surface Temperature
3. Describe, in your own words, what is meant by "global mean surface temperature," and "cloud albedo."

Use your answers to parts A through D along with your graphs to answer the following questions. Respond to the "why" questions with brief (2-3 sentence maximum) responses.

4. (a) How does the global mean surface temperature change (increase, decrease or remain constant) as the % of greenhouse gases increases? Why?
   (b) How does the global mean surface temperature change as the percent cloud cover increases? Why?
   (c) How does the global mean surface temperature change as the cloud albedo increases? Why?
   (d) How does the global mean surface temperature change as the ground albedo increases? Why?

5. (a) What is the range of global mean surface temperature when the percent of greenhouse gases is changed from 0 to 200 percent? (Give your answer as a single numeric value, e.g., 5 K)
   (b) What is the range of global mean surface temperature when the percent of cloud cover is changed from 0 to 100 percent?

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(c) What is the range of global mean surface temperature when the cloud albedo is changed from 30 to 90 percent?

(d) What is the range of global mean surface temperature when the ground albedo is changed from 5 to 65 percent?

6. Based on your answer to #5, what variable could account for the largest change in global mean surface temperature?

7. What would happen to the surface temperature if all the greenhouse gases were eliminated from today's atmosphere?

8. If the amount of greenhouse gases doubled, the Earth would be warmer. The warmer global mean surface temperature would result in more melting of the polar ice caps and snow. This would change the mean global ground albedo. The warm temperatures would also enhance the evaporation rate from the oceans and lead to a change in mean global cloud coverage.

   (a) In this scenario, would the mean ground albedo increase or decrease? Why? Based on your graph of mean ground albedo and temperature, how would the surface temperature change?

   (b) In this scenario, what would happen to the amount of cloud coverage? Why? Based on your graph of cloud cover and temperature, how would the surface temperature change?

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