Carbon Dioxide -- Summary

When the earth was in its infancy, some four-and-a half billion years ago, it is believed that the atmosphere was predominantly composed of carbon dioxide, which would have put its CO_2 concentration, in terms of the units most commonly used today, at something on the order of 1,000,000 ppm. Ever since, however, the CO_2 content of the air - in the mean - has been dropping. By 500 million years ago, in fact, the atmosphere's CO_2 concentration is estimated to have fallen to only 20 times more than it is today, or something on the order of 7500 ppm; and by 300 million years ago, it had declined to close to the air's current CO_2 concentration of 370 ppm, after which it rose to about five times where it now stands at 220 million years before present (Berner 1990, 1992, 1993, 1997; Kasting 1993). Then, during the middle Eocene, some 43 million years ago, the atmospheric CO_2 concentration is estimated to have dropped to a mean value of approximately 385 ppm (Pearson and Palmer, 1999); while between 25 to 9 million years ago, it is believed to have varied between 180 and 290 ppm (Pagani *et al*., 1999). This latter concentration range is essentially the same range over which the air's CO_2 concentration oscillated during the 100,000-year glacial cycles of the past 420,000 years (Fischer *et al*., 1999; Petit *et al*., 1999). With the inception of the Industrial Revolution, however, the air's CO_2 content once again began an upward surge that has now taken it to the 370 ppm level, with the promise of significantly higher values still to come.

In addition to its variation over geologic time, the atmosphere's CO_2 concentration exhibits a strong seasonal variation. It declines when the terrestrial vegetation of the Northern Hemisphere awakens from the dormancy of winter and begins to grow in the spring, thereby extracting great quantities of CO_2 from the air; and it rises in the fall and winter, when much of the biomass produced over the summer dies and decomposes, releasing great quantities of CO_2 back to the atmosphere. Over the past four decades that this phenomenon has been accurately measured, it has been observed that this yearly "breath of the biosphere" has risen in strength by approximately 20%, due primarily to the aerial fertilization effect of the ongoing rise in the mean value of the air's CO_2 concentration (Idso *et al*., 1999), but influenced by a number of other factors as well (Zimov *et al*., 1999).

The air's CO_2 content also varies spatially over the surface of the earth. Most spectacular in this regard are the local concentration enhancements observed over large metropolitan areas due to high levels of vehicular traffic and commercial activities. Idso *et al*. (1998a, b), for example, measured CO_2 concentrations near the center of Phoenix, Arizona that were 50% greater than those measured over surrounding rural areas. Significant enhancements of the air's CO_2 concentration may also be observed in the vicinity of burning coal seams and naturally occurring high-CO_2 springs. In Italy, the CO_2-enriched air near such springs has enabled oak trees to transpire less water and thus maintain a better internal leaf water status in the face of drought than similar trees growing in ambient air a short distance away from the springs (Tognetti *et al*., 1998); and in Venezuela, it has allowed herbs and trees growing near a high-CO_2 spring to continue to sequester carbon during dry periods of the year when plants exposed to normal air just tens of meters away actually lose carbon (Fernandez *et al*., 1998). In fact, Schwanz and Polle (1998) have observed that naturally-CO_2-enriched trees appear to experience less stress of *all* kinds than trees growing in ambient air.

It is interesting to note, in this regard, that some naturally-occurring high-CO_2 springs produce *very* high CO_2 concentrations in their immediate vicinity; and it is therefore only natural to wonder if such high concentrations might be detrimental to vegetation. Apparently, they are not; for studies carried out at 10,000 ppm CO_2 have produced positive responses in plants (Gouk *et al*., 1999; Louche-Tessandier *et al*., 1999), as have experiments conducted at 35,000 ppm (Fernandez *et al*., 1998). Also of interest within this plant health context is the fact that atmospheric CO_2 enrichment has been observed to have little effect on the growth of the noxious bracken weed (Caporn *et al*., 1999) and that it has helped oat plants infected with barley yellow dwarf virus considerably more than it has helped uninfected plants (Malmstrom and Field, 1997). Hence, even very high CO_2 concentrations - some as much as 100 times greater than those of the past century - appear to benefit earth's vegetation.

A final concern related to the ongoing rise in the air's CO_2 concentration is the worry that it may lead to catastrophic global warming. There is little reason to believe that such will ever occur, however, for several observations of historical changes in atmospheric CO_2 concentration and air temperature suggest that it is climate change that drives changes in the air's CO_2 content and not *vice versa*. In a study of the global warmings that signaled the demise of the last three ice ages, for example, Fischer *et al*. (1999) found that air temperature always rose first, followed by an increase in atmospheric CO_2 some 400 to 1000 years later. Likewise, Petit *et al*. (1999) found that for all of the glacial inceptions of the past half-million years, air temperature consistently dropped before the air's CO_2 content did, and that the CO_2 decreases lagged the temperature decreases by *several* thousand years. In addition, the multiple-degree-Centigrade rapid warmings and subsequent slower coolings that occurred over the course of the start-and-stop demise of the last great ice age are typically credited with causing the minor CO_2 concentration changes that followed them (Staufer *et al*., 1998); and there are a number of other studies that demonstrate a complete *uncoupling* of atmospheric CO_2 and air temperature during periods of significant climate change (Cheddadi *et al*., 1998; Gagan *et al*., 1998; Raymo *et al*., 1998; Indermuhle *et al*., 1999). Hence, there are no historical analogues for CO_2-induced climate change; but there are many examples of climate change-induced CO_2 variations.

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Methane (Temperature Implications) -- Summary

Following water vapor, carbon dioxide (CO_2) and methane (CH_4) are the next most powerful greenhouse gases of earth's atmosphere; and both have experienced large concentration increases over the course of the Industrial Revolution. Hence, it is only logical that we should attempt to learn everything we can about the prior relationships of these two gases to the planet's near-surface air temperature (T_A) before attempting to predict the future thermal state of the globe based on their anticipated concentration trajectories.

We begin this task with our analysis of the study of Kirchner (2002), who constructed a pair of graphs that depict T_A as linear functions of the air's CO_2 and methane concentrations based on 400,000 years of pertinent data derived from the Vostok ice core. These plots indicate, in his words, that "despite greenhouse gas concentrations that are unprecedented in recent earth history, global temperatures have not risen nearly as much as the correlations in the ice core records would indicate that they could." In fact, he says that "for the current composition of the atmosphere, current temperatures are anomalously cool by many degrees."

So, just how "anomalously cool" is the planet's current temperature? Kirchner's T_A vs. CO_2 plot suggests that the earth is currently about 10°C too cool, while his T_A vs. CH_4 plot - which is by far the better defined and more robust of the two relationships - suggests that the globe is fully *40°C* too cool. Consequently, these observationally-based relationships provide absolutely *no basis* for characterizing earth's current temperature as anomalously high, as the world's climate alarmists always do. Rather, it is the air's CH_4 and CO_2 concentrations that are currently "anomalously high," with earth's temperature sitting squarely in the normal range.

What is the take-home message of these observations? We suggest they imply that T_A *must* be the determinant of atmospheric CH_4 concentration, and not vice versa, *as long as humanity is not a part of the picture*. For nearly all of the past 400,000 years, this latter condition has applied; and the T_A vs. CH_4 relationship derived by Kirchner *has never been violated*. As mankind's numbers and their impact on the atmosphere's trace gas concentrations have skyrocketed over the past few centuries, however, the planet has clearly outgrown this relationship; and the atmosphere's CH_4 concentration has risen to levels far above anything experienced over the entire history of the Vostok ice core. What is more, it has done so without any significant impact on global air temperature; and the same would appear to hold true for CO_2, although the scatter in Kirchner's temperature vs. CO_2 plot is sufficient to allow for significant independent movement by both of these parameters.

Additional light has been shed on the subject by two reports that provide CO_2, methane and temperature data stretching a full 650,000 years back in time (Siegenthaler *et al*., 2005; Spahni *et al*., 2005), based on measurements made on East Antarctica's Dome Concordia ice core, which was originally extracted and cursorily analyzed by Augustin *et al*. (2004), as described in our Editorials of 30 Nov 2005 and 7 Dec 2005. These data indicate that the atmosphere's current CO_2 concentration is about 30% higher than it was at any other time over the last 650,000 years, and that the air's current methane concentration is *130%* higher, which high concentrations have been described as "geologically incredible." Hence, if the world's climate alarmists are correct about the tremendous warming power they attribute to these two top greenhouse gases, one would logically expect the earth to be currently experiencing some incredibly high air temperatures. So what do the ice core data indicate in this regard?

Both the Dome Concordia and Vostok data sets suggest that the peak temperature of the current interglacial or Holocene was *not* incredibly higher than the peak temperatures of *all* of the past four interglacials, the earliest of which is believed to have been nearly identical to the Holocene in terms of earth's orbit around the sun. In fact, the Holocene's peak temperature was not higher than those of the preceding four interglacials by even a tiny *fraction* of a degree. In fact, it was *lower*. In fact, the work of Petit *et al*. (1999) revealed that the peak temperature of the Holocene was *more than 2°C lower* than the average peak temperature of the prior four interglacials. What is more, earth's *current* temperature is *lower still*.

In light of these several real-world observations, we are *forced* to conclude that if there is anything *unusual* or *unnatural* or *unprecedented* about earth's current air temperature compared to the temperatures of prior interglacials, it is that it is so much *colder* now in spite of there being so much more CO_2 and methane in the air. Clearly, therefore, earth's climate system does not operate the way the world's climate alarmists claim it does.

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EXPERTS:

CRAIG D. IDSO is the Chairman of hte Board and founder
SHERWOOD B. IDSO is now the President
Center for the Study of Carbon Dioxide and Global Change
P.O. Box 25697
Tempe, AZ 85285-5697
staff@co2science.org

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The Carbon Dioxide information Center http://cdiac.esd.ornl.gov/

The Fraser Institute's Independent Summary for Policy Makers with sections on greenhouse gases.