# GW 101

## Global Warming Theory in a Nutshell

Every scientific theory involves assumptions. Global warming theory starts with the assumption that the Earth naturally maintains a constant average temperature, which is the result of a balance between (1) the amount of sunlight the Earth absorbs, and (2) the amount of emitted infrared ("IR") radiation that the Earth continuously emits to outer space. In other words, energy in equals energy out. Averaged over the whole planet for 1 year, those energy flows in and out of the climate system are estimated to be around 235 or 240 watts per square meter.

Greenhouse components in the atmosphere (mostly water vapor, clouds, carbon dioxide, and methane) exert strong controls over how fast the Earth loses IR energy to outer space. Mankind's burning of fossil fuels creates more atmospheric carbon dioxide. As we add more $CO_2$, more infrared energy is trapped, strengthing the Earth's greenhouse effect. This causes a warming tendency in the lower atmosphere and at the surface. As of 2008, it is believed that we have enhanced the Earth's natural greenhouse effect by about 1%.

Global warming theory says that the lower atmosphere must then respond to this energy imbalance (less IR radiation being lost than solar energy being absorbed) by causing an increase in temperature (which causes an increase in the IR escaping to space) until the emitted IR radiation once again equals the amount of absorbed sunlight. That is, the Earth must increase its temperature until global energy balance is once again restored. **This is the basic explanation of global warming theory.** (The same energy balance concept applies to a pot of water on a stove set on "low". The water warms until the rate of energy loss through evaporation, convective air currents, and infrared radiation equals the rate of energy gain from the stove, at which point the water remains at a constant temperature. If you turn the heat up a tiny bit more, the temperature of the water will rise again until the extra amount of energy lost by the pot once again equals the energy gained from the stove, at which point a new, warmer equilibrium temperature is reached.)

Now, you might be surprised to learn that the amount of warming directly caused by the extra $CO_2$ is, by itself, relatively weak. It has been calculated theoretically that, if there are no other changes in the climate system, a doubling of the atmospheric $CO_2$ concentration would cause less than 1 deg C of surface warming (about 1 deg. F). This is NOT a controversial statement…it is well understood by climate scientists. (As of 2008, we were about 40% to 45% of the way toward a doubling of atmospheric $CO_2$.)

BUT…everything this else in the climate system probably WON'T stay the same! For instance, clouds, water vapor, and precipitation systems can all be expected to respond to the warming

tendency in some way, which could either amplify or reduce the manmade warming. These other changes are called “feedbacks,” and the sum of all the feedbacks in the climate system determines what is called ‘climate sensitivity’. Negative feedbacks (low climate sensitivity) would mean that manmade global warming might not even be measurable, lost in the noise of natural climate variability. But if feedbacks are sufficiently positive (high climate sensitivity), then manmade global warming could be catastrophic.

Obviously, knowing the strength of feedbacks in the climate system is critical; this is the subject of most of my research. Here you can read about my latest work on the subject, in which I show that feedbacks previously estimated from satellite observations of natural climate variability have potentially large errors. A confusion between forcing and feedback (loosely speaking, cause and effect) when observing cloud behavior has led to the illusion of a sensitive climate system, when in fact our best satellite observations (when carefully and properly interpreted) suggest an IN-sensitive climate system.

Finally, if the climate system is insensitive, this means that the extra carbon dioxide we pump into the atmosphere is not enough to cause the observed warming over the last 100 years — some natural mechanism must be involved. Here you can read about my favorite candidate: the Pacific Decadal Oscillation.

# About

Roy W. Spencer received his Ph.D. in meteorology at the University of Wisconsin-Madison in 1981. Before becoming a Principal Research Scientist at the University of Alabama in Huntsville in 2001, he was a Senior Scientist for Climate Studies at NASA’s Marshall Space Flight Center, where he and Dr. John Christy received NASA’s Exceptional Scientific Achievement Medal for their global temperature monitoring work with satellites. Dr. Spencer’s work with NASA continues as the U.S. Science Team leader for the Advanced Microwave Scanning Radiometer flying on NASA’s Aqua satellite. He has provided congressional testimony several times on the subject of global warming.