Systems Thinking Exercise: The Dynamics of Global Warming

Consider the issue of global warming. In 2001, the Intergovernmental Panel on Climate Change (IPCC), a scientific panel organized by the United Nations, concluded that carbon dioxide (CO_2) and other greenhouse gas emissions were contributing to global warming. The panel stated that "most of the warming observed over the last 50 years is attributable to human activities."

The amount of CO_2 in the atmosphere is affected by natural processes and by human activity. Anthropogenic CO_2 emissions (emissions resulting from human activity, including combustion of fossil fuels and changes in land use, especially deforestation), have been growing since the start of the industrial revolution (Figure 1). Natural processes gradually remove CO_2 from the atmosphere (for example, as it is used by plant life and dissolves in the ocean). Currently, the net removal of atmospheric CO_2 by natural processes is about half of the anthropogenic CO_2 emissions. As a result, concentrations of CO_2 in the atmosphere have increased, from preindustrial levels of about 280 parts per million (ppm) to about 370 ppm today (Figure 2). Increases in the concentrations of greenhouse gases reduce the efficiency with which the Earth's surface radiates energy to space. This results in a positive radiative forcing that tends to warm the lower atmosphere and surface. As shown in Figure 3, global average surface temperatures have increased since the start of the industrial revolution.

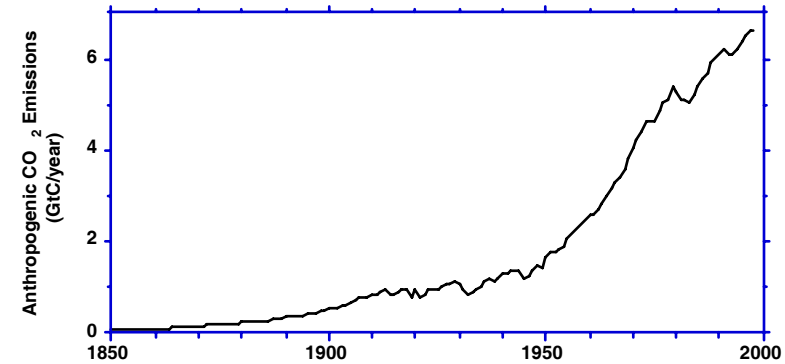


Figure 1. Global CO_2 emissions resulting from human activity (billion tons of carbon per year)

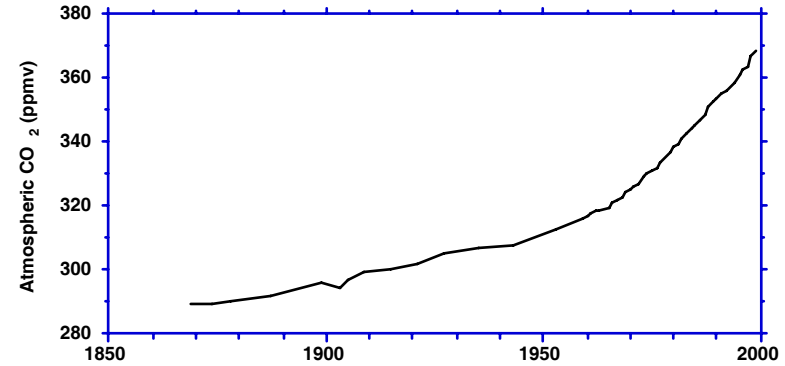


Figure 2. Atmospheric CO_2 concentrations, parts per million.

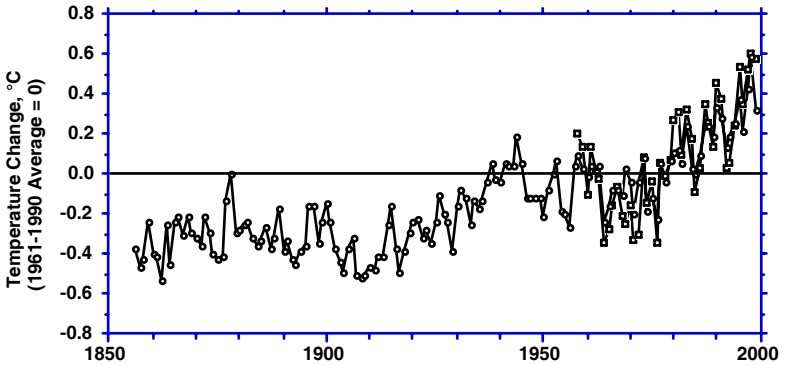
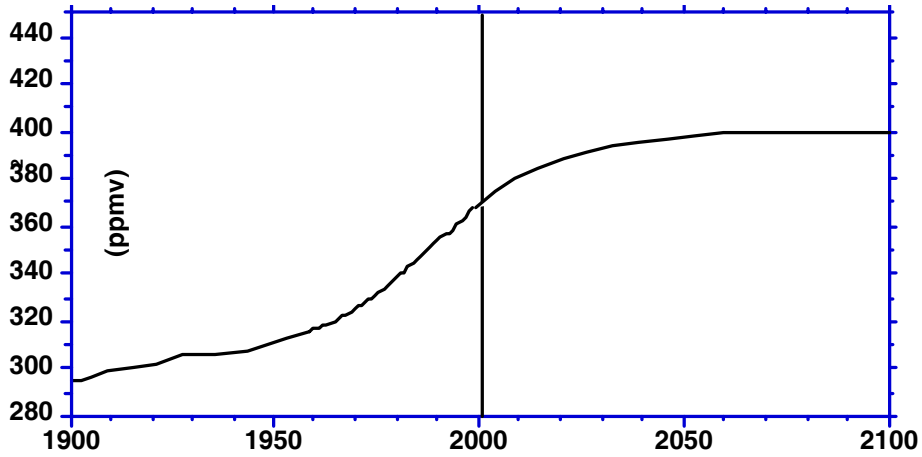
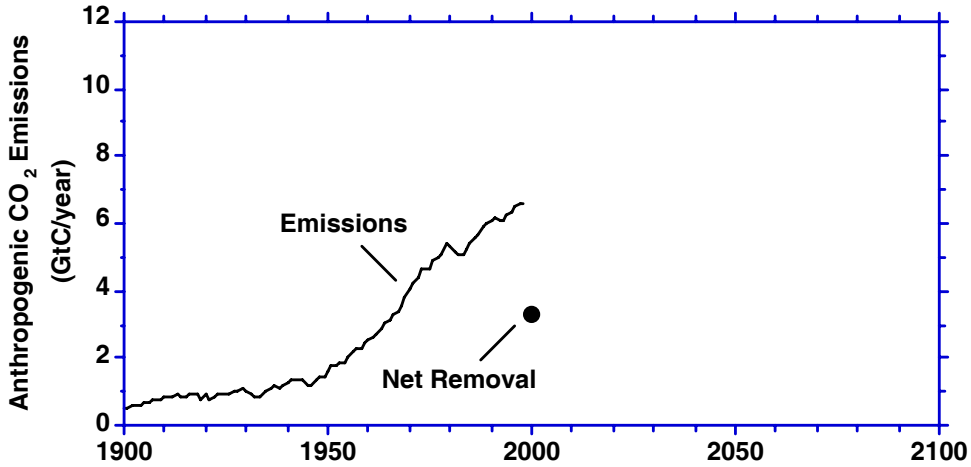


Figure 3. Average global surface temperatures, °C. The zero line is set to the average for the period 1961-1990.

Now consider a scenario in which the concentration of CO_2 in the atmosphere gradually rises to 400 ppm, about 8% higher than the level today, then stabilizes by the year 2100, as shown here:



1. The graph below shows anthropogenic CO_2 emissions from 1900-2000, and current net removal of CO_2 from the atmosphere by natural processes. Sketch:
   a. Your estimate of likely future net CO_2 removal, given the scenario above.
   b. Your estimate of likely future anthropogenic CO_2 emissions, given the scenario above.



2. Assuming CO_2 concentrations follow the scenario above, the average global temperature would most likely:
   - ❑ Continue to rise through the year 2100.
   - ❑ Continue to rise, then stabilize by the year 2100.
   - ❑ Rise for a few more years, then peak, gradually fall and stabilize above current levels.
   - ❑ Stabilize now at current levels.
   - ❑ Rise for a few more years, then peak, gradually fall and stabilize below current levels.
   - ❑ Rise for a few more years, then peak and continue to fall through the year 2100.
   - ❑ Immediately drop, then stabilize by the year 2100 below current levels.

3. Why? Explain your choices (*briefly*):