CO_2 greenhouse effect: boon or bane?

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An unprecedented global heat wave. Melting polar ice caps. Rising sea levels. Withered water supplies. Uncertain agricultural productivity. These are but a few of the calamities said in a recent report of the U.S. National Research Council (NRC) to be looming on the horizon, as the atmospheric concentration of carbon dioxide (CO_2) continues to rise inexorably in response to mankind's gratification of its insatiable appetite for fossil fuels such as coal, gas, and oil. And, in the opinion of a recent report of the U.S. Environmental Agency (EPA), there is absolutely nothing we can do about it.

Pretty scary? You bet. Edgar Allan Poe must be smiling down (or is it up?) at his modern-day imitators.

But is it true? Now that's the rub. Whereas the great master of the macabre never intended that his words be read as gospel, the NRC and EPA reports come to us with the blessings of such venerable organizations as the U.S. National Academy of Sciences, whose good offices seem to rank close to those of Deity. At least that is the feeling one gets when confronted with the publicity hype generated by the two reports. Nevertheless, the question still remains, are the reports true?

There is no question that the atmospheric CO_2 content has been rising steadily over the past quarter-century. That much has been proven by direct measurement. Neither is there any question that it has been generally increasing ever since the inception of the Industrial Revolution, although some question still exists about the magnitude of rise. Even the proposition that atmospheric CO_2 will continue to rise for decades and centuries to come is questioned by but few people. Indeed, there is even no controversy over the NRC report's estimate that a nominal doubling of the atmospheric concentration from 300 to 600 parts per million (ppm) will most likely occur by the year 2065. So what's all the fuss about?

To answer this question, an elite cadre of the atmospheric sciences community has turned to complex numerical models of how the atmosphere is believed by them to function. Requiring high-speed computers to obtain solutions to their many sets of simultaneous equations, these models predict that the most likely consequence of a 300 to 600 ppm doubling of the atmospheric CO_2 concentration will be a 3 ± 1.5°C rise in mean global air temperature. The models additionally indicate that the warming in polar regions, particularly the north polar region, will be several times greater than the global mean. And from these two major conclusions flow all of the subsequent calamities mentioned at the beginning of this article.

Numerical models vs. reality

A bothersome fact, however, is that the real world does not appear to behave as the models predict. For instance, from data and equations in the NRC report, it can be calculated that over the 100-year period from 1880 to 1980 the mean surface air temperature of the northern third of the globe should have increased by about 3°C. However, actual temperature data for this time period and region, also in the NRC report, indicate a warming of only 0.3°C. This result, as well as those of several other "natural experiments" conducted by myself and others (*Boundary-Layer Meteorol.* 1982 *22* 227), implies that Earth's surface air temperature sensitivity is a full order of magnitude less than that suggested by the models.

An even greater discrepancy is uncovered when the last four decades of this 100-year span are considered. During this period of most rapid increase in atmospheric CO_2 concentration, the temperature trend of the northern third of the globe was actually downward—and downward at the dramatic rate of over a tenth of a degree C per decade (*J. Environ. Qual.* 1983 *12* 159). Not only have temperatures dropped; snowfall has increased as well. Indeed, a recent satellite study (*Bull. Amer. Meteorol. Soc.* 1982 *63* 1132) has shown that between 1966 and 1980 there was a net increase in the areal extent of Northern Hemispheric seasonal snow cover amounting to 3,000,000 square kilometers, with the increase in snow cover being accompanied by a trend towards earlier accumulation in the fall and later ablation in the spring.

Of course, all of this is in contrast to the computer model predictions that with increasing CO_2 "snowmelt arrives earlier and snowfall begins later." But it is in striking harmony with a singularly unique model study (*Nature* 1979 *280* 668)

which neglected the conventional greenhouse effect of CO_2 and looked at the consequences of the supposedly weaker interaction of CO_2 with solar radiation. In that case, the predictions matched reality. Enhanced concentrations of atmospheric CO_2 were found to "delay the recrystallization of snow and dissipation of pack-ice and result in a cooling rather than a warming effect" and to "contribute to an extension of snow and ice seasons . . . marked by delayed snowmelt in spring, and early snow deposition in autumn."

But that suggests that CO_2 is an *inverse* greenhouse gas, which is tantamount to scientific heresy. Perhaps. But let it be remembered that many heretics of yesteryear are the acknowledged fathers of many of today's respected fields of research. Moreover, evidence is rapidly accumulating to indicate that the proponents of this radically new view of CO_2 may ultimately be so immortalized as well.

One compelling piece of evidence comes from a recent study of the so-called continuum absorption of water vapor (*J. Atmos. Sci.* 1982 *39* 2923). Previously neglected in all prior model studies of CO_2 effects on climate, inclusion of this factor reduced the size of the CO_2-induced enhancement of thermal radiation to the Earth's surface by a full order of magnitude over approximately 40% of the globe. This reduction was enough to make the CO_2-induced enhancement of thermal radiation in this broad equatorial region less significant than the CO_2-induced depletion of solar radiation, as I demonstrate in a forthcoming article in the *Journal of Climatology*. In addition, I also indicate in that article how the Arctic haze of high northern latitudes may similarly preempt the conventional greenhouse properties of CO_2, to produce the dramatic north polar cooling of the past four decades.

Of course, none of this evidence actually *proves* the case one way or the other. But it certainly provides reason for keeping an open mind on the question—at least for the next few decades.

So what else is new? In addition to climatic consequences, the recent greenhouse reports consider a number of biological ramifications. One which is probably more of a cross between biology and physics involves streamflow. Based upon the supposition that runoff is the simple difference between precipitation and evapotranspiration, and the assumption that evapotranspiration is controlled solely by temperature, the NRC report concludes that streamflow rates of the major western U.S. watersheds will be reduced by some 40% to 75% with a doubling of the atmospheric CO_2 content.

Fortunately, this analysis fails to account for the proven effects of increased CO_2 concentrations on plant stomates. In a recent review of the literature pertinent to this topic, for instance, it was found that a 300-600 ppm doubling of the atmospheric CO_2 concentration generally reduces plant evaporative water losses by about a third (*Agric. Water Manage.* 1983 *7* 55). And including this effect in a model used to simulate the significance of changed stomatal resistances for steamflow, A. R. Aston of the Australian CSIRO has concluded that "we can expect streamflow to increase from 40 to 90% as a consequence of doubling the atmospheric CO_2 concentration" (*J. Hydrol.* 1984 *67* 273). Thus, once again, conventional wisdom, particularly as expreseed in the NRC and EPA greenhouse reports, appears to be rebuffed by experimental data from the real world.

Agricultural effects

In the area of agriculture the two reports appear more conservative, even exuding a mild optimism, as they conclude that the incremental yield increases of the recent past will probably continue into the future. However, this is the one area where the effects of CO_2 *are* well known, and simple extrapolations—and not speculations, as in the reports' treatments of climate—provide a clear picture of *fantastic* benefits for the entire world.

To begin with, CO_2 is one of the prime raw materials consumed in the photosynthetic process, and well over a century of documented scientific research has demonstrated that when atmospheric CO_2 is increased, so also is photosynthesis increased. Indeed, B. A. Kimball has recently reviewed the literature on this topic and analyzed results of literally hundreds of observations of this phenomenon (*Agron. J.* 1983 *75* 779), concluding that a doubling of the CO_2 content of the atmosphere will in all likelihood lead to a 33% increase in global agricultural production, and that a tripling of the atmospheric CO_2 content will boost it by 67%. Consequently, it is not unreasonable to believe that the quadrupling or six-fold increase in atmospheric CO_2 foreseen in the NRC and EPA reports could well *double* crop yields the world over.

Concomitant with this yield increase is the reduction in plant evaporative water loss mentioned in connection with streamflow. When the two factors are combined to create a water use efficiency parameter, defined as the yield produced per unit of water used, it is found that plant water use efficiency doubles for a mere doubling of the atmospheric CO_2 content. And a recent report by H. H. Rogers *et al.* (*Science* 1983 *220* 428) indicates that this increase in plant water use efficiency is a linear function extending to at least a quadrupling of the atmospheric CO_2 concentration, for both C_3 and C_4 crops and even trees. As a result, the amount of water needed to produce the doubled yield foreseen in the previous paragraph should drop to a small fraction of what is currently needed to produce but half as much food.

Not only will these changes in plant water use efficiency benefit existing agriculture; they will also allow the bringing into profitable production of great tracts of arid and semi-arid lands presently not suitable for cultivation. In addition, the unmanaged biosphere will benefit as well; for natural plant communities should be able to greatly extend their ranges, pushing into areas where they are currently not able to survive and successfully reproduce due to lack of water. Indeed, the desert should "blossom as the rose" (Isaiah 35:1) and the face of the whole terrestrial landscape be dramatically transformed. Nothing could be better for the planet.