Global Warming

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1. What is Global Warming?

Global Warming is the increase of Earth's average surface temperature due to effect of greenhouse gases, such as carbon dioxide emissions from burning fossil fuels or from deforestation, which trap heat that would otherwise escape from Earth. This is a type of greenhouse effect.

Is global warming, caused by human activity, even remotely plausible? Earth's climate is mostly influenced by the first 6 miles or so of the atmosphere which contains most of the matter making up the atmosphere. This is really a very thin layer if you think about it. In the book The End of Nature, author Bill McKibbin tells of walking three miles to from his cabin in the Adirondack's to buy food. Afterwards, he realized that on this short journey he had traveled a distance equal to that of the layer of the atmosphere where almost all the action of our climate is contained. In fact, if you were to view Earth from space, the principle part of the atmosphere would only be about as thick as the skin on an onion! Realizing this makes it more plausible to suppose that human beings can change the climate. A look at the amount of greenhouse gases we are spewing into the atmosphere (see below), makes it even more plausible.

2. What are the Greenhouse Gases?

The most significant greenhouse gas is actually water vapor, not something produced directly by humankind in significant amounts. However, even slight increases in atmospheric levels of carbon dioxide (CO_2) can cause a substantial increase in temperature.

Why is this? There are two reasons: First, although the concentrations of these gases are not nearly as large as that of oxygen and nitrogen (the main constituents of the atmosphere), neither oxygen or nitrogen are greenhouse gases. This is because neither has more than two atoms per molecule (i.e. their molecular forms are O_2 and N_2, respectively), and so they lack the internal vibrational modes that molecules with more than two atoms have. Both water and CO_2, for example, have these "internal vibrational modes", and these vibrational modes can absorb and reradiate infrared radiation, which causes the greenhouse effect.

Secondly, CO_2 tends to remain in the atmosphere for a very long time (time scales in the hundreds of years). Water vapor, on the other hand, can easily condense or evaporate, depending on local conditions. Water vapor levels therefore tend to adjust quickly to the prevailing conditions, such that the energy flows from the Sun and re-radiation from the Earth achieve a balance. CO_2 tends to remain fairly constant and therefore behave as a controlling factor, rather than a reacting factor. More CO_2 means that the balance occurs at higher temperatures and water vapor levels.

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Thus, we see that Global Warming is not something far off in the future - in fact it predates almost every living human being today.

4. How do we know if the temperature increase is caused by anthropogenic emissions?

Computer models strongly suggest that this is the case. The following graphs show that 1) If only natural fluctuations are included in the models (such as the slight increase in solar output that occurred in the first half of the 20th century), then the large warming in the 20th century is not reproduced. 2) If only anthropogenic carbon emissions are included, then the large warming is reproduced, but some of the variations, such as the cooling period in the 1950s, is not reproduced (this cooling trend was thought to be caused by sulfur dioxide emissions from dirty power plants). 3) When both natural and anthropogenic emissions of all types are included, then the temperature evolution of the 20th century is well reproduced.

5. Response of Government: Develop "Carbon Sequestration" Technology

Many government agencies around the world are very interested in maintaining fossil fuel use, especially coal. It should be noted that US energy use, which is enormous, is increasing, not decreasing. Furthermore, we are not going to run out of coal in the near term (oil may begin to run low sometime after 2010). Methods for reducing carbon emission levels while still burning coal are now investigation by government and industry, as we now discuss.

We believe that a major increase in renewable energy use should be achieved to help offset global warming. While there are some US government programs aimed in this direction, there is simply not enough money being spent yet to achieve this goal in a timely manner. A primary goal of many new programs is not to increase renewables, but rather, is to find ways to capture the extra CO_2 from electricity generation plants and "sequester" it in the ground, the ocean, or by having plants and soil organisms absorb more of it from the air.

6. Possible Problems with Carbon "Sequestration"

One of the Carbon sequestration approaches under investigation is the possibility of depositing CO_2 extracted from emission streams in large pools on the Ocean bottom. It is possible that such pools will not be stable, and may either erupt to the surface, or diffuse into the ocean and alter the oceans pH.

Another scheme under investigation is the idea of stimulating phytoplankton growth on the ocean surface by dusting the surface with iron (the limiting nutrient). This will cause an increased uptake of carbon by the plankton, part of which will find its way to the ocean bottom. Fishing companies are considering using this to increase fish harvests while simultaneously getting credit for carbon sequestration. Serious ecological disruptions could occur, however, especially if this approach is conducted on a sufficiently large scale.

Another idea is to stimulate Earth's terrestrial ecosystems to take up more carbon dioxide. While the impacts here are more difficult to ascertain, an important point to note is that these systems are not thought to be able to completely absorb all the extra CO_2. At best, they may be sufficient to help the US stabilize carbon emission rates for a few decades, but even if this is achieved, stabilization of rates are not likely to return the Earth to pre-industrial carbon levels. Worse, biological feedbacks to global warming, such as forest fires, drying soils, rotting permafrost, etc, may actually greatly accelerate carbon emissions, i.e. we may experience massive carbon de-sequestration.

Reference

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