One of the points that Dr. Richard Lindzen made during his keynote speech at the 2nd **International Conference on Climate Change**, held in New York City March 8-10 this year, is that we global warming skeptics need to be careful about what aspects of the theory of manmade global warming we dispute.

And I fully agree.

In an e-mail I just responded to this evening, I once again found myself defending the existence of the Earth's "greenhouse effect". I'm talking about the Earth's **natural greenhouse effect**, not mankind's small enhancement of it. And it's amazing how many scientists, let alone lay people, dispute its existence.

I'll admit I used to question it, too. So, many years ago Danny Braswell and I built our own **radiative transfer model** to demonstrate for ourselves that the underlying physics were sound.

To briefly review: because water vapor, clouds, carbon dioxide, and methane in the atmosphere absorb and emit infrared radiation, the atmosphere stays warmer in the lower atmosphere and cooler in the upper atmosphere than it would otherwise be without the greenhouse effect.

Even though the physical process involved in this is radiative, the **greenhouse blanket** around the Earth is somewhat analogous to a real blanket, which we all know tends to hold heat in where it is being generated, and reduce its flow toward the colder surroundings. A blanket – real or greenhouse — doesn't actually create the separation between hot and cold…it just reduces the rate at which energy is lost by the hot, and gained by the cold.

In the case of the Earth, most sunlight is absorbed at the surface, which then heats and moistens the air above it. This solar heating causes the lower atmosphere to warm, and the greenhouse effect of the water vapor thus generated helps keep the lower atmosphere warm by reducing its rate of cooling. (Long before radiation can make the surface too warm, though, **convective air currents** kick in…e.g. thunderstorms…and transport much of the excess heat from the lower to the upper atmosphere. As a result, the lower atmosphere never gets as warm as the greenhouse effect 'wants' to make it.)

So where do the objections to the "greenhouse effect" come in?

IT'S NOT A REAL GREENHOUSE

The processes involved in the atmospheric greenhouse effect are not the same as what happens in a real greenhouse. Yes, we all know that, but the misnomer has stuck, and it is not going away anytime soon. A real greenhouse physically traps warm air, preventing convective air currents from carrying warm air out of the greenhouse, which would then be replaced by cooler air coming into the greenhouse. In contrast, the infrared atmospheric greenhouse effect instead slows the rate at which the atmosphere cools radiatively, not convectively.

IT VIOLATES THE SECOND LAW OF THERMODYNAMICS

A second objection has to do with the Second Law of Thermodynamics. It is claimed that since the greenhouse effect depends partly upon cooler upper layers of the atmosphere emitting infrared radiation toward the warmer, lower layers of the atmosphere, that this violates the 2nd Law, which (roughly speaking) says that energy must flow from warmer objects to cooler objects, not the other way around.

There are different ways to illustrate why this is not a valid objection. First of all, the 2nd Law applies to the behavior of whole systems, not to every part within a system, and to all forms of energy involved in the system…not just its temperature. And in the atmosphere, temperature is only one component to the energy content of an air parcel.

Secondly, the idea that a cooler atmospheric layer can emit infrared energy toward a warmer atmospheric layer below it seems unphysical to many people. I suppose this is because we would not expect a cold piece of metal to transfer heat into a warm piece of metal. But the processes involved in **conductive heat transfer** are not the same as in radiative heat transfer. A hot star out in space will still receive, and absorb, radiant energy from a cooler nearby star…even though the NET flow of energy will be in the opposite direction.

In other words, a photon being emitted by the cooler star doesn't stick its finger out to see how warm the surroundings are before it decides to leave.

Furthermore, we should not confuse a reduced rate of cooling with heating. Imagine you have a jar of boiling hot water right next to a jar of warm water sitting on the counter. The boiling hot jar will cool rapidly, while the warm jar will cool more slowly. Eventually, both jars will achieve the same temperature, just as the 2nd Law predicts.

But what if the boiling hot jar was by all by itself? Then, it would have cooled even faster. Does that mean that the presence of the warm jar was sending energy into the hot jar? No, it was just *reducing the rate of cooling* of the hot jar. The climate system is like the hot jar having an internal heating mechanism (the sun warming the surface), but its ability to cool is reduced by its surroundings (the atmosphere), which tends to insulate it.

Another way the objection is voiced is that a layer of the atmosphere that absorbs infrared energy at a certain rate must then also emit it at the same rate, so how can that layer "trap" any energy to warm? This misconception comes from a misunderstanding of **Kirchoffs Law**, which only says that the infrared opacity of a layer makes that layer's *ability* to absorb and emit IR the same. The actual rate of infrared absorption by a layer depends upon that opacity AND

the temperatures of the emitting layers above and below, but the rate of emission depends upon the same opacity and the temperature of the layer itself. Therefore, the rate of infrared flows in and out of the layer do not have to be equal, and if they are not equal, the layer will either warm or cool radiatively.

THE ATMOSPHERE IS ALREADY OPAQUE TO THE TRANSFER OF INFRARED ENERGY

Some claim that since the atmosphere is already quite opaque to the transfer of infrared energy, adding a little more CO2 won't do anything to warm the lower atmosphere and surface. While there is a grain of truth to this, it must be remembered that the Earth's surface does not radiatively cool directly to outer space, but to the layer of air above it, which in turn cools to the next layer of air above it, etc.

Think of it like several blankets covering your body on a cold night. Your body does not lose energy directly to the cold air outside of the blankets, but to the first blanket, which then transfers heat to the second blanket, etc.

Finally, the most vivid evidence that infrared radiation can cool something below the temperature of its surroundings – in seeming contradiction to the 2nd Law — is what happens on a clear calm night. The Earth's surface cools by losing infrared radiation, which then chills the air in contact with it. This nighttime cooling causes a thin layer of cold air to build up near the surface…even though it is colder than the ground below the surface, or the air immediately above it.

There is no way for cooler air aloft coming down to the surface to be causing this effect because when air descends from any altitude, it will always be warmer (not colder) than its surroundings, due to adiabatic compression.

Therefore, we have a cold air layer sandwiched in between two warmer layers, becoming colder still as night progresses. Is this a violation of the Second Law of Thermodynamics? No,

because the entire depth of the atmosphere – as a system — is indeed losing infrared energy as a whole to the cold depths of outer space.

The same thing happens to the top of your car when the sun sets…it cools by infrared radiation to a temperature cooler than the air, and as a result is often the first place you will see dew form.

THE GREENHOUSE EFFECT WORKS…FOR NOW

The greenhouse effect is supported by laboratory measurements of the radiative absorption properties of different gases, which when put into a radiative transfer model that conserves energy, and combined with convective overturning of the atmosphere in response to solar heating, results in a vertical temperature profile that looks very much like the one we observe in nature.

So, until someone comes along with another quantitative model that uses different physics to get as good a simulation of the vertical temperature profile of the atmosphere, I consider objections to the existence of the 'greenhouse effect' to be little more than hand waving.

[source: http://www.drroyspencer.com/2009/04/in-defense-of-the-greenhouse-effect/]