Carbon Dioxide and the Greenhouse Effect

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David: People have difficulty accepting scientists' claim that carbon dioxide is dangerous. It's invisible, it's only a very minor component of air, and it seems harmless, in the sense that we get it into our lungs when we breathe without it causing harm. And we make it, too, breathing out more than we breathe in.

Bill: Their doubt must be due to more than that, for most people accept that lead in tap water is dangerous. Yet they can't see or taste the lead in contaminated water, and they can hold a lead fishing sinker in their hands without it causing blisters or having any other obvious unhealthy effect.

David: Maybe people find the effect of carbon dioxide hard to grasp because, while scientists say that it traps heat near the Earth's surface by making the atmosphere opaque, the air looks clear to us. We can see the stars just fine at night.

Bill: What scientists mean is that the atmosphere is opaque to IR or infrared light, a color of light that we cannot see, but which is involved in the cooling the Earth's surface. People know that materials can be more transparent to one color of light than another – for example, the yellow lenses of ski googles that are said to block blue haze and make seeing the terrain easier.

David: Yes, but yellow and blue are both colors that we can see. People can't see IR and discount its effect.

Bill: True, you can't see it, but if you stand close to a fireplace, you sure can feel the IR warming your legs.

David: What would the world look like if you could see only IR?

Bill: The landscape would be covered with a perpetual haze. Objects more than a mile away would be indistinct and objects more than three or four miles away would be complete obscured. Imagine a grey day on the seacoast, when the fog is thin enough that you can see across the street, but thick enough that you can't make out the boats moored on the other the bay.

David: The units in which scientists measure carbon dioxide are hard to grasp. First, a number like 410 parts per million – and that's the value that I most recently saw in the news – seems trivially small. Furthermore, unless you know that carbon dioxide levels were only 300 parts per million in 1900, today's number means nothing.

Bill: I agree that a comparison with past values is always necessary. Scientists should say something like, "410 parts per million, up from 300 in the 1900, and rising at 2 per year".

David: But even that way of putting it doesn't give any sense of how bad the increase is. We don't really care about carbon dioxide. We care about the global warming it causes.

Bill: Scientists sometimes express the rise in carbon dioxide in terms of the temperature change that it is likely to cause – a 100 parts per million rise causing a one-degree Celsius increase in temperature, say.

David: If you want to connect with the average American, should be saying a 1.8 degree Fahrenheit increase. But the trouble with using temperature is that the relationship is so poorly known. A 100 parts per million increase in carbon dioxide could cause anywhere between a one degree Fahrenheit and a three degrees rise in temperature. Climate skeptics would lowball the number and doom-mongers would highball it, and nobody could keep track.

Bill: What about the distance that IR light can penetrate? That's a much more precisely known number. Should scientists be saying, "the IR distance is 8900 feet, down from 9730 feet in 1900, and is decreasing by 12 feet per year"?

David: I'm glad you're using feet and not meters. But that way of describing it would take a bit of getting used to. One thing I like about it is that the distance decreases with time. Decreasing numbers almost always cause trouble when they get down near zero – like the balance in somebody's bank account. Scientists say that carbon dioxide traps heat. "Traps" is a very poorly chosen word, because it implies that the heat is stuck near the Earth's surface and just keeps on building up there. That's obviously not the case; if it were, temperatures would not fall every winter.

Bill: A more correct way of putting it would be to say that "carbon dioxide resists the flow of heat". Suppose that you put an electric blanket on your bed and then cover it with a quilt. The quilt resists the flow of heat. That's why we give insulation an R-value; the "R" is for "resistance". The temperature of the electric blanket needs to rise to provide enough thermal force to push the heat through the quilt.

David: That's right. The temperature of the bed doesn't rise indefinitely, but only high enough so that it pushes the same amount of heat out as the electric blanket produces.

Bill: That's called "equilibrium". Now if you add a second quilt, you add more resistance, and the temperature of the electric blanket needs to rise even further.

David: Heat isn't the only quantity that acts that way; I think that electricity in a wire acts similarly. The wire has electrical resistance, so you need a voltage at the battery to push the electricity through. And if you make the wire more resistive, say by making it longer, you need a higher voltage battery to maintain the same electric current.

Bill: Water in a garden hose acts that way, too. The pressure of the water main pushes the water against the resistance of the hose. By making the hose longer (or thinner), it becomes more resistive to the flow of the water, and you need a higher-pressure water main to get the same amount of flow. Of course, with most houses, you stuck with whatever pressure the water company supplies, so if you make your garden hose longer, the flow just goes down.

David: The notion of that carbon dioxide makes the Earth's atmosphere more resistive to the flow of heat explains why the Greenhouse Effect doesn't "saturate".

Bill: The more quilts you pile on the bed, the hotter it gets. However, the magnitude of the temperature increase does diminish a little for each successive quilt; the temperature increase for five quilts versus four is not nearly as dramatic as for two quilts versus one.

David: Is that any way to "prove" that carbon dioxide causes a Greenhouse effect?

Bill: I suppose that you could compare to Earth to the Moon. The Moon gets exactly the same amount of sunlight as the Earth, but has no atmosphere and therefore no Greenhouse effect. It is about 100 degrees colder than the Earth.

David: That's not the greatest comparison. I would really prefer a planet that has an atmosphere with no Greenhouse gases to a Moon with no atmosphere at all.

Bill: How about the other way around. Venus is a planet with a very thick atmosphere that is almost totally carbon dioxide, and its surface temperature is hot enough to melt lead.

David: Yes, but Venus is also closer to the sun, so it gets more sunlight than the Earth. It's not a very good example, either.

Bill: Actually, Venus has so many clouds reflecting sunlight back into space that it actually absorbs *less* solar energy than the Earth. But I see your point. What about looking back to the Earth's past, to the Ice Age.

The Earth was about twenty degrees Fahrenheit colder than today. And air bubbles trapped in the Antarctic ice prove that the atmosphere had a lot less carbon dioxide then.

David: Yes, but lots of things were different during the Ice Age. How can you separate the effect of all the extra ice and snow reflecting a sunlight back to space from the effect of decreased carbon dioxide?

Bill: That's where the computer models come in. They are able to gauge the relative importance of the many factors.

David: And at that point, scientists have reached their limit of what they can explain to people like me.