

6.2 Grading Using Models to Predict Future Conditions Worksheet

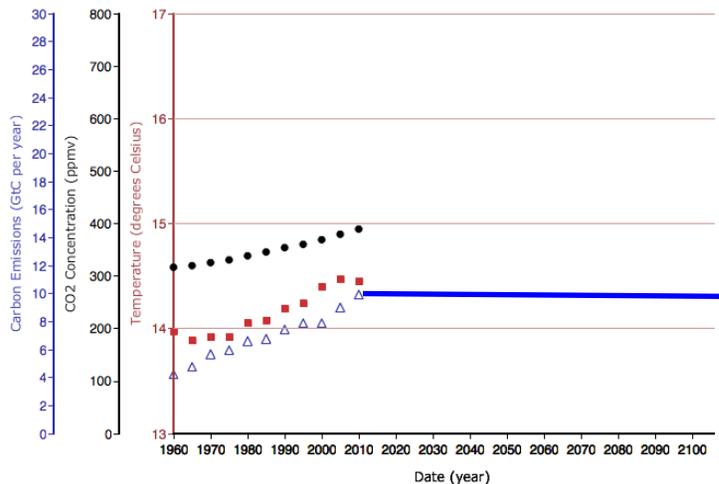
This worksheet has “grading” in the title because at this point, students can be held accountable for correct answers. Level 4 (correct) responses to the questions are in **blue bold italics** below.

Red italics suggest ways to grade student responses by giving them points for correct or partially correct answers. There are 20 points total on this worksheet.

Visit <http://scied.ucar.edu/simple-climate-model> to use the Very, Very Simple Climate Model. In this model, average global temperature is determined entirely by the amount of carbon dioxide (CO₂) in the atmosphere and its effect on temperature (the greenhouse effect).

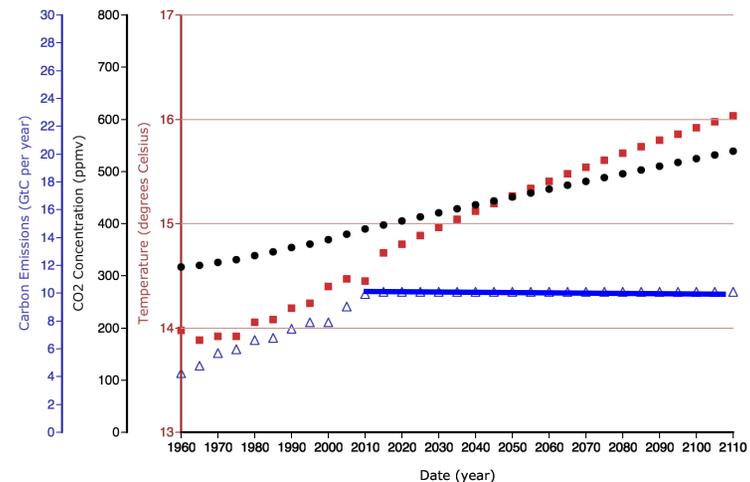
Scenario #1: CO₂ emissions stay constant. The amount of CO₂ that humans release into the atmosphere each year has been increasing. What if we could stop this trend so that the amount we release into the atmosphere each year doesn’t change over time? In this scenario, the rate at which we are currently adding CO₂ to the atmosphere is the rate that we will emit CO₂ in the future, around 10 gigatons of carbon per year (10 GtC/yr).

1. Your predictions. On the graph below, indicate your predictions for the trends over the next century if CO₂ emissions stay constant at 10 GtC/yr. Draw a blue line showing constant emissions of 10 GtC/yr. Draw a black line (continuing from the black dots) for the concentration of CO₂ in the atmosphere and a red line (continuing from the red squares) for temperature. ***Predictions will vary. 1 point for each line, 2 points total.***



2. Results. To explore this scenario, use the controls along the left side of the model to:

- Set "Carbon Dioxide Emissions" to 10 GtC/yr.
- Under “show which graphs” check all three boxes.
- Click the "Play" button.
- Record the results on the graph below. Draw a blue line for emissions, a black line for CO₂ concentration and a red line for temperature. ***Lines should be similar to those shown below. 1 point for each line, 2 points total.***



3. How do the results compare to your prediction?

Answers will vary. 1 point.

4. In Scenario #1, what would happen to global temperature over time?

Over time, the global temperature is increasing with each passing year. 1 point.

5. If CO₂ emissions stay constant at 10 GtC/yr, what is the predicted global temperature in the year 2100?

The predicted global temperature in 2100 is about 16 degrees Celsius. 1 point.

6. Explain why CO₂ concentration in the atmosphere will continue to rise even though emissions stay the same?

Even though the rate at which we emit CO₂ stays the same over time in this scenario, the concentration of CO₂ in the atmosphere continues to rise because more CO₂ is entering the atmosphere than leaving the atmosphere each year (i.e., there is an unbalanced flux so the atmospheric pool of CO₂ grows over time).

1 point.

7. Explain why temperature continues to rise in this scenario even though CO₂ emissions level off at a rate of 10 GtC/yr?

The predicted increase in temperature can be explained by the greenhouse effect. In an atmosphere with a higher concentration of CO₂, retention of infrared radiation within Earth's atmosphere is increased, and consequently temperatures on the Earth increase.

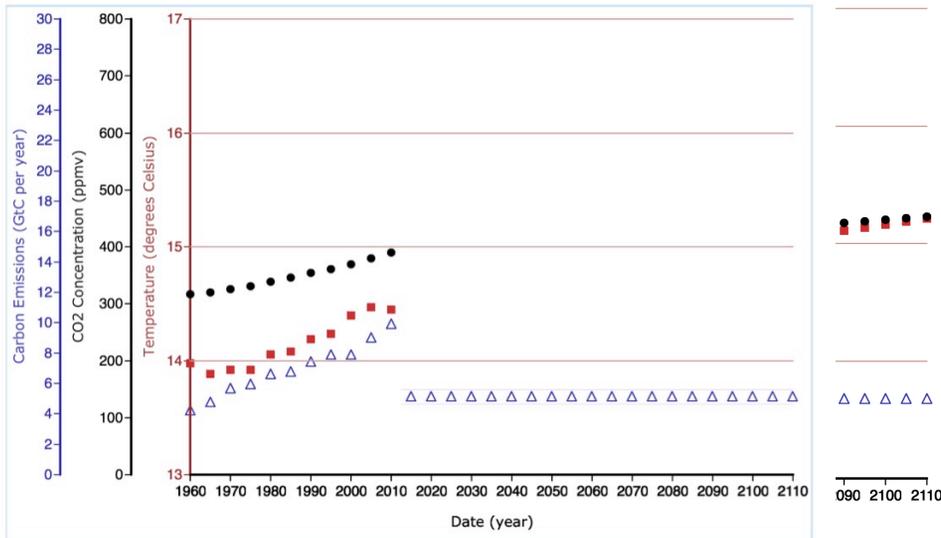
1 point.

Scenario #2: CO₂ emissions are cut in half and then remain constant. What would happen to atmospheric CO₂ concentration and temperature over time if people cut CO₂ emissions in half (to 5 GtC/yr) and kept emissions at that level into the future? Note that this is the question that is asked in the assessment you may have completed about what would happen if fossil fuel use were cut in half.

8. Your predictions. On the graph below, indicate your predictions for the trends over the next century if CO₂ emissions are cut in half and continue at 5 GtC/yr. Draw a black line (continuing from the black dots) for the concentration of CO₂ in the atmosphere and a red line (continuing from the red squares) for temperature. *Predictions will vary. 1 point for each line, 2 points total.*

9. Results. Using the simulation:

- Using the simulation settings, figure out how to test the scenario in which CO₂ emissions are reduced to 5 GtC/yr and remain at that level over time.
- Run the simulation.
- Record the results on the graph below. Draw a black line for CO₂ concentration and a red line for temperature. *Lines should be similar. 1 point for each line, 2 points total.*



10. Describe the patterns in the red and black lines (CO₂ concentration and temperature) on the graph for the results of Scenario #2. How does this compare to your predictions?

CO₂ concentration and temperature continue to rise but at a slower rate compared with Scenario 1. Students should compare the result to their prediction. Comments regarding how this relates to their predictions will vary.

1 point for each question answered, 2 points total.

11. Explain why CO₂ concentration and temperature continue to rise even when fossil fuel emissions are cut in half?

Even though the rate at which we emit CO₂ is cut in half in this scenario, the concentration of CO₂ in the atmosphere continues to rise because more CO₂ is entering the atmosphere than leaving the atmosphere each year (i.e., there is an unbalanced flux so the atmospheric pool of CO₂ grows over time). The increase in atmospheric CO₂ concentration over time (even with half the current level of emissions) along with the greenhouse effect explains why temperatures continue to rise in this scenario.

1 point.

12. What is the predicted global temperature in the year 2100 for this scenario?

About 15.2 degrees Celsius.

1 point.

13. Do you think cutting fossil fuel emissions in half would solve our global climate change problem? Why or why not?

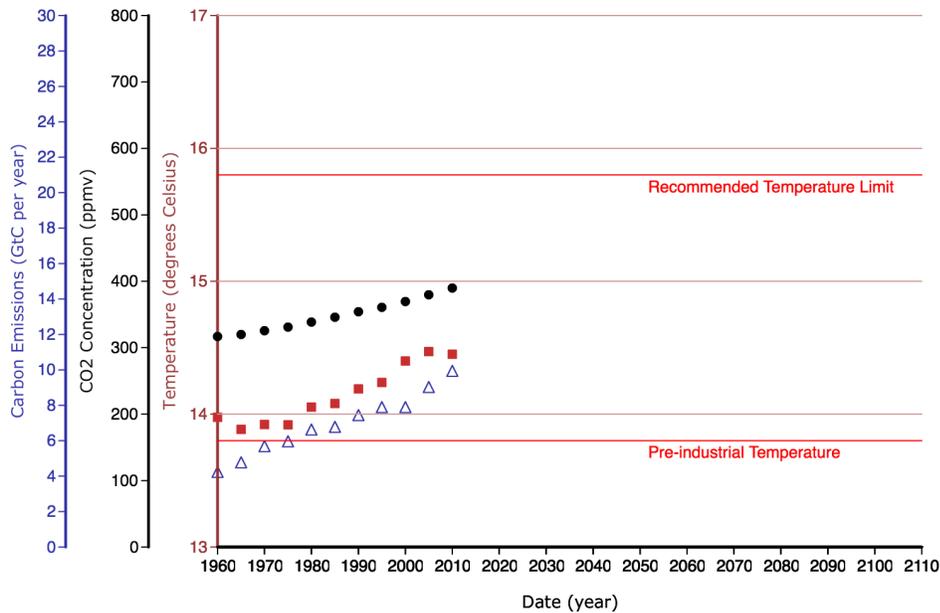
Cutting fossil fuel emissions in half would be more helpful for solving our global climate change problem than what we are doing now (i.e., continuing to increase CO₂ emissions each year). However, cutting emissions in half would not completely solve the global climate change problem. CO₂ concentration in the atmosphere would continue to rise and consequently the temperature of the planet would continue to rise as well.

1 point.

Limiting climate change: Many scientists agree it is very important that we not allow the climate to warm more than 2°C above the average global temperature prior to the Industrial Revolution (early 19th century). Many scientific models predict disastrous storms, sea level rise, and harmful effects on plants, animals and humans if the Earth warms more than 2°C. You can add lines on the climate model graph for the pre-industrial average temperature and the recommended warming limit by checking the box “Show Warming Limit Targets” (below the graph).

We are currently emitting about 10 GtC/yr and global emissions increase by about 2.5% each year. At this rate we will surpass the 2°C recommended warming limit before the end of this century. Use the model (change the CO₂ emissions rate) to determine what we would need to do to ensure that we did not surpass 2°C warming. Remember that the graph ends at 2100, but we would not want to surpass 2°C warming even after 2100 (so we would need the temperature to level off before the 2°C line).

14. Graph your results below.



Explain your scenario including:

- How did you set CO₂ emissions and why?
- What was the result?
- What do you think humans would have to do to keep our CO₂ emissions low enough to stay below the Warming Target Limits?

Responses and graphs may vary.

A CO₂ Emission of 2 Gigatons per year results in the above graph that has “leveled off” for both temperature and CO₂ concentration.

A CO₂ Emission of 0-1 Gigatons per year results in a decreasing overall trend for both temperature and CO₂ concentration.

A CO₂ Emission of 3+ Gigatons per year results in an increasing overall trend for both temperature and CO₂ concentration, although it may be slight for the lower numbers.

1 point for graph, 1 point for explanation, 2 points total.