Pre-Industrial Atmospheric CO_2 and Proxy Air and Sea Surface Temperature Data Provide No Evidence that Changes in CO_2 Drive Changes in Temperature

Center for Science and Public Policy

www.scienceandpolicy,org

And

Center for the Study of
Carbon Dioxide and Global Change
www.co2science.org

January 2007

Introduction

In a recent news release, Britain's Meteorological Office predicted 2007 will be the warmest year ever recorded during the period of instrumental temperature assessment, due to continued CO_2-induced global warming and the anticipated consequences of the current El Niño situation (Reuters 3 Jan 2007). Likewise, other recent news releases continue to claim that the past decade was the warmest of the past millennium. And once again, climate alarmists are contending there should no longer be any debate about whether greenhouse gas-induced global warming is or is not occurring, only what should be done about it.

Actually, there *is* no question about whether the globe has warmed over the past century or so, only what was *responsible* for the warming; for essentially everyone acknowledges that temperatures rose significantly over this period, as the planet struggled to recover from the global chill of the Little Ice Age. There is also beginning to be a consensus about the practical significance of the warming: growing seasons have lengthened and plant productivity has increased almost everywhere, primarily as a result of the increase in air temperature and the concomitant increase in the atmosphere's CO_2 concentration. So what, if anything, should be done about it?

We believe few people would want to turn back the climatic clock to the conditions that doomed Greenland's Viking colonists and created extreme hardship in Northern Europe and elsewhere. Likewise, not many people have a problem with longer growing seasons and increased vegetative biomass production. So what's all the fuss about?

It's pretty much a tempest in a computerized teapot. For many years climate modelers have been predicting that the ongoing rise in the atmosphere's CO_2 concentration will intensify earth's natural greenhouse effect and boost surface air temperatures to levels that will create all sorts of planetary havoc, melting polar ice caps, raising sea levels, flooding some parts of the globe while turning others into deserts, reducing agricultural productivity, and on and on *ad infinitum*. And now, clones of Al Gore would have us believe that because atmospheric CO_2 and global temperature have both been rising over the past century or so, the increase in atmospheric CO_2 *must* be what is driving the warming – or at least the lion's share of it – which is dogmatically asserted to be sure to produce a host of catastrophic consequences.

In assessing such claims, it is important to remember that *correlation does not prove causation*, and that causation, if it *does* exist, could well be operating in *reverse* fashion from what climate alarmists contend, i.e., climate change could be causing the observed changes in atmospheric CO_2 concentration. Hence, it is important to analyze as much data as possible when evaluating claims of cause-and-effect relationships between two parameters; and several scientific papers of the past few years have given us a wealth of data of the type we need to determine if there is indeed any causal relationship between the air's CO_2 content and surface air temperature. Consequently, we here review the results of those studies, first across the wide sweep of geologic time, and then over the more recent past.

CO_2 and Temperature Throughout Geologic Time

We begin our investigation with the study of Rothman (2002), who derived a 500-million-year history of the air's CO_2 content based on considerations related to the chemical weathering of rocks, volcanic and metamorphic degassing, and the burial of organic carbon, along with considerations related to the isotopic content of organic carbon and strontium in marine sedimentary rocks. The results of this analysis suggest that over the majority of the half-billion-year record, earth's atmospheric CO_2 concentration fluctuated between values that were *two to four times greater than those of today* at a dominant period on the order of 100 million years (see Figure 1 below). Over the last 175 million years, however, the data depict a long-term decline in the air's CO_2 content.

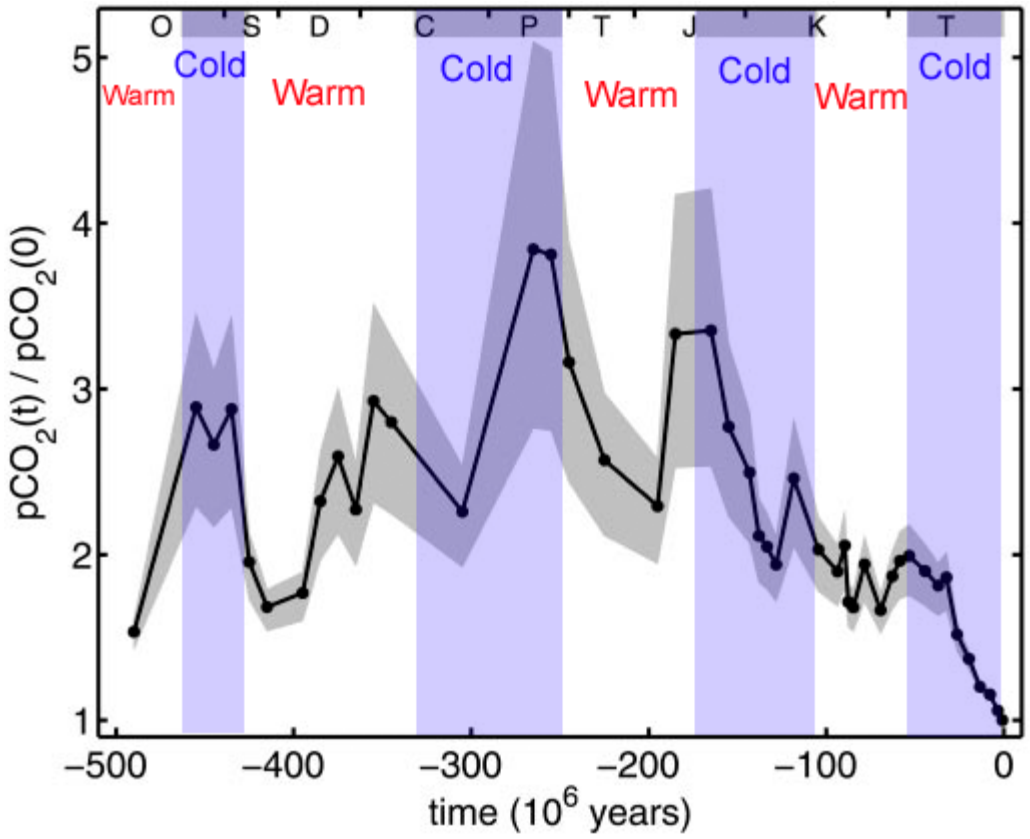

Figure 1. A 500-million-year record of the atmosphere's CO_2 concentration (relative to that of the present = 1), as derived by Rothman (2002), together with indications of periods of relative cold and warmth.

With respect to the question of what correspondence might exist between ancient climates and atmospheric CO_2 concentrations, Rothman correctly reports that the CO_2 history of Figure 1 "exhibits no systematic correspondence with the geologic record of climatic variations at tectonic time scales." In fact, a simple visual examination of Rothman's plot of CO_2 and concomitant major cold and warm periods clearly indicates that the three most striking *peaks* in the air's CO_2 concentration occur either totally or partially within periods

of time when earth's climate was relatively *cool*. Consequently, not only is there no proof in these data for the climate-alarmist claim that high atmospheric CO_2 concentrations tend to warm the planet, there are times when just the *opposite* could be imagined to be implied.

For a more detailed look at the most recent *fifty* million years of earth's thermal and CO_2 history, we consult the plots of Figure 2, which were prepared by Pagani *et al*. (2005). As can be seen there, about 43 million years ago, the atmosphere's CO_2 concentration was approximately 1400 ppm and the oxygen isotope ratio (a proxy for temperature) was about 1.0 per mil. Then, over the next ten million years, the air's CO_2 concentration experienced three *huge oscillations* on the order of 1000 ppm from peak to valley (red portion of Figure 2). And how did temperature respond to these large CO_2 swings? In the case of the first two oscillations it appeared to respond *not at all*, exhibiting an uninterrupted slow decline, represented by the steady upward trend in $\delta^{18}O$. Following the third rise in CO_2, however, temperatures seemed to respond, but in the *opposite direction* to what one would have expected according to the CO_2-induced global warming hypothesis, as the rise in CO_2 was followed by the sharpest drop in temperature (rise in $\delta^{18}O$) of the entire record.

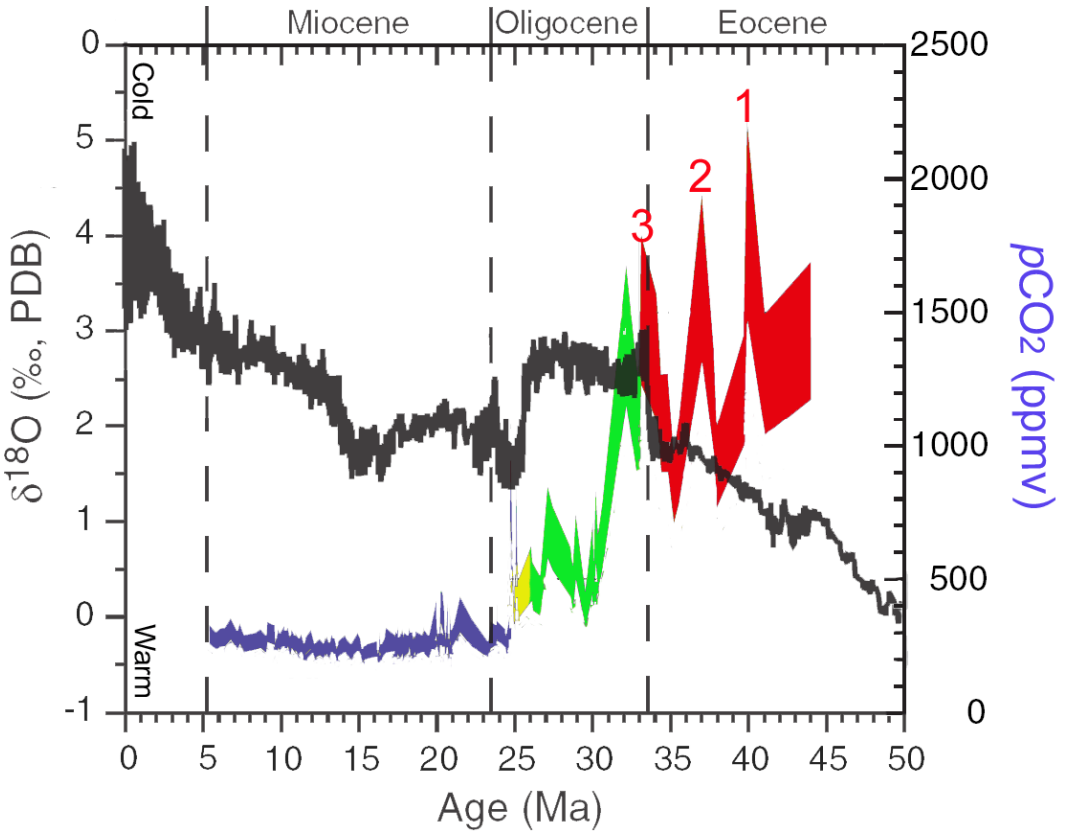

Figure 2. Atmospheric CO_2 concentration (multicolored line) and proxy temperature (black line) over the past 50 million years as derived by Pagani *et al.* (2005).

Following this large drop in temperature between 34 and 33 million years before present (Ma BP), the oxygen isotope ratio hovered around a value of 2.7 per mil from about 33 to 26 Ma BP, indicating little change in temperature over that period. The corresponding

CO_2 concentration (green section of Figure 2), on the other hand, was anything but constant, experiencing about a 500 ppm increase around 32 Ma BP, after which it dropped a full 1000 ppm over the next two million years, only to rise again by a few hundred ppm, defying – again and again and again – the common causal assumption of the CO_2-induced global warming hypothesis.

Next, around 26 Ma BP, the oxygen isotope ratio dropped to about 1.4 per mil (implying a significant *rise* in temperature), during which time the air's CO_2 content (short yellow portion of Figure 2) *declined*, which is once again just the *opposite* of what one would expect were CO_2 the all-important driver of climatic change climate alarmists make it out to be. Then, from 24 Ma BP to the end of the record at 5 Ma BP, there were relatively tiny variations in atmospheric CO_2 content (blue portion of Figure 2); but there were *large* variations in oxygen isotope values, both up and down; and all of these many observations, according to Pagani *et al*. (2005), "argue for a decoupling between global climate and CO_2," and stand in *clear contradiction* of the CO_2-induced global warming hypothesis.

CO_2 and Temperature Throughout the Latter Part of the Pleistocene

Several studies have shed additional light on the CO_2-temperature relationship throughout the last 800,000 years of dramatic glacial-interglacial cycles. Fischer *et al*. (1999), for example, examined trends of atmospheric CO_2 and air temperature derived from Antarctic ice core data that extended back in time a quarter of a million years. Over this period, the three most dramatic warming events experienced on earth were the terminations of the last three ice ages; and for each of these climatic transitions, earth's air temperature always *rose* well in *advance* of the *increase* in atmospheric CO_2. In fact, the air's CO_2 content did not begin to rise until 400 to 1,000 years *after* the planet began to warm.

Another team to study the CO_2-temperature relationship was that of Petit *et al*. (1999), who discovered that during all glacial *inceptions* of the past half million years, temperature always *dropped* well *before* the *decline* in the air's CO_2 concentration; and they say their data indicate that "the CO_2 decrease lags the temperature decrease by several thousand years." Likewise, Mudelsee (2001) determined that variations in atmospheric CO_2 concentration lagged behind variations in air temperature by 1,300 to 5,000 years over the past 420,000 years. In addition, during certain climatic transitions characterized by rapid warmings of *several degrees Centigrade*, which were followed by slower coolings that returned the climate to essentially full glacial conditions, Staufer *et al*. (1998) observed the atmospheric CO_2 concentration derived from ice core records to typically vary by *less than 10 ppm*. And here, too, they considered the CO_2 perturbations to have been caused by the changes in climate, rather than vice versa.

Many other studies have also demonstrated this *reverse coupling* of atmospheric CO_2 and temperature (Cheddadi *et al*., 1998; Gagan *et al*., 1998; Raymo *et al*., 1998), where temperature is the independent variable that appears to induce changes in CO_2. What is more, Steig (1999) noted cases of the *inverse* coupling of the two parameters, when they demonstrated that between 7,000 and 5,000 years ago, atmospheric CO_2 concentrations increased by just over 10 ppm at a time when temperatures in both hemispheres *cooled*.

Moving closer to the present, Caillon *et al*. (2003) measured the isotopic composition of argon – specifically, $\delta^{40}Ar$, which they argue "can be taken as a climate proxy, thus providing constraints about the timing of CO_2 and climate change" – in air bubbles in the Vostok ice core over the period that comprises what is called Glacial Termination III, which occurred about 240,000 years ago. The results of their tedious but meticulous analysis led them to ultimately conclude that "the CO_2 increase lagged Antarctic deglacial warming by 800 ± 200 years."

This finding, in the words of Caillon *et al*., "confirms that CO_2 is not the forcing that initially drives the climatic system during a deglaciation." Nevertheless, they and many others continue to hold to the view that the subsequent increase in atmospheric CO_2 – which is believed to be due to warming-induced CO_2 outgassing from the world's oceans – serves to amplify the warming that is caused by whatever prompts the temperature to rise in the first place. This belief, however, is founded on unproven assumptions about the strength of CO_2-induced warming and is applied without any regard for biologically-induced negative climate feedbacks that may occur in response to atmospheric CO_2 enrichment. Also, there is no way to objectively determine the strength of the proposed amplification from the ice core data. And in consequence of these several observations, the role of CO_2 as a *primary driver* of climate change on earth would appear to be going, going, *gone*; while the CO_2 warming *amplification hypothesis* rings mighty hollow.

Another departure from standard greenhouse effect theory occurred over the 17,000-year period following the penultimate deglaciation, when the air's CO_2 content was essentially constant but air temperature declined to values characteristic of glacial times (see Figure 3). And an even greater departure from climate-alarmist dogma occurred immediately thereafter, when CO_2 finally began to *fall* but temperature began to *rise*, which is *yet again* just the opposite of what climate alarmists suggest should occur.

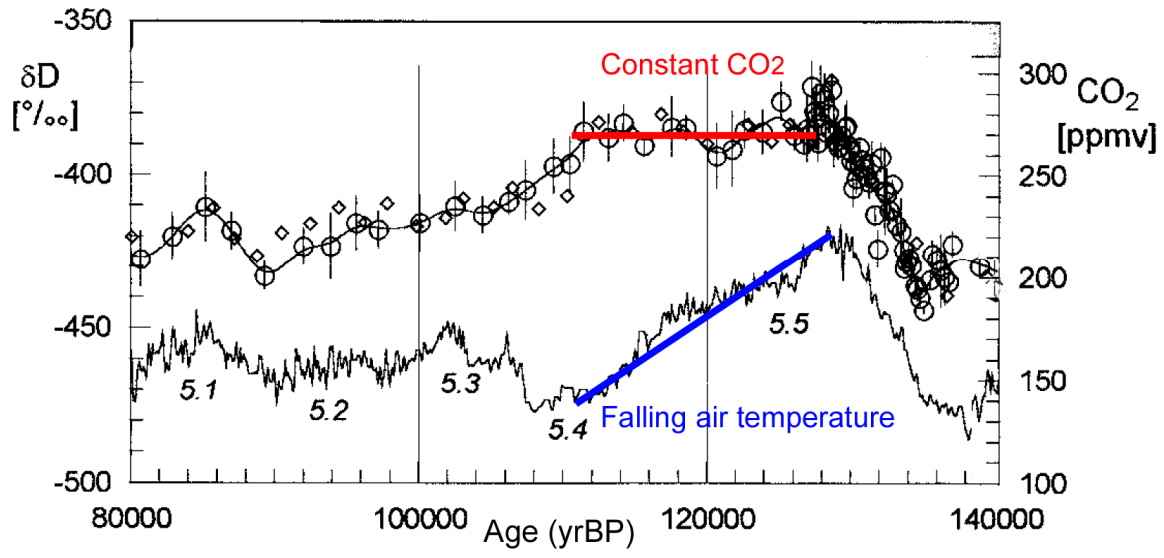

Figure 3. Atmospheric CO_2 and proxy temperature data from Fischer *et al*. (1999).

Also discoverers of an *inverse* greenhouse relationship were Indermuhle *et al*. (1999), who determined that after the termination of the *last* great ice age, the CO_2 content of the air gradually *rose* by approximately 25 ppm in almost linear fashion between 8,200 and 1,200 years ago, over a period of time that saw a slow but steady *decline* in global air temperature. On the other hand, when working with a high-resolution temperature and atmospheric CO_2 record spanning the period 60 to 20 thousand years ago, Indermuhle *et al*. (2000) discovered four distinct periods when temperatures rose by approximately 2°C and CO_2 rose by about 20 ppm. However, one of the statistical tests they performed on the data suggested that the shifts in the air's CO_2 content during these intervals *followed* the shifts in air temperature by approximately 900 years; while a second statistical test yielded a mean CO_2 lag time of 1200 years.

Another pertinent study comes from Siegenthaler *et al*. (2005), who analyzed CO_2 and proxy temperature (δD, the ratio of deuterium to hydrogen) data derived from an ice core in Antarctica. Results of their analysis revealed a coupling of Antarctic temperature and CO_2 in which they obtained the best correlation between CO_2 and temperature "for a lag of CO_2 of 1900 years." Specifically, over the course of glacial terminations V to VII, they indicate that "the highest correlation of CO_2 and deuterium, with use of a 20-ky window for each termination, yields a lag of CO_2 to deuterium of 800, 1600, and 2800 years, respectively." In addition, they note that "this value is consistent with estimates based on data from the past four glacial cycles," citing in this regard the work of Fischer *et al*. (1999), Monnin *et al*. (2001) and Caillon *et al*. (2003), and once again confirming that it is *temperature* that is the *robust leader* in this tightly-coupled relationship, while *CO_2* is but the *humble follower*, providing only a *fraction* (which could well be miniscule) of the total glacial-to-interglacial temperature change.

These observations do little to inspire confidence in climate-alarmist claims that the CO_2 produced by the burning of fossil fuels will lead to catastrophic global warming, with predicted warmings in some of their scenarios that rival those experienced in glacial-to-interglacial transitions. Nevertheless, Siegenthaler *et al*. stubbornly state that the new findings "do *not* cast doubt ... on the importance of CO_2 as a *key amplification factor* [our italics] of the large observed temperature variations of glacial cycles."

In vivid contrast to this *unsupported contention*, it is our opinion that when temperature leads CO_2 by *thousands* of years, during both glacial terminations *and* inceptions (Genthon *et al*., 1987; Fischer *et al*., 1999; Petit *et al*., 1999; Indermuhle *et al*., 2000; Monnin *et al*., 2001; Mudelsee, 2001; Caillon *et al*., 2003), there is *plenty* of reason to believe that CO_2 plays but a *minor* role in enhancing temperature changes that are *clearly induced by something else*, which latter italicized point is an *undisputed fact* that is clearly born out by the ice core data.

Consequently, whereas Thomas Stocker (the second and corresponding author of the Siegenthaler *et al*. paper) was quoted by the BBC's Richard Black (BBC News, 24 Nov 2005) as saying of the relationship they observed between δD and CO_2, *without any additional evidence*, that it is "a very strong indication of the important role of CO_2 in climate regulation," we say it is "a very strong indication of the important role of *climate*

in CO_2 regulation." Why? Because *like Mary's little lamb*, and as evidenced by *650,000 years of real-world data*, wherever *temperature* went over this period, CO_2 was (mostly) "sure to follow," which *by definition* is "a very strong indication of the important role of *climate* in CO_2 regulation" and *not* the opposite.

Conclusion

In considering the findings of the several studies that have broached the question of the relationship between carbon dioxide and temperature over the past half million or so years, it is clear that (1) sometimes the two parameters are totally out of sync with each other, as when one rises and the other falls, (2) sometimes one is in transit to a higher or lower level, while the other is in stasis, and (3) even when both move in harmony, temperature almost always moves first, and by hundreds to thousands of years.

Clearly, there is no way these real-world observations can be construed to even *hint* at the possibility that a significant increase in atmospheric CO_2 will necessarily lead to *any* global warming, much less the catastrophic type that is predicted to produce the apocalyptic consequences that are driving fear-ridden governments to abandon all sense of rationality in the current hysteria over "what should be done about" the ongoing rise in the air's CO_2 content. We need to get *real* about this issue. We need to look at *real* phenomena that have *really* occurred in the *real* world. And in spite of all the computer simulations to the contrary, we have got to realize what these real data are really telling us.

Consider, in this regard, the findings of Petit *et al*. (1999) portrayed in Figure 4 below, which indicate that the current interglacial is by far the coolest of the five most recent such periods. In fact, the peak temperatures of the four interglacials that preceded it were, on average, more than 2°C warmer than that of the one in which we currently live.

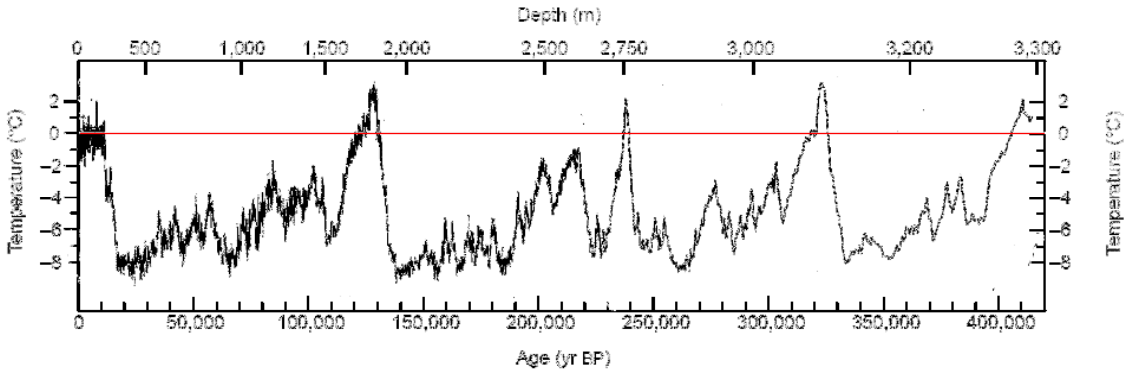

Figure 4. Temperature history derived by Petit *et al*. (1999) from an ice core extracted from the Russian Vostok drilling station in East Antarctica.

This observation raises some interesting questions. First, was the temperature of the last decade of the 20th century in anyway unprecedented or unusual in terms of typical interglacial temperatures? The answer, clearly, is *yes*; but it was not unusual in the way suggested by the world's climate alarmists, who claim it was unusually warm. It was *not*

unusually *warm*; it was unusually *cool*. Second, is the current temperature of the globe a sign of dangerous human interference with earth's climate system? Clearly, it is *not*, for the highly-hyped claim of a human influence on temperature is based on the contention that the planet's current temperature is uncommonly *high* (Crowley, 2000), when it has clearly been significantly warmer than it is now during parts of all preceding interglacials for which we have good proxy temperature data.

But can the higher temperatures of the past four interglacials be attributed to higher CO_2 concentrations caused by some *non*-human influence? *Absolutely not*, for atmospheric CO_2 concentrations during all four prior interglacials never rose above approximately 290 ppm, whereas the air's CO_2 concentration today stands at nearly 380 ppm.

Combining these two observations, we currently have a situation where compared with the mean conditions of the preceding four interglacials, there is currently 90 ppm *more* CO_2 in the air than there was then, and it is currently more than 2°C *colder* than it was then, which adds up to *one huge discrepancy* for the world's climate alarmists and their claim that high CO_2 concentrations lead to high temperatures. The situation is unprecedented, all right, but *not* in the way the public is being led to believe.

References

Caillon, N., Severinghaus, J.P., Jouzel, J., Barnola, J.-M., Kang, J. and Lipenkov, V.Y. 2003. Timing of atmospheric CO_2 and Antarctic temperature changes across Termination III. *Science* **299**: 1728-1731.

Cheddadi, R., Lamb, H.F., Guiot, J. and van der Kaars, S. 1998. Holocene climatic change in Morocco: a quantitative reconstruction from pollen data. *Climate Dynamics* **14**: 883-890.

Crowley, T.J. 2000. Causes of climate change over the past 1000 years. *Science* **289**: 270-276.

Fischer, H., Wahlen, M., Smith, J., Mastroianni, D. and Deck, B. 1999. Ice core records of atmospheric CO_2 around the last three glacial terminations. *Science* **283**: 1712-1714.

Gagan, M.K., Ayliffe, L.K., Hopley, D., Cali, J.A., Mortimer, G.E., Chappell, J., McCulloch, M.T. and Head, M.J. 1998. Temperature and surface-ocean water balance of the mid-Holocene tropical western Pacific. *Science* **279**: 1014-1017.

Genthon, C., Barnola, J.M., Raynaud, D., Lorius, C., Jouzel, J., Barkov, N.I., Korotkevich, Y.S. and Kotlyakov, V.M. 1987. Vostok ice core: Climatic response to CO_2 and orbital forcing changes over the last climatic cycle. *Nature* **329**: 414-418.

Indermuhle, A., Monnin, E., Stauffer, B. and Stocker, T.F. 2000. Atmospheric CO_2 concentration from 60 to 20 kyr BP from the Taylor Dome ice core, Antarctica. *Geophysical Research Letters* **27**: 735-738.

Indermuhle, A., Stocker, T.F., Joos, F., Fischer, H., Smith, H.J., Wahllen, M., Deck, B., Mastroianni, D., Tschumi, J., Blunier, T., Meyer, R. and Stauffer, B. 1999. Holocene carbon-cycle dynamics based on CO_2 trapped in ice at Taylor Dome, Antarctica. *Nature* **398**: 121-126.

Monnin, E., Indermühle, A., Dällenbach, A., Flückiger, J, Stauffer, B., Stocker, T.F., Raynaud, D. and Barnola, J.-M. 2001. Atmospheric CO_2 concentrations over the last glacial termination. *Nature* **291**: 112-114.

Mudelsee, M. 2001. The phase relations among atmospheric CO_2 content, temperature and global ice volume over the past 420 ka. *Quaternary Science Reviews* **20**: 583-589.

Pagani, M., Authur, M.A. and Freeman, K.H. 1999. Miocene evolution of atmospheric carbon dioxide. *Paleoceanography* **14**: 273-292.

Pagani, M., Zachos, J.C., Freeman, K.H., Tipple, B. and Bohaty, S. 2005. Marked decline in atmospheric carbon dioxide concentrations during the Paleogene. *Science* **309**: 600-603.

Pearson, P.N. and Palmer, M.R. 1999. Middle Eocene seawater pH and atmospheric carbon dioxide concentrations. *Science* **284**: 1824-1826.

Pearson, P.N. and Palmer, M.R. 2000. Atmospheric carbon dioxide concentrations over the past 60 million years. *Nature* **406**: 695-699.

Petit, J.R., Jouzel, J., Raynaud, D., Barkov, N.I., Barnola, J.-M., Basile, I., Bender, M., Chappellaz, J., Davis, M., Delaygue, G., Delmotte, M., Kotlyakov, V.M., Legrand, M., Lipenkov, V.Y., Lorius, C., Pepin, L., Ritz, C., Saltzman, E. and Stievenard, M. 1999. Climate and atmospheric history of the past 420,000 years from the Vostok ice core, Antarctica. *Nature* **399**: 429-436.

Raymo, M.E., Ganley, K., Carter, S., Oppo, D.W. and McManus, J. 1998. Millennial-scale climate instability during the early Pleistocene epoch. *Nature* **392**: 699-702.

Rothman, D.H. 2002. Atmospheric carbon dioxide levels for the last 500 million years. *Proceedings of the National Academy of Sciences USA* **99**: 4167-4171.

Royer, D.L., Wing, S.L., Beerling, D.J., Jolley, D.W., Koch, P.L., Hickey, L.J. and Berner, R.A. 2001. Paleobotanical evidence for near present-day levels of atmospheric CO_2 during part of the Tertiary. *Science* **292**: 2310-2313.

Siegenthaler, U., Stocker, T., Monnin, E., Luthi, D., Schwander, J., Stauffer, B., Raynaud, D., Barnola, J.-M., Fischer, H., Masson-Delmotte, V. and Jouzel, J. 2005. Stable carbon cycle-climate relationship during the late Pleistocene. *Science* **310**: 1313-1317.

Staufer, B., Blunier, T., Dallenbach, A., Indermuhle, A., Schwander, J., Stocker, T.F., Tschumi, J., Chappellaz, J., Raynaud, D., Hammer, C.U. and Clausen, H.B. 1998. Atmospheric CO_2 concentration and millennial-scale climate change during the last glacial period. *Nature* **392**: 59-62.

Steig, E.J. 1999. Mid-Holocene climate change. *Science* **286**: 1485-1487.