

Breaking the Carbon Cycle: Atmospheric Catastrophe

Temperatures on Earth are kept stable largely as the result of the long-term "carbon cycle", which acts as a thermostat, cooling the planet if temperatures rise and heating it when temperatures fall. But it isn't perfect...

Step 1: Breaking the Thermostat

1. The average surface temperature of the Moon is about -25 Celsius, but the average temperature on Earth is much warmer, about $+15$ Celsius. The Moon is the same distance from the Sun as the Earth, so why is it so much colder?
2. The carbon dioxide in our atmosphere is constantly being buried in ocean sediments, from where it cannot return to the atmosphere – yet the amount of CO_2 in the atmosphere isn't decreasing. How does the lost CO_2 get replaced?
3. Suppose that we "turn up" the amount of solar radiation Earth receives, but only by a small amount.
 - a) How would this affect temperatures in the short term?
 - b) How would the change in temperature affect precipitation rates?
 - c) How would the change in precipitation rates affect CO_2 levels in the atmosphere?
 - d) How would the change in CO_2 levels affect temperatures in the long term?
4. Now suppose that the amount of solar radiation were turned up by a much larger amount. For how long can the negative-feedback carbon cycle (above) do its job – when does the thermostat "break" and lose its ability to counteract the rising temperature?

Step 2: Runaway Greenhouse

5. With the CO_2 cycle gone, other less forgiving processes can take over. Assume that solar radiation is increased just slightly above the amount where the carbon cycle "breaks".
 - a) How would this affect temperatures in the short term?
 - b) How would the temp. change affect the amount of water vapor in the atmosphere?
 - c) How would the change in the amount of water vapor in turn affect temperatures?
6. What is the limit of this cycle – when will the positive-feedback process finally stop?
7. What would atmospheric conditions be like when this finally happens? Is there an example of these kind of conditions elsewhere in the Solar System?