The CO2 Newsletter, created, published, and edited by William N. Barbat, ran from 1979 to 1982.

In 2025, the family of Mr. Barbat donated an original set of all issues to Dr. Marc Hudson, and agreed that these could be digitised and placed online as a resource for anyone who wants to understand how long we've known about the carbon dioxide and global warming problem.

CO_2 Newsletter©

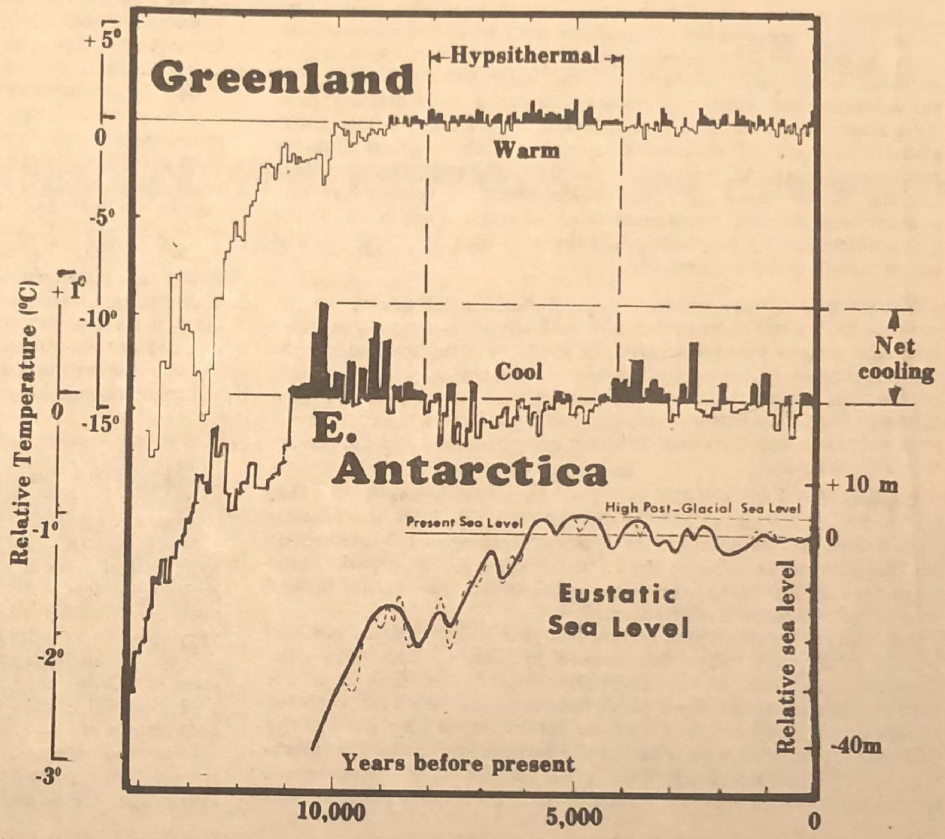
Volume 2, Number 6 **Sept.-Oct., 1981**

A bimonthly summary of advances in knowledge of the CO2-greenhouse problem, and of the social, political, and economic implications.

Southern Hemisphere Puzzles:

-will warmer be wetter?

-will warmth grow ice?



Two aspects of a potential global warming due to CO_2 buildup which have been perceived as 'silver linings' are an expectation of wetter growing conditions in Australia and a possible increase in volume of ice on Antarctica.

Australia's climate during the Hypsithermal Age (about 8000 to 4000 years before present) was apparently wetter than today but temperature records from Antarctic ice cores and from pollen sequences and sea-floor cores from New Guinea raise doubts that temperature trends in the Southern Hemisphere have coincided in direction with those in the Northern Hemisphere. Hence, Australia may have become drier with warming, and might continue to do so.

Major ice-age cooling and interglacial warming appear nearly synchronous between hemispheres, but lesser temperature swings of one millenium to several millenia in duration may have occurred in opposite directions between north and south. Diametrically opposed oscillations may have resulted from past variations in latitude of the 'climatic equator'. Comparing Dansgaard's Camp Century paleotemperature record from northwest Greenland with the record derived by C. Lorius, L. Merlivat, J. Jouzel and M. Pourchet (1979) from Ice Dome 'C' of East Antarctica shows **cooling** during the Hypsithermal which followed a period of maximum post-ice age warming. Warmest post-ice age temperatures in New Guinea are reported to have been about 9400 BP which is prior to the Hypsithermal.

Ages of the Ice Dome 'C' data as shown have been approximated from a simple ice flow model assuming a constant rate of accumulation during the past 10,000 years and a variable rate for the transition period from ice age to interstadial. A more accurate age comparison will be possible when carbon-14 datings are made available.

Lorius's group notes that a Vostok ice core (also from East Antarctica) "indicates the same succession of climatic periods with a slightly different chronology." However, the Byrd Station ice core record from West Antarctica "shows no apparent agreement with this sequence due to the difficulty of interpreting its complicated glaciological regime."

The authors indicate that the average precipitation rate at Ice Dome 'C' was 25% less during the last ice age, yet the dome may have been 100 m higher in elevation at that time. This precipitation increase calculates to be about 3 additional millimeters per year per 1°C of temperature rise, which—if it is representative of the inland area of Antarctica—offers little hope of offsetting any potential ice destruction at West Antarctica from a CO_2-induced warming.

(Ice core references were kindly furnished by A.J. Gow, Snow & Ice Branch, Corps of Engineers, Hanover, NH. The sea level curve shown is that of R.W. Fairbridge.)

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"Facts do not cease to exist because they are ignored."

—Aldous Huxley

Editorial

Completion of our second year of publication offers a convenient time to compare progress on the CO_2 problem with hopes and expectations.

On the scientific front, emphasis on the carbon budget seems to have declined, while polar research efforts have been providing new paleoclimatic and glaciologic information at a breathtaking pace. Altogether, the polar data, paleoclimatic data from sea-floor cores, global syntheses of continental climates such as Karl Butzer's monumental work on the Hypsithermal Age, and recent refinements in regional climate modeling now provide climatologists with a much sounder base for their hypotheses. The 'information explosion' on the CO_2 problem is very heartening, but the need for more hard data and better models is no less pressing.

Newspapers and magazines are now publishing articles on the CO_2 problem with greater frequency and with deeper understanding. Not long ago, editors seemed to print at least one article predicting the rapid return of an ice age climate for every article predicting CO_2-greenhouse warming, and the CO_2 articles often received less prominence. The public was confused about climate trends, the news media were confused, and the scientific community also gave the impression of being confused.

Reports in the news media now give the public the impression that the scientific community is much more unified in its climatic assessments, and that the controversial aspects of the CO_2 problem do not negate the concept of greenhouse warming. Newspapers and magazines are beginning to address the CO_2 problem as real and in need of political and industrial attention.

An outstanding contribution of the last year was an article a group of NASA atmospheric physicists headed by James Hansen. In their systematic analysis of the short-term modulating factors of the post-1880 global temperature curve they quantified both the expected effects of large injections of volcanic ash (short, sharp dips) and the theoretical reduction of solar luminosity by sunspots (longer, larger swings, such as the 1940-1970 cooling). Their sunspot correlation to recent temperature trends provides a more definite basis for attributing past cyclic temperature variations—as deduced from ice cores—to variable solar activity. Also the authors introduced a value (2°C above pre-industrial) for global average temperature which may correspond to temperatures of the Mesozoic era. This value may or may not be accurate, but it provides food for thought. Geologists note that the Mesozoic era was devoid of ice sheets!

On the political scene the hearings held July 31 by two subcommittees of the House Committee on Science and Technology might appear to have set the CO_2 effort back considerably. The overall results of government-sponsored programs had to be defended vigorously, and the new administration wants assurance that sociological and political implications of the CO_2-greenhouse problem were not derived ideologically. However, the net effect on future CO_2 research may be very beneficial.

Despite encouraging advances in scientific understanding and in reporting, very little progress was noted in the supplanting of CO_2-producing energy sources with non-CO_2 sources. While the CO_2 output from petroleum combustion slackened, increased CO_2 production from coal consumption and accelerated wood-cutting to replace high cost oil may have offset that decline. Oil might yet make a strong comeback if attempts by OPEC nations to maintain high prices ultimately fail, as Milton Friedman has predicted they will.

With their large subsidies removed, solar and wind now show little ability to penetrate the free market on a grand scale. Also skyrocketing interest rates are reportedly a major factor causing utility companies to scrap planned nuclear plants and build coal plants instead.

The more we know about the CO_2-greenhouse problem, the less we seem to do about it.

●

The intended role of the **CO_2 Newsletter** is to collect and disseminate knowledge acquired by others. When we do inject an opinion, we seek to emphasize a point of logic that somehow got lost in complexity.

Much wasted effort seems to be going into the projecting of hypothetical **rates** of fossil fuel use into the future. Based on available reports, the fraction of man-made CO_2 taken up by natural sinks is expected to remain pretty much the same whether man's outpourings are very small or very large compared to current output.

If so, we should be speaking of expected impacts in terms of the **total mass** of CO_2 released, not the speed at which CO_2 is released. Otherwise, political leaders may concern themselves only with slowing the outpourings of CO_2 rather than halting them.

From the viewpoint of many future generations, each ton of CO_2 released by man to the atmosphere represents a legacy identical to every other ton no matter how many tons are released in a given year.

Feedback

"Bill Barbat, Editor
CO_2 NEWSLETTER
P.O. Box 24
[Teton] Village, WY 83025

'Dear Bill,

"Thanks for sending your June-August issue, with your account of our report 'Energy Strategy for Low Climatic Risks' woven into your attack on mon[e]tarism and your rehash of Atomic Industrial Forum press packets, all under the heading 'Inflation Disrupts the Capital Marketplace.' It arrived as I was preparing to write you pointing out the many errors in your commentary on my earlier letter which you kindly printed some months ago.

"Having read your latest comments, I fear life is too short to keep writing you corrections. Nearly everything you say in an effort to summarize our detailed and heavily documented report is either a distortion or your own invention. Readers who take the trouble to obtain our study (which will be published in book form this December by Brick House Publishing Co. of Andover, Massachusetts) will scarcely recognize it from your paraphrase. You've simply read it far to carelessly, added things that weren't there, lifted concepts out of context in an apparent effort to caricature them, and used our work as a vehicle for your own pro-nuclear polemics.

"Your readers would, I think, be better served if in noting new works (such as ours) you simply quoted their abstracts or conclusions, in full or in a coherent block, and confined your editorializing to editorials. So long as you keep on mixing news with comment—a bad journalistic practice—I'd really rather that you didn't write about our work. I don't have time to get into an apparently divergent regression of letters correcting your mistakes.

"You may print this letter if you print it in full.

"Sincerely,
(signed, Amory)
"Amory B. Lovins
"c/o FOE, 124 Spear St., San Francisco, CA 94105, 5 September 1981"

●

Dear Amory:

We would do a disservice to the CO_2 problem to introduce an adversary situation. Great care has been taken among CO_2 scientists to address facts rationally, to avoid all contumelious mention of persons and

More Feedback

publications (despite some deep personal conflicts and controversies), and to pursue a constructive course faithfully.

Readers are urged to obtain a copy of 'Energy Strategy for Low Climate Risks' and judge the reporting in light of our editorial policy, namely:

- To address the problem of **halting** the CO_2 buildup, not merely retarding it, which requires that emphasis be placed on feasible energy substitutions rather than reducing consumption;
- To concentrate on the areas of greatest technical and economic difficulty in substitutions, namely the industrial and transportation sectors.

Your 14-page 'executive summary' was too lengthy for inclusion intact, and certain material that we considered of interest to our readers was not included. Also in your very recent entry into the CO_2-greenhouse discussions, you have introduced energy schemes radically different from prior, well-researched anti-CO_2 schemes (not referenced by you), which form the basis for our 'divergent regression'. Documentation is for legal work, not scientific work.

My article was not intended to discredit monetarism (which has changed economic studies from an idealogical to a rational basis) but to speculate that distorted indicators may have prompted monetary intervention, which in turn may have created a cure worse than the disease. The invited comments from Milton Friedman (below) correct that misconception.

We seem to share many of the same goals but differ largely in reference sources. One question arises: If a democratic majority desires nuclear energy to halt the CO_2 buildup, do you feel that they should be allowed to have it?

Truly yours,

Bill (-W.N.B.)

"Dear Mr. Barbat:

"I am sorry to report that your interpretation of why interest rates are so high on page 8 of the newsletter for June-August 1981 that you sent me will not hold water. You are not allowing for the fact that there is a flexible exchange rate. What is attracted is capital and not money. An inflow of capital from abroad does not add to the money supply. It has no effect on the money supply unless the Fed chooses to increase the money supply. If the Fed does not choose to do so, the effect of an inflow of capital is to raise the exchange rate to the point at which the balance of payment on current account depreciates to an extent to offset the excess of the inflow of capital over the outflow of capital.

"As a result, it is simply not correct to argue that there has been a technical misapplication of 'monetarism'.

"There is no doubt that the normal link between inflation and interest rates has been broken as I pointed out in a recent *Newsweek* column of which I enclose a copy. However, I am still searching for an explanation of why that has occurred.

Sincerely yours,
Milton Friedman
Senior Research Fellow"
Hoover Institution on War, Revolution and Peace, Stanford, California 94305, October 5, 1981

Excerpts from recent reports

[Note: asterisks denote references herein deleted.]

From **'Climate Impact of Increasing Atmospheric Carbon Dioxide', by J. Hansen, D. Johnson, A. Lacis, S. Lebedeff, P. Lee, D. Rind, and G. Russell, SCIENCE 28 August 1981:**

"Atmospheric CO_2 increased from 280 to 300 parts per million in 1880 to 335 to 340 ppm in 1980(*), due mainly to burning of fossil fuels . . . The Co_2 abundance is expected to reach 600 ppm in the next century, even if growth of fossil fuel use is slow (*).

". . . The most sophisticated models suggest a mean warming of 2° to 3.5°C for doubling of the CO_2 concentration from 300 to 600 ppm (*).

"The major difficulty in accepting this theory has been the absence of observed warming coincident with the historic CO_2 increase. In fact, the temperature in the Northern Hemisphere decreased by about 0.5°C between 1940 and 1970 (*), a time of rapid CO_2 buildup. In addition, recent claims that climate models overestimate the impact of radiative perturbations by an order of magnitude (*) have raised the issue whether the greenhouse effect is well understood. . .

"The greenhouse theory can be tested by examination of several planets, which provide an ensemble of experiments over a wide range of conditions. . . Observed surface temperatures of [Mars, Earth, and Venus] confirm the existence and order of magnitude of the predicted greenhouse effect . . .

"Model Time Dependence

"The time dependence of the earth's surface temperature depends on the heat capacity of the climate system. Heat capacity of land areas can be neglected since the ground is a good insulator. However, the upper 100 m of the ocean is rapidly mixed, so its heat capacity must be acounted for . . .

"The great heat capacity of the ocean and ready exchange of continental and marine air imply that the global climate response to perturbations is determined by the response of the ocean areas. However, this response is affected by horizontal atmospheric heat fluxes from and to the continents. Ready exchange of energy between the ocean surface and atmosphere 'fixes' the air temperature, and the ocean removes from the atmosphere any net heat obtained from the continents.

". . . there may be sufficient heat exchange between the mixed layer and thermocline to delay full impact of a climate perturbation by a few decades. . .

"The warming calculated with the one-dimensional model for the CO_2 increase from 1880 to 1980 (*) is 0.5°C if ocean heat capacity is neglected . . . The heat capacity of just the mixed layer reduces this to 0.4°C, a direct effect of the mixed layer's 6-year thermal response time. Diffusion into the thermocline further reduces the warming to 0.25°C for (diffusion coefficient) = $cm^2\ sec^{-1}$, an indirect effect of the mixed layer's 6-year e-folding time, which permits substantial exchange with the thermocline.

"The mixed-layer model and thermocline model bracket the likely CO_2 warming . . .

"Lack of ocean processes primarily introduces uncertainties about the time dependence of the global CO_2 warming. The full impact of the warming may be delayed several decades, but since man-made increases in atmospheric CO_2 are expected to persist for centuries (*), the warming will eventually occur.

"Radiative Climate Perturbations

"Identification of the CO_2 warming in observed climate depends on the magnitude of climate variability due to other factors. Most suspected causes of global climate change are radiative perturbations, which can be compared to identify those capable of counteracting or reinforcing the CO_2 warming.

". . . Since the effect is linear for small changes of luminosity, a change of 0.3 percent would modify the equilibrium global mean temperature by 0.5°C, which is as large as the equilibrium warming for the cumulative increase of atmospheric CO_2 from 1880 to 1980. Solar luminosity variations of a few tenths of 1 percent could not be reliably measured with the techniques available during the past century, and thus are a possible cause of part of the climate variability in that period.

". . . Temporal variability of stratospheric aerosols due to volcanic eruptions appears to have been responsible for a large part of the observed climate change during the past century . . .

". . . Although man-made troposheric aerosols are obvious near their source, aerosol opacity does not appear to have increased much in remote regions (*). Since the climate impact of anthropogenic aerosols is also reduced by the opposite effects of absorbing and high-albedo materials, it is possible that they have not had a primary effect on global temperature. . .

". . . some limits are implicitly placed on global cloud feedback by empirical tests of the climate system's sensitivity to radiative perturbations. . .

". . . The net impact of measured trace gases has . . . been an equilibrium warming of 0.1°C or slightly larger. This does not alter analyses of temperature change over the past century, but trace gases will significantly enhance future greenhouse warming if recent growth rates are maintained . . .

"Observed Temperature Trends

"Data archives (*) contain surface air temperatures of several hundred stations for the last century. Problems in obtaining a global temperature history are due to the uneven station distribution (*), with the Southern Hemisphere and ocean areas poorly represented, and the smaller number of stations for earlier times.

"We combined these temperature records with a method designed to extract mean temperature trends . . . None of our conclusions depends on the nature of the smoothing.

"Northern latitudes warmed ~0.8°C between the 1880s and 1940, when cooled ~0.5°C between 1940 and 1970, in agreement with other analyses (*). Low latitudes warmed ~0.3°C between 1880 and 1930, with little change thereafter. Southern latitudes warmed ~0.4°C in the past century. . . The global mean temperature increased ~0.5°C between 1885 and 1940, with slight cooling thereafter.

"A remarkable conclusion . . . is that the global temperature is almost as high today as it was in 1940. The common misconception that the world is cooling is based on Northern Hemisphere experience to 1970.

"Another conclusion is that global surface air temperature rose 0.4°C in the past century, roughly consistent with calculated CO_2 warming. The time history does not follow the course of the CO_2 increase . . . indicating that other factors must affect global mean temperature.

"Model Verification

"Natural radiative perturbations of the earth's climate, such as those due to aerosols produced by large volcanic eruptions permit a valuable test of model sensitivity . . .

"To relate these empirical tests to the CO_2 greenhouse effect, we illustrate the flux changes in the [one dimensional radiative-convective] model when CO_2 is doubled . . . The net effect is . . . an energy gain for the planet ($+2.5$ W m^{-2}) with heating of the ground ($+4.3$ W m^{-2}) and cooling of the (upper) atmosphere (-1.8 W m^{-2}). These flux changes are independent of feedbacks and are not sensitive to the critical lapse rate . . .

"Years later (after CO_2 doubling) . . . the surface temperature has increased 2.8°C. Almost half the increase (1.2°C) is the direct CO_2 greenhouse effect. The remainder is due to feedbacks, of which 1.0°C is the well-established H_2O greenhouse effect . . .

"Surface warming of 3°C for doubled CO_2 is the status after energy balance has been restored. This contrasts with the Agung case and the cases considered by Idso(*), which are all nonequilibrium situations.

"The test of the greenhouse theory provided by the extremes of equilibrium climates on the planets and short-term radiative perturbations is reassuring, but inadequate. A crucial intermediate test is climate change on time scales from a few years to a century.

"Model versus Observations for the Past Century

"Simulations of global temperatures change should begin with the known forcings: variations of CO_2 and volcanic aerosols. Solar luminosity variations, which constitute another likely mechanism are unknown, but there are hypotheses consistent with observational constraints that variations not exceed a few tenths of 1 percent . . .

"Volcanic aerosol radiative forcing can be obtained from Lamb's (*) dust veil index (DVI), which is based mainly on atmospheric transmission measurements after 1880 . . .

". . . We examine the hypothesis of Hoyt (*) that the ratio . . . of umbra to penumbra areas in sunspots is proportional to solar luminosity . . .The resulting [ratio] has no observational corroboration, but serves as an example of solar variability of plausible magnitude.

"Radiative forcing by CO_2 plus volcanoes and forcing by CO_2 plus volcanoes plus sun both yield a temperature trend with strong similarity to the observed trend of the past century . . . If only the heat capacity of the mixed layer is included, the amplitude of the computed temperature variations is larger than observed. However, mixing of heat into the deeper ocean with [diffusion coefficient] = 1 cm^2 sec^{-1} brings both calculated trends into rough agreement with observations.

". . . All models with sensitivities of 1.4° to 5.6°C provide a good fit to the observations. The smallest acceptable sensitivity is 1.4°C, because it requires zero heat exchange with the deeper ocean. Sensitivities much higher than 5.6°C would require greater heat exchange with the deep ocean than is believed to be realistic (*).

"Radiative forcing by CO_2 plus volcanoes accounts for 75 percent of the variance in the 5-year smoothed global temperature, with correlation coefficient of 0.9. The hypothesized solar luminosity variation improves the fit, as a consequence of the luminosity peaking in the 1930's and declining into the 1970's, leaving a residual variance of only 10 percent. The imposed fit provided by Hoyt's solar variations represents a posteriori selection, since other hypothesized variations that we examined . . . degrade the fit . . .

"Projections into the 21st Century

"Prediction of the climate effect of CO_2 requires projections of the amount of atmospheric CO_2, which we specify by (i) the energy growth rate and (ii) the fossil fuel portion of energy use . . .

"Energy growth has been 4 to 5 percent per year in the past century, but increasing costs will constrain future growth . . .

"Fossil fuel use will be limited by available resources . . . Full use of oil and gas will increase CO_2 abundance by ~50 percent of the preindustrial amount. Oil and gas depletion are near the 25 percent level, at which use of a resource normally begins to be limited by supply and demand forces (*). But coal, only 2 to 3 percent depleted, will not be so constrained for several decades.

"The key choice is between coal and alternatives that do not increase atmospheric CO_2. We examine a synfuel option in which coal-derived synthetic fuels replace oil and gas as the latter are depleted, and a nuclear/renewable resources option in which the replacement fuels do not increase CO_2. We also examine a coal phaseout scenario: after a specific date coal and synfuel use are held constant for 20 years and then phased out linearly over 20 years.

"Projected global warming for fast growth is 3° to 4.5°C at the end of the next century, depending on the proportion of depleted oil and gas replaced by synfuels . . . Slow growth, with depleted oil and gas replaced equally by synfuels and nonfossil fuels, reduces warming to 2.5°C. The warming is only slightly more than 1°C for either (i) no energy growth, with depleted oil and gas replaced by nonfossil fuels, or (ii) slow energy growth, with coal and synfuels phased out beginning in 2000 . . .

"When should the CO_2 warming rise out of the noise level of natural climate variability? An estimate can be obtained by comparing the predicted warming to the standard deviation, σ, of the observed global temperature trend of the past century . . .

"The predicted CO_2 warming rises out of the 1σ noise level in the 1980's and the 2σ level in the 1990's . . . This is independent of the climate model's equilibrium sensitivity for the range of likely values, 1.4° to 5.6°C. Furthermore, it does not depend on the scenario of atmospheric CO_2 growth, because the amounts of CO_2 do not differ substantially until after the year 2000. Volcanic eruptions the size of Krakatoa or Agung may slow the warming but barring an unusual coincidence of eruptions, the delay will not exceed several years.

". . . We conclude that CO_2 warming should rise above the noise level of natural climate variability in this century.

"Potential Consequences of Global Warming

". . .Paleoclimatic evidence suggests that surface warming at high latitudes will be two to five times the global mean warming . . . Climate models predict the larger sensitivity at high latitudes and trace it to snow/ice albedo feedback and greater atmospheric stability, which magnifies the warming of near-surface layers . . . Since these mechanisms will operate even with the expected rapidity of CO_2 warming, it can be anticipated that average high-latitude warming will be a few times greater than the global mean effect.

". . . A major regional change in the doubled CO_2 experiment with our three-dimensional model (*) was the creation of hot, dry conditions in much of the western two-thirds of the United States and Canada and in large parts of central Asia. The hot, dry summer of 1980 may be typical of the United States in the next century if the model results are correct. However, the model shows that many other places, especially coastal areas, are wetter with doubled CO_2.

". . . The summer temperature in [the vicinity of the East Antarctic ice sheet] is about -5°C. If this temperature rises 5°C, deglaciation could be rapid, requiring a century or less and causing a sea level rise of 5 to 6 m (*). . .

"Climate models (*) indicate that 2°C global warming is needed to cause 5°C warming at the West Antarctic ice sheet. A 2°C global warming is exceeded in the 21st century in all the CO_2 scenarios we considered, except no growth and coal phaseout . . .

"Discussion

"Many caveats must accompany the projected climate effects. First, the increase of atmospheric CO_2 depends on the assumed energy growth rate, the proportion of energy derived from fossil fuels, and the assumption that about 50 percent of anthropogenic CO_2 emissions will remain airborne. Second, the predicted global warming for a given CO_2 increase is based on rudimentary abilities to model a complex climate system with many nonlinear processes. Tests of model sensitivity, ranging from the equilibrium climates on the planets to perturbations of the earth's climate, are encouraging, but more tests are needed. Third, only crude estimates exist for regional climate effects . . .

"Political and economic forces affecting energy use and fuel choice make it unlikely that the CO_2 issue will have a major impact on energy policies until convincing observations of the global warming are in hand. In light of historical evidence that it takes several decades to complete a major change in fuel use, this makes large climate change almost inevitable . . ."

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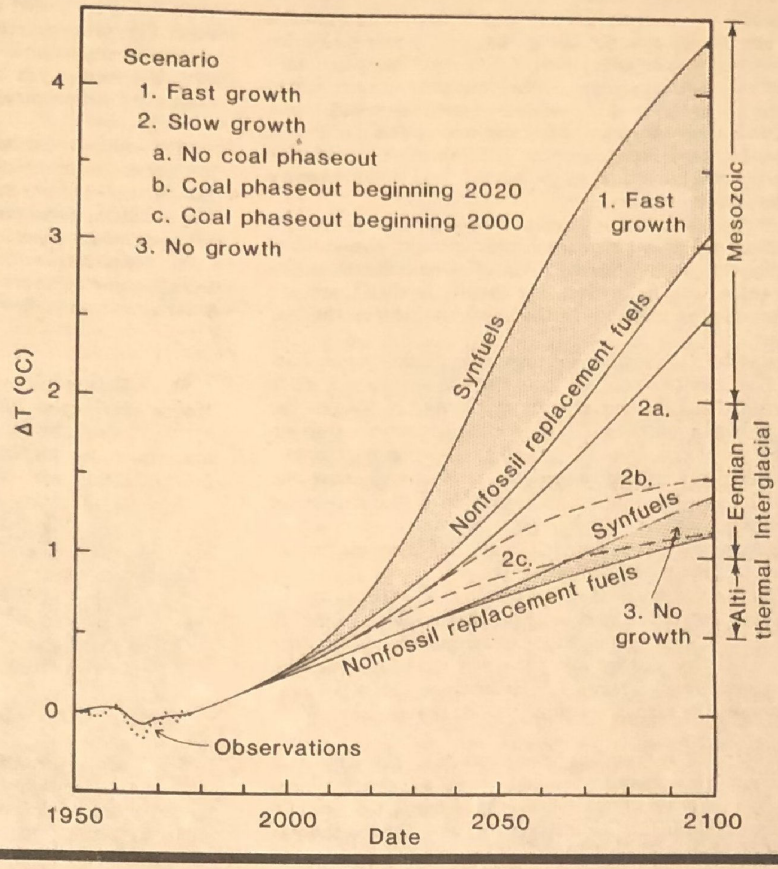
From **'Greenhouse on Venus', an unsigned report in GEOTIMES, June 1981:**

"Pioneer-Venus spacecraft data prove that the 482°C surface temperature of Venus is due to an atmospheric greenhouse effect . . .

"Pioneer measurements of atmosphere composition, temperature

From 'Climate Impact of Increasing Atmospheric Carbon Dioxide', by J. Hansen, D. Johnson, A. Lacis, S. Lebedeff, P. Lee, D. Rind, and G. Russell, SCIENCE 28 August 1981.



Projections of global temperature. The diffusion coefficient beneath the ocean mixed layer is 1.2 cm^2 sec^{-1}, as required for best fit of the model and observations for the period 1880 to 1978. Estimated global mean warming in earlier warm periods is indicated on the right.

profiles and radiative heating enabled a team to predict Venus's surface temperature, but agree with temperatures measured at various altitudes above the surface by the 4 Pioneer-Venus probes.

"The accuracy of the Venus atmospheric heat-balance predictions increases the probability of making similar predictions for the Earth, including changes in Earth's atmospheric heat budget caused by burning fossil fuels . . ."

●

From **'West Antarctic ice volume: the interplay of sea level and temperature, and a strandline test for absence of the ice sheet during the last interglacial', by J.H. Mercer in 'Sea Level, Ice, and Climatic Change' (Proceedings of the Canberra Symposium, December 1979), IAHS Publication no. 131:**

"During the last 700,000 years, the oxygen isotopic composition of the ocean shows that only at the height of the last interglacial (marine substage 5e) was less water locked up in ice sheets than at present. This is consistent with a contemporaneous +5 m high stand of sea level. Additionally, deep-sea cores indicate that during this interval subtropical water in the eastern North Atlantic briefly penetrated 10° further north than it does today, and widespread evidence from land biota points to a warmer global climate. This strongly suggests that warmth caused the low ice sheet volume. The most likely source of the extra ocean water is West Antarctica, which contains the requisite amount of ice and whose fringing ice shelves would start to recede if the offshore waters warmed above -1.5°C during summer. Re-formation of this ice sheet during **gradual** climatic cooling late in the last interglacial would have resulted in the sea failing to its present level, and staying there until temperature had fallen enough to initiate the Laurentide ice sheet. Evidence from strandlines supports a stepwise drop in sea level at the end of the last interglacial. This suggests that although shrinkage of the Antarctic ice sheet by grounding line recession, from its ice-age maximum to its present size, was caused directly by the eustatic sea level rise during Northern Hemisphere deglaciation and only indirectly by global warming, further shrinkage to the point of total ungrounding has depended directly on rising temperature."

—Abstract

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From **'Detecting CO_2-induced climatic change', by T.M.L. Wigley & P.D. Jones, NATURE 16 July 1981:**

"Although it is widely believed that increasing atmospheric CO_2 levels will cause noticeable global warming, the effects are not yet detectable, possibly because of the 'noise' of natural climatic variability. An examination of the spatial and seasonal distribution of signal-to-noise ratio shows that the highest values occur in summer and annual mean surface temperatures averaged over the Northern Hemisphere or over mid-latitudes. The spatial and seasonal characteristics of the early twentieth century warming were similar to those expected from increasing CO_2 based on an equilibrium response model. This similarity may hinder the early detection of CO_2 effects on climate."

—ABSTRACT

●

From **'Is Antarctica Shrinking?, by Sharon Begley, Rita Dallas and Ron Givens, NEWSWEEK, October 5, 1981:**

". . . Many scientists endure the sounds of silence [of Antarctica] in the hope of answering two basic questions of antarctic research: is the ice sheet getting bigger or smaller, and what effect do rising levels of atmospheric carbon dioxide (CO_2) have on it? As man burns fossil fuels, he adds CO_2 to the air and creates what is known as the 'greenhouse effect' - a layer of gas that traps heat and warms the globe. Common sense says that such a warming will melt the ice sheets and raise sea levels; some geologists predict that the seas could rise 20 feet in the next 200 years, inundating all the world's ports and many of its cities. But it is also possible that the warmer air would have a completely opposite effect: since it can carry more moisture, it could increase the snowfall on Antarctica and make the continent grow . . .

"East Antarctica, with 83 percent of the ice, is a 'true' continent since it sits on regular bedrock above sea level. But West Antarctica across the Transarctic Mountains, is a 'marine' ice sheet, sitting on the ocean floor and an archipelago. Because the eastern sheet is above sea level, it has stayed intact for at least 10 million years. The western one resembles an unprotected cube of ice and, according to some geologist, it disappeared entirely during a warm spell 124,000 years ago . . .

"The role of the ice shelves in keeping Antarctica from sliding into the sea is highlighted in a new book, 'The Last Great Ice Sheets.' (*) It argues that a 6-degree [presumably Fahrenheit] rise in temperature

brought on by the greenhouse effect would melt thin ice sheets in the Northern Hemisphere. Antarctica, where the ice is an average of 6,000 feet thick, wouldn't feel any direct effect of the warmer air for thousands of years, says geologist George Denton of the University of Maine. But it would be threatened by rising seas. The melting northern ice would raise sea levels around the globe, and Antarctica's ice shelves, pinned to the sea floor today, would rise with the water until they were ripped from their moorings . . . runaway [ice] streams would draw ice down from the interior of the continent until the whole sheet disappeared within 200 years because of an insidious feedback effect: as the initial increase in sea level melted some of the sheet, it would raise the water level still farther, until West Antarctica was just a memory in the mind of a homeless penguin.

". . . Previous theories that had predicted a much quicker meltdown haven't held up. Evidence shows that ice simply couldn't surge out of Antarctica fast enough to make it disappear in a few decades. Even the slow meltdown scenario has its critics, 'My feeling is that there are enough layers of foundation underneath the sheet to stabilize the ice,' says [Anthony] Gow . . .

"Curiously, researchers read different messages in the frozen bubbles [in ice cores]. Last month scientists from the University of Bern in Switzerland reported that CO_2 rose steeply at the end of the last ice age, when the earth began warming. 'Carbon dioxide shows a tremendous increase 12,000 years ago, from 200 to 280 parts per million (ppm),' says Bernard Stauffer. That may be coincidence or it may be cause and effect; because there have been so many unexplained fluctuations of CO_2 in the past, scientists aren't sure whether the gas causes a warming trend or simply amplifies an existing one. Indeed, CO_2 levels rose as high as 400 ppm in the past without melting the ice. . .

". . . By measuring the volume of trapped bubbles, scientists can tell how thick the ice sheet was in the past . . . French glaciologist Dominique Reynaud and Ian Whillans of Ohio State University found that the ice has grown about 725 feet thicker since the end of the last ice age. 'We think that by raising temperatures, CO_2 makes more snow fall over Antarctica and increases the rate of accumulation on the ice,' says Whillans.

. . . the British Antarctic Survey has been measuring the Antarctic Peninsula, with disquieting results. In the past 30 years global temperatures rose by nearly two degrees. 'We have hard evidence of a retreat in the Antarctic Peninsula, or disintegration of the ice shelves at their edges,' says [Charles] Swinthinbank. . .

"Whether a warming trend would dump more snow on the southern continent or make it melt remains unanswered . . . prudence means erring on the pessimistic side. Charles Bentley of the University of Wisconsin, for one, doesn't believe in the 'super-rapid retreat' scenario. But he says, 'the seriousness of what could happen is great enough that we have to keep investigating to make sure I'm right and they're wrong.' Civilizaton arose as the earth grew warm 8,000 years ago. It would be a cruel trick if that warmth obliterated its own creation."

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From **'Statement of Mr. John Marcum, Office of Science and Technology Policy to the Subcommittee on Natural Resources, Agriculture and Environment and the Subcommittee on Investigations and Oversight, House of Representatives Committee on Science and Technology, July 31, 1981':**

". . . I believe that this problem[the atmospheric build-up of carbon dioxide] deserves serious study . . . Since so much media attention is focussed on the potential problems with nuclear energy, it is important that we not lose sight of the potential costs associated with accelerated use of fossil fuels, including long-term CO_2-induced climate changes . . .

"The new director of OSTP, Dr. George A. Keyworth . . . asked me to tell you that he considers atmospheric build-up of CO_2 an important issue. Neither of us are experts in this area and we look forward to improving our understanding of dimensions of this problem through our interaction over the next two years with the National Academy of Sciences' panel which will be carrying out the CO_2 study mandated by Section 711 of the Energy Security Act of 1980 . . .

"This week we received from the Academy a revised proposal to carry out the comprehensive independent assessment of the national CO_2 program requested by Congress last year . . .

"On the basis of the peer reviews, we felt that the original proposal had some serious flaws. There was a consensus that focusing on a single 'expected value' scenario, as the NAS proposed, would be premature and could lead to an unproductive effort given the large uncertainties involved on almost all aspects of the atmospheric CO_2 buildup. Consequently, we suggested to the Academy that the panel consider several exploratory scenarios, noting the problems involved in scenario selection and description, and the tendency for well-detailed but low-probability scenarios to take on a life of their own. We also felt that through eliminating some redundancy with other government programs and taking fuller advantage of on-going international activities, the total cost could be brought more into line with constrained funds available in the revised agency budgets.

". . . We hope that by immediately beginning to assess the government CO_2 program, the Academy panel will be able to help us make course correlations, as needed, in the agency program. . .

"We have not yet had a chance to look in detail at the balance between the different elements of the government's CO_2 research program . . .

"Based on our initial review, our view is that the most critical areas for further study are the physical phenomena—the global carbon cycle and climate . . . further advances in our understanding of environmental and social impacts clearly depend on better understanding of the physical systems involved.

". . . we plan to wait for the findings of the Academy study before considering how to advise the President on any policy implications of the build-up of atmospheric CO_2 . . ."

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From **Testimony by Joseph Smagorinsky on the CO_2 Problem' at the House hearings of July 31, 1981:**

". . . it would be most useful to concentrate on relevant studies being undertaken by the National Academy of Sciences, including some of the international facets of the question . . .

"The [NAS] study will comprise two principal activities:

"- A continuing critical review of the government-wide carbon dioxide research and assessment program in the context of the National Climate Program . . .

"- Development of independent assessments of the CO_2 issue and certain of its specialized aspects . . .

"More particularly, the Academy will

"- **Perform critical assessments of scientific knowledge on selected topics . . .**

"Initiate and evaluate studies on the socio-economic impacts of climatic changes . . .

"- Review international activities . . .

". . . the Academy, under its newly formed comprehensive study, commissioned a new evaluation and assessment of what has been learned in the interim [since the Charney Report] . . .

"The input into our deliberations is an assumption on the projected loading rate of atmospheric CO_2 . . .

" . . . we are employing a doubling as a convenient benchmark. In any event, the range of effects between present concentrations and a doubling covers no significant thresholds, and our conclusions are not critically dependent on the detailed time evolution of CO_2 concentrations . . .

"Finally, despite the admitted existence of numerous uncertainties, the concensus on the nature and magnitude of the problem has remained remarkably constant throughout this long worldwide process of study and deliberation. The most recent projections of future energy consumption suggest a slackening in the growth in energy consumption, but nevertheless even the most conservative estimates imply major CO_2 injections. The details of the natural carbon cycle and future disposition of injected CO_2 are still unclear, but it seems certain that much man-made CO_2 will remain in the atmosphere. Although questions have been raised about the magnitude of climate effects, none deny that changes in atmospheric CO_2 concentration have the potential to influence the heat balance of the earth and atmosphere. Finally, although possibly beneficial effects on biological photosynthetic productivity have been recognized, none deny that an altered climate would to some extent influence how humanity secures its continuing welfare . . ."

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From **'Testimony of Stephen H. Schneider' at the House hearings of July 31, 1981:**

". . . why worry at all about the CO_2 issue? A brief review may be helpful to put perspective on the need for evaluating potential impacts and public policy responses.

"The Corn Belt and Great Plains of the United States comprises the principal food producing and exporting region in the world. We owe much of this to favorable climatic resources of the region. For a number of years, particularly in the mid-1930s and the mid-1950s, and to a lesser extent in the past few years, climatic conditions have not always been as favorable; economic and social hardship followed in the wake of these episodes of bad weather. But some 5000 to 8000 years ago, when mean global temperatures were perhaps 1-2°C warmer than today, dunes of drifting dust covered major portions of the high plains and prairie-like

conditions now found generally west of the Missouri River invaded deep into the present Corn Belt, stretching all the way into Indiana, in what some archaeologists have called the 'prairie peninsula.' While CO_2-induced climate change is certainly not the only—nor even necessarily a principal—cause of this climatic event, the important message for our purposes is that seemingly small changes in global temperature can be reflected by large, regional changes in temperature and precipitation patterns . . . we will have to learn to adapt—or to migrate—should such climatic shifts occur in the future.

". . . The human activity now believed by most atmospheric scientists to have the greatest likelihood of modifying the **global** climate is the release of carbon dioxide to the atmosphere from the burning of fossil fuels (coal, oil and gas) and, probably to a lesser extent, from the destruction and burning of vast tracts of forest land, particularly in the tropics. This concern has recently been endorsed by a study of the National Academy of Sciences (*) and by an international meeting of experts held under the sponsorship of the United Nations Environment Program, International Council of Scientific Unions, and the World Meteorological Organization (*).

". . . Fossil fuels . . . are really storehouses of ancient carbon dioxide and solar energy . . .

"Global Climate Response

". . . Such CO_2 increases as projected are relatively unprecedented—at least if they occurred we have insufficient measurements to verify either how much CO_2 was there or what climate changes occurred. As, in this sense, they are unprecedented, we have little choice but to build models of the earth's climate in order to simulate the sensitivity of the present climate to projected CO_2 increases. Although there is considerable uncertainty in the reliability of such models, since there is no **direct** verification possible, nevertheless indirect tests of the models can and have been done. Indeed, assessments by national and international groups of scientists almost always produce the same conclusions: that a fixed doubling of carbon dioxide would increase global surface temperatures by something between 1.5 and 4°C. Unfortunately, CO_2 in the real world is not a fixed doubling, but a smooth increase over time. The effects of the oceans in altering the actual course of the climate over time relative to the effects predicted with model calculations in which CO_2 is doubled and held fixed is now a subject of debate in the scientific community. It is important to predict the actual time-evolution of CO_2-induced climatic change because it affects what is needed for human societies to determine how to react to the problem: namely, scenarios of regional climatic changes.

"Regional Climatic Response

". . . those few models which have been applied to this problem tend to suggest certain coherent features. These include wetter subtropical and monsoonal rainbelts, longer growing seasons in the high latitudes, wetter springtimes in high and midlatitudes, and—most problematically for our future agriculture—drier midsummer conditions in mid- and some higher latitudes. Considerable uncertainty still remains.

"Physical CO_2 Impacts

"Given a scenario of regional climatic change, we can next estimate its physical impacts in the environment and society. Most important . . . would be its effects on crop yields. Next is the potential for altering the range of some pests which could impact on human or animal health . . . Perhaps the most dramatic, even if far off, potential event, would be the breaking of part of the West Antarctic Ice Sheet, possibly resulting in a five- or so meter sea level rise . . .

"Economic, Social and Political Impacts

". . . given scenarios of behavioral assumptions, carbon cycle response, global climatic response, regional climatic response, physical impacts and economic infrastructure in the future, we can estimate, particularly for agriculture, some potential economic, social and political impacts . . . in the aforementioned case of coastal flooding, a five- to eight-meter sea level rise would cause something on the order of a trillion dollars in lost U.S. property alone. However, if such an event occurred one hundred and fifty years in the future, it would certainly not be viewed by most present policy makers as 'worth' a trillion dollars, but rather would have to be discounted significantly, depending on one's economic—and ethical—view of discounting the future.

"Policy Responses

". . . 'policy responses' . . . include the possibility to adapt, prevent, or even attempt to ameliorate the buildup of CO_2 or its consequences.

". . . if we wait ten or twenty years before proceeding with . . . actions, then we will have to adapt to a larger amount of CO_2 and its consequences than if actions were taken now to either increase our options to deal with CO_2 in the future, or to eliminate CO_2 emissions . . . ."

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From **'Carbon Dioxide and Public Policy, by Chester L. Cooper, Institute for Energy Analysis Newsletter (Oak Ridge Associated Universities), Fall 1981:**

"Scientists are growing increasingly concerned about carbon dioxide emissions from fossil fuels and the rate at which CO_2 is being accumulated in the atmosphere. Much of this concern stems from their belief that, if this trend continues, a gradual but significant shift in global temperature and precipitation will ensue . . . On a historical timescale, this prospect is by no means remote; it is likely to occur during the next century - possibly during our children's lifetime.

"The broad picture thus far emerging from scientific investigation is ominous, but the critical details are still murky: How much? How soon? Who benefits? Who loses? These uncertainties comprise a difficult hurdle for members of the CO_2 research community who would engage the early attention of politicians and government officials . . .

"Governments . . . tend to operate on short time-horizons; 'long-range' planning is measured in years, not in decades. It is not surprising, then, that the concept of 'stewardship' tends to be the stuff of political rhetoric rather than national or international policy . . .

"There are three possible broad governmental responses to a formal warning by the scientific community that the continued global consumption of fossil fuels may cause early, dangerous accumulations of CO_2 in the atmosphere: (1) to ignore the warning on the grounds that the matter is long-term and its implications uncertain; (2) to acknowledge the warning but to adopt a passive, wait-and-see posture on the grounds that the steps there must be taken to address the issue are too costly in the light of the important, outstanding questions; of (3) to heed the warning, and put in train appropriate national and international plans and policies.

". . . The uncertainty that still surrounds the nature, extent, and degree of CO_2 effects reinforces a natural reluctance on the part of governments to take costly, 'premature' steps to deal with a risk that is long-term in political terms and imprecisely defined in scientific terms.

". . . there is some hope that the day of reckoning might be postponed if not avoided: global energy consumption appears to be growing at a slower pace than had been projected even a few years ago, and renewable and other CO_2-benign energy technologies may help to offset CO_2 effects . . . it is conceivable that the CO_2 problem may be pushed back a few decades, during which time national and international decision-makers may become more sensitive . . ."

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From **'Climatic signal of ice melt features in southern greenland', by Michael M. Herron, Susan L. Herron & Chester C. Langway Jr. NATURE 1 October 1981:**

"The stratigraphic record of melt features in intermediate depth polar ice cores has provided valuable data on past summer climate (*) . . . Recently . . . a 901-m deep ice core was mechanically drilled in southern Greenland . . . [resulting] in a 2,200 year record with consistently

high quality data . . . the temporal variations in melt feature abundance, expressed as annual melt per cent (AMP), provide proxy data on summer climate that can complement other records extending back thousands of years. The AMP profile indicates that relatively warm summers prevailed from about AD 950 until AD 1500 culminating in the thirteenth and fourteenth centuries. The periods from about 300 to 150 BC, AD 350 to 550, and AD 1550 to 1800 had relatively little summer melting . . ."

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From **'Warming Up', unsigned article in the Washington Post, September 5, 1981:**

". . . there is a general consensus that the current concentration [of CO_2 is likely to double sometime during the next century . . .

"An important new contribution, by a team of NASA atmospheric physicists, now concluded that the carbon dioxide is causing a warming, one large enough to have very unfavorable consequences in the next century.

"The prediction is that the mean global temperature will increase by 1 to 4.5 degrees centigrade by the end of the coming century . . . A . . . middle range estimate—2.5-degree warming—is based on the prospect of slow energy growth, with oil and gas being replaced equally by synthetic fossil fuels and non-fossil fuels.

". . . these are among the possible—though still uncertain—results. Precipitation patterns would shift, creating a hot, dry climate in the western two-thirds of the United States and Canada, now the world's bread basket . . . the drought last summer 'may by typical' of the next century's weather. The West Antarctic ice sheet is likely to melt, causing a sea level rise of about 16 feet, flooding 25 percent of Louisiana and Florida and 10 percent of New Jersey . . .

". . . this 2.5 degree increase . . . would mean a world temperature that would 'approach the warmth of the Mesozoic, the age of dinosaurs.'

". . . the authors predict . . . that the warming will be clearly measurable—over and above normal climate variations—by the 1990s, and perhaps even in this decade. Since the amount of warming depends most strongly on energy growth and the type of fuels used, and since it takes decades and billions of dollars to make major shifts in energy use, it is not too soon to begin thinking seriously about how carbon dioxide should affect U.S. energy choices now."

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From **'Heating Up the Atmosphere', unsigned article in the New York Times, August 29, 1981:**

"For years there have been doomsday predictions that burning of fossil fuels might bring about a climatic catastrophe . . .

The chief weakness in such theories has been lack of evidence that the greenhouse effect is actually occurring. Though carbon dioxide in the atmosphere has been increasing, temperatures in the Northern Hemisphere have been falling over the last 30 years. But now seven scientists from the National Aeronautics and Space Administration claim to have found evidence that, on a global basis, carbon dioxide has already been warming the Earth for a century.

"Their study finds that the warming predicted by various computer models of the greenhouse effect is consistent with worldwide temperature readings since 1880—and with observations from Venus and Mars. That gave them confidence that the effect is real and that the models can predict it . . . it is significant that a respected team of scientists has now joined the group warning of possible catastrophe.

"What, if anything, should be done? The nation seems to be turning to the worst possible fuels in terms of carbon dioxide. It is depending less on solar and nuclear power, which emit no carbon dioxide at all. And among the fossil fuels, it is shifting from natural gas and oil, which emit little carbon dioxide, to coal and synthetic fuels, which emit much more.

"The greenhouse effect is still uncertain to warrant total alteration of energy policy. But this latest study offers fair warning: that such a change may yet be required is no longer unimaginable."

When the rains stop and the wells go dry

The return of a warmer climate as the 1930s to the U.S. and Russia is expected to be accompanied by widespread drought in the interior regions which presently support extensive dryland or unirrigated farming, principally of grains. Temporary relief may come from well-water irrigation using underground supplies, but since the natural recharge of aquifiers also requires continued precipitation, these water supplies may be 'mined out' quite rapidly.

On both the North American and Asian continents large unused volumes of fresh water presently flow northward into the Arctic Ocean. Even with moderate global warming, these northern areas are likely to still have a large surplus available for export southward to the areas which are expected to become parched. Russia presently is constructing a canal system to divert water from the north-flowing Pechora River to the south-flowing Kama River, a tributary of the Volga. Recently the Russian government authorized a study to tap 25 km^3 of water per year at the confluence of the Ob and Irtysh Rivers, then pump it to a height of 100 m and transport it 2200 km in canals up to 160 m wide. The staggering cost of about \$50 x 10^9 may prevent this project or any other massive diversion from progressing beyond the planning state until Russia feels threatened by extreme drought in its principal farm belts.

Similar massive diversions of north flowing water in Canada and Alaska to the contiguous U.S. have been proposed from time to time. Following not long after the 1963 U.S. Supreme Court decision which allocated a large volume of Colorado River water to Arizona that would eventually reduce California's take considerably, one of the world's largest engineering firms, Ralph M. Parsons Company, proposed an extensive scheme of dams, canals and tunnels to divert approximately 125 km^3 of water per year southward from the MacKenzie and Yukon Rivers. The water would be transported through a reservoir to be constructed in the 'Rocky Mountain Trench' of British Columbia, to deliver water to 33 U.S. states, 7 Canadian provinces, and 3 states of Mexico. Power dams to be constructed on the Stikine and Skeena Rivers were proposed to lift the water to the Rocky Mountain trench.

The cost estimate in 1964 was \$100 x 10^9, and in a recent article in **Scientific American** the cost was placed at \$200 x 10^9. Termed the NAWAPA plan (North American Water and Power Alliance), the proposal of this ambitious scheme has led to considerable debate among the Canadians over the desirability of exporting any water whatsoever to the U.S. (The U.S. has never asked Canada directly if it would consider exporting its water.)

Some Canadians note that water is an unending renewable resource, and suggest that it is preferable to sell water rather than non-renewable resources as oil, gas and minerals, which can be sold only once. An opposite 'dog in the manger' view held by some would continue to allow the waters to flow unused to the ocean rather than to relinquish Canadian sovereignty over the waters. In between, many feel that Canada should first make certain of filling its own water needs before considering any water exports. The Canadians appear particularly loathe to sacrifice scenic areas and wildlife habitats if they thought that the water would be used wastefully in the U.S. Also the Canadians would not consider selling their water at less than its value to them for power production, irrigation or future developments.

If a plan such as NAWAPA is ever to be considered seriously as a countermeasure to an expected CO_2-induced climate change, it would be necessary for the U.S. to make the plan attractive to Canada from all angles. Probably substantial countermeasures would have to be undertaken toward bringing CO_2 production to a halt in order to assure the Canadians that any climate change could be halted before the surplus Canadian water was expected to dry up.