A Simple "Bucket" Model of CO_2-Related Global Warming

Adam Anderson, 2006
Wilson High School
Portland, OR

Indroduction

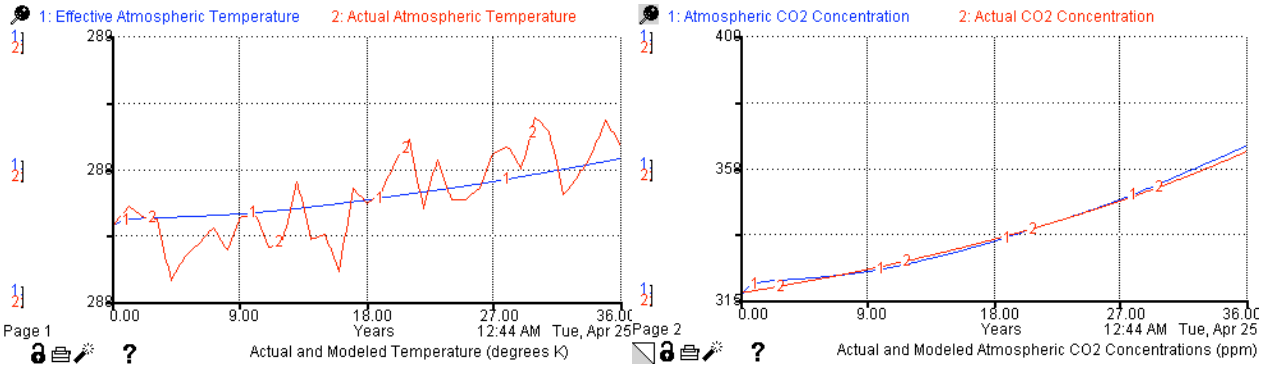
Since the dawn of the industrial age, the combustion of fossil fuels has led to a dramatic increase in the atmospheric concentration of CO_2, from around 280 ppm in preindustrial times to its current level around 380 ppm. Unlike the diatomic gases N_2 and O_2 that comprise most of the atmosphere, CO_2 absorbs infrared radiation from the sun, causing additional warming. In the context of the current, rapidly increasing CO_2 concentration, this is a major source of global warming.

While carbon's atmospheric form, CO_2, is most obviously involved in global warming, carbon is also cycled through several different sinks. Most importantly, there is a carbon exchange between the atmosphere and ocean, as well as the ocean and terrestrial biomass. Other cycling processes exist within these major sinks.

Climate

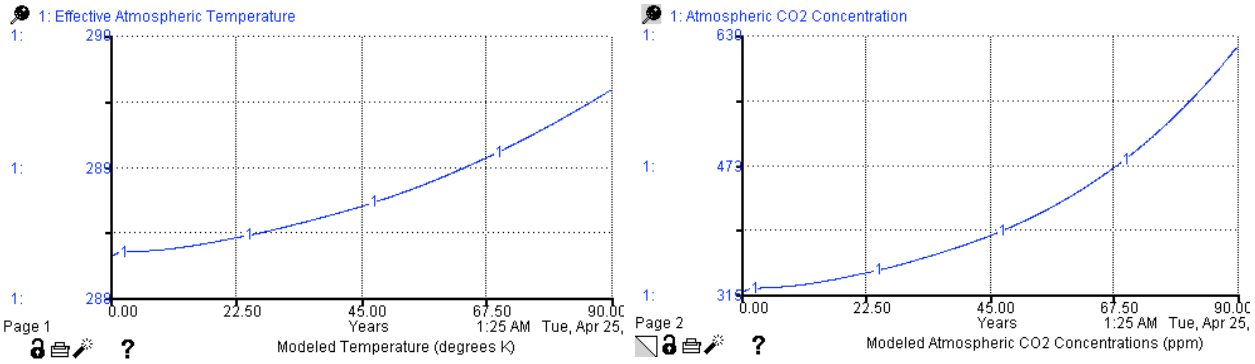
Atmospheric Carbon

Carbon in Oceans ***Carbon in Biomass***

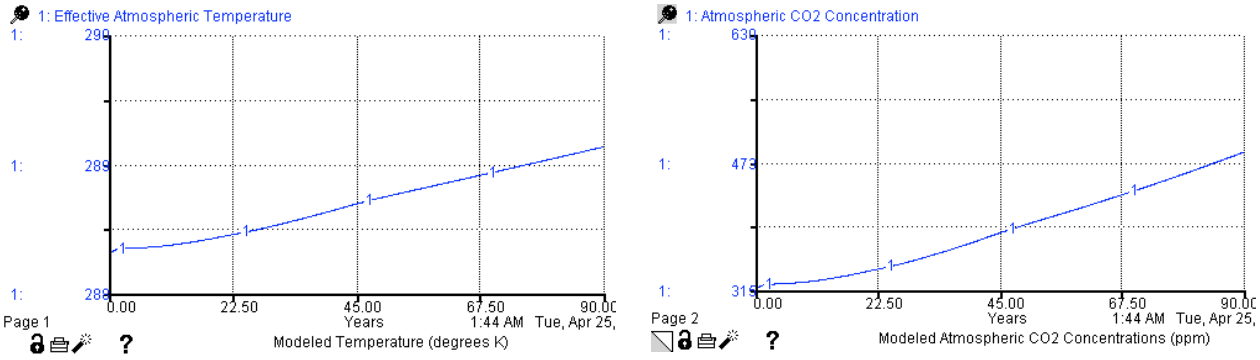


Results

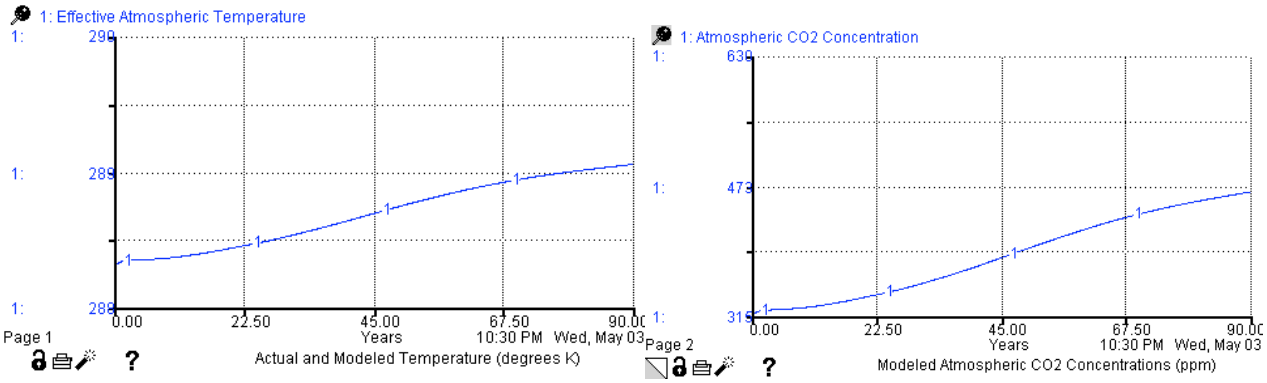
Results using actual CO_2 emissions data, and compared with global temperature and CO_2 concentration from 1960 to 1996.



Results from continuous consumption of fossil fuels at the current rate of 2.25%



Under the conditions of the Kyoto Protocol, the problem still exists but is not as extreme.



The best-case scenario, assuming that CO2 emissions adhere to an environmental Kuznets curve whose turning point is today.

Important Feedback Loops

Ice-Albedo Feedback

As global temperature rises, ice and snow tend to melt, exposing more bare earth. Since ice and snow are white, they tend to reflect more incident solar energy than bare earth. Thus, an increase in the global temperature will tend to decrease the overall reflectivity, or albedo, of the earth. The result is a positive feedback loop in which global warming accelerates itself, ceteris

paribus.

Biotic Growth Feedback

When global temperature and CO_2 levels increase, plants tend to grow more and take up more overall carbon from the atmosphere. Whether this effect occurs is, of course, contingent on whether humans can limit their deforestation of the earth. Holding all other factors constant, the biotic growth would be a negative feedback loop, counteracting global warming and increases in CO_2 concentration.

Temperature-Solubility Feedback

An increase in the global temperature decreases the solubility of CO_2 in water. The uptake of carbon by the oceans is directly dependent on this solubility. The result is positive feedback for CO_2 concentration and temperature, whereby temperature increases, decreasing the amount of carbon that is sequestered by oceans, and leading to greater levels of CO_2 and atmospheric warming.

Policy Considerations

As a global problem, successfully combating CO_2 emissions and global warming requires collective action by all nations. While Kyoto sought to do this, its inability to attract the US as a signatory was damaging to its potential for success. Moreover, climate-carbon models, including this one, suggest that the standards set by Kyoto are only a beginning in dealing with global warming. Some, such as Daniel Esty at Yale, propose the creation of a global environmental organization to confront this and other problems. Whatever organization or agreement is used, it should include strict economic incentives to force technological change and innovation. High gas taxes and carbon trading are two examples. It is also important that some mechanism exists by which clean technology can be inexpensively transferred to developing countries, so that their industrialization has less environmental impact. Perhaps a global monetary fund could be reserved for development of clean energy sources in developing countries, as a part of an agreement to lower greenhouse gas emissions. While these are just several small ideas, it is clear that there is a need for aggressive collective action to reduce the emissions of greenhouse gases by all nations.