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THE WHITE HOUSE
WASHINGTON

October 22, 1990

MEMORANDUM FOR MEMBERS OF THE GLOBAL CHANGE STRATEGY TASK
FORCE

FROM: D. ALLAN BROMLEY *NIM*

SUBJECT: Opening Statement by Dr. John Knauss for the
Second World Climate Conference

As promised, attached is a copy of the opening statement by Dr. John Knauss, head of the U.S. Delegation to the Second World Climate Conference. We are not requesting a review for style or editing, but would ask that you read these draft remarks in the context of our major policy issues which we will be discussing at Tuesday's meeting. Please treat the attached statement as close hold.

3 pm 19/X/90

Opening Statement of Dr. John Knauss
Second World Climate Conference
November 6-7, 1990

A great American statesman, philosopher, and sometime scientist, Benjamin Franklin once observed that science is an essential element of public service and public policy making. The Second World Climate Conference and this Ministerial are testament to the fact that science and environmental policy are but two sides of the same coin.

The science which has resulted from the World Climate Program, initiated from the First World Climate Conference in 1979, is now an essential element in public policy making. Based on concerns then which included the effects of greenhouse gases; depletion of stratospheric ozone; widespread, persistent

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drought and the possibility of global cooling, the First World Climate Conference began a process to study the key issues that are now the center of our current policy discussions. The World Climate Program has served as a focus for international scientific cooperation and provided much of the information available today. Many contributed to this effort. Naturally, I am proud of the U.S. role and the role of U.S. scientists made to this successful Program.

We must now reaffirm our commitment to the World Climate Program and to associated programs dealing with research on climate and climate change. The U.S. pledges to continue its support of international climate and climate change research. We also pledge our continued support for the infrastructure that supports these programs, such as the World Weather Watch, the International Global Ocean Observing System, the Global Atmosphere Watch and the Climate Studies Fund.

I have studied the Conference Statement from the scientific proceedings carefully. This Statement identifies the key issues that must be address if the science in this area is to contribute to the public policy debate.

Several themes from this past week's conference have

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emerged. We must ensure that all of our often disparate activities are fully coordinated. We must engender broad participation in these global efforts, particularly from developing countries.

Data and information are the foundation of understanding. It is essential that there is full, open and efficient access to and exchange of information and data. Without this full and open exchange, our efforts are for naught. Closely linked to this is our ability of our institutions to use the information and data to translate scientific understanding into policy decisions.

If these themes are put into practice, they will make a good scientific program better. In many respects, the work of the World Climate Program is the foundation of the Report of the Intergovernmental Panel on Climate Change (IPCC). The IPCC Report provides the first complete assessment of the science, impacts and possible responses to climate change. It summarizes our present state of knowledge. It brings to light the gaps and uncertainties and it suggests actions to address them. The World Climate Program can, and I believe, will respond to the challenge this presents.

Yes, there are gaps, there are unanswered questions, and

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the models are based on assumptions which are not certainties. But that doesn't mean we should not act. More knowledge, more information, better models will always be required. The United States is not waiting; we are already taking action.

We are taking actions now that, although they may affect the climate, have other benefits. We estimate that current U.S. environmental initiatives, when implemented, will reduce net emissions of greenhouse gases.

These initiatives include:

- phasing out the production of CFCs, halons, and other ozone depleting substance by the year 2000 ((under the Montreal Protocol))
- reducing transportation emissions of reactive gases ((Clean Air Act amendments, just signed into law by President Bush))((to be resubmitted to the U.S. Congress when it reconvenes in 1991))
- improving energy efficiency ((DoE initiative, proposed regulations, Clean Air Act Amendments))
- controlling emissions of methane from landfills ((EPA initiative, no proposed regulations))
- increasing the forested areas in the U.S. through an

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aggressive tree planting program ((Presidential initiative, America the Beautiful))

This is a comprehensive approach to a technically, economically and politically complex issue.

There is a desire among the global community to leave for our grandchildren an atmosphere not significantly different than the one we now enjoy. From a scientific perspective and based on our current scientific understanding, this means our objective should be to focus on the concentrations of greenhouse gases in the atmosphere. To do this, we must consider all sources and sinks and understand, as best we can, the dynamic processes involved. How we set specific objectives can only be decided in the context of international negotiations, with the widest possible participation. The U.S. is eager for such negotiations to get underway in the appropriate forum.

Science and environmental policy are but two sides of the same coin. This Conference is the bridge between science and policy decisions. Our role here is not to determine a framework convention on climate change. That is a task assigned to our negotiators beginning in February 1991 in

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Washington, D.C. We should not attempt to predetermining the results of those negotiations any more than scientists should predetermine the results of scientific research. Let us use our time to reflect on how best to meld science with policy. Let us use our time here to build a strong, yet flexible bridge to make science an essential component of public policy making.

DRAFT: DO NOT QUOTE OR DISTRIBUTE

[August 30, 1990]

THE MAKING OF A GREENHOUSE POLICY

by D. Allan Bromley

[draft article for Fall issue of

Issues in Science and Technology]

Within the past several years, global change has become the archetypal science policy issue. It combines almost all of the elements of public policy debates that have a substantial scientific component: questions about scientific data and conclusions, the difficulty of translating scientific analysis into politically relevant terms, competing interests with multiple agendas, differing international perspectives on common problems, and decision-making based on less-than-complete information. It has

received an enormous amount of attention from politicians, from environmentalists, from the media, and from the public. Since I became Assistant to the President for Science and Technology last August, no issue has consumed more of my time than has global change.

Given the broad slate of science policy issues that demand attention, it can sometimes be frustrating to dwell so predominantly on a phenomenon -- anthropogenic climate change on a global scale -- that has yet to be conclusively demonstrated. Not that the global environment has never changed. At the height of the last ice age about 20,000 years ago -- not long, in geological terms, before humans are widely believed to have first crossed the Bering land bridge into North America -- glaciers over two kilometers high covered much of the northern United States and Europe, and sea level was 100 meters lower than at present. These natural changes in the Earth's climate have occurred throughout its history, and they will continue to occur in the future.

It is also true that, during the past century, human society has entered into a new and momentous relationship with the global environment. For the first time in history, our species has become an agent capable of influencing the entire planet. We have altered the face of the Earth by clearing forests, building cities, and converting wild lands to agriculture. We have changed the composition of the Earth's atmosphere by burning fossil fuels, expanding agriculture, and producing and releasing industrial compounds. As Roger Revelle and Hans E. Suess wrote as early

as 1957, "human beings are now carrying out a large-scale geophysical experiment of a kind that could not have happened in the past nor be reproduced in the future."

It may be, as many have suggested, that global climate change will become a problem of very serious consequence. Certainly, the possibility of such change is being taken seriously by all governments, and appropriate actions are being considered to deal with the possible effects of climate change.

It may also be that the other issues usually subsumed under the term "global change" -- such as ozone depletion, the adequacy of food and water supplies, deforestation, desertification, levels of biodiversity, or soil erosion -- turn out to be more serious in terms of human impact than global climate change. The only reasonable course is to move forward on all of these issues simultaneously.

Scientific knowns and unknowns

Bertrand Russell once wrote, "The most savage controversies are those about matters as to which there is no good evidence either way." Certainly if more were known about global change, the policy disputes would not be nearly so acrimonious. If it were possible, for example, to unequivocally associate the warmer-than-average years of the 1980s with the greenhouse effect, multibillion-dollar decisions affecting life-styles and the quality of life would appear less open to question. If computer models of the earth system could precisely mimic the observed temperatures changes

of the past century, they would provide a more solid foundation for policymaking. For that matter, the policy debate will be quite different in the year 2000 if temperatures rise sharply in the 1990s.

For now, though, it is important for policymakers clearly to keep in mind what is known and what is not known about the Earth system. Based on exacting measurements of atmospheric gases and the bubbles trapped in ice sheets, researchers know that the level of carbon dioxide in the atmosphere has increased by about 25 percent since preindustrial times. Atmospheric levels of methane, another potent greenhouse gas, have doubled over the same period. Chlorofluorocarbons (CFC's) released into the atmosphere, which are almost certainly responsible for the ozone hole over Antarctica, also act as greenhouse gases, as do several other atmospheric constituents with increasing concentration levels, including tropospheric ozone and nitrous oxide.

Computer models of the atmosphere reproduce the current global climate and changes of seasons with a fair degree of accuracy. When these models are run with twice as much carbon dioxide in their atmospheres, global average surface temperature is somewhere between 1.5 and 4.5 degrees Celsius higher than at present. However, the treatment in these models of such fundamental and important features of the Earth system as clouds, oceans, and ice remain suspect. It may be that the models inadequately simulate some fundamental aspect of the Earth system that drastically reduces the predicted climate effects of greenhouse gas emissions -- or makes them worse.

Thus, computer models have been unable to specify with any certainty the magnitude, rate, or timing of future climate change. Nor do models give much indication of how potentially-important climate variables -- including mean annual temperatures, seasonal and daily maximums and minimums in temperature, seasonal and annual precipitation, the degree and frequency of variations in precipitation, and the degree and frequency of extreme events such as storms -- might change.

Furthermore, present models are totally unable to make reliable climate predictions on regional and local scales, yet these are essential if we are to be able to quantify the detailed impacts of global change.

The geological record also offers incomplete clues to the effects of greenhouse forcing. Earth scientists have found that global temperatures and atmospheric carbon dioxide levels have risen and fallen naturally and largely in parallel for the past 160,000 years. However, it is difficult to tell whether temperatures lead carbon dioxide or vice versa, and the mechanisms connecting these natural fluctuations remain obscure.

The same pattern of concrete observations paired with uncertain implications marks the record of global temperatures. Scientists now generally agree that the planet has warmed up by 0.3 to 0.6 degrees Celsius during the past century. But very few scientists would claim that they are yet able to determine whether any of that warming can be attributed to an enhanced greenhouse effect or whether it represents a natural fluctuation. Of particular interest in this regard have been recent precise temperature measurements by satellite of the global atmosphere. They show that,

even though surface measurements in some regions indicate that the 1980s were one of the warmest decades on record, average global temperatures did not increase from 1979 to 1989. Yet the magnitude and rate of increase of anthropogenic loading of the atmosphere with greenhouse gases were at unprecedented levels during the 1980s.

Based on climatic modeling and paleoclimatic research, scientists now generally agree that continued loading of the atmosphere with greenhouse gases will lead to global climate change. But without further research, the nature and dimensions of that change will remain elusive. Furthermore, we are only beginning to understand what the impacts of a potential change might be on agricultural productivity, sea level changes, biological productivity in the oceans, shifting vegetation patterns, storm patterns and severity, droughts, and the like. The various components of the geosphere, hydrosphere, atmosphere, and biosphere are bound up in a fantastically intricate and mutually counterbalancing system, and it will be many years before we can reliably predict how changes in one part of the system affect every other part.

Numerous uncertainties

Many of the observations made above also appear in the report of Working Group I of the Intergovernmental Panel on Climate Change (IPCC), an international body of hundreds of scientists and government officials set up by the United Nations Environment Program and World Meteorological Program to establish a global

consensus on the likely causes and consequences of climate change. The charge to Working Group I, which was chaired by the United Kingdom, was to assess the current scientific understanding of climate change. The second working group, chaired by the Soviet Union, assessed the possible environmental and socioeconomic effects of a changing climate. The third, chaired by the United States, sought to identify potential responses to climatic changes.

The three working groups presented their reports at the end of the summer as input to the Second World Climate Conference in Geneva on October 29 - November 7, 1990. These reports are an important resource for policymakers grappling with issues of global change. They will be among the most authoritative statements on the causes and consequences of climate change well into the future.

Nevertheless, to read the reports of the IPCC is to be struck again by the formidable difficulties that still surround this subject. Working Group I devoted considerable attention to scientific uncertainties in its report (although they tend to be minimized in the Executive Summary), concluding that "much uncertainty exists in the prediction of global climate properties such as temperatures and rainfall" and that "even greater uncertainty exists in predictions of regional climate change, and the subsequent consequences for sea level and ecosystems."

Working Group II's study of potential impacts also cited the uncertainties hampering their task, pointing out that "confidence in regional estimates of critical climate factors is low, [particularly] of precipitation and soil moisture, where there is considerable disagreement between various general-circulation-model and paleoanalog

results." The working group also found many scientific questions surrounding the relationships between climate change and biological effects and between biological effects and socioeconomic impacts. Uncertainties about the lengths of time lags at each step from emissions to climate change to socioeconomic impacts are particularly troublesome, because the severity of impacts depends on the ability to adjust and hence partially on the length of the lags.

Finally, Working Group III concluded that the existing uncertainties make it very difficult to determine which responses to potential climate change make sense. It wrote: "The consideration of climate change response strategies . . . presents formidable difficulties for policymakers. On the one hand, the information available to make sound policy analyses is inadequate because of: (a) remaining scientific uncertainties regarding the magnitude, timing, rate, and regional consequences of potential climate change; (b) uncertainty with respect to how effective specific response options or groups of options would be in actually averting potential climate change; and (c) uncertainty with respect to the costs, effects on economic growth, and other economic and social implications of specific response options or groups of options."

These many uncertainties do not argue for inaction (a point to which I shall return later). But they do make it exceedingly difficult to impose policies that may have large additional costs on specific sectors of society or on specific countries, because the affected sectors or countries can legitimately point to the uncertainties in arguing against the policies. The wrangling involved in getting a Clean Air Act

through Congress gives some indication, on a much smaller scale, of what will be involved in negotiations over global change.

At the same time, any discussion of uncertainties must acknowledge the fact that the unknowns cut both ways: climate models could understate as well as overstate the extent of the problem. For example, there is growing suspicion from the paleoecological data -- as yet unconfirmed -- that atmosphere-ocean interactions may harbor the possibility of surprises. If it should turn out, for example, that relatively small, and not as yet understood, mechanisms could shift ocean circulation patterns from one stable configuration to another, the potential impacts could be large.

A better known example of a climatic surprise was the development of the ozone hole over Antarctica. The ozone hole was not predicted or originally understood, although its detailed chemical mechanisms have now been explained at the molecular level. Nevertheless, the ozone hole has demonstrated that, contrary to long-held assumptions, our atmosphere is not so large, nor its inertia so great, that human activities cannot affect it under certain circumstances on human time scales. Human release of CFCs, combined with unique meteorological conditions, created the ozone hole in only a few decades at most.

The need for research

In the absence of a clearly identifiable signal of greenhouse warming -- which the IPCC deems unlikely for a decade or more -- there is only one way to reduce the uncertainties associated with global change: through concerted national and international research programs. In the United States, such a program has been organized by the Working Group on Global Change of the federal interagency Committee on Earth and Environmental Sciences. This U.S. Global Change Research Program -- a government-wide effort to monitor and understand the Earth system and predict global change -- is designed to significantly expand data gathering, research, and modeling activities. A significant component of the program is environmental observations and measurements from space.

The budget that President Bush sent to Capitol Hill last January -- reflecting the compelling case made by the Committee on Earth and Environmental Sciences for a comprehensive, national program -- called for a 57 percent increase in funding for the program, to a total of over \$1 billion. This is far more than any other nation is spending on global change research and in my view is a clear indication of this Administration's commitment to what President Bush has termed "global stewardship."

The committee has focused on three classes of key scientific questions: What global change has occurred in the past and is occurring now? What physical, chemical, biological, geological, and social processes are involved in global change? And how well can global change be predicted globally and regionally? To address

these questions, the committee has divided the research program into seven interdisciplinary scientific elements: climate and hydrologic systems, biogeochemical dynamics, ecological systems and dynamics, earth system history, human interactions, solid earth processes, and solar influences.

To take one important research area as an example, the committee has emphasized the need to better understand both natural and anthropogenic flows of greenhouse gases. According to the IPCC, a reduction of over 60 percent in carbon dioxide emissions would be needed to stabilize the concentration of the gas at current levels – a restriction that would sharply reduce living standards around the world and cause widespread suffering in poorer nations. But the natural fluxes of carbon dioxide are approximately 20 times the anthropogenic ones, so the same net effect can be obtained through only a 2 to 3 percent increase in the gas's natural sinks. Innovative ideas on ways to draw carbon dioxide from the air – such as macroalgal ocean farming and fertilizing microalgal blooms – are now being proposed. Much more study of natural sources and sinks is needed, of course, to determine if proposals such as these are viable.

The economic factor

This scientific research will be an indispensable part of our response to the possibility of global change. But it is important to keep in mind that even if all of

the physical, chemical, and biological questions surrounding global change were answered tomorrow, appropriate policies would still be far from obvious. Global change is an inherently interdisciplinary problem, drawing not only on the natural sciences but on economics, sociology, and (especially in the last few years) politics. The full range of questions surrounding global change cannot be answered without input from the social sciences.

The most obvious intersection of global change with the social sciences involves future emissions. It is certainly possible to conceive of a world that supports an even larger population while releasing fewer greenhouse gases into the atmosphere (although the costs required to achieve such a world are likely to be very great). It is also possible to conceive of a world with global greenhouse emissions at least several times today's level, particularly if CFC's are not fully controlled and if countries begin to rely much more extensively on coal for increased energy needs.

The major social uncertainties revolve around population growth rates, the pace and nature of economic development, and the availability of new technologies. These uncertainties are particularly acute for the developing world. According to the World Resources Institute, developing countries already account for a substantial portion of total greenhouse emissions when all greenhouse gases are included; in fact, the top five greenhouse contributors in 1987 were the United States, the Soviet Union, Brazil, China, and India. Furthermore, the relative contribution of the developing countries is going to continue to increase as their industrialization proceeds.

Economics research will also be crucial in estimating the costs of either mitigating climate change by reducing greenhouse-gas emissions now or adapting to climate change after it occurs. Such research will enable sound comparisons of the costs of various policies aimed at mitigation with the benefits, in terms of reduced adaptation costs, that those policies would yield. Such comparisons, using discounting to reflect the earlier occurrence of mitigation costs, must be the basis for sound policymaking.

Several promising estimates of costs are already being developed, but no one doubts that these estimates will inevitably rest on numerous simplifying assumptions. One problem is that the nature of costs varies from place to place. In the developed countries, costs of lowering energy usage can be measured in terms of reduced economic growth, which causes economic hardships to substantial numbers of people. But in the developing world, reduced economic growth must be measured in more stark terms: lives lost, hunger increased, social instability heightened. Similarly, the costs of climate change in the developing world are likely to be higher and more disruptive than in the developed nations, where it is more likely that the resources to adapt to changing climates will be available.

The central role of economics research in global change was a major consideration in the White House Conference on Science and Economics Research Related to Global Change, which was held in Washington, D.C., on April 17-18, 1990. Hosted by Michael Deland, Chairman of the Council on Environmental Quality, Michael Boskin, Chairman of the Council of Economic Advisors, and myself, the

conference brought together delegations from 17 countries and from the European Community and the Organization for Economic Cooperation and Development to explore what we know and do not know about the scientific, economic, and policy questions surrounding global change.

The conference was organized around a straightforward but surprisingly unexplored question: How best can the results of both scientific and economic research into global change be integrated into the policymaking process? Although the format of the conference received some criticism, it achieved much of what it set out to achieve. In particular, several promising proposals on international cooperation emerged from the conference, including one to establish a series of research institutes devoted to the scientific, economic, and policy issues surrounding the global environment. The transnational and multidisciplinary nature of such institutes would provide an added dimension to national and international discussions of global change.

An insurance policy against climate change

After a year of intense involvement with this issue, I am convinced that, at present, no justification exists for imposing substantial new costs on society solely to lower greenhouse-gas emissions. But the climate models and paleoclimatic data cannot be ignored, and the United States and other countries cannot wait until all of

the facts are known to take action. Enhanced levels of research -- in many areas -- are one form of action, but they are not, by themselves, enough.

Thus, the Bush Administration has instituted a number of policies that will reduce greenhouse-gas emissions and that are justified for other reasons as well. I think of them as an "insurance policy" that will delay any possible adverse effects of climate change while research and technology development proceed. Among these policies are the following:

- o The United States is committed to phasing out the manufacture of CFC's by the year 2000 to protect the stratospheric ozone layer. Based on their greenhouse properties, CFC's accounted for 14 percent of all greenhouse-gas emissions in the 1980s, and if not controlled they could account for as much as 25 percent of the additional emissions over the next century.

- o The Clean Air Act now being debated in Congress will substantially reduce emissions of greenhouse gases by fostering more efficient use of energy. The Environmental Defense Fund has estimated that the acid rain provisions of this legislation alone, if implemented, will have an effect comparable to that of removing fully one fifth of the U.S. automotive fleet (22 million automobiles) from our highways for a period of 10 years.

- o The U.S. Department of Energy is developing a National Energy Strategy that will include an aggressive commitment to energy conservation and energy security. Energy conservation is the quickest and most effective way to reduce

greenhouse-gas emissions and can have a number of other benefits, including improved economic efficiency, reduced emissions of other pollutants, and less U.S. dependence on imported oil. In addition, technology development is a crucial hedge against the possibility of future warming, because it will ease the transition from processes that produce greenhouse gases (if substantial emission reductions prove necessary). Research and development on non-fossil-fuel technologies -- including nuclear energy and solar energy -- will be an important component of any national or international strategy to address global change.

These initiatives address the source component of the greenhouse gas question. Turning to the sink component, this country is again taking concrete steps.

- o The President has proposed a combined public and private sector initiative to plant a billion trees per year for five years on private land across America, trees that will eventually absorb 13 million tons of carbon annually. This is just part of the United States' current carbon emissions -- about 5 percent if such a program were continued for 20 years -- but these trees will provide additional benefits, such as recreational areas and heightened public awareness of environmental issues.

- o At the Houston Summit Conference in July, the President proposed that a global forestry convention be negotiated as soon as possible to curb deforestation, protect biodiversity, address threats to the world's forests, and promote actions that expand and strengthen forests.

All of these actions are justified for other reasons, yet together they can have a substantial impact on greenhouse-gas emissions. Preliminary estimates by the Environmental Protection Agency indicate that, using a measure of global warming potential that accounts for residence times in the atmosphere, these actions would hold U.S. greenhouse-gas emissions at 1987 levels until at least the year 2000. This would provide a ten-year window of opportunity to determine what future actions are necessary.

Insurance policies against the possibility of climate change are not limited to our own country. As in the case of deforestation, the United States can also influence the actions of other countries in ways that are mutually beneficial. I believe that this country now has a unique window of opportunity in which to provide Third World and Eastern European nations with technology, know-how, and financial assistance to permit them sustained economic growth with minimal damage to the global environment. If we do this on our own initiative, we will gain three benefits: we act to preserve the quality of the environment; we have the potential of substantial positive political fall-out; and we gain access for American industry to what will inevitably be a very large global market. If, on the other hand, we are pressured or are perceived to be pressured into taking such action, we will gain the first benefit but stand to lose the second and much of the third.

A Framework Convention

These considerations will be very much a part of the next major step in the making of a greenhouse policy: the establishment of a Framework Convention on climate change. At the Malta summit last December, President Bush proposed that the first negotiating sessions leading to such an international agreement be held in the United States, an offer that he has repeated several times since.

In considering the outlines of a Framework Convention, a useful analog is the Vienna Convention for the Protection of the Ozone Layer, which was established by the United States and 20 other countries in 1985. The Vienna Convention established a framework for international scientific and technical cooperation on ozone destruction. It did not, however, set limits on CFC emissions. Rather, it included provisions to establish protocols as further research demonstrated the need for additional action. The 1987 Montreal Protocol on Substances that deplete the Ozone Layer was the result of this process.

A Framework Convention on global change could serve the same function, although CFC emissions and greenhouse-gas emissions are quite different phenomena. Such a convention would establish general principles and obligations, based on a negotiated international consensus, by which future steps can be taken. It would be designed to gain the adherence of the largest possible number of countries while permitting timely action to be taken. The United States is now in the process of

formulating its position for the negotiations, with coordination being provided by a White House Working Group on Global Change that I chair.

This negotiating position will reflect the extensive discussions that have been taking place within the U.S. government on environmental issues. As one example of these discussions, I might cite the Administration's work on emissions trading. If future restrictions on greenhouse emissions prove necessary, market-based approaches to implement those restrictions would be far preferable to command-and-control approaches. One such market-based approach involves a comprehensive system in which all sources and sinks of all greenhouse gases are treated on a common footing in terms of an appropriate greenhouse warming potential. Such a measure would include established scientific knowledge regarding the greenhouse effectiveness of individual chemicals and their average lifetime in the atmosphere.

Once such a comprehensive approach is adopted, it becomes easier to use market forces to achieve reductions in greenhouse gas emissions at minimum costs. This could well encompass bilateral and multilateral arrangements in which a given country might find it economically attractive to help another country achieve net global benefits at lower total cost than if each country were to act independently. This process of emissions trading has been successfully implemented in a number of situations, and it bears much promise for dealing with emissions of greenhouse gases.

Such innovative approaches are going to be essential to meet the main challenge of international agreements on climate change: establishing mechanisms that are both effective and workable. The negotiations leading to a Framework

Convention and any subsequent protocols will encompass an unprecedented range of national and international policies, and no country is likely to be coerced into actions that are not in its long-term interests. But ensuring a stable and predictable environment is in everyone's interest, and actions that genuinely help to achieve that end will carry great force.

THE WHITE HOUSE

WASHINGTON

October 23, 1990

MEMORANDUM FOR THE PRESIDENT

FROM: ROGER B. PORTER

SUBJECT: The Second World Climate Conference

This responds to your request for an assessment of prospects for the Second World Climate Conference, which will be held in Geneva from October 29 to November 7.

The Conference will address the climate change agenda for the 1990s.

The First World Climate Conference, held in 1979, defined the world climate program that has been the basis for joint action over the past decade. The broad objective of the Second Conference is to set the international agenda for climate change activities for the next decade.

The Conference will review three reports of the Intergovernmental Panel on Climate Change (IPCC) -- on scientific evidence, potential effects, and response strategies. It will then attempt to identify principles for negotiations on a framework convention on climate change. These negotiations will begin next February (in Washington) and run at least through March 1992.

The U.S. will be a leader in discussions on research.

The Conference is divided into two parts. During the first week, scientists will discuss changes needed in the world climate research program for the next ten years. While no official delegations have been invited, U.S. scientists will be led by Dr. Joe Friday, head of Commerce's National Weather Service. Because the U.S. is the world leader in global climate change research (spending nearly \$1 billion in 1991), we will urge greater research commitments from others, including developing countries.

We may be isolated in negotiations on the declaration.

During the second week, ministers will attempt to remove the extensive brackets in a draft declaration. The U.S. is likely to be isolated on three familiar issues.

- There will be wide support for endorsing the precautionary principle, which would obligate

governments to attack climate change problems regardless of the uncertainty over causes and solutions.

- The northern Europeans and the Nordics want to establish targets and timetables. We have refused, citing the probable negative effects on growth.
- Developing countries want a commitment to receive new and additional resources to address climate change problems. We have challenged the view that resources for the environment should be isolated from resources for other activities.

We also may be criticized for our refusal to endorse the report of the IPCC's science panel. We question the report's analysis of the threat posed by the greenhouse effect and its call for prompt action. Because the U.S. position is well known, however, other countries are likely to criticize us less stridently than in the past.

The U.S. will attempt to focus attention on practical next steps.

The head of our delegation, NOAA Administrator John Knauss, will take a pragmatic approach. He will refuse to get drawn into extensive debates over rhetoric in the draft declaration. If necessary, we will table a no-frills draft that we could sign. Instead, he will focus on our willingness to begin negotiations on a framework convention on climate change. He will also emphasize the strong U.S. record of action on climate change -- notably the recent Clean Air Act.

Our strategy appears sound. Any lingering criticism will probably dissipate by February, when attention will turn to the framework convention.

The U.S. is being unfairly criticized for its level of representation.

The press has criticized the U.S. for sending John Knauss, when Prime Minister Thatcher and Chancellor Kohl may attend. In fact, if Thatcher and Kohl attend, they will address the Conference at the beginning of its second week. For the rest of the week, all countries will be represented by environment ministers. Knauss is accepted in this group, having been the U.S. delegate at the Bergen and Noordwijk Conferences.

#9 Things We Are Doing - No Repet

Q - When will ~~the~~ strike out on our - What needs to be known -

If had answer -

- Can't say for sure -
Likely question asked
& answered

1) Most Compelling Science - Magnitude: Rate

2) Cost - - -

3.) What will we get - 60 - Bank -

4.) What impact will we have.

University of Illinois
at Urbana-Champaign

Physics Department
Loomis Laboratory of Physics
1110 West Green Street
Urbana, Illinois 61801
Phone 217-333-3827

July 18, 1990

Teresa Goreman
Old Executive Office Bld.Rm 227
White House
Washington D.C. 20500

Dear Ms Goreman:

Paul Roelling suggested that I write to you about my research in climate. At present there is only wild speculation about what the crude computer models may or may not be right. The argument is restricted to whether they are right or wrong.

No one had considered that there may be other explanations that lie outside the realm of the present debate.

My research on volcanic aerosols has shown that they have the potential to be an alternative explanation to the observed data.

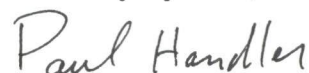
The reason most climate modelers have neglected the effect of volcanoes on climate is that they are unaware of the recent Greenland ice core work which at the present times is still only partly published.

The enclosed newspaper article from the LA Times shows just how powerful this alternative paradigm is. It not only explains the present drought in California, the low lake levels on the Great Lakes but the 100 year heating of the earth. It also explains the disappearance of the drought in the Sahel as well as the fact that India has had three good monsoons in a row.

Large volcanic eruptions can cool the earth and lack of these eruptions will cause the earth to warm. The 1500 year record from the Greenland ice core shows that volcanic activity has decreased quite dramatically in the last hundred years and therefore more radiation is striking the earth. Thus the earth should be warming up. The ice core data also explain the appearance of the Little Ice Age of 1300-1850 AD and the extreme warmth of the period 1000-1250 AD when Greenland was green and trees grew there. See enclosed talk given at the University of Chicago this spring.

I believe that I can be very helpful to the White House's present position on global warming. If you would be interested in a presentation I would be happy to provide one. You may wish to call Fred Seitz as a reference (212-570-8423).

Sincerely yours,



Paul Handler
Professor of Physics

Enclosures.



DEPARTMENT
OF PHYSICS
CENTENNIAL
1890-1990

Science / Medicine

University of Illinois
217-333-3827

Weather: Physicist Paul Handler says America's dry periods, corn production in the Midwest and the level of Lake Michigan can be determined by volcanic activity.

By THOMAS H. MAUGH II
TIMES SCIENCE WRITER

California's 4-year-old drought will not ease until a volcano erupts at latitudes near the Equator, according to University of Illinois physicist Paul Handler.

Volcanic eruptions in that region produce stratospheric dust and sulfur dioxide gas that prevent a small portion of sunlight from reaching the Earth's surface, thereby altering climate in what Handler believes to be highly predictable ways.

He has linked volcanic eruptions—to corn production in the Midwest, water levels of the Great Salt Lake and Lake Michigan, warming of the Pacific Ocean, the colonization of Greenland, the "little ice age" that afflicted Europe in the middle of this millennium and even the disappearance of the Mesa Verde Indians in the Southwest and the Kahoki Indians in Illinois.

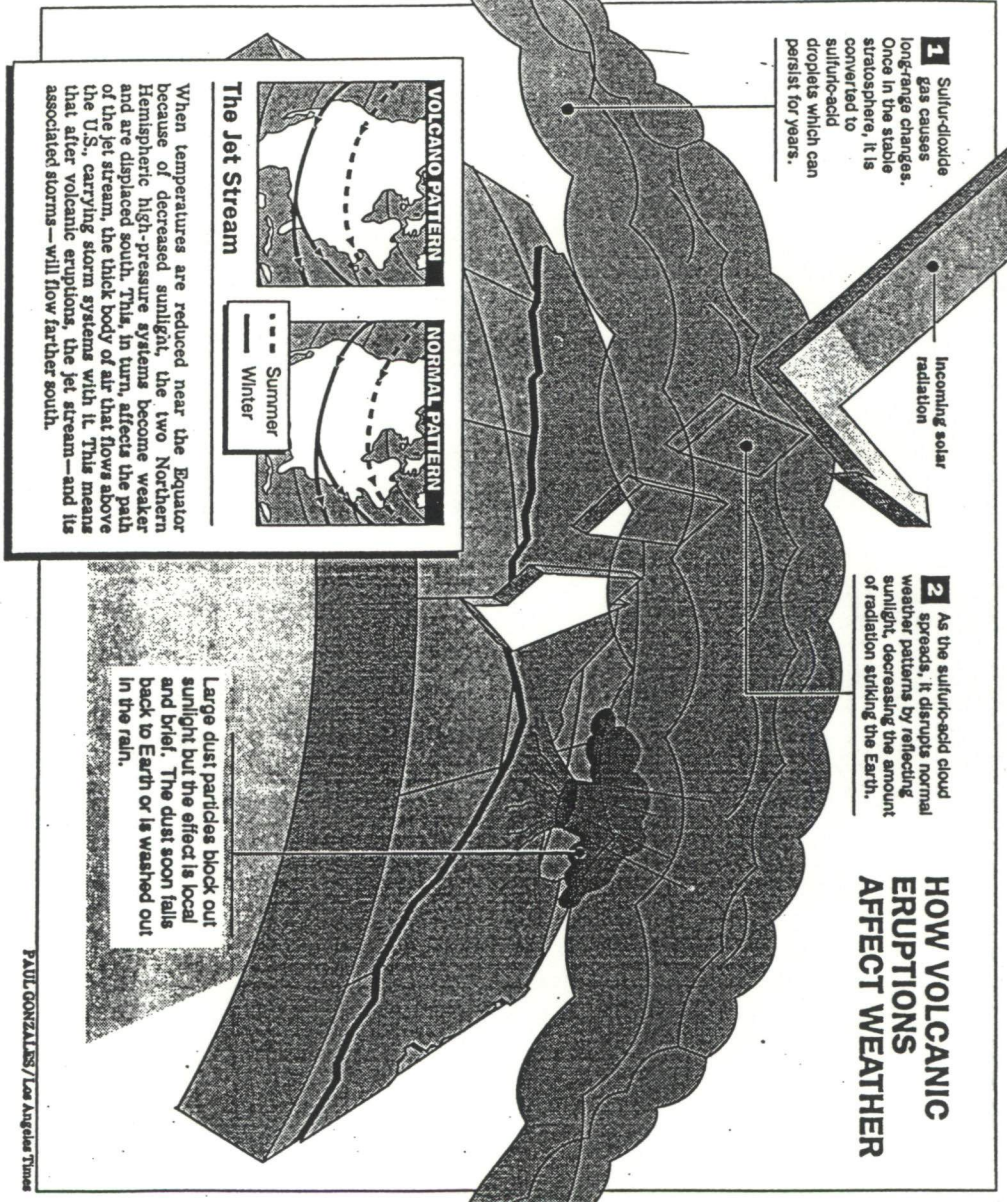
Handler's theory is controversial and not widely accepted, and most climatologists consider him an outsider whose ideas are too simplistic.

But he is one of the few who forecast continuing drought in California this winter and the return of rainfall to the drought-stricken Sahel Desert in North Africa in 1988.

"I'm a little skeptical, but I'm not ruling him out," said meteorologist Kenneth Bergerman of the National Academy of Sciences in Washington. "I think it is worth [further study]. If he is correct, it has strong implications for climate prediction."

"We think of Paul Handler's work as being rather innovative and interesting," said solar physicist Kenneth Schatten of the National Aeronautics and Space Administration in Greenbelt, Md. "But I think it has yet to be really accepted by the scientific community. It's research on the forefront of our knowledge, and thus there may be both some good and some bad in it. I wouldn't believe everything is 100% correct... but he has done a lot of positive work."

Handler came to climatology late in life after 23 years working with microelectronics. He first became interested in the subject in the early 1970s while he was



PAUL GONZALEZ/Los Angeles Times

correlates with the "little ice age" in Europe, a period when glacier movement increased dramatically. In the Alps and average temperatures were an estimated 5 degrees cooler than now.

Although there was a brief period of volcanic activity in the late 19th Century, volcanic activity has been relatively low throughout the 20th Century, leading to an overall warming. That warming, Handler cautions, is superimposed on the warming caused by the greenhouse effect, which results from the release of carbon dioxide into the atmosphere from burning of fossil fuels.

"I think volcanoes are an important source of climate change over the last 100 years," said climatologist Allan Robock of the University of Maryland in College Park. "The data indicate that the greenhouse warming was observed, but was masked to some extent by volcanoes... That implies that greenhouse warming will continue into the future."

Most of Handler's correlations have been retrospective, but they do have some predictive value as well. Geochemist Mary Jo Spencer of the University of New Hampshire in Durham has been studying ice cores, extending back 800 years, obtained in Greenland from a site near a U.S. radar installation.

Spencer noted that in Handler's initial studies, based only on literature reports of volcanic eruptions, "he was missing some events." That is, he had climatic events for which there were apparently no volcanic eruptions. "Now we have much more complete information over the period he is looking at. Lo and behold, in most cases where he was missing events, we now have one."

Handler's correlations are not restricted to the United States and Europe. He has also linked volcanoes to El Niños, a recurring Pacific Ocean phenomenon whose name—a reference to the Christ Child—was coined by Spanish fishermen because the phenomenon typically begins around Christmas.

El Niño is a huge mass of warmer-than-normal water off the coast of Peru extending far out into the Pacific. It has previously been linked to a variety of weather events around the world, including drought in the United States and weaker-than-normal monsoons in the Indian subcontinent.

"From 1870 to the present, over 80% of all El Niño events can be shown to have occurred after the appearance of low-latitude stratospheric aerosols," Handler said. "The conventional wisdom is that those 20 or so El Niño events occurring directly after a volcanic eruption were all coincidences. I don't think so."

Climinate vs. Volcano

sure systems adjacent to the continental United States, the California High and the Bermuda High, become weaker and are displaced south of their normal positions and farther from land.

The strength and position of these highs passed north of California, leaving a large water deficit.

Handler has been able to extend his observations on climate and volcanoes as far back as AD 550, using data on stratospheric acidity extracted from ice cores drilled in Greenland by several research-

ers. (The approximate location... of the But how does... data...)

production and began to perceive correlations between crop production and volcanoes.

In particular, he noted a link between corn production in the American Midwest and volcanic eruptions in the low latitudes, roughly between 25 degrees south and 25 degrees north.

Whenever an eruption occurred in the low latitudes, corn yield in the states of Indiana, Iowa and Illinois was always above average the following year. Conversely, when no eruption occurred for a period of time, corn yields plummeted because of drought.

Handler's reasoning: Volcanic eruptions spew ash and sulfur dioxide into the stratosphere, the upper layer of the Earth's atmosphere. The ash can block sunlight dramatically, but it is washed out by rain in days or weeks. But the sulfur dioxide is converted to sulfuric acid, which condenses with water to form extremely small particles called aerosols.

The aerosols are rained out of the stratosphere over a two- to five-year period. But while they are present, they absorb a small fraction of the sunlight reaching Earth and prevent it from reaching the surface. After the eruption of the Mexican Volcano El Chichon in April, 1982, for example, the low-latitude solar radiation was reduced by more than 7.7% for many months.

When temperatures are reduced near the Equator because of decreased sunlight, the two Northern Hemispheric high-pres-

sure low-pressure systems that determine the path of the jet stream, the mile-thick, 60-mile-wide body of air that flows over the United States at a height of 10 miles and speeds of up to 200 m.p.h., carrying storm systems with it. This means that when volcanic eruptions have introduced aerosols into the stratosphere, the jet stream—and its associated storms—will flow farther south over the United States.

In the Northern Hemisphere, the effect of the decrease in low-latitude radiation is to prolong the spring and fall seasons, while decreasing the intensity and duration of summer.

For the summer period, the jet stream will be located in the northern United States rather than Canada, which should bring more rain and cloudiness to the north-central United States than normal. In effect, the volcanic aerosols would prolong the higher rainfall of May and June into July and August, which normally are drier.

In the absence of volcanic eruptions, the opposite occurs: The jet stream moves farther north, and rainfall is reduced in the United States.

Handler notes that "there was very little stratospheric aerosol during the 1930s. The stratosphere was just very, very clear, and that may be a possible explanation of why there was a drought then. The same was true during the 1950s."

That is the situation Southern California finds itself in now. The stratosphere is very clear, and most of the winter storms that normally bring rain and snowfall have

were first recorded, to the present. His correlation shows that levels of the lakes always rise after volcanic eruptions, beginning one to two years after the presence of aerosols. The lag time, he said, is caused by the need for rainfall to replenish ground water reservoirs before excess water begins flowing into the lakes.

He noted that the highest levels of the lakes, historically, occurred after the massive eruptions of the Indonesian volcano Krakatau in 1883 and El Chichon in 1982. "No one has ever been able to explain variations in the lake levels before," he said.



University of Illinois
Physicist Paul Handler's theory offers explanation of rainfall patterns.

volcanoes can generally be determined by examining the chemical composition of the ash and aerosols. The data suggest some intriguing possibilities.

He noted, for example, a sharp drop in volcanic activity beginning about AD 850 and lasting until about AD 1300, which resulted in a greater amount of radiation striking the Earth's surface and warming the Northern Hemisphere (the hasn't studied the Southern Hemisphere). During that period, colonization increased dramatically in Greenland and Iceland, trees grew profusely and agricultural colonies were established.

Those colonies prospered between AD 1100 and 1250 and the population of Greenland reached 80,000, a figure it would not attain again until the 20th Century. But when volcanic eruptions became more common again after AD 1350, the colonies began withering away. "Archaeological excavations show that the people got shorter and looked sicker," he said. By 1410, the colonies had either disappeared or lost contact with the outside world.

But the same conditions that benefited Greenland must have wreaked havoc in the U.S. Midwest and Southwest. The climate there would have become much more arid, making it almost impossible to raise corn and other food crops, which most likely led to the disappearance of both the Kahoiki and Mesa Verde tribes. "It got so dry that there was no human habitation in the plains around 1200," he said.

From about 1350 to 1750, volcanic activity was higher than normal. This activity

ing the Equator induce warming of the ocean? Handler says that evaporative cooling—the same phenomenon by which sweating cools the body—is the dominant factor. The decreased sunlight leads to a decrease in Equatorial winds. The decreased winds lead to decreased evaporative cooling and, hence, to increased water temperatures—El Niño. The El Niño reinforces the changes in the jet stream that affect U.S. weather.

One outspoken critic of Handler is atmospheric scientist Clifford F. Mass of the University of Washington in Seattle, whose views probably represent those of most climatologists.

According to Mass, "The big problem is that he uses extremely weak eruptions, many of which never put significant aerosol into the stratosphere, so they couldn't have had any climatic impact."

Mass also argues that the use of data from ice cores "gives him a huge number of events. If he has an El Niño, he can always find some kind of event the year before."

In Mass' own research, he looked at only the largest volcanic eruptions and found "no correlation at all."

For his part, Handler recognizes the reluctance of climatologists to accept his conclusions. But he has some questions for them: "Can you explain why the monsoons of 1942 to 1949 were above normal? Why Lake Michigan and Salt Lake hit peaks in 1986? Why the Sahel had rainfall again in 1988? My theory can."

Talk given at the University of Chicago, Spring 1990

A Short Review of Global Climate

by

Paul Handler

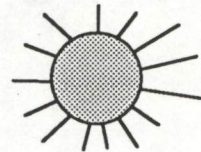
**University of Illinois
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Volcanoes and Climate a 200 year-old Mystery

Why is it that approximately two hundred years after Benjamin Franklin first published his ideas on the association of volcanic eruptions with climate anomalies no one has been able to clearly demonstrate their effect on global climate? The reasons for the failure are manifold.

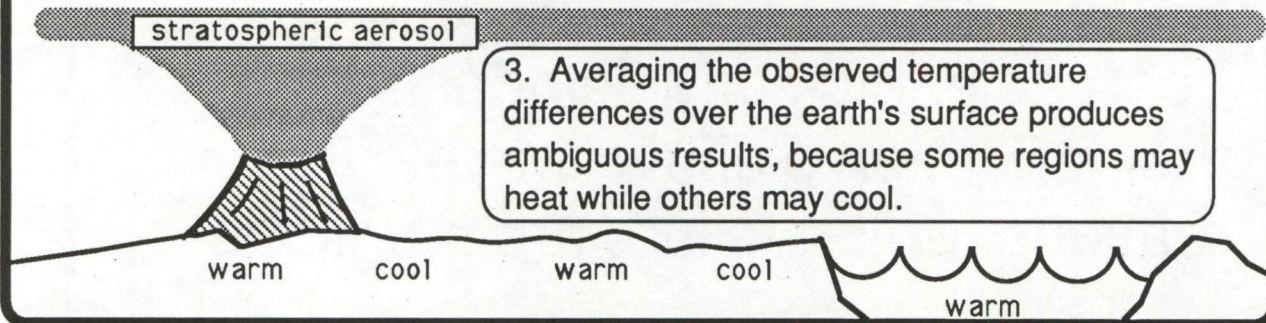
Researchers fell into a number of logical fallacies from which they have never been able to extricate themselves.

The first fallacy was that volcanoes would always produce a cooling at the surface by blocking out solar energy, however...



1. Contrary to expectations, the cooling effect was found to be only about one-tenth to one-hundredth of the expected value.

2. The small temperature changes, as has been shown by A.B. Pittock in a global climate model, arise from a combination of wind and soil moisture changes which can result in either warming or cooling at the surface.



The Second Fallacy

Researchers believed that all volcanoes were alike. Recent evidence shows that the regional climate response is very latitude dependent.

For example, low-latitude volcanoes seem to produce a set of global climate anomalies such as the El Niño.

High-latitude volcanoes seem to produce the set of global anomalies associated with the anti-El Niño state.

Thus the **average** climate effect resulting from compositing both high- and low-latitude eruptions could be close to zero.

It is now understood that the number of stratospheric aerosols was underestimated

The new data from the Greenland, Antarctica and other ice cores show that there were many unknown eruptions which produced significant aerosols. The large signals in the ice cores implies that these aerosols must have induced significant reductions in solar radiation for many months.

Most climatologists are unaware of the existence of these volcanic aerosols. Therefore they usually do not attribute the abnormal climate events of those years to their volcanic source.

The Eruption of 536 A.D. from an unknown volcanic source

The densest and most persistent volcanic aerosol in history was observed during A.D. 536-537 in Europe, the Middle East and China.

According to one contemporary writer, conditions were such that "the sun was dark and its darkness lasted for eighteen months; each day it shone for about four hours, and still this light was only a feeble shadow."

"The sun . . . seems to have lost its wonted light, and appears of a bluish color. We marvel to see no shadows of our bodies at noon, . . .

We have had . . . a spring without mildness and a summer without heat. . ."

Cold and drought finally succeeded in killing off the crops in Italy and Mesopotamia and led to a terrible famine in the immediately following years.

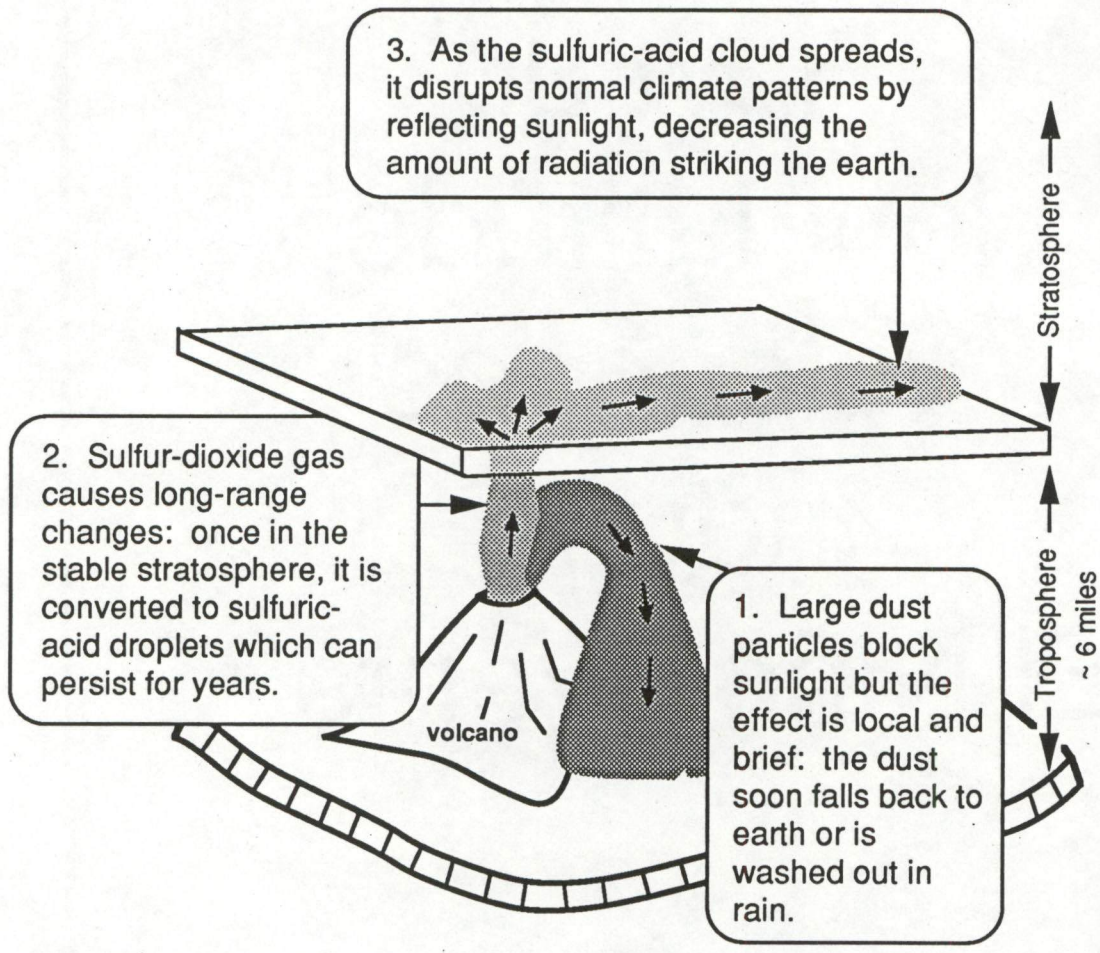
In some regions of China it is estimated that 70-80% of the population died of starvation in 536 and 537 A.D. (not quite species extinction).

The El Niño has been shown to be associated with a worldwide set of climate anomalies.

Volcanic aerosols are also distributed worldwide. It can be shown that the loss of radiation from volcanic aerosols is most probably the cause of all the major El Niño events of the last 120 years.

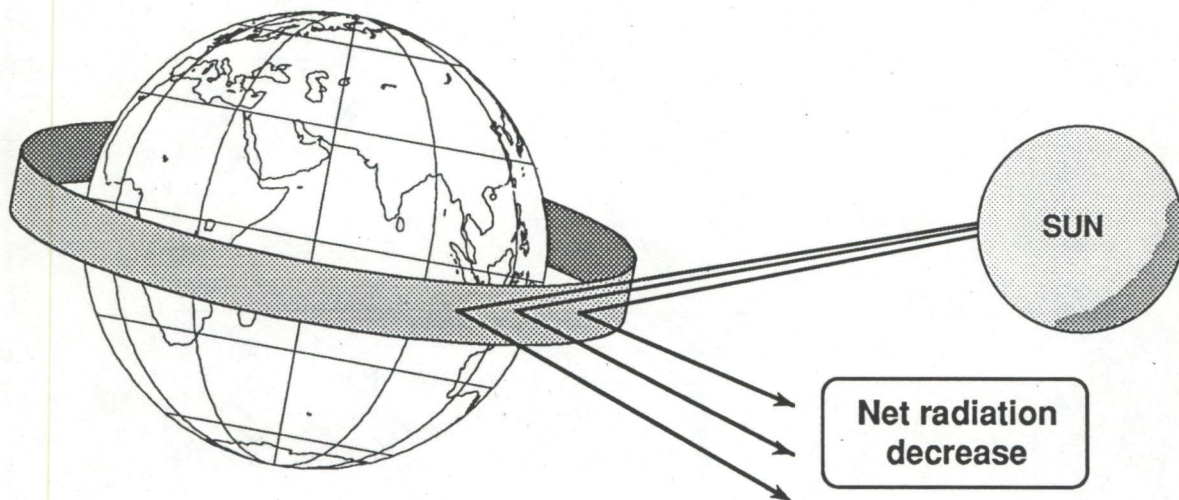
How do
low-latitude
volcanoes
induce
El Niño events?

How volcanic eruptions affect the climate



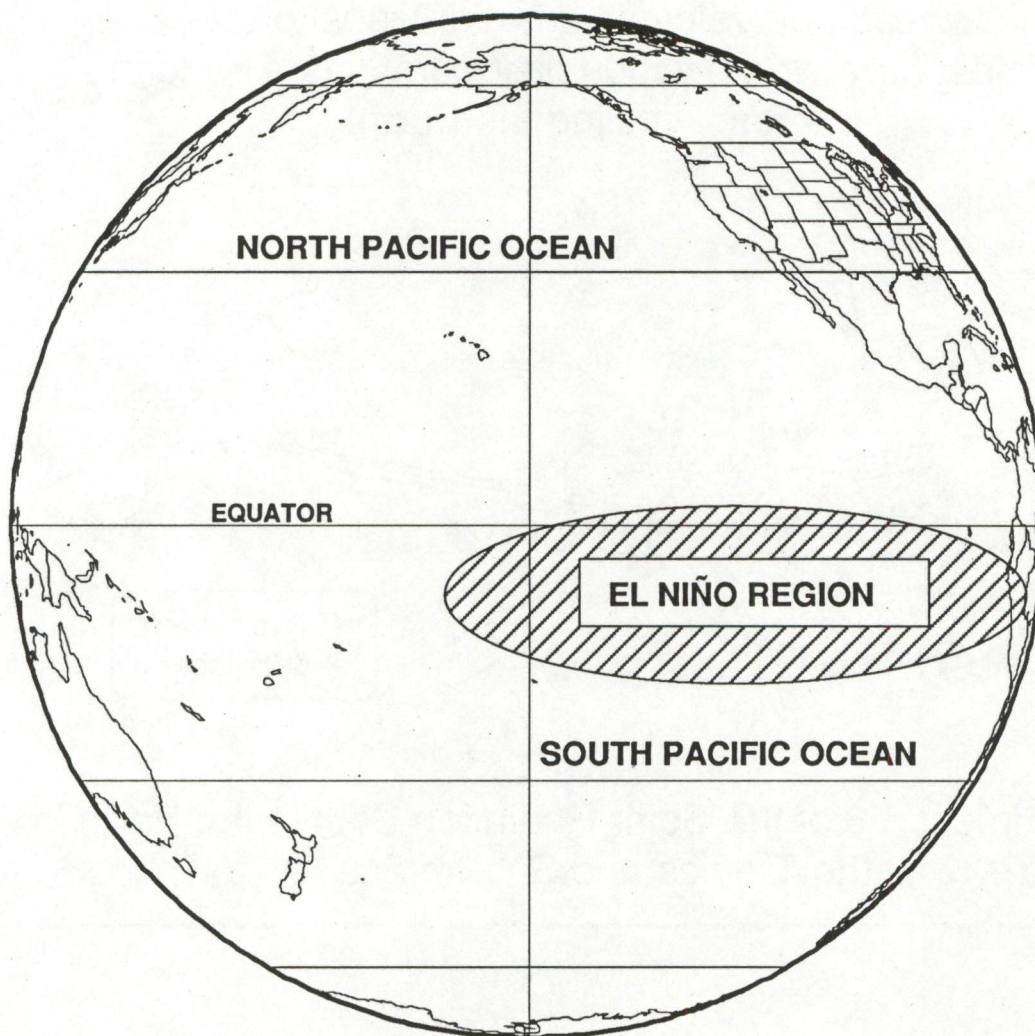
Reflection of Solar Radiation by a Low-Latitude Stratospheric Aerosol

The sulfuric-acid cloud resulting from a low-latitude volcanic eruption rises to the stratosphere where winds distribute it as a band of aerosol circling the Earth.



Note: Almost 5/6 of the Solar Radiation Strikes the Earth in the Tropics and Sub-tropics

El Niño Region in the South Pacific Ocean



The 11 Strongest El Niño Events in the last 120 years As Listed by Quinn et al.

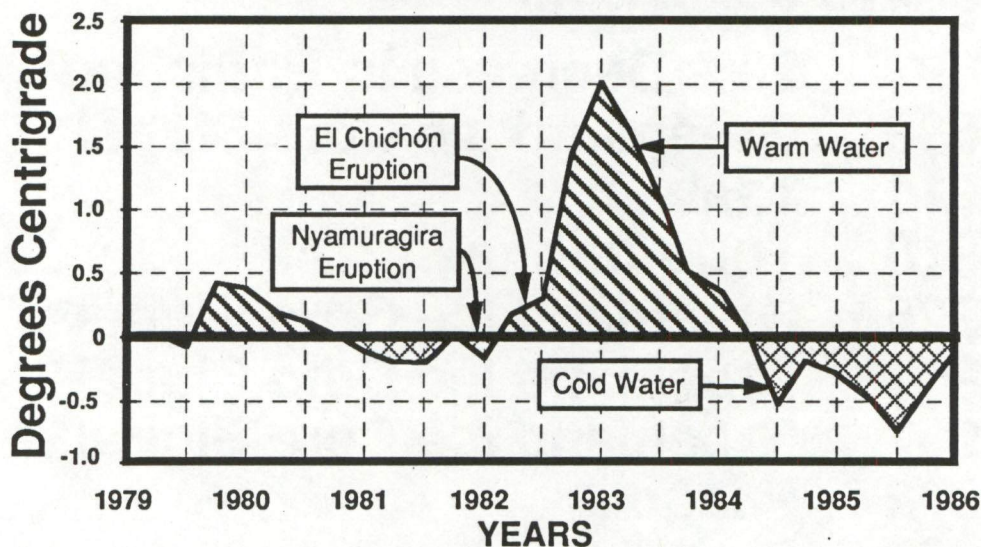
	<u>El Niño</u>	<u>Eruption or Major source of Evidence</u>
1.	1877	Cotopaxi
2.	1884	Krakatau
3.	1891	20% Decrease in Radiation†
4.	1899	Greenland Ice Core Signal*
5.	1911	Taal
6.	1918	Tungurahua
7.	1925	Greenland Ice Core Signal*
8.	1941	Greenland Ice Core Signal*
9.	1957	Greenland Ice Core Signal*
10.	1972	Fuego
11.	1982	El Chichón

*The south Greenland ice core (Lyons et al.) shows that there was a significant volcanic eruption preceding each of these events.

†Solar radiation intensity measurements at Montpellier, France, show a 20% decrease in the direct solar beam for December 1890 through March 1891 (Kimball, 1924).

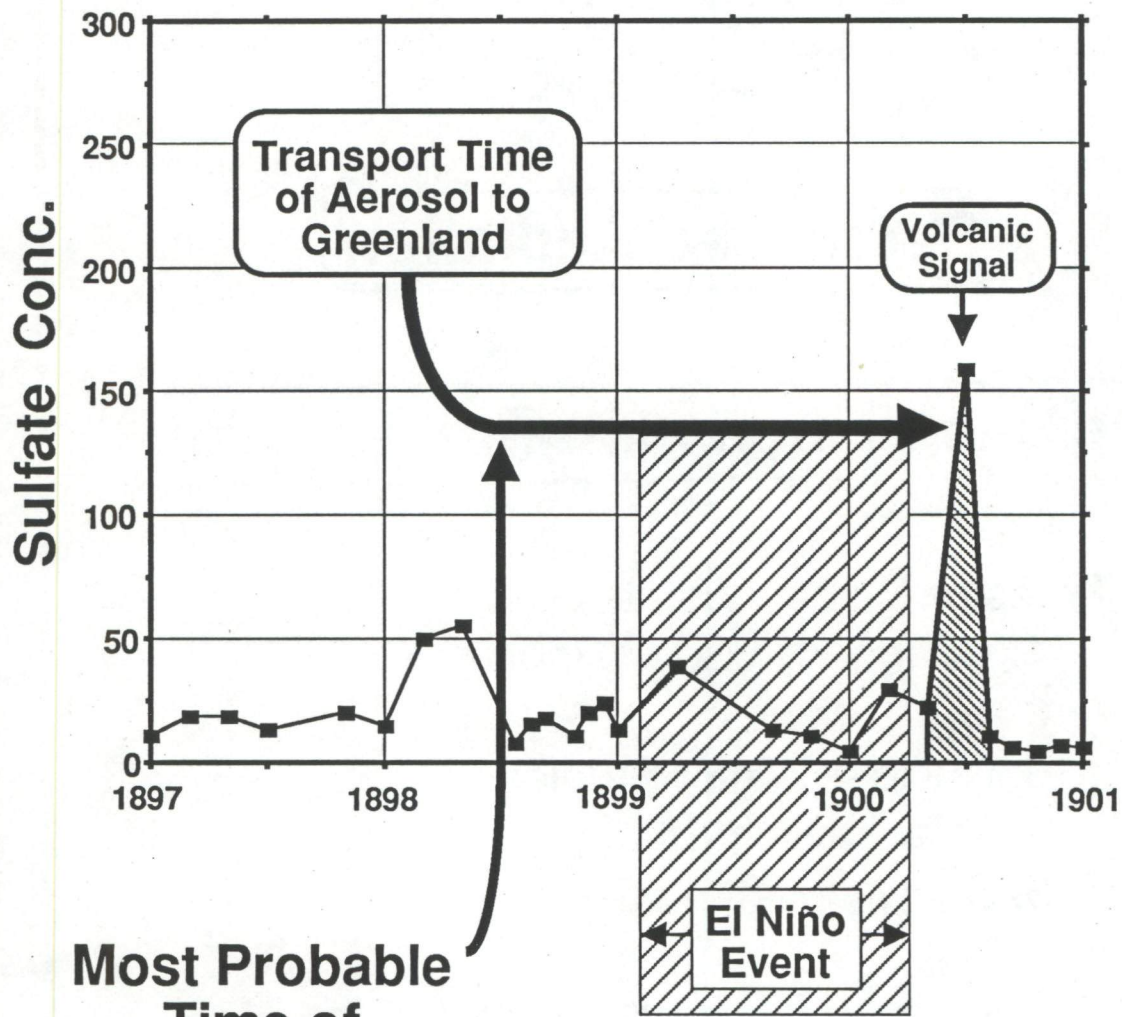
The sequence of events in this figure is an example of the timing between the volcanic eruptions and the appearance of the warmer-than-normal water in the eastern tropical Pacific Ocean.

WARMER-THAN-NORMAL WATER AFTER THE EL CHICHON ERUPTION



Nyamuragira produced enough aerosol to initiate a mid-sized El Niño by itself. The eruption of El Chichón generated the largest aerosol in 100 years. Together these aerosols produced one of the largest El Niño events in the last 100 years.

Evidence from the Greenland Ice Sheet of an excess sulfate peak which is assumed to be associated with an unreported volcanic eruption prior to the 1899 El Niño event. Note that the signal to noise ratio is very large.



**Most Probable
Time of
Low-Latitude
Eruption was
Mid 1898**

The source of this eruption is still uncertain. Note that the peak height is 4 times the rms background.

Global Climate Simulations All Predict That

Decreased Radiation

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graph TD; A[Decreased Radiation] --> B[Decreased Monsoon Precipitation];
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Decreased Monsoon Precipitation

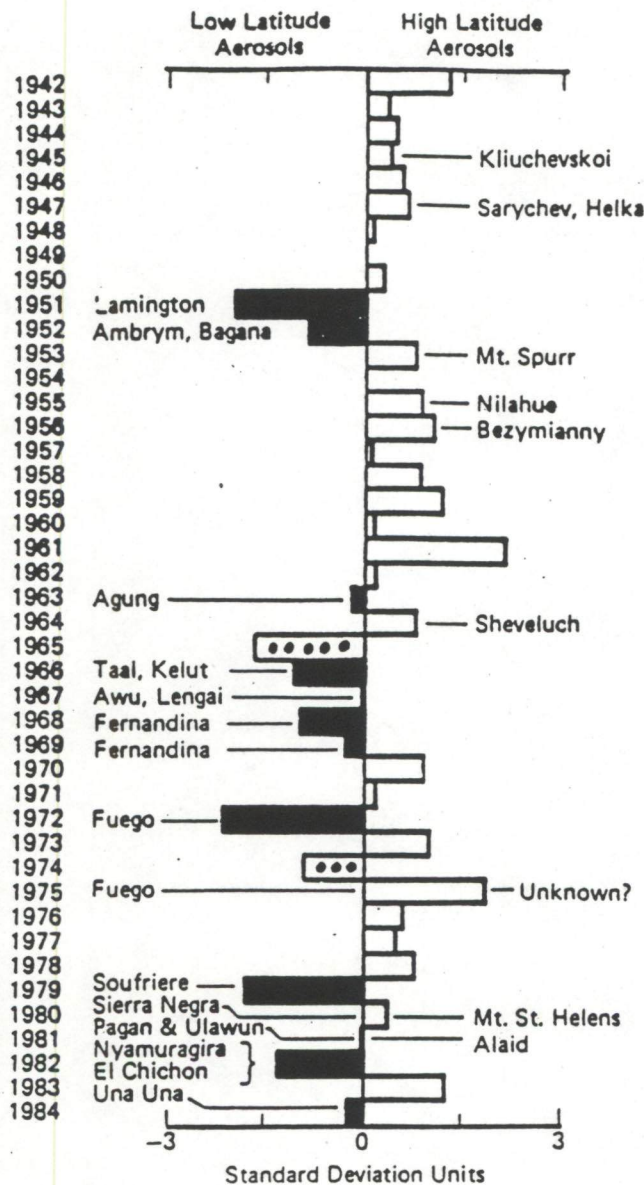
Types of Global Climate Simulations:

1. Changes in Solar Radiation
2. CO₂ Studies
3. Nuclear Winter Studies
4. Milankovitch Studies
5. Snow Cover Studies

The Monsoon is an integral part of the El Niño/Southern Oscillation as shown by Meehl (1987).

Indian Monsoon

Deviations from the 120 Mean for the years 1942-1984



This shows the deviation of the Indian Monsoon rainfall from average and the names of both low (left) and high latitude volcanoes.

The models all predict that the Indian Monsoon will be below normal after the eruption of a low-latitude volcano.

Note that the years 1942-1949 are all above normal and there are no reported low-latitude eruptions.

Note that in 1951-52 after the three eruptions the monsoon is below average.

Then there is a ten year period of no low-latitude aerosols and no poor monsoons. The next poor monsoon occurs directly after the eruption of Agung in 1963.

Note the increased frequency of low-latitude eruptions after 1963 and the increased frequency of below average monsoon rainfall.

The conventional wisdom claims all this happened by chance.

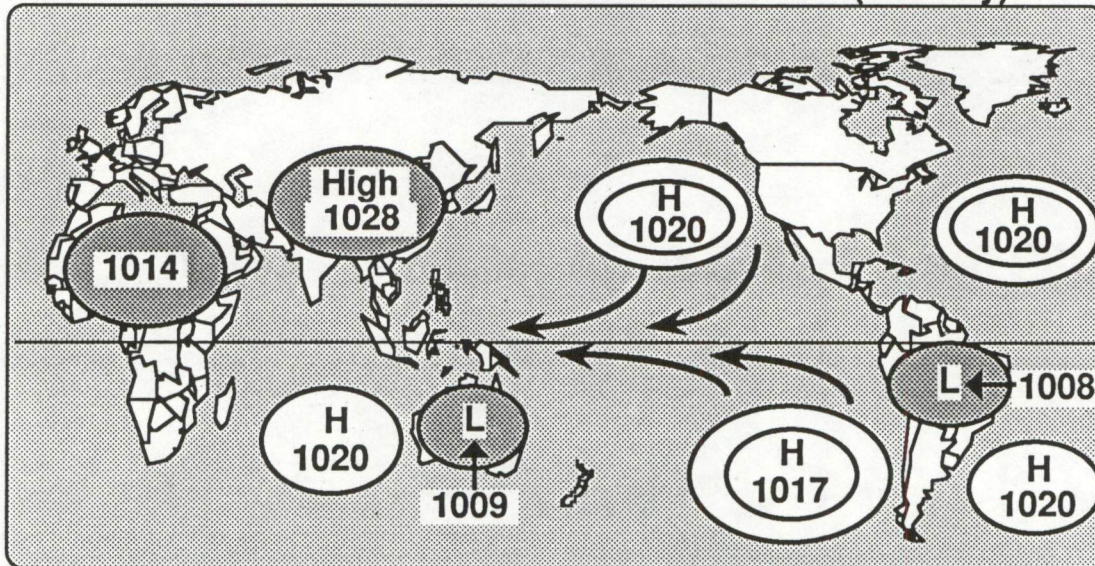
The drought in the Sahel also began in the late '60's, when the frequency of low-latitude eruptions increased.

CRITERIA FOR A CLIMATE MODEL

- 1. EXPLAIN THE PAST**
- 2. EXPLAIN THE PRESENT**
- 3. PREDICT THE FUTURE**
- 4. OBEY THE LAWS OF PHYSICS**

The Physical Mechanism for the Simultaneous Generation of El Niño and the Poor Indian Monsoon

A. Global Sea Level Pressure Distribution in mb (January)



B. Global Sea Level Pressure Distribution in mb (July)

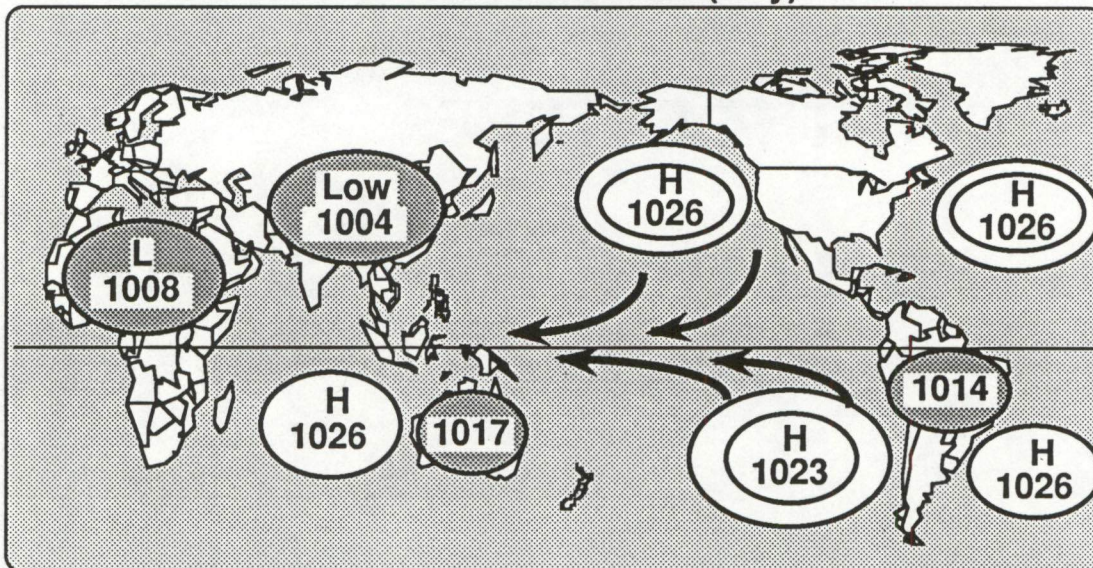
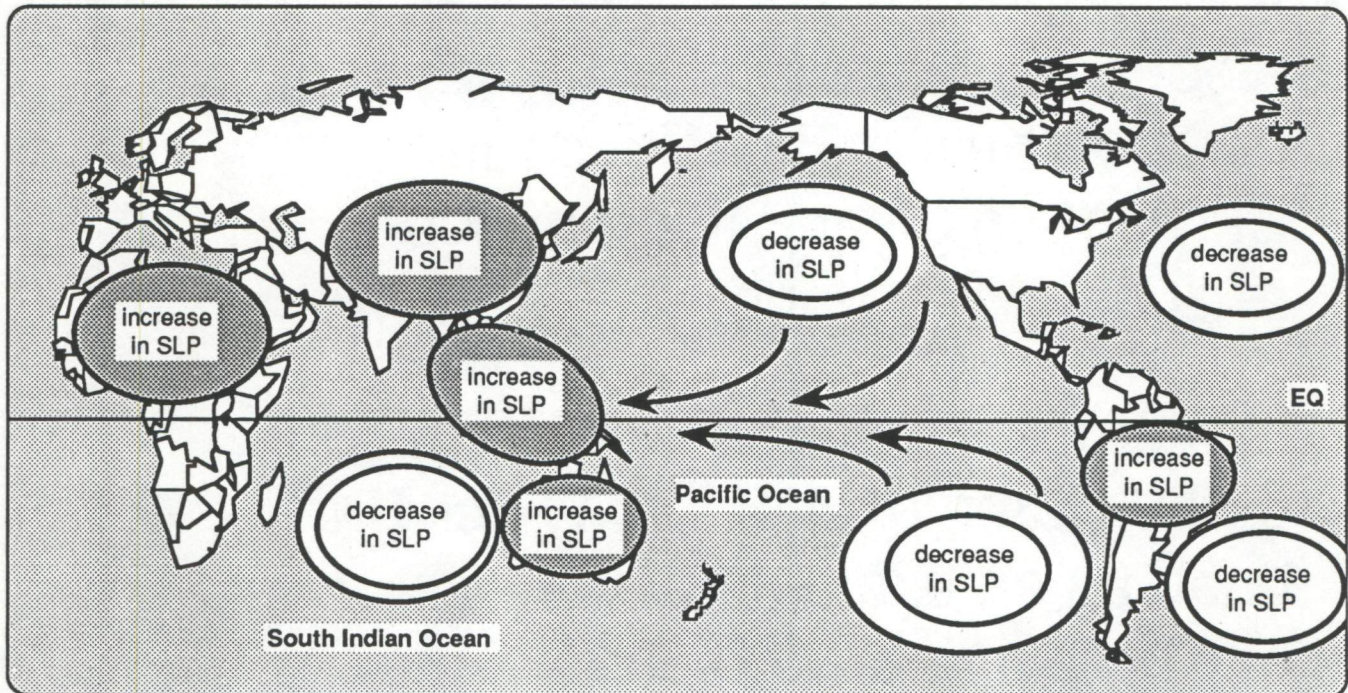


Figure A shows the Sea Level Pressure in January. Figure B shows the Sea Level Pressure in July. Note that the Sea Level Pressure of both Northern and Southern Hemisphere anticyclones increases by about 6 mb over the period of time from January to July. This air mass shift is related to the greater land area in the Northern Hemisphere.

Conservation of airmass requires that air be transferred from the Northern Hemisphere land masses to the oceanic anticyclones as the sun moves to the Northern Hemisphere in July.

Change of Sea Level Pressure for Conditions of Decreased Incoming Solar Radiation in Tropical and SubTropical Regions



A decrease of radiation caused by a stratospheric aerosol over the low-latitudes including the Eurasian low decreases the amount of air mass transferred to the anticyclones. Therefore, the pressure gradient between the center of the high pressures of the oceanic anticyclones and the ITCZ is reduced. Accordingly, the winds along the equator are reduced by a few meters/second. Reduced winds are usually the first sign of the El Niño; they allow warmer than normal sea surface temperatures to form. The major anticyclones affecting the El Niño region are the North and South Pacific high pressure centers as indicated by the wind arrows.

The poor Indian Monsoon results from the decreased gradient of pressure between the weakened Southern Indian Ocean anticyclone and the higher than normal pressure over the Eurasian land mass. Drought in East Africa is also likely when this wind system is weaker than normal.

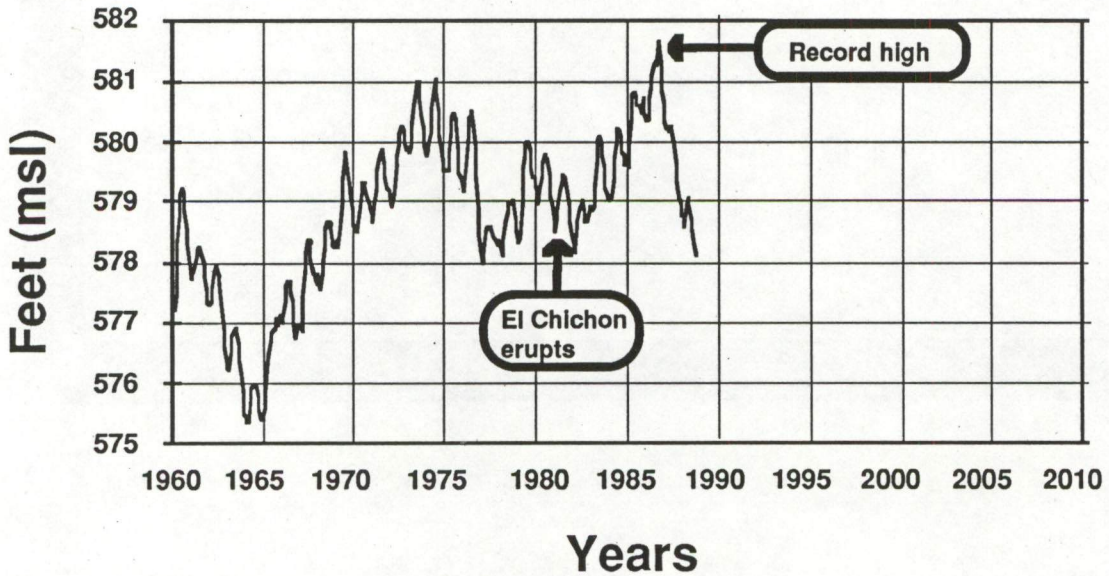
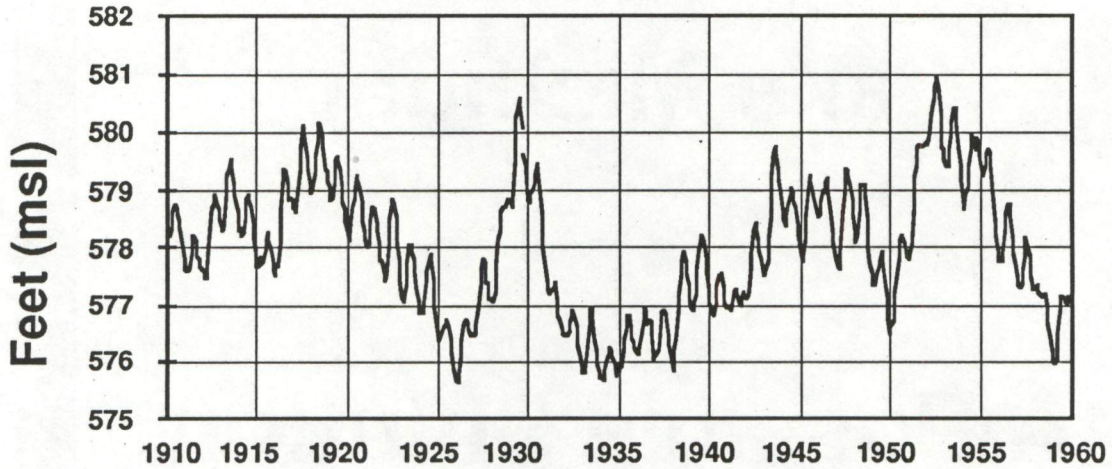
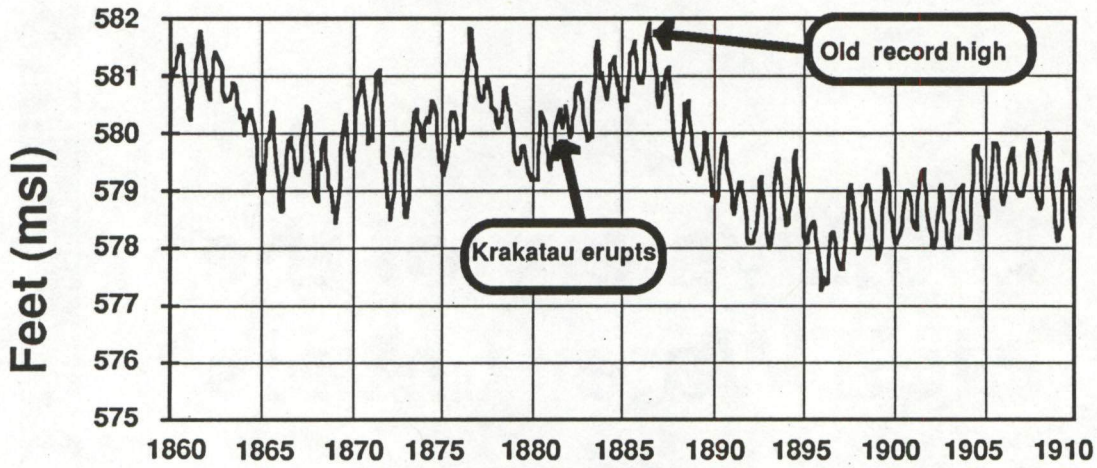
If the hypothesis is correct it should be able to explain climate change in other parts of the world besides the El Niño region and the monsoon regions of the world.


In the next few pages, the variation of the water level of Lake Michigan is used as an example of the explanatory power of the volcanic hypothesis.

**The Mystery of the
High Water Levels
of
Lake Michigan**

A Possible Solution

Michigan Lake Level 1860-1988






This graph show the water level of Lake Michigan from 1860 to the present. Two record heights are indicated during this period.

Note that the TWO record high water levels occur just a few years after the TWO biggest volcanic eruptions of the last 120 years, those of Krakatau and El Chichon.

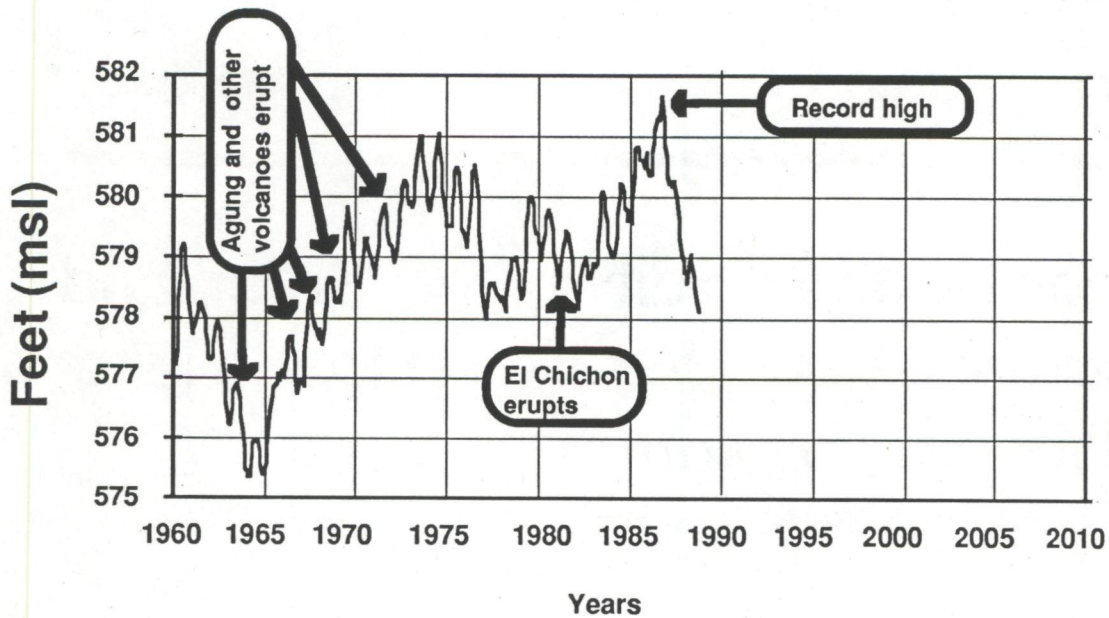
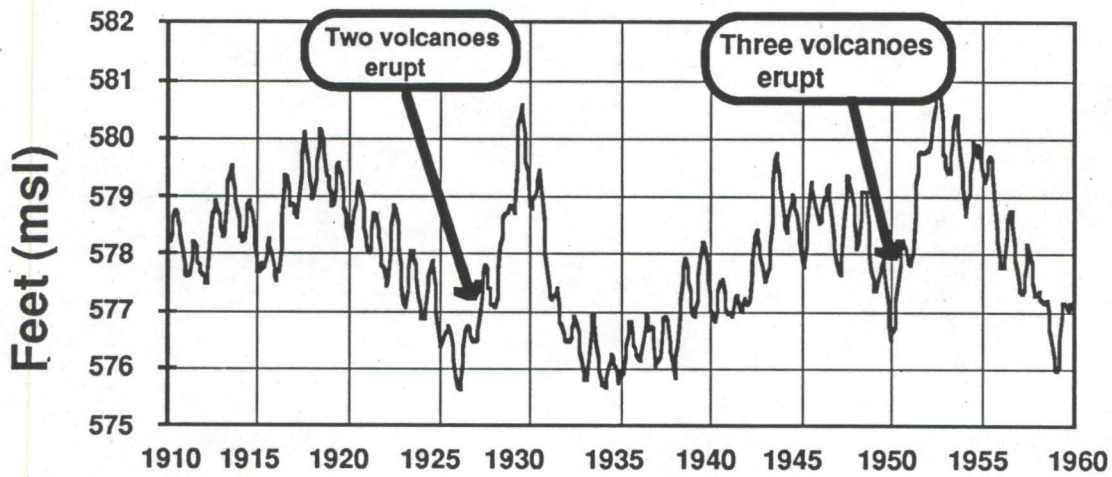
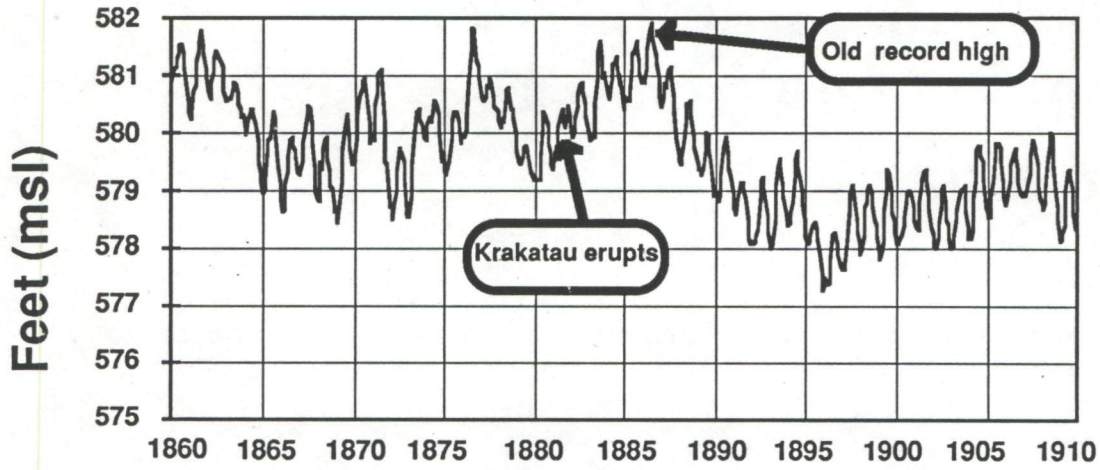
If this were a cause and effect relationship, then the other peaks in the record should be related to low-latitude volcanic eruptions as well.

The next page shows that most of the major increases in lake level over the last 100 years followed the eruptions of low-latitude volcanoes as in the case of the two indicated record heights.

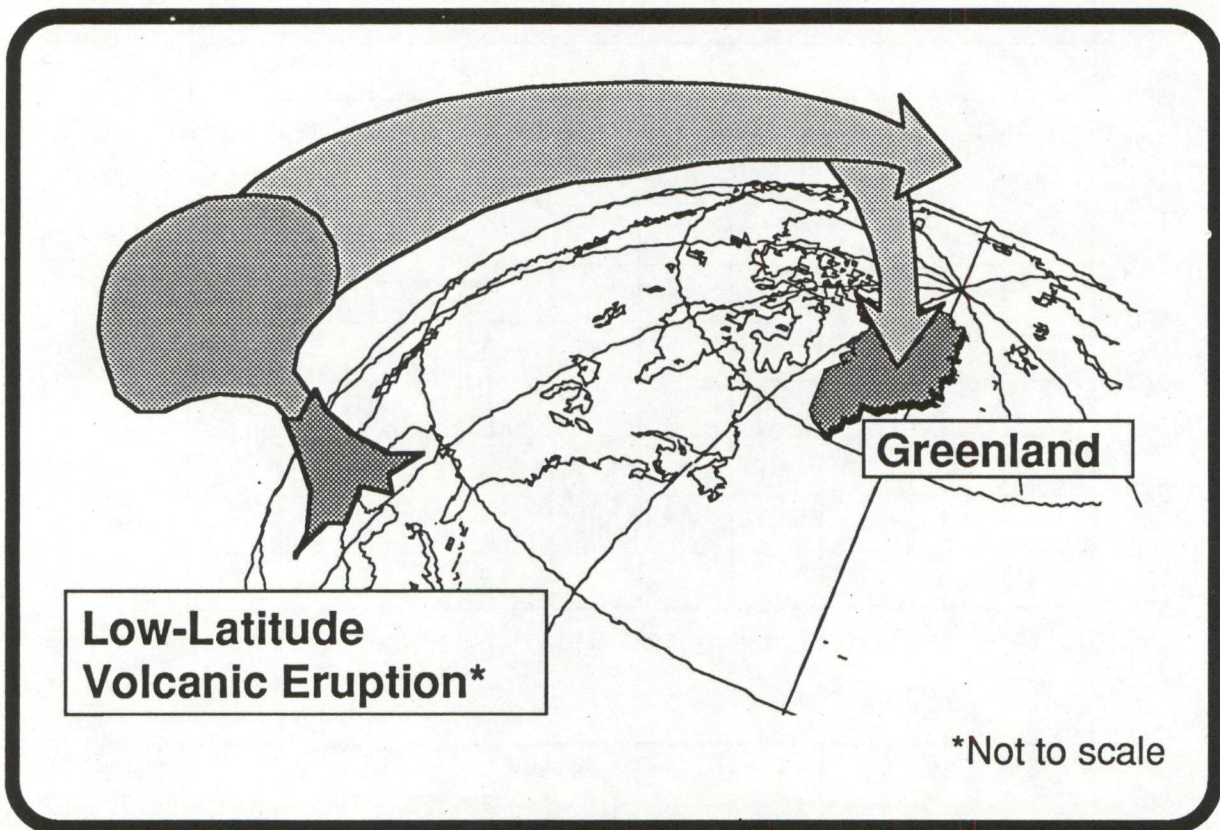


There is at present no alternative explanation for the observed variation in lake level.

Michigan Lake Level 1860-1988

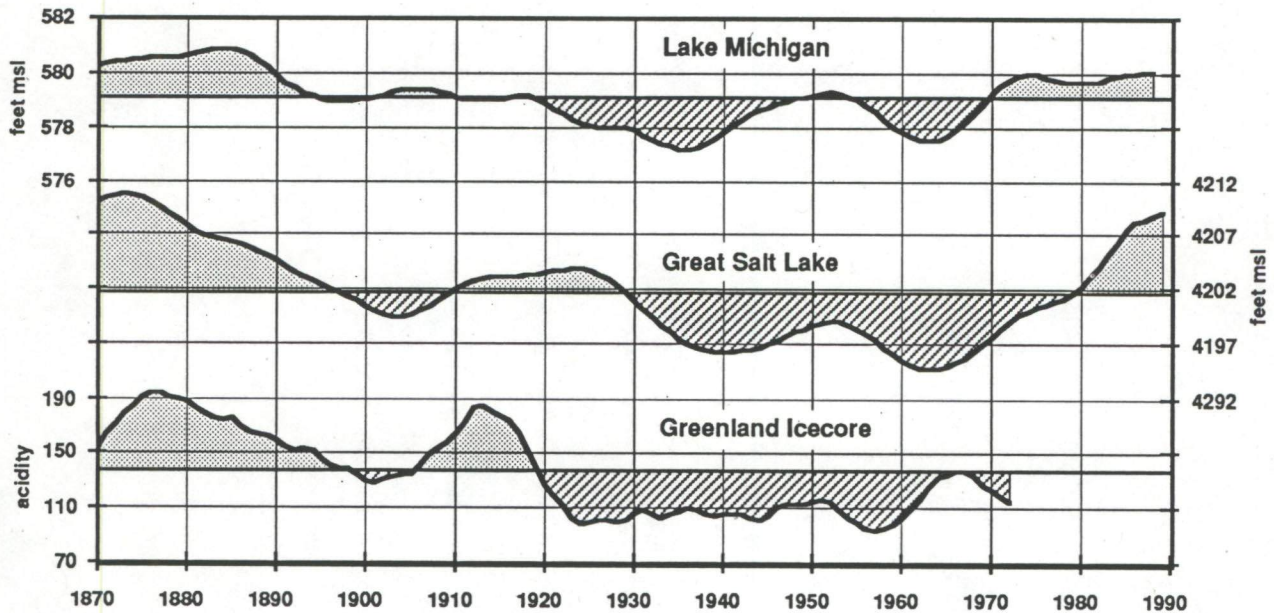


The volcanic aerosol, composed mainly of acid, is transported through the stratosphere to Greenland where it is deposited in the snow.



A record of the acidity in the Greenland ice core is shown in relation to the lake level in the next figure.

Comparison of 10 Year Moving Average of Lake Michigan and Great Salt Lake Water Levels with the Greenland Ice Core Acidity of the Last 120 Years



- NOTE: 1. When Greenland Ice Core Acidity was high (1870-1900), the Lake Water Levels were high.
2. When Greenland Ice Core Acidity was low (after 1920), the Lake Levels were low.
3. After 1963 the increase in volcanic activity was followed by rising Lake Levels.

**The Volcanic Record
From
Greenland Ice Cores**

550 A.D.

to

1972 A.D.

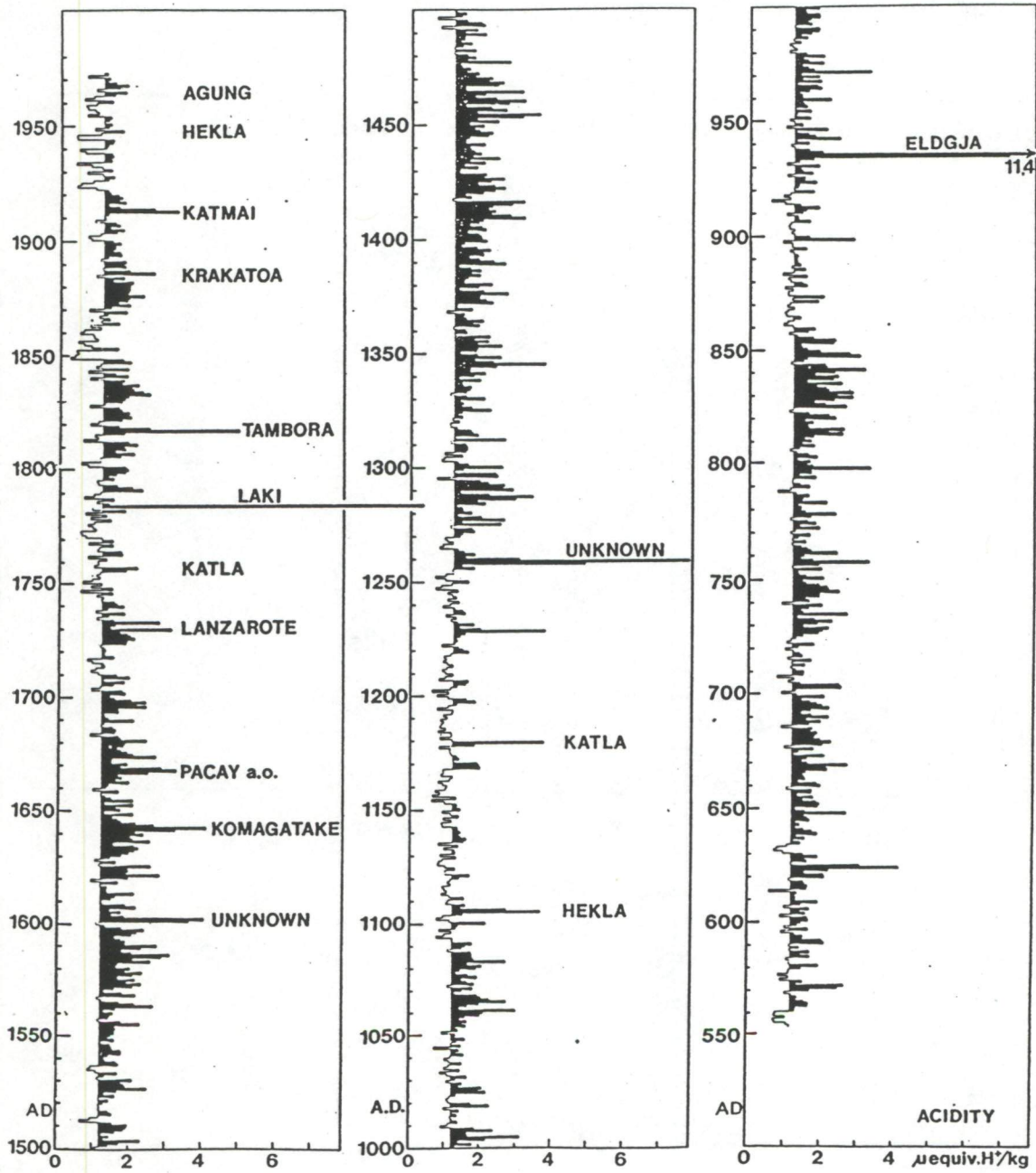
The opposite page shows the volcanic acidity in the Greenland ice core as measured by Hammer et al. (1980). The data run from 550-1972. The very large spikes are Icelandic eruptions which because of their closeness to Greenland give very large signals.

Note the drop in acidity right after 850 A.D. which on the average persists until about 1250 A.D. The decrease in volcanic activity, which is associated with the drop in acidity, resulted in a greater amount of solar radiation striking the earth's surface over this 400 year period of time. The persistent increase in radiation induced a warming of the climate. Trees grew in Greenland and there were many agricultural colonies established. The Iceland and Greenland colonies prospered between 1100 and 1250 A.D. Iceland's population reached a maximum at that time, a level not exceeded until the 20th century. The increase in volcanic activity after 1300 A.D. cooled global temperatures sufficiently so that the Greenland colonies began to suffer the effects. By 1410 A.D. the colonies had either disappeared or lost contact with the outside world.

The dramatic increase in volcanic activity after 1300 A.D. is believed to have brought on the Little Ice Age, a period when glacier growth increased dramatically in the Alps and the rest of the world lasting until about 1850 A.D.

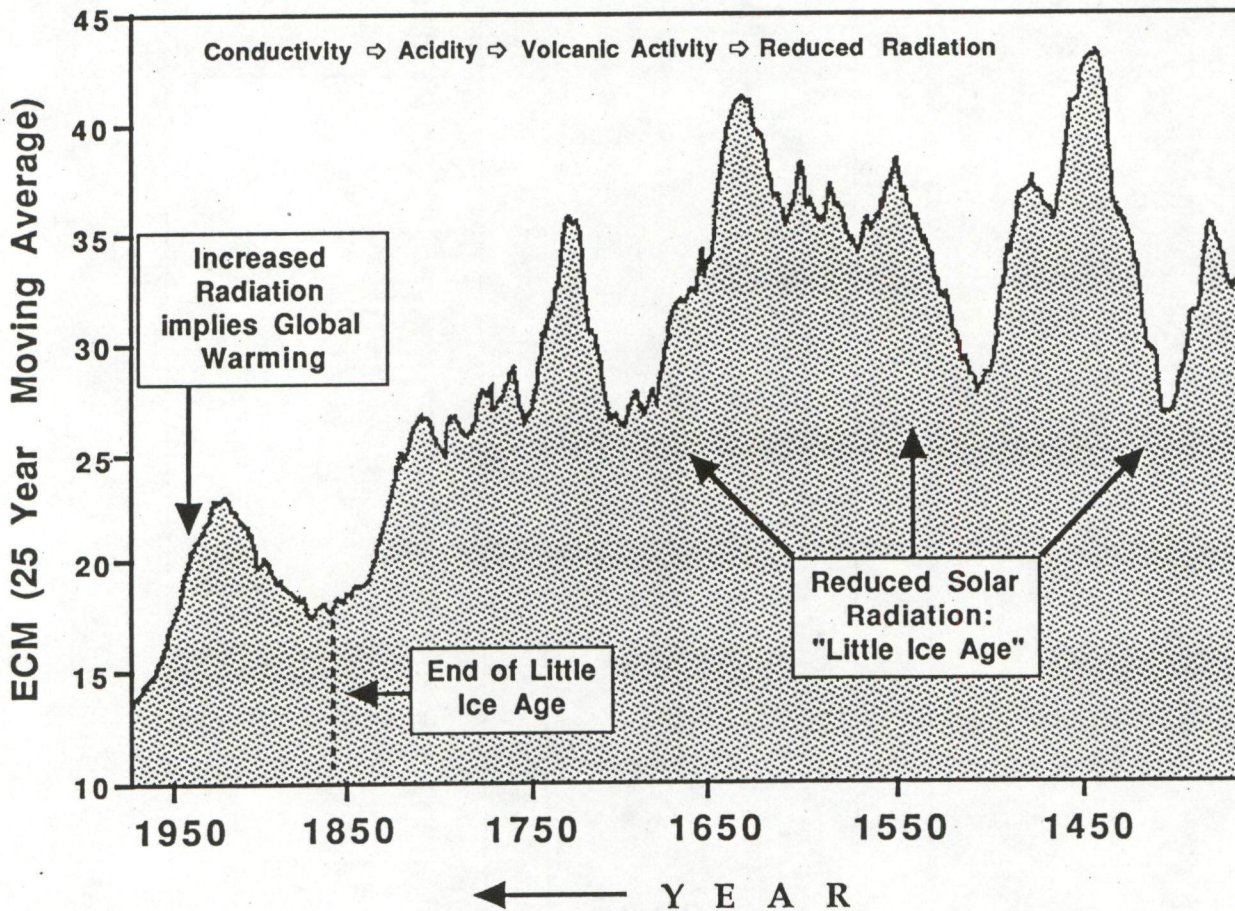
In the next transparency I will show a smoothed record taken from a second ice core so that you can see in detail what was happening during the past century.

Measure of Acidity in the Greenland Ice Sheet as Taken by Hammer et al. 1980



The End of the Little Ice Age

This figure shows the 25 year moving average of the solid conductivity of the central Greenland ice core for the last 600 years. The height of the signal is related to the amount of volcanic aerosol deposited from the stratosphere. Thus during the Little Ice Age the amount of solar radiation reaching the surface was less than at present.



The Little Ice Age is assumed to have ended about 1850 as indicated in figure. Since that time the acidity level has fallen by at least a factor of two. The amount of solar radiation reaching the surface has increased and thus may be the cause of the global warming of the past 150 years.

Since there have been no significant new volcanic eruptions during the past five years, the stratosphere is very clear and more radiation is striking the earth. Climate events which have resulted from the increased radiation are:

The excellent rains in the Sahel since 1988

The above average monsoon rainfall in India since 1988

The above average rainfall in Australia since 1988

The good rains in most of Africa since 1988

The position and strength of the California High since late 1987

The absence of any new El Niño events in 1988, 1989, and 1990

The rapid decrease in the level of Lake Michigan since 1986

The explanatory power of this hypothesis should be compared with all other alternative models.

Department of Justice, Environment & Natural Resources Division

Date:

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U.S. Department of Justice

Environment and Natural Resources Division

Office of the Assistant Attorney General

Washington, D.C. 20530

August 24, 1990

MEMORANDUM

TO: Members of the Task Force on Climate Approaches

FROM: Dick Stewart
Assistant Attorney General

SUBJECT: Draft Outline of Research and Analysis to Support the
Comprehensive and Incentives Approaches

As promised, attached is a draft outline for the interim report the Task Force will present to the DPC subgroup on global change. Please review it and make any comments; we would very much appreciate receiving your comments by COB Thursday, September 6, 1990, by fax at 514-0557. We would especially appreciate your thoughts on whether any relevant items or information have been omitted, and on suggested relative priorities for the tasks identified.

We will then prepare a more complete draft of the report, which will be reviewed at a meeting of the Task Force at 10:00 a.m. on Thursday, September 13, at the Department of Justice, Room 2603.

Task Force on Climate Approaches

**Outline of September 1990 Interim Report:
Research and Analysis to Support the
Comprehensive and Incentives Approaches**

Comprehensive Approach

I. Measuring and Monitoring Atmospheric Greenhouse Gas (GHG) concentrations

Measuring and monitoring current and future levels, distributions, dynamics

-- Current Administration efforts:

- CEES agencies, e.g. NASA, NOAA

-- Future work: ensure coverage of all gases

II. Comparative Indices of Impacts of GHGs

-- Current Administration efforts:

-- Considerable work has been done on the relative radiative forcing of many GHGs. Scientific uncertainties in the current estimates remain, chiefly surrounding the residence time of CO₂, and atmospheric chemical reactions of other gases such as O₃ precursors. Work has been done by IPCC WG I, NASA, NOAA, NSF, EPA, DOE

-- Future work:

-- harmonizing various approaches

-- indirect effects attributable to various gases' atmospheric reactions

-- residence times of GHGs: carbon cycle, hydroxyl dynamics

-- saturation effects; relation to concentrations of same gas and other gases

-- discount rates/time horizons

-- designing a "full impacts" index: incorporating into the index all the environmental externalities, in addition to radiative forcing (the endpoint currently measured in the index), that are associated with GHGs,

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in order to ensure that proper incentives are provided to manage GHGs for the optimal environmental outcome. This would include incorporating the very salient non-warming impacts of GHGs: direct effects of CO₂ on vegetation, toxicity of CO and other gases to organisms, and ozone depletion impacts associated with halocarbons. Address technical and analytic issues in a "full impacts" index.

-- institutional mechanisms for adopting a consensus index and adjusting it to new research results

III. Measuring and Monitoring net GHG emissions

(A) Measuring actual net GHG emissions

-- Current Administration efforts:

- numerous agencies collect and analyze data on various gases, sources, sinks, sectors, and industries.

- data are generally adequate on US and other industrialized nations' emissions of GHGs from fossil fuel combustion (generally measured by data on fuel inputs and knowledge of typical combustion techniques), and on world emissions of halocarbons

-- Future work:

- develop practical techniques of measuring net GHG emissions, including direct observation; remote sensing; proxies or surrogates, such as fuel or fertilizer input data coupled with assumed output rates (e.g. combustion or cultivation techniques), or acreage or livestock data coupled with assumed output rates; economic simulations; and so forth. Ensure that measurement assumptions do not distort policy responses.

- expand monitoring capacity and data to cover all gases, sources, and sinks: data are especially needed on non-point sources of CH₄ and N₂O, e.g. agriculture, livestock; hydroxyl dynamics and atmospheric chemical reactions yielding tropospheric O₃; non-point sources and sinks of CO₂, including oceanic biota, terrestrial biota, long-term sequestration, plant lifecycles, grasses, soils, and trees, extent and effects of deforestation, and sink behavior.

- expand monitoring capacity and data to cover all nations.

- ensure that future data presentations are comprehensive, e.g. avoid CO₂-only or fossil fuels-only charts in IPCC, NES, and other reports except as adjuncts to complete GHG presentation.

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(B) Assembling inventories of net GHG emissions by country-- Current Administration efforts:¹

- EPA analysis of CO₂, CH₄, CFCs, HCFCs, N₂O, CO, NO_x, NMHCs; includes US and other nations
- DOE/NES analysis of CO₂, CH₄ from energy sector; includes US only

-- Future work:

- identify assumptions and modeling underlying existing inventories
- improve accounting of all nations, gases, sources and sinks, as described under "(A) Measuring," above
- develop production and consumption disaggregations, e.g. by sector
- develop models correlating net GHG emissions to socioeconomic and demographic variables, e.g. growth rate of per capita GNP

(C) Forecasting and monitoring net emissions in the future

This task is needed to (i) better forecast future emissions to predict future concentrations, and to validate economic forecasting models with empirical data, and (ii) verify nations' compliance with agreements or adherence to claims of national policy.

Future work is needed on:

- developing technologies and capabilities described under "(A) Measuring actual net GHG emissions," above
- assessment of institutional options for monitoring arrangements:
 - arrangements for monitoring and reporting and their relation to sovereignty concerns, e.g. voluntary or mandatory national reporting; "national technical means" of observation of other nations' activities; remote sensing; atmospheric observations; international oversight bodies (e.g. UNEP investigators); permission for on-site inspections
 - economic modeling as forecasting tool and as check against reported quantities

¹ Efforts outside the government include: OECD project on all gases, solicited from member states; WRI (in conjunction with UNEP/UNDP) on CO₂, CH₄, CFCs, all nations; Harvard Kennedy School on CO₂ and CFCs, many nations.

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- bilateral trade partner review under emissions trading
- institutional incentives to encourage development and application of monitoring & reporting, such as assuring credit for net GHG limitation actions (e.g. "no regrets" actions) upon a showing by the emitter of successful monitoring practices
- verification procedures
 - rules; burden of proof
 - forum (international or bilateral, political or scientific adjudicators, etc.)

IV. **Evaluating the comparative cost-effectiveness of piecemeal, partial, and comprehensive approaches.**

Advocacy of the comprehensive approach is based in part on the intuitively strong hypothesis that the marginal costs of control vary across gases, sources, sinks, and nations, so that for any assumed limitation obligation,² each nation's least-cost mix of limitation strategies would be different and all nations, regardless of their current GHG inventories, would be better off under a comprehensive approach than under an approach which placed separate limitation obligations on each gas or sector.³

- (A) Extent and costs of net GHG limitations achieved by "no regrets" policy options within a comprehensive framework.

² Thus, given an assumed objective, the task is to assess the comparative costs of achieving it under different policy designs. This task does not assess the overall rationality or economic efficiency of the chosen objective. Nor does it question whether each policy design would achieve the objective; that topic is addressed in Part V, below, on the environmental effectiveness of different approaches.

³ The aggregate shares calculated in the inventories (in Part III(B), above) do not indicate the costs of incremental limitations for each nation. Simply because a nation currently has a large share in methane, for example, does not mean that that nation would find methane reductions costlier than CO₂ reductions, at the margin. Economic analysis is needed to test the hypothesis of varying costs and to demonstrate the benefits to every nation of being afforded the cross-gas, cross-sector, and source-sink flexibility of the comprehensive approach.

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"No regrets" actions are actions taken for other (non-climate) reasons but which influence net GHG emissions. One may calculate the percent limitations or reductions achieved by these policy actions using the comprehensive approach, and also calculate the cost per policy action. This is a first step toward assessing the marginal costs of GHG avoidance from different gas/source/sink policy options and hence toward assessing the relative cost-effectiveness of the comprehensive versus piecemeal approaches.

-- Current Administration efforts:

- EPA analysis of US policies
- DOE/NES analysis of US energy policies

-- Future work:

- expand to carry out similar analyses for other nations' options under international (e.g. Montreal Protocol, forestry agreement) and national (other "no regrets") actions
- expand to cover influence of agricultural subsidies
- model full marginal cost functions (see below)

(B) Information and analyses needed to map full comparative cost-effectiveness functions and variations by gas, source, sink, sector, nation. This task is to move beyond analyses of specific existing policy programs and to evaluate the full marginal cost functions facing policy makers and private actors.

-- Current Administration efforts:

- DOE/NES analysis for US energy sector policies and afforestation

-- Future work:

- expand to cover all gases, sources, sinks, sectors
- expand to cover other nations
- assess full social costs, using general equilibrium model rather than expenditures by the regulated industry.⁴ Make use of forthcoming Second Generation GHG Emissions model (J. Edmonds

⁴ The comparative impacts on macroeconomic and international variables (e.g. trade, competitiveness, economic growth) would require separate study.

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developing for DOE). Analyze costs over time, relation to innovation.⁵

-- include (qualitative) evaluation of non-economic costs to response options, e.g. cultural or institutional barriers to certain policies

- (C) Use cost-effectiveness analyses to evaluating costs and benefits to the US and other nations of possible piecemeal, partial and comprehensive options that will be suggested for international policy design; e.g. policies addressing: CO2 only, all GHGs, or all GHGs except those covered under the Montreal Protocol; sources only, point sources only, all sources and sinks, or sources and terrestrial sinks only; all sectors, or certain sectors (e.g. energy, industry, transport, agriculture, forestry).

V. **Evaluating environmental benefits of the comprehensive approach.**

(A) Cross-factor shifts

Advocacy of the comprehensive approach is based in part on the intuitively strong hypothesis that including all gases, sources and sinks ensures better effectiveness in any effort to limit contributions to potential radiative forcing, in particular because piecemeal rules applying to one gas, source (or sector), or sink will engender shifts of socioeconomic activity from regulated to unregulated modes, undercutting achievement of policy goals.

-- Current Administration efforts:

-- DOE/NES study will address CO2 and CH4 emissions from energy sector; should consider potential tradeoffs

-- Future work:

-- conduct case studies of cross-gas shifts: e.g. fossil fuel switching (coal to gas) induced by CO2-only policies, and impacts on CO2-to-CH4 emissions shifts due to CH4 leakage⁶

-- expand cross-gas shift studies, e.g. apply coal-to-gas CO2-CH4 shift analysis to actual global GHG output

⁵ Evaluation should also address the likely economic impacts in the US and worldwide of potential future changes in the understanding of the gas-comparison index, and means to cushion adverse impacts (e.g. periodic public science reviews).

⁶ Such studies are being conducted, e.g. by Rodhe (1990).

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and in light of likely GHG emissions/leaks from future coal and gas facilities

-- evaluate other cross-gas shifts, e.g. CH₄ to N₂O in agriculture under a CH₄-only policy

-- evaluate cross-source/sector shifts: e.g. under a transport-only policy, possible shift from fossil fuel combustion on board vehicles to electric cars powered by central utility combustion, or to use of intensely cultivated biomass fuels; e.g. under an energy-only or fossil fuel-only policy, possible shift to biomass fuels whose cultivation emits other GHGs

-- evaluate side benefits of encouraging sink expansion: e.g. soil erosion, biodiversity, timber management

(B) Incorporating all environmental externalities into a "full impacts" comparative index

Current comparative indices focus on relative radiative forcing, or the potential of trace gases to contribute to atmospheric warming. Several of the GHGs have important non-warming impacts on the environment which are not reflected in the index; consequently use of an index limited to radiative forcing would provide distorted incentives that yield potentially undesirable results. In order to internalize these non-warming externalities, the index should be broadened to incorporate at least the salient global impacts: direct effects of CO₂ on plant productivity and water use efficiency; ozone depletion from halocarbons; and toxicity of other gases. Technical and analytic will arise in the effort to compare these multiple impacts on commensurate spectra.

-- Current Administration efforts:

-- conceptual thinking about the design of a "full impacts" index

-- Future work:

-- attempts to construct a quantified "full impacts" index

VI. **Addressing the objection that the comprehensive approach is infeasible because of "inadequate science and monitoring."**

Future work:

-- assess the time and expense needed to answer scientific questions, develop proxy measurement devices, and build monitoring capabilities to achieve a workable comprehensive approach

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-- compare the costs of acquiring this needed information to the socioeconomic and environmental costs (and foregone benefits) of adopting a piecemeal policy design for want of such information

-- develop policy and institutional designs that offer incentives for needed research (e.g., an agreement could offer opportunities to emitters to earn credit for limitation actions upon demonstration of accomplishment, thus giving emitters incentives to undertake the research needed to develop new monitoring capabilities)

-- consider intermediate approaches such as incremental or phased-in designs toward comprehensivity

VII. **Integrating prior and concurrent law and policies into a comprehensive approach.**

-- Current Administration efforts:

-- devising means to ensure that international agreement integrates (gives credit for) "no regrets" actions, other international agreements (forestry, VOCs, GHGs covered by ozone agreements), other domestic laws and initiatives

-- Future work:

-- demonstrate incentive advantages of integration

- lack of integration would yield disincentives to take actions, even "no regrets" actions
- address possible overclaiming (see "monitoring" and "verification," above)

-- demonstrate advantages for other nations under integrated design

-- demonstrate environmental advantages of integration

-- address issues of legal grafting presented by terms or design of other agreements, laws

-- consider possible offset model (e.g. defining any limitation obligations in terms of CO2 emissions, to satisfy those eager for CO2 limits, but authorize offsets for any verifiable limits on any GHG, source, or sink, thus effectively constructing a comprehensive approach)

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Incentives and Market-based Approaches:
Emissions trading, fees, and related economic instruments

I. **Emissions trading**

(A) Domestic trading

- Current Administration efforts:
 - review of past and current experience, e.g. lead phasedown, netting/bubble/offset program, CFCs trading, new acid precipitation trading scheme. Primarily EPA, DOE, CEA.
 - consider application to GHGs; consider issues of implementation, e.g. informal versus formal trading; who would trade; duration of allowances; means of distributing allowances; market power; hoarding; scope of GHGs, sectors, sources and sinks; monitoring trades; etc.
- Future work:
 - model relative cost savings under trading

(B) International trading

- Current Administration efforts:
 - present US experience and suggestions at international discussion on application to climate
- Future work:
 - extend analysis of above issues to international context, e.g. informal versus formal trading; who would trade; duration of allowances; means of distributing allowances; market power; hoarding; scope of trading among GHGs, sources, sinks, sectors, industries, geographical areas, stages of development; monitoring trades
 - in addition, consider international institutions; trade and aid implications; sovereignty issues; trading as a decentralized, market-based vehicle for resource and technology transfers⁷
 - identify opportunities for cross-national

⁷ In addition, consider the options for trading within regional associations such as OECD, EC, ASEAN. Evidently the EC and OECD are both considering association-wide policies.

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trades, and hence likely trading partners (for the US and worldwide)

-- model relative cost savings under trading

II. Economic instruments in general

-- pursue contact with OECD regarding Environment Ministerial in January and Economic Instruments Workshop in December⁸

⁸ Preparing for the OECD Workshop on Economic Instruments, December 1990, will involve considerations of forum and cosponsorship, logistics and timing, relation to other OECD meetings, relation to other international meetings, invitees, topics to address, a September experts meeting, publicity at the sundsvall IPCC Plenary in August, and US presentation(s) at the December workshop.

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THE WHITE HOUSE

WASHINGTON

September 20, 1990

MEMORANDUM FOR MEMBERS OF GLOBAL CHANGE STRATEGY TASK FORCE

FROM:

D. ALLAN BROMLEY

Auan

SUBJECT:

Article on Comprehensive Approach

Dick Stewart and Jonathan Wiener at Justice have been asked by the American Enterprise Institute to submit an article on the comprehensive, market-based approach to dealing with global climate change. The draft of their article is attached. Given the high level of attention that will undoubtedly be bestowed on the article, moving this issue more into the forefront of public debate than perhaps had previously been the case, review of the article by the members of the task force seems appropriate.

Please provide any comments you may have on the article by the close of business on Monday, September 24 to Jonathan Wiener at 514-2701, with copies to Nancy Maynard of my staff.

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4007

DRAFT, 9/19/90
Please do not cite
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Policy Design for Climate Change:
Comprehensive and Market-Based Approaches

Richard B. Stewart and Jonathan B. Wiener¹

The world community is moving toward a framework convention on climate change: the first negotiating session will be hosted by the United States in February 1990. What should be the approach of any international agreement on climate change? Many have called for immediate controls on greenhouse gas emissions. The discussion to date has been dominated by proposals to restrict carbon dioxide (CO₂) emissions, especially from sources in the energy sector of the economy. Proposals have tended to focus on rigid reduction targets with strict timetables, imposed internationally, to be met uniformly by all nations, and on technology-based standards such as "best available control technology."

Following these suggestions would amount to reinventing the square wheel. They rely on clumsy, outworn environmental policy designs -- piecemeal, command-and-control, technology-based, centrally administered, inflexible approaches that ignore relevant costs and benefits. These proposals concentrate myopically on what is deemed currently "understood" or "achievable." They fail to use incentives that will advance long-run economic and environmental goals. They hobble innovation and investment. Their piecemeal character is self-defeating, undercutting environmental progress by inducing shifts in economic activities from regulated sectors to other, unregulated sectors.

Issues for policy

Potential climate change is an issue of enormous complexity. The "greenhouse gases" -- CO₂, methane, nitrous oxide, tropospheric ozone, halocarbons like chlorofluorocarbons (CFCs), and others -- are numerous and are emitted by myriad

¹The authors are, respectively, Assistant Attorney General and Special Assistant to the Assistant Attorney General, Environment and Natural Resources Division, U.S. Department of Justice. The views expressed are their own and do not necessarily represent the views of the Department of Justice or the United States.

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different sources. Each greenhouse gas ("GHG") has a different capacity to trap heat in the atmosphere, called its "relative radiative forcing." Each also has other direct (chemical) effects on the atmosphere and on plant and animal life; for example, CO₂ enhances plant photosynthesis and water use efficiency, while CFCs deplete the stratospheric ozone layer. One GHG or another is emitted or affected by virtually every ecological and socioeconomic activity in every sector of every nation. Several of the gases are removed from the atmosphere by "sinks"; for example, CO₂ is removed in the photosynthesis carried on by trees, crops, grasses, and oceanic phytoplankton, and stored in plant material, soils, and the deep ocean. Any change in average annual global temperature would be a product of complex interactions and feedbacks among the composition of the atmosphere, cloud formation, ocean circulation, terrestrial sinks of GHGs, albedo (reflectivity), and other phenomena, and would in turn affect patterns of local temperature, precipitation, sea level, soil moisture.

The debate over policy approaches to potential climate change presents at least four basic kinds of issues:

1. To what extent and when will climate change occur? The recent First Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) collects the best evidence scientists have on this question. While it finds that anthropogenic increases in GHGs are likely to yield increases in atmospheric temperature, it concludes that major uncertainties frustrate our ability to forecast the magnitude, timing, or regional patterns of any climate change.

2. What are the costs and benefits of climate change, and of measures to limit or adapt to it? In light of these costs and benefits, what actions, if any, are warranted now? Scant analysis has explored these questions. Information on the impacts of potential climate change -- and on the costs of response measures -- is difficult to develop. A key issue on which not enough is known is finding the appropriate combination of preventive measures, to limit GHG emissions or expand GHG sinks, and adaptive measures, to anticipate and minimize adverse effects of climate change. Meanwhile, the United States is taking actions that make sense in their own right (for other environmental or economic reasons) but that also reduce GHG emissions or preserve or expand sinks. Examples include phasing out CFCs by 2000; the President's initiative to plant a billion trees annually; and the conservation incentives in the acid rain provisions of the proposed Clean Air Act.

3. If limitation efforts are warranted -- whether through actions that make sense in their own right, development of new low-emitting technologies and practices, or otherwise -- should they be confined to CO₂ emissions and limited to

- DRAFT page 3 -

particular sectors, such as energy, or should they address all GHGs, sources and sinks?

4. Should any domestic or international limitation measures employ traditional command-and-control regulations, or make use of market-based economic incentive tools?

This article focuses on the third and fourth issues identified above. It argues that a piecemeal, gas-by-gas, source-by-source, command-and-control approach is both ecologically unsound and economically imprudent. If limitations investments or measures are to be implemented -- a big "if" that can only be decided based on a more extended look at scientific uncertainties and at costs and benefits of action and inaction -- then they should take a "comprehensive" approach and use market-based economic incentives. We are addressing not "how much" action to take, if any, but "how to" implement any decision to limit GHGs.

Better approaches

Experience has shown the inadequacy of employing piecemeal command-and-control approaches in environmental policy. For example, under the old Clean Air Act, scrubbers were mandated for most utility plants, thus imposing costs on society that could have been saved by allowing the least-cost solution at each plant, discouraging investments in fuel conservation, and, ironically, reducing emissions of one gas -- sulfur dioxide -- while impairing fuel efficiency and thereby increasing emissions of another -- CO₂. Similarly, piecemeal control of residuals in different environmental media (land, air, water) have often simply shifted these residuals around, rather than encouraging a net reduction in total pollution. Comprehensive, incentive-based approaches to deal with the array of environmental problems are now deservedly finding increased favor. For example, the tradeable credits system in the Clean Air bill proposed by the Administration would apply market-based incentives to reduce sulfur emissions, and encourage energy conservation, reducing CO₂ emissions markedly while saving about \$ _____ billion annually in control costs.

The need for fresh thinking is acute in climate policy design. Given the interrelationship of climate variables and the wide range of activities that generate greenhouse gases, repeating the old mistakes in the climate arena would be seriously environmentally counterproductive and economically disruptive. Piecemeal approaches would probably move GHGs around in a conjurer's shell game, never achieving claimed reductions.

Whatever level of climate protection the international community may choose to purchase, it ought to implement its

- DRAFT page 4 -

choice according to a comprehensive approach that embraces all the greenhouse gases ("GHGs"), their sources and sinks. Even in the absence of an international agreement, a comprehensive approach provides the best basis for identifying appropriate actions that make sense on other grounds and also affect GHGs, and for targeting investments in technologies that would affect GHG emissions. From the climate perspective, the environmental variable of concern is not narrowly definable as emissions of CO₂, or carbon content of fuels, or energy efficiency. It is the net emissions (sources less sinks) of all greenhouse gases, weighted by their relative impacts on the environment. Policy designs must be as comprehensive as the ecological reality they seek to address. In climate perhaps more than anywhere else, squeezing the balloon at one end just bulges it out at another.

In addition, any climate policy should harness market incentives to achieve environmental goals, rather than using command-and-control techniques that would needlessly raise the already formidable costs of achieving substantial reductions and would stagnate vital innovation. Because the costs of different response measures will be different in different places -- for example, the cost of curtailing CO₂ emissions in a nation with brand new power plants will likely be more than the cost of the same percentage reduction in a nation with old, retirement age plants, or a nation with abundant afforestation opportunities -- it makes no sense for everyone to adopt uniformly the same specific technologies or percentage reductions. Nor does it make sense to specify and thereby entrench current techniques and discourage innovation of better new techniques.

Carboncentric thinking

Those proposing immediate GHG reductions typically focus on limits, often through adoption of specific "best available" technology, on CO₂ emissions from fossil fuel combustion. Many such proposals are made by nations who would enjoy a comparative competitive advantage under such policies -- those who rely on non-carbon or low-carbon energy sources (such as nuclear, hydropower, or natural gas) or who expect to conserve energy more cheaply than their trading rivals. But such a narrow focus is neither warranted by the factual information about greenhouse gases, nor by sound policy.

First, it is clear that the greenhouse effect is not a question of CO₂ alone. CO₂ is portrayed as the chief culprit in potential global warming because of past accumulations of CO₂ and its large volumetric abundance in current total output. But CO₂ is, molecule for molecule, the weakest of the anthropogenic greenhouse gases. Because any limitation policies must necessarily address future increments of net GHG emissions, it is the comparative impact of additional amounts of each gas that

- DRAFT page 5 -

must be addressed. Estimates of the "relative radiative forcing" of the various greenhouse gases (their ability to trap heat in the atmosphere) /Chart on GHGs' residence time, relative radiative forcing)/ show that a unit of CO₂, notwithstanding its long typical residence time in the atmosphere, is the least potent contributor to potential warming. Moreover, because there is already so much CO₂ in the atmosphere (about 80% of it due to natural emissions), the band of the electromagnetic spectrum that CO₂ molecules block is already almost fully occluded, and additional molecules of CO₂ confront the "saturation effect" -- a sort of atmospheric rule of diminishing marginal returns -- meaning that the incremental radiative forcing of the next CO₂ molecule emitted will be measurably less than that of the previous molecule and thus the current relative potencies shown in /chart above/ tend to overstate the impact of future CO₂ compared to the other GHGs. And the amount of CO₂ in the atmosphere is not growing as rapidly as that of other GHGs; the atmospheric concentration of CO₂ is growing at about 0.3% per year, while methane is growing at about 1% per year and CFCs at over 4% per year.

Meanwhile, CO₂ provides significant non-warming benefits that the other greenhouse gases do not. CO₂ is the grist of photosynthesis. Empirical studies repeatedly show that higher concentrations of CO₂ in the atmosphere substantially improve plant productivity and increase the efficiency with which plants use water. The other greenhouse gases confer no such benefits, and some pose serious non-warming threats; CFCs, for example, deplete the stratospheric ozone layer. In order to provide a sound guide to policy choices, the relative radiative forcing index shown above in chart X should be expanded to incorporate the full environmental impacts of each GHG. CO₂ would receive a credit for enriching plant growth while CFCs received a debit for ozone depletion.

The upshot is that, unit-for-unit, CO₂ is the most environmentally benign of the greenhouse gases. If society and the biosphere had to accept any given amount of predicted warming, then on purely environmental grounds and abstracting from the costs of limitation strategies, it would prefer to have as much of the warming due to CO₂ and as little due to other GHGs. CO₂ is in a sense the last gas, on environmental grounds, whose incremental additions one would want to restrict.

Of course, any extensive measures to limit net GHG emissions -- even under a comprehensive approach -- would mean some efforts to limit emissions of CO₂, the most prevalent anthropogenic GHG. But the extent of limitations on CO₂ or any other specific GHG should not be mandated by international fiat. The costs of limiting each GHG would probably vary considerably among nations, and a uniform restriction on one GHG -- such as a rule requiring a 20% reduction in CO₂ alone -- would impose undue

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costs on nations who could achieve the same net GHG result through policies or technologies affecting other gases. Accordingly, each nation should enjoy the flexibility to adopt whatever mix of policies relating to different GHGs it finds least costly and burdensome, so long as it achieves its goal in terms of net weighted GHG limitations.

Second, focus on the energy sector alone is inappropriate. Certainly the energy sector produces a large share of global anthropogenic CO₂, CO, VOCs and NO_x. But the greenhouse gases arise from a variety of sources in every sector of activity, including agriculture, where rice paddies and ruminant livestock disgorge enormous amounts of methane, and fertilized fields release nitrous oxide; forestry, where tree-cutting and soil disruption liberate about 25 to 33% of global anthropogenic CO₂; industry, which emits large amounts of CFCs, VOCs, CO, and NO_x; transportation, which yields CO, VOCs, and CFCs, in addition to CO₂; and the residential and commercial sector, which also produce VOCs and CFCs. /chart on sources & sectors/

Third, sinks deserve serious attention. It is net emissions that must be addressed. The net flux of greenhouse gases into the atmosphere is the result of both emissions from surface sources and removal by surface sinks, including ocean mixing, oceanic phytoplankton, trees, grasses, soil biota, crops, and tropospheric chemical reactions. Plants remove carbon dioxide from the atmosphere during photosynthesis; thus preserving and properly managing forests and other vegetation, or protecting phytoplankton from anthropogenic injury, can help sequester carbon released from surface sources.

The Comprehensive Approach

Any climate policy design must be "comprehensive" to match the diverse character of GHGs, their sources and sinks. Any choice of GHG-relevant actions that are justified in their own right, investment in new technologies, or design of limitations strategies, should be based on net GHG emissions, encompassing all GHGs, sources and sinks, and weighting GHGs according to an index of their comparative environmental impacts, similar to the index of relative radiative forcing in chart X above. This comprehensive design would ensure that no important GHG is ignored, while, as described above, providing incentives to limit the most environmentally damaging GHGs first rather than fixing narrow-mindedly on one gas or sector.

The comprehensive approach would also cure the bane of piecemeal approaches: unwanted shifts to unregulated activities that continue to produce environmental degradation. For example, under a CO₂-only approach, utilities would likely be encouraged

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to undertake fuel switching from coal to natural gas, because with current combustion techniques coal burning produces almost twice as much CO₂ per BTU as burning natural gas. But use of natural gas leads to methane emissions, because methane leaks from natural gas mining and transportation systems. One recent study estimates that a 3-6% rate of methane leakage from natural gas transport would fully offset all the CO₂ savings from switching from coal to natural gas. Such leakage rates are probably at the high end of the average in many advanced industrialized countries, but may be typical elsewhere. A swift expansion of natural gas transport capacity to comply with a stiff CO₂ reduction strategy could well mean use of hastily designed new facilities, or older facilities in disrepair, with leakage rates higher than today's. The net result could be greater net GHG emissions than in the absence of the CO₂ reduction effort. Even if the methane leakage rate only offset, say, 50% of the CO₂ savings, the CO₂-only policy would be severely undermined. The comprehensive approach, on the other hand, would encompass methane emissions and thereby ensure that methane leakage is included in a nation's net GHG emissions inventory and in the incentives and efforts to limit net GHG emissions.

An even more obvious inadvertent shift would attend efforts to restrict fossil fuel consumption that were applied piecemeal to one group of nations (such as OECD countries). Those nations would most likely respond by limiting imported fuels first, thus lowering prices for those fuels on world markets and raising the quantity consumed in other nations. Depending on the sensitivity of consumption to prices and the efficiency of fuel combustion in the various countries, total GHG emissions might even rise. Over the slightly longer term, unilateral or industrialized-only restrictions could induce GHG-emitting industries to move to unregulated locations. These concerns point up the need for wide international cooperation on any limitations strategies.

Each of these shifts would undercut or even cripple the effectiveness of the piecemeal policy. The experience of past piecemeal approaches indicates that it is often the unanticipated shifts -- whether from air pollutants to solid wastes, or from launcher numbers to MIRVed warheads -- that can most effectively render narrow policy thinking obsolete.

The "net emissions" aspect of the comprehensive approach would also provide significant benefits by encouraging sink expansion, through enhanced forest growth and preservation, and protection of phytoplankton habitats from pollution. In addition to limiting net GHG emissions, these activities would provide side benefits in biodiversity, oceanic food webs, reduced soil erosion, and better timber management.

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The comprehensive approach would also deliver important economic benefits. It allows each nation the flexibility to devise its own cost-effective policy mix. Because the marginal costs of abatement will vary by gas, source, sink, technique and across nations, this flexibility will enable the diverse responses needed to ensure an overall least-cost response. For example, the least-cost policy option for limiting net emissions in one nation may be switching from coal to natural gas, while for another nation it may be changing agricultural practices to reduce methane and nitrous oxide emissions, and for another it may be reducing deforestation and ensuring sustainable forest management. Put another way, reducing emissions of CO₂ from fossil fuel combustion (or stopping deforestation, or any other single tactic) might be the cheapest way to limit overall net GHG emissions in one nation, but the most expensive in another. Global costs of limiting GHGs would be significantly reduced by allowing the flexibility afforded under the comprehensive approach.

Applying the comprehensive approach

Any initial convention on climate change should promote a cooperative scientific research and reporting agenda that follows the comprehensive approach by examining all GHGs, sources and sinks. It should also provide that a future protocol (if any) containing limitations obligations must follow a comprehensive approach. The convention could even state that any actions taken after a chosen baseline date will count toward any eventual limitation obligations under a future protocol (if any), relying on a provisional index of relative GHG impacts annexed to the convention. This would assure nations that their own actions, including actions justified in their own right and steps taken pursuant to both domestic policy and other international agreements, would receive "credit" if and when limitations are agreed upon. Without such advance assurances, nations will be discouraged from taking even GHG-limiting steps justified on other grounds; they would hesitate lest the protocol negotiation refuse to give credit for such prior actions, and would hold them in abeyance pending protocol negotiations.

The major objection that has been raised to the comprehensive approach is that the current science is not up to monitoring certain sources and sinks, such as non-point sources of methane and nitrous oxide. The objectors say that we should "do what we can now" and wait until later to design a comprehensive approach. Monitoring many such emissions is not easy. But it is not beyond our reach, if we focus current research efforts to support a comprehensive approach. Moreover, experience belies the suggestion that piecemeal initiatives can eventually be transformed into a comprehensive strategy. Piecemeal measures tend to create constituencies with vested

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interests that ensure their perpetuation. For example, the overbroad Prevention of Significant Deterioration (PSD) provisions in the Clean Air Act limit industrial development in many regions of the nation, often without environmental justification. But other regions oppose efforts to relax these limits for fear that industrial and economic development will shift to regions now subject to PSD controls. Similarly, any initial global climate agreement (whether pursued through obligations to limit GHGs or to invest in new technologies) that aimed at energy sector CO2 limitations would benefit certain nations relative to others. The favored nations would resist development of a more comprehensive approach that would treat all nations with an even hand. It is accordingly vital to ensure a "level playing field" by adopting a comprehensive approach at the outset.

The pertinent question is not what is immediately "feasible," but whether the costs of proceeding with a flawed policy design are less than the costs of doing the necessary groundwork to develop and implement a comprehensive approach. One need not wait for perfection; in the interim, proxy-based estimates of difficult-to-measure emissions could be used. The framework convention or other agreement could provide incentives to develop and improve monitoring by offering credit for reductions in difficult-to-monitor GHGs upon a demonstration of the relevant monitoring techniques to an expert panel. Nations who see such reductions as to their benefit (either where the measures are justified in their own right or taken under an agreed limitation obligation) -- and entrepreneurs looking to contract with those nations -- would invest in developing the monitoring capabilities required.

Market-based incentives

The virtues of market-based economic incentives for environmental protection are increasingly well-recognized. Market-based tools include fees or taxes, tradeable allowances, and deposit-refund programs. They have demonstrated success in several important environmental applications, including the tradeable credits program used to phase out lead in gasoline -- achieved at about half the cost (amounting to hundreds of millions of dollars) of a traditional non-trading regulatory program -- and efforts to reduce litter of glass and aluminum containers. Both fees and tradeable allowances are now being used in the U.S. program to eliminate CFC use under the Montreal Protocol; and tradeable allowances have been proposed for the acid rain reduction provisions of the new Clean Air Act, with projected national savings of \$_____ billion annually as compared to a command-and-control program. We have meanwhile learned a great deal about the drawbacks of traditional regulatory approaches, in terms of their cost, obstacles to innovation and

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resource use efficiency, ecological shortsightedness, and administrative burdens. The common feature of the new tools is that they respond to market-failure -- such as pollution -- by redirecting and harnessing market forces to correct the problem. They provide powerful incentives for socially and environmentally responsible behavior. At the same time, they allow flexibility among market actors, promote decentralized decisionmaking about response tactics, further least-cost solutions by allowing those who can fix the problem most cheaply to do so first, and stimulate efficient resource use and broad-scale innovation in technologies and practices.

Market-based techniques are especially well-suited to implementing limitation measures, if any are adopted, for GHGs. Because GHG emissions arise from so many diverse and pervasive sources, the costs of abatement are bound to vary widely among emitters. Market-based mechanisms use that variation to social advantage by imposing some restraint on total emissions -- a limit on the net quantity emitted, or a fee on each unit emitted -- but then letting the market allocate the burden of mitigative measures to those who can most easily shoulder it.

In the climate context, two main economic instruments have been suggested: tradeable emissions allowances, and emissions taxes. Tradeable allowances set a total limit on net emissions, issue that sum of allowances to emitters, and let emitters trade them. Those for whom emissions reductions or sink expansions are relatively more expensive will buy allowances, while those who can achieve them cheaply will sell allowances. This gives an incentive to each emitter to develop new means of limiting emissions at less cost than its competitors, so that it can sell its allowances at a profit. Emissions controls, efficient use of fuels and other inputs, and innovation of new emissions limitations techniques become profit centers for the emitter. The market allocates abatement actions to those who do so at least cost, reducing the overall cost to society. Such a technique could be used to limit net GHG emissions through emissions trading. Domestically, governments could issue allowances for amortized net GHG emissions. Allowances would count toward net emissions of GHGs. Those issued allowances, such as electric utilities, could meet their allowance limits through energy conservation, fuel switching, reducing methane leaks from energy systems, arranging for tree planting, or arranging for reductions in other GHGs by other actors. The value of activities relating to different gases would be calculated according to an index of the comparative environmental impacts of the GHGs. Government clearinghouses, private brokers, and banks could act to facilitate trading among disparate parties and across periods of time.

International reallocations of national obligations through trades would also be advantageous. Such trades could

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consist of informal, bilateral reallocations of obligations to limit GHGs. One nation could satisfy its obligations by investing in response actions in another. For example, Nation A could provide new energy technology to Nation B, in return for all or part of the value of B's reduction in emissions. Or Nation C could plant and manage trees in D's territory while offering agricultural aid to compensate for the reduced available arable land in D. Nation E might earn the opportunity to record certain emissions reductions achieved in Nation F in return for debt forgiveness promised to F. Given significant international variations in marginal costs of limitation, such trades would likely enable the world economy to realize substantial cost savings. These arrangements would demonstrate the power of applying Adam Smith's lessons of comparative advantage to global environmental resources.

Trading could also be more formalized, with allowances issued to nations according to negotiated allocations. Allowances could be made of limited duration, or leasable, to relieve fears of hoarding or other distortions due to exercise of market power. Such trading in GHG limitations would also serve as a market-based, decentralized vehicle for introducing needed low-GHG-emitting technology into the developing world. It would point technology toward those who needed it most, and stimulate innovation by industrialized nations of technologies useful in developing nations. At the same time this framework would obviate creation of a heavily bureaucratized, centralized regulatory authority and technology assistance fund, with attendant opportunities for waste and misallocation of benefits.

Emissions taxes for net GHG emissions are another important option. The tax rate could be geared to the GHG index value of the emissions activity. Like emissions trading, emissions taxes offer a least-cost solution that promotes innovation and efficient resource use. Such a plan could make excellent sense domestically, especially where the focus is on specifying the cost of a GHG limitation program more precisely than the quantity of emissions avoided, or where revenue raising is a major goal. International application of a tax would raise many more difficult questions: Would nations cede their sovereignty to an international tax authority? How would the tax be set? How would the potentially enormous revenues raised be allotted and expended?

Conclusion.

[to add]

- DRAFT page 12 -

BOX A

List of international events

Intergovernmental Panel on Climate Change (IPCC), including its recent First Assessment Report and its structure for pursuing further research.

Conference of OECD Environment Ministers in January 1991

Second World Climate Conference in November 1990

Bergen Conference in May 1990

Washington Conference on Science and Economics Relating to Global Change in April 1990

Cairo Conference in December 1989

Noordwijk Conference in October 1989

Toronto Conference in June 1988

GLOBAL WARMING: WHAT WE KNOW

Time bomb or teapot tempest? Scientists still think the earth is heating up, though they're less sure how much or how fast. Some precautions make sense in any case. **■ by Peter Nulty**

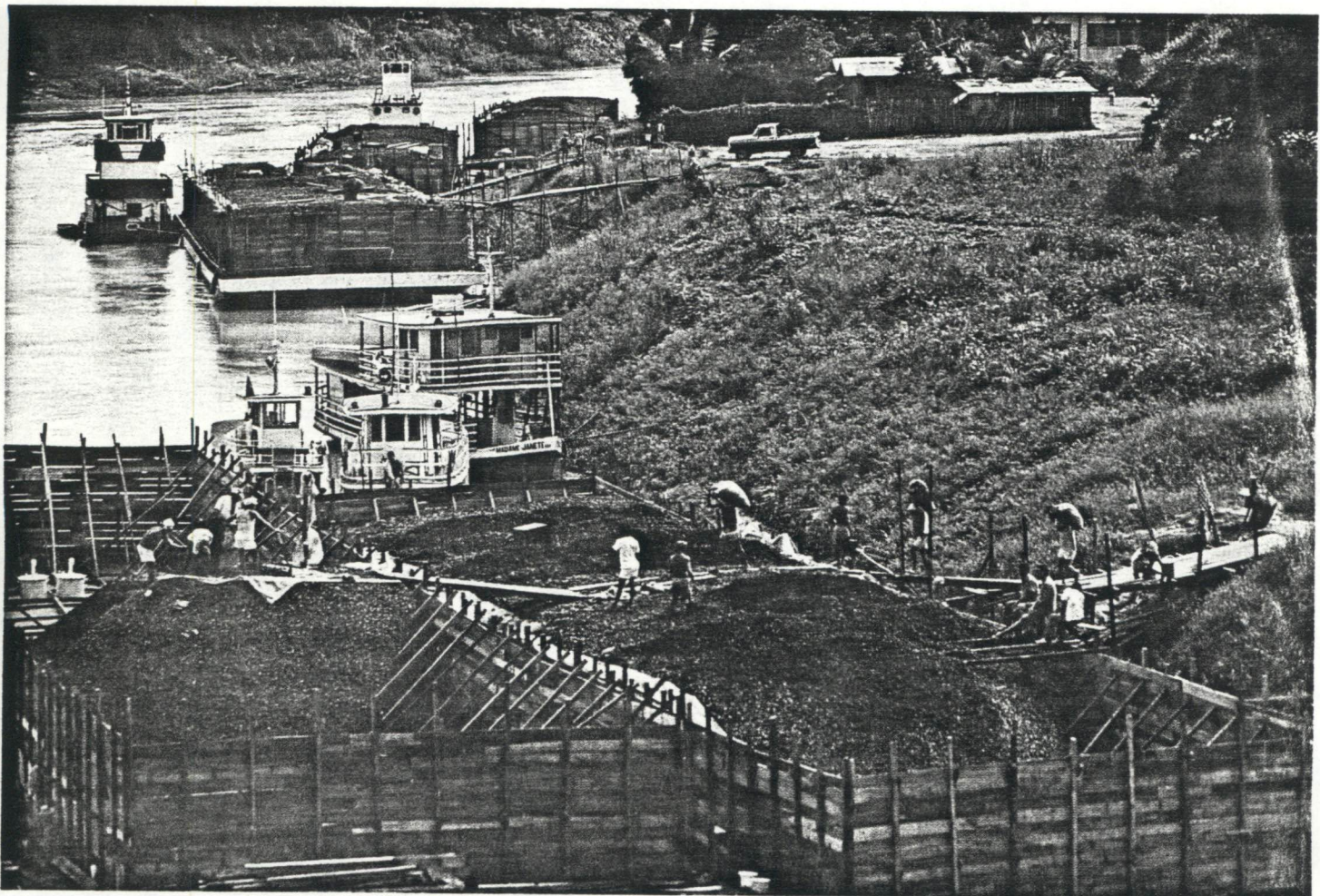
IT IS THE YEAR 2000-something. The earth is warming up because gases like carbon dioxide (CO_2), created by burning fossil fuels, are accumulating in the atmosphere. Pilot T. J. "Red" Barren is a veteran of the global campaign to reverse the buildup. He has flown over the world's oceans, dropping fertilizers to promote growth of microorganisms that consume CO_2 . He has seeded the atmosphere with aerosols, tiny particles that cause water vapor to condense

into clouds that reflect the sun's rays away from the earth.

From his home overlooking Denver, Barren sometimes tries to picture the city as it must have been decades ago, back in the 1990s. Then Denver was smoggy by day and blazed with light at night. Now it's dark at night and ablaze by day. Stiff taxes on carbon dioxide pollution have made coal-generated electricity too expensive to waste on outdoor lighting. And in the sun, the roofs of Denver are an eye-

squinting white, required by law in order to reflect the sun's rays. A dark green forest of drought-resistant loblolly pines begins at the city's outskirts and stretches eastward almost unbroken across the once Great Plains to the Mississippi. When ranchers started going bust in the heat, the whole country went nuts planting trees to soak up the excess CO_2 .

Could this really happen? Two years ago, when the Midwest was parched by drought



Ben & Jerry's ice cream uses Brazil nuts like these from Rio Branco to show that saving forests is worthwhile economically as well as environmentally.

and Yellowstone Park was in flames, the scientists answered with a resounding yes. Some even warned that a global warming has begun that will bring catastrophe in the 21st century, destroying agriculture and flooding coastal lowlands like Florida and Bangladesh. Since then, however, further research strongly suggests that natural phenomena



Weyerhaeuser tests drought-resistant loblolly pine trees that could help slow global warming.

like clouds and ocean currents may mitigate the greenhouse effect. So while most experts still believe in their guts that the globe will warm up, they are now less certain that disaster will result. Nearly everyone is worried, but not as worried as two years ago.

The critical questions are how much the earth will warm, and how fast. Right now forecasts for global warming are little more than hunches based on skimpy evidence from a very young branch of science. Computer models estimate that the mean global temperature will rise between 1.8° and 10° Fahrenheit sometime in the next 50 to 100 years—a very broad range of possibilities. A 2° increase in 100 years might be manageable, while 9° over 50 years could raise sea levels and burn out croplands at a disastrous clip. Resolving the debate among climatologists will take a while.

Yet if the uncertainties are great, so are the consequences of misjudgment. Reducing the gases that promote the greenhouse effect could cost trillions—wasted money if the globe isn't warming much after all. But if nobody does anything and the world heats up rapidly, the damage could be incalculable and irreversible. Fortunately, business, government, and citizens *can* do much to help, including conserving energy and planting a billion trees a year as President Bush has proposed. Most of the ideas make sense whether global warming gets worse or not.

Here's what scientists know, what they

don't know, and what can be done until they solve the riddle:

The facts about global warming are sparse but compelling. Certain gases in the atmosphere, principally water vapor and CO₂, trap heat radiating from the earth's surface. If they did not, the earth's average temperature would be roughly 0° instead of just over 59°, and everything would be frozen solid. Human activity creates greenhouse gases that include CO₂ (mainly from combustion), methane (from crops and livestock), and chlorofluorocarbons, or CFCs (from aerosol spray cans, air conditioners, and refrigerators).

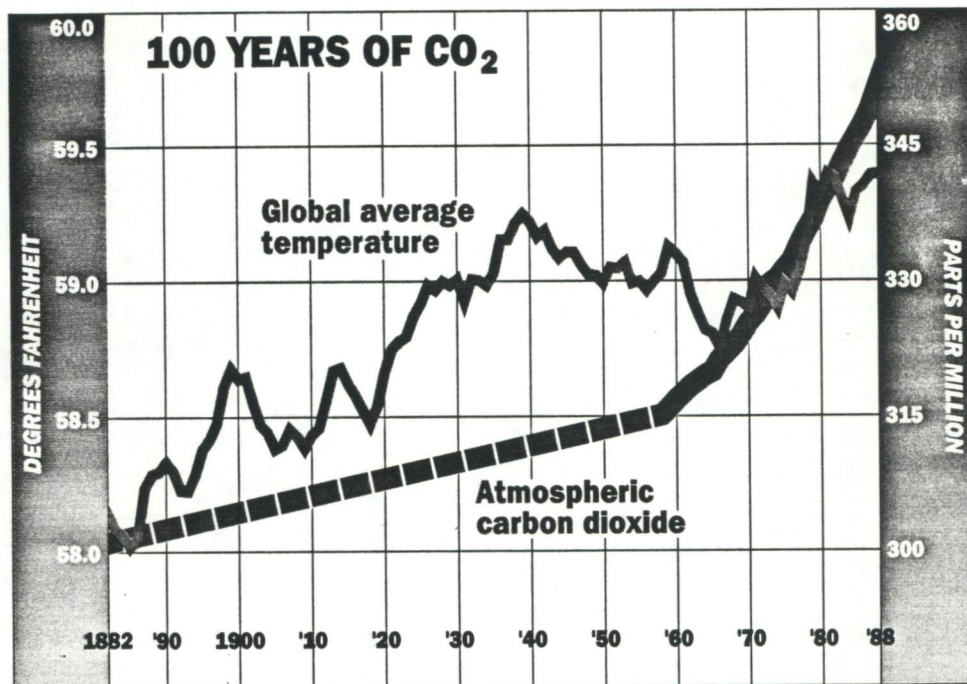
Unquestionably the greenhouse gases mankind is spewing forth are accumulating in the atmosphere. Regular measurements of CO₂ taken since the 1950s, for instance, show that concentrations have increased at the rate of about 0.5% per year. James Hansen, a leading expert with NASA's Goddard Institute for Space Studies, estimates that the CO₂ added to the atmosphere since the Industrial Revolution got rolling about 1800 has the heating power of roughly one watt—equal to a single tiny Christmas tree bulb—per square meter of the earth's surface. That may not sound like much, but it doesn't take a lot to alter the world as we know it. The global mean temperature at the height of the last ice age 18,000 years

ago was 51°, just 8° cooler than today.

Add to these facts three pieces of circumstantial evidence and it becomes clear why alarms are sounding: Laboratory analysis of glacial ice as much as 160,000 years old indicates that global temperature and CO₂ levels in the atmosphere do in fact rise and fall *together*. Temperature readings that are not necessarily reliable suggest that the globe has warmed about 1° in the past 100 years (see chart). And the decade of the 1980s was the warmest in this century.

SOME OF the unanswered questions are most intriguing. Global climate is the product of interactions among many elements. The largest single factor is the oceans, which have 1,000 times more capacity to store heat than the atmosphere. But climate is also affected by land masses, the biosphere (living things), the atmosphere, clouds, glaciers, the sun, the tilt of the earth, and more. The computer programs that predict global warming are mainly simulations of the atmosphere called general circulation models. So far they take little account of how the atmosphere is cooled or warmed by the oceans, clouds, and other factors.

Then consider the Case of the Missing CO₂. The finite quantity of carbon on earth is recycled through the atmosphere, water,



Some scientists fear that the century-long rise in global temperatures, shown here as a five-year running average, results partly from carbon dioxide produced by burning fossil fuels like coal and oil. Skeptics point out, however, that most of the temperature rise came before CO₂ levels started moving up sharply and that the average temperature worldwide actually fell between 1940 and the mid-1960s.

and living things. Plants, for instance, take carbon dioxide from the atmosphere, break it apart, give off the oxygen, and use the carbon to build new cells and grow. When plants die and decay, CO₂ is formed and passes into the air or water. Fossil fuels like coal and oil constitute a huge store of carbon that was taken out of the cycle millions of years ago when the vegetation that created them became trapped in the earth.

Man is putting that carbon back into circulation by burning fossil fuels. Using a rough estimate of how much fossil fuel the modern world has consumed, scientists have calculated how much CO₂ has been released into the atmosphere by the process. But when they analyze the atmosphere, they find only half the predicted amount.

At a recent hearing held by the National Academy of Sciences' policy committee, James Hansen was asked where the carbon went. "We're not really sure," he replied. "There must be a carbon sink somewhere. Maybe it's the northern forest." Translation: Something big is absorbing carbon—maybe all those trees in Canada and Scandinavia and the U.S.S.R. But for forests to soak up half the CO₂ produced, the trees would have to be either bigger or more numerous than they were before the Industrial Revolution. A spokesman for the American Forestry Association says no evidence indicates that has happened. Maybe the mysterious sink is something in the oceans, which contain 55 times as much carbon as the atmosphere and 20 times more than plants.

Nor were the experts able to tell the NAS hearing what causes CO₂ levels to rise and fall with temperature through time, as evidenced by those samples of glacial ice. Clearly some natural force or forces can move CO₂ levels up and down independently of man. No one knows what they are—or what they are up to right now.

ANOTHER MYSTERY: the so-called feedbacks, reactions to global warming that will either speed it up or slow it down. An atmosphere richer in CO₂, a natural fertilizer, could make plants grow larger. Will we have basketball-size tomatoes, or just weeds as big as telephone poles? How much carbon will super plants soak up? Or take clouds, a potentially bigger factor. In a warmer world, more water will evaporate and the weather could become cloudier. More clouds could reflect more sunlight. But they will also trap more heat from the earth's surface because

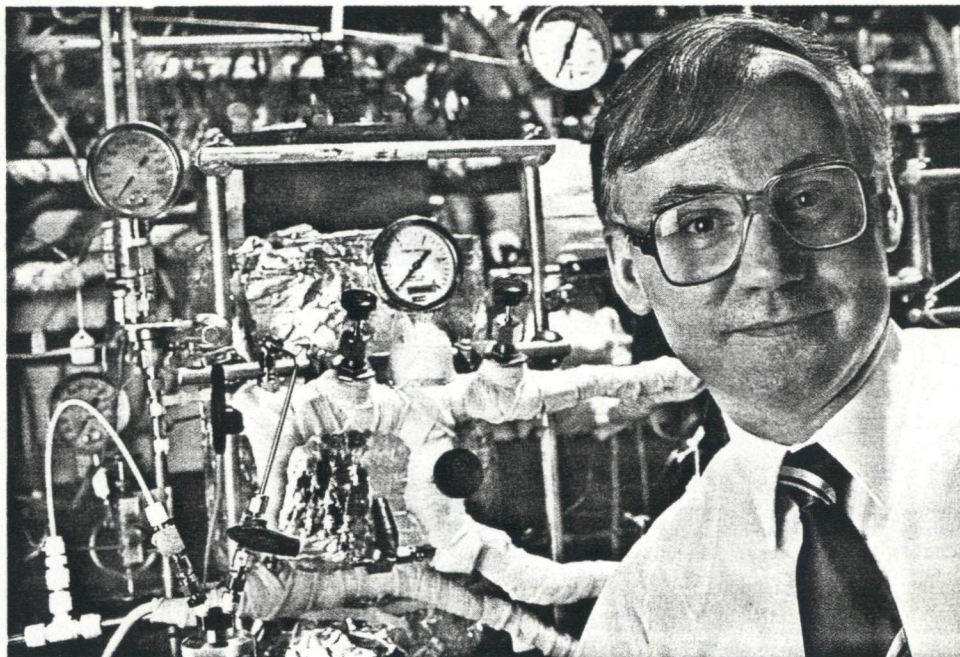
REPORTER ASSOCIATE *Alicia Hills Moore*

they are made of water vapor, another greenhouse gas. Will more clouds have a net warming or a net cooling effect?

One fascinating aspect of the cloud question: Scientists have discovered that sulfur dioxide, a pollutant from smokestacks that is blamed for acid rain, also causes clouds to form. That might explain why many industrial regions of Earth have not warmed up as much in the past century as the computer climate models say they should have. And it raises the possibility that if the U.S. scrubs sulfur from smokestack emissions, the air will be not only cleaner but hotter as well.

alarmists can be hard to tell from the skeptics. Lindzen says his hunch is that the globe will warm between 1° and 2° in the next century. One of his chief antagonists, Stephen Schneider of the National Center for Atmospheric Research in Boulder, Colorado, says he's 90% sure of at least that much warming. NASA's Hansen, who stunned Congress in 1988 by suggesting that global warming had begun, says he is more optimistic today that the worst-case scenario won't come to pass. Still, he adds, "We could be building a time bomb for ourselves."

What then should be done? The Congress-



CHARLIE ARCHAMBAULT

Chemists like Du Pont's Leo Manzer seek out substitutes for CFCs, which add to the greenhouse effect.

Says Ned Ostenso, an assistant administrator of the National Oceanic and Atmospheric Administration: "Our knowledge of the global system is still pretty rudimentary, but we're learning that it's made up of wheels within wheels within wheels."

No one knows how these feedbacks will add up, and that has led to some sharp exchanges between the alarmists and the skeptics among climatologists. One prominent skeptic, Richard Lindzen, a professor of meteorology at MIT, recently suggested that in certain climes global warming might decrease the amount of water vapor in the upper atmosphere, which would have a cooling effect. Alarmists scoff at Lindzen's suggestion, arguing that water vapor will increase in the lower atmosphere—with the opposite result.

With uncertainties like these, it is perhaps not surprising that sometimes the

sional Budget Office is studying "carbon charges," excise taxes that would penalize the use of carbon-rich fuels like coal. The less carbon in the fuel, the lighter the tax. The CBO estimates that the charges needed just to keep the CO₂ emission rate where it is would come to \$17 for a ton of coal, which now costs \$30, and 8.6 cents per gallon of gasoline. A study by the Electric Power Research Institute, an industry R&D organization, estimates that after discounting to present value, the cost to the U.S. economy of cutting CO₂ emissions 20% would be \$800 billion to \$3.6 trillion over the next century. The lower estimate assumes growing use of clean energy at a price competitive with coal. Such a technology exists: nuclear power.

With so much at stake, the Bush Administration is wisely seeking international participation in any plan to roll back CO₂

YOUR PALATE MAY HAVE ADJUSTED
TO AN AGE OF DIET SODA AND LIGHT BEER.
BUT WHAT ABOUT YOUR SOUL?


emissions. The expense of unilateral reductions would put the U.S. at a disadvantage in world markets while its industrialized competitors and the Third World increase emissions in pursuit of economic development. Besides, one country acting alone wouldn't have much effect. The U.S. is participating in an intergovernmental panel on climate control that will issue a scientific report in the fall on the dangers of global warming. Members, including Western European powers, Japan, and the Soviet Union, will try to get together on solutions. The model is the Montreal protocol of 1988, in which 30 nations agreed to phase out CFCs.

Roger Sedjo of Resources for the Future, a research center in Washington, D.C., estimates that planting 1.1 billion acres of new forest, roughly equivalent to the area of the contiguous states west of the Mississippi, would soak up all 2.9 billion tons of carbon that gets added to the atmosphere each year. Says Sedjo: "We are talking big numbers, increasing the world's forests by some 16% at a cost of maybe \$500 billion. But if this is an emergency and it's paid for out of a global checkbook, it can be done."

BUSINESS CAN DO a number of things that make sense in their own right and also help limit global warming. Pacific Gas & Electric is building a \$10 million research center to look for ways to save energy in lighting. Du Pont, among others, is at work on substitutes for CFCs, which deplete the ozone layer. Weyerhaeuser is developing loblolly pines that get by with little water. Trees also help conserve energy: Lawrence Berkeley Laboratories and the American Forestry Association estimate that the shade produced by 100 million trees planted in empty spaces in suburban and commercial neighborhoods around the country could save \$4 billion a year in air conditioning bills.

One creative new product comes from Ben & Jerry's Homemade Inc. The Vermont gourmet ice cream maker is mixing a new flavor called Rain Forest Crunch that contains Brazil nuts harvested from the wilds of the Amazon jungle. Since carbon dioxide entering the atmosphere as a result of deforestation accounts for roughly 20% of the worldwide annual buildup of CO₂, Ben & Jerry's figures that creating demand for nuts might save the trees from the settler's ax—and help curb global warming.

Think of the salve to your conscience next time you happen on some Rain Forest Crunch. Eat all you want: Save a tree. **F**



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U.S. Department of Justice
Land and Natural Resources Division

Office of the Assistant Attorney General

Washington, D.C. 20530

June 4, 1990

MEMORANDUM

TO: D. Allan Bromley
Assistant to the President
for Science & Technology

CC: C. Boyden Gray
Counsel to the President

Stephen I. Danzansky
Deputy Assistant to the President
Director of Cabinet Affairs

Robert E. Grady
Associate Director for Natural Resources,
Energy and Science

Theresa Gorman
Associate Director for Environment, Energy
and Natural Resources Policy

FROM: Dick Stewart *DS*
Assistant Attorney General

SUBJECT: Work of the Task Force to Further Develop the
"Comprehensive" and "Trading" Approaches to Possible
Climate Change Agreements

This memorandum summarizes our work over the past three weeks in gearing up the Task Force on the Comprehensive and Emissions Trading and recommends several further initiatives.

The first meeting was held on May 16, and attended by DOE, EPA, NOAA, OSTP, State, USDA, USTR, and the White House Counsel's office. We distributed in advance a list of issues to be considered by the Task Force (attached). The attendees agreed with the mission of the Task Force and developed a work plan outline employing three subgroups, to address the practical workings of:

(1) the comparative index of the environmental impacts of greenhouse gases (including both warming and non-warming impacts, and using discounting or time horizons to account for the time value of investments in mitigation),

(2) measuring and monitoring net (both source and sink) emissions of greenhouse gases (seeking to identify and fill knowledge gaps regarding, e.g., sinks for CO₂ and sources of CH₄ and N₂O), and

(3) emissions trading.

(The attached list of issues elaborates on each of these elements.) During the next two weeks, we held preliminary meetings to set up the three subgroup activities planned on May 16. Our next anticipated meeting will be held on June 19 or 20, at which relevant U.S. government experts will present the state of knowledge on the first area, the index.¹

Meanwhile, several related activities have been ongoing, including:

- o Boyden Gray has organized an informal group from several agencies to assess what percentage reductions in greenhouse gas emissions will be obtained by current Administration policies. This effort will be an excellent heuristic for full development of the comprehensive approach. It relies heavily upon, and demonstrates the operation of, the index of gases' comparative impacts. It also suggests the areas in which our ability to monitor and predict future emissions is weak. The numbers developed to date are tentative and could profit from several elaborations, including assessments of additional policies not yet included in the calculations, e.g. reductions in agricultural subsidies; calculations of these numbers for selected other nations; and attention to the use of discount rates.
- o DOE is pursuing climate policy issues under the National Energy Strategy. Our Task Force will work closely with the DOE NES staff.
- o EPA's draft Incentives Task Force report has devoted some attention to the emissions trading approach.
- o The Committee on Earth & Environmental Sciences (CEES) Working Group on Mitigation and Adaptation Research Strategies (MARS), under the direction of John Knauss,

¹The scheduling of these meetings has been hampered by related meetings occurring abroad during May and June. For example, next week I and others will attend the IPCC Response Strategies Working Group meeting in Geneva, and at the end of June the parties to the Montreal Protocol will meet.

is preparing the federal research strategy for responses to potential global climate change.

Dr. Knauss has stated that the top priority of the MARS group should be generating the research needed to support the comprehensive approach: the measurement and monitoring of all greenhouse gases, and the comparative index. Along these lines, the MARS subgroup on mitigation is addressing emissions of several (though not all) greenhouse gases in several sectors.

Despite our urging and Dr. Knauss' statement, the index does not seem to be receiving attention. Some members of the MARS group have said that the index ought to be developed by the CEES Working Group on Global Change (GC), a more purely science-oriented group, but that group does not appear to be doing so. We believe for several reasons that the MARS group is the appropriate setting for this work,² and we urge you to indicate to Dr. Knauss that you agree with his and our view and that you believe the MARS group should, working with our Task Force as we develop the design and policy rationale for the index, include the index as a top-level priority in its research plan.

²First, the development of the index is essential to the success of the comprehensive approach. Second, Dr. Knauss has stated his support for the endeavor. Third, the index is a basic policy tool for use in designing or assessing mitigation strategies. Although it is founded on sciences, it will require policy analysis judgments at several stages; for example, the choice of discount rates, and the rationale relied upon for that choice, is a policy judgment, not a pure science judgment. Similarly, the integration of warming impacts and non-warming impacts of gases in the index will require careful policy choices. Fourth, the translation of the index from our work to the international arena may be more effective if the MARS, or both the MARS and the GC, rather than the GC alone, undertakes these efforts. In the international arena, the index has been developed in the Science Working Group of the IPCC. But that Group's index makes uncertain choices on discount rates, and omits non-warming impacts. In order for us to improve that index, it will be helpful to argue that the next stage of work on the index should occur in the Response Strategies Working Group, which can assemble the multidisciplinary team needed to perform this task (and which the U.S. chairs). In making that argument it will be very helpful if our work within the U.S. government has been parceled out in like fashion to the our Task Force and the MARS group.

In order to advance the comprehensive and emissions trading groups further, we hope to:

- expand the group of agencies giving input to our three subgroups. For example, our work on the index will involve EPA, DOE, NOAA, NASA, and others, and we hope to establish a firmer bridge to the CEES-MARS.
- meet informally during the next week with those of our group who will be in Geneva for the RSWG plenary session.
- schedule a meeting on the elements of an index, and possibly also on measuring and monitoring emissions, for June 19 or June 20, at DOJ. The meeting will include presentations by experts from NOAA, EPA, DOE, USDA, and possibly others as well.
- based in part on the meeting just mentioned, develop a model of the benefits and costs -- both economic and environmental -- of using the comprehensive approach. We will also develop an assessment of the additional work needed to bring the comprehensive approach to fruition, and the time and resources needed for that effort.
- develop in greater detail the issues involved in implementing emissions trading. We will work with CEA, Commerce, DOE, DOI, EPA, USDA, USTR, State, and others to develop a draft design for international trading and a draft design for domestic trading. We will also work towards an economic model that estimates the benefits and costs of allowing trading in each context.
- discuss these approaches informally with interested research institutions outside the government. It would be useful to be able to arrange and fund contract studies of these approaches by independent think tanks in the near future.
- present papers, seminars and discussions on these approaches for audiences including, as appropriate: relevant U.S. government personnel (including posts abroad), the DPC Climate Strategy Group, the President's Council of Advisors on Science and Technology and nongovernmental organizations likely to be helpful, and appropriate international seminars through the IPCC and OECD.

We should publish articles, perhaps ranging from fully footnoted tracts in academic journals to op-eds

in newspapers, that explain our approaches. We have also been invited to put our papers on the World Press Centre's non-advocacy worldwide electronic information service.

The key to advancing our approaches may well be educating audiences to their desirability and generating vigorous discussion among thinking observers. I suggest that we pursue as many of these avenues as we can.



U.S. Department of Justice
Land and Natural Resources Division

Office of the Assistant Attorney General

Washington, D.C. 20530

May 14, 1990

MEMORANDUM

TO: Terry Davies, EPA/OPPE
Gary Evans, USDA
Bob Reinstein, USTR
Dick Schmalensee, CEA
Dick Smith, State/OES
J.R. Spradley, DOC/NOAA
Linda Stuntz, DOE/OPPA

CC: Theresa Gorman, OPD
Jeff Holmstead, WH Counsel
Nancy Maynard, OSTP

FROM: Dick Stewart *DS/stw*
Assistant Attorney General

SUBJECT: Issues to be Considered by the Task Force on the
"Comprehensive" and "Trading" Approaches to Possible
Climate Change Agreements

For your consideration, attached please find a draft list of issues that the task force might explore. There may be other issues and sub-issues that need to be considered as well, and I look forward to hearing your views on Wednesday, May 16.

COMPREHENSIVE/EMISSIONS TRADING TASK FORCE

Draft List of Issues 5/14/90

Issues to be developed in further detail by the task force might include:

I. "Comprehensive" approach:

1. Gaps and difficulties in measuring sources and sinks of greenhouse gases. For some, measurement information is available, e.g. fossil fuel combustion emissions of CO₂, while for others, measurement information is currently highly uncertain, e.g. certain emissions of CH₄. What would be needed to overcome these gaps and difficulties, and how long would it take?

2. Related difficulties in developing the capacity to monitor net emissions of greenhouse gases. Issues include monitoring nonpoint sources and sinks such as agricultural fields, forests, and plankton; monitoring and verifying changes in total abundance of sources and sinks; monitoring and verifying changes in source output rates and sink uptake rates; development of reliable and more easily monitorable proxies or surrogates for actual source output and sink uptake; burdens of proof in demonstrating new net emissions rates and new monitoring methods; economic incentives to develop improved monitoring methods.

3. Developing institutions for monitoring and compliance assurance.

4. Developing a comparative parameter or "index" of the environmental impacts of the various gases. Issues include defining the lifetimes of certain gases, relating the index function to ambient concentrations of gases (the "saturation" or "window" question), use and choice of discount rates, incorporating non-warming impacts of gases, mapping the index function over time, and relating the index to net emissions from different sources and sinks.

5. If a comprehensive approach is not immediately feasible for all relevant gases, sources and sinks, an agreement might target first those for which it is feasible, and then phase in additional gases, sources, and sinks as the science and data improve. The initial agreement or set of agreements should not preclude a comprehensive approach; should promote attention to all gases, sources and sinks; should promote relevant scientific research; and could provide incentives for development of a

comprehensive approach, e.g. by rewarding those who demonstrate the capacity to monitor (or even limit) net emissions of various gases, including gases not covered in the original agreement.

6. Relationship between a comprehensive approach and agreements that deal with particular gases, sources, and sinks, such as the Montreal Protocol on Substances that Deplete the Ozone Layer, the sulphur and nitrogen protocols and the upcoming volatile organic compounds (VOCs) protocol to the Long-Range Transboundary Air Pollution (LRTAP) convention, and a possible agreement on forests. The comprehensive approach can remain consistent with these other specific agreements if it provides additional incentives to reduce the deleterious activities addressed by those agreements, but does not allow nations to escape their obligations under those agreements.¹ Categorically excluding the subjects of these other agreements from the climate agreement would forfeit the chance to add incentives for additional reductions in the deleterious activities.

7. Initial allocations. How might they differ under the comprehensive and gas-by-gas approaches? Issues in setting baselines.

¹Take, for example, the case of CFCs and halons, which are both ozone-depleting substances regulated under the Montreal Protocol and greenhouse gases likely to be regulated in a comprehensive approach. Under the comprehensive approach, nations would be free to vary their mix of reductions of CO₂ and CFCs/halons, except that CFC/halon reductions must still be at least as deep and as rapid as those called for in the Montreal Protocol and its progeny (i.e. London June 1990). In other words, only additional reductions in CFCs/halons beyond or faster than the reductions called for under the Montreal Protocol (likely to be a phaseout by 2000) could serve to offset CO₂ reductions, thereby enabling the nation to forego some reductions in CO₂; extra reductions in CO₂ could not allow a nation to reduce CFCs/halons less strictly or less rapidly than it is required to accomplish under the Montreal Protocol.

At the same time, the question of the baseline to be used for the greenhouse gas agreement would remain open: the agreement could give nations credit for all reductions in CFCs and halons after a certain date or level, or only for reductions that go beyond their Montreal Protocol obligations. The choice of the baseline for computation would not lift the legal obligation to comply with the Montreal Protocol. On the other hand, using a baseline that accounts for only reductions in CFCs and halons beyond those mandated under the Montreal Protocol could give nations a prospective incentive to slow down the negotiations of more stringent reduction schedules under the Montreal Protocol, whereas a baseline counting all reductions in CFCs and halons would not.

8. Defining the terms of agreement and the terms for admission to an initial or subsequent agreement. These could differ for different nations or categories of nations, and could include research commitments as well as emissions limitation commitments.

9. Documenting the advantages to the comprehensive approach: avoids ignoring important gases, offers flexibility to different economic, institutional and social circumstances, enhances sink development.

II. "Emissions trading" approach:

A. National (Domestic) Trading

1. Informal vs. formal trading: considerations may differ depending on whether joint arrangements are permissible subject to governmental oversight (informal trading) or whether an allowance/permit system is created (formal trading). That is, informal trading can occur through ad hoc mutual reallocations of emissions by two or more parties to meet their aggregate obligations. Formal trading involves the inventory, registration, or issuance of some kind of permits or allowances, with subsequent trading to be denominated in these permits or allowances. Variations and permutations of these approaches can also be devised.

2. Identifying which gases, sources and sinks could feasibly be included in a trading system.

3. Identifying who would trade, and to whom emissions and emissions reductions are assigned. For example, emissions attributable to electricity use (and attendant tradeable allowances) could be assigned to utilities, appliance manufacturers, end users (businesses, farms & households), or some combination. Similarly, emissions attributable to gasoline combustion (and attendant tradeable allowances) could be assigned to oil extraction companies, oil refiners, automobile manufacturers, automobile owners, or some combination.

4. Consideration given in return for emissions allowances, including financial and technology assistance that may flow to allowance sellers. Important distributional impacts may concern national policymakers, as they have in the debates about the Clean Air Act here.

5. Facilitating trades. National and subnational governmental bodies could act as information clearinghouses, allowance/permit banks, brokers, auctioneers, and so forth. Private entities might also take on these roles.

6. Monitoring trading. Emissions would have to be monitored under any agreement, but trading would require some oversight of the trades. Depending on who does the trading, monitoring could be designed in different ways. National or subnational governmental bodies could perform this role, perhaps hiring private contractors. Monitoring could consist of spot checks, on site verification (e.g. of sinks), reporting or registration requirements, designated times and places for trading, or other arrangements. Administrative costs and financing of such institutions need to be considered.

7. Nature and duration of allowance/permit rights. Trading could involve, sales, leases, or other arrangements. Allowances could expire or diminish in face value over time. Sophisticated markets for trade currency might arise (as well as black markets if conditions limit the transferability of allowances), including futures and options markets. The tax status of allowance transactions could also be important. These arrangements can be structured to address concerns about "hoarding" and market-cornering by wealthy parties (see below).

8. Dealing with moral concerns about trading, such as the "license to pollute" issue and the notion that extra reductions should "go to benefit society." Comparison to regulation and emissions taxes.

9. Dealing with economic concerns about trading. Concerns may include: "hoarding" of tradeable rights; fears that wealthy parties would buy up all of the poorer parties' rights; monopsony and monopoly problems; hindrances to trading related to inadequate awareness of other market participants; problems of transferring allowances across industry lines and along vertical market lines.

10. Possible environmental concerns. Trading in greenhouse gases generally has no "hotspot" problem because the gases mix globally in the atmosphere. But there may be spatial distribution issues regarding, e.g., the residence time of short-lived gases such as CH₄, and the toxicity of gases such as CO and tropospheric O₃. These issues may be too detailed and insufficiently significant to address at this time.

11. Initial and subsequent allocation of allowances: how would it differ if trading is available or not. Would the option of trading ease or exacerbate "gaming" of the initial allocation? What would the length of rights be? What flexibility should government have to modify the total stock? Would government derive revenue by auctioning rights off, taxing them, or other means?

12. Use of empirical experience with trading to deal with these issues. Also, what trading has occurred under the Montreal Protocol?

13. Documenting and predicting the advantages to trading: allocative efficiency (possibly start with an explanation of the ordinary gains from trade), incentives to reduce emissions, dynamic efficiency and innovation, incentives to use resources efficiently, incentives for sink enhancement, more affordable pollution control, equity.

14. Relationship to other laws, e.g. laws pertaining to clean air, energy production, forestry, and agriculture. Relationship of national law to subnational governmental law, e.g. federalism concerns, the ability of states to impose requirements that affect trading, preemption of state law.

B. International Trading

In addition to the elements listed above under national trading, the following issues may be relevant:

1. Informal or formal trading. As with national trading, international trading could initially occur "informally" through ad hoc bilateral or regional governmental treaties. Or more formal trading systems could be created, involving the issuance of allowances or permits in which trades are to be denominated.

2. Identifying who would trade. International trading could be undertaken, on a bilateral, multilateral or regional basis, by national governments. Yet private enterprises may be better situated to identify and make productive trades. Trades by private enterprises could be subject to clearance or monitoring by national governments. A mixed system of trading by both governments and enterprises could also be created.

Nations with different economic systems may find trading to be best conducted by different actors. For example, fully centrally planned economies may not find trading by "private" entities to be appropriate. At the extreme, must a nation have a domestic trading program in operation in order to participate effectively in international trading?

3. International institutions to monitor trading. The questions concerning who would trade have important implications for how trading would be monitored, and for the degree of formality and comprehensiveness of the international institutions monitoring trades. Unrestricted private trading, for example, could require a more elaborate international clearinghouse and monitoring apparatus than might a system limited to trading by national governments. Private trading could also (or alternatively) be monitored by national governments. Trading by national governments would presumably be monitored by an international body. Monitoring could vary from simple reporting requirements to prior approval requirements; procedures could be routine or elaborate. International monitoring mechanisms such as inspections and audits might also raise concerns about sovereignty.

4. Scope of trades. Trading could occur among any interested parties within a global "bubble," or it could be conducted under regional "bubbles." The scope chosen could vary depending on the gas, sources and sinks in question.

5. Consideration for trades and related trade and development issues. Trading of net greenhouse gas emissions would create a new medium of exchange, with associated flows of capital and technology. Trading could be a vehicle for resource transfers to developing nations. If developing nations have lower reduction costs than developed nations, perhaps owing to their ability to shift directly to non-fossil fuel energy sources and their abundant afforestation opportunities, developing nations could earn resources by selling excess allowances. (The same could be true of other low-cost reducers, such as planned economies about to turn over their capital stock, and nations that develop useful innovations.) Some argue that this mechanism poses the risk of undue economic leverage for developing nations, and that it will influence the gaming of initial allocations. Others see this mechanism as a decentralized, market-based alternative to resource flows dictated by international organizations, central international assistance funds, and preferential terms for technology transfer demanded by developing nations. This raises important issues regarding international aid and trade regimes. There may also be important issues regarding international trade regimes, e.g. international energy markets, GATT, efforts by national governments to distort international trade in allowances or to protect domestic allowance holders, and others; and regarding international aid regimes, e.g. alternatives to central aid funds, and the calculation and ownership of the net emissions impacts of ongoing aid-funded projects.

6. Facilitating trades. International organizations and national governments could serve as information clearinghouses, brokers, bankers, auctioneers, and so forth. In some national economies and in the world economy, private entities might also assume these roles.

7. Dealing with moral, environmental and economic concerns. The usual concerns raised by trading may be influenced, in an international context, by the variety of cultures and stages of development of different nations. Some nations have expressed the view that trading is a "license to pollute" and therefore immoral. Experience with some debt-for nature swaps (esp. Bolivia) suggests that trades for sink resources may raise concerns about sovereignty and local opposition to outright sales of sink development rights to other nations. Some nations unfamiliar with trading may express the view that it is simply a means to allow illicit emissions. There are also sharp concerns that developed nations would "buy up" all the allowances held by developing nations. One means for

addressing these concerns would be to make allowances leasable for a term of years rather than fully alienable.

8. Initial allocation of allowances: how will it be set? How will the opportunity to trade affect the allocation-setting process? Will it tend to ease or exacerbate "gaming"? What scope would there be for varying the basis of allocation across nations? What flexibility would there be for subsequently modifying the stock of rights? The opportunity for modifications in the allocation of rights among nations (as opposed to the total stock) could discourage trading, because nations anticipating the allocations to be renegotiated might fear that selling some of their allowances would demonstrate that their initial allocations were "too high" and should be reduced.

9. Use of empirical experience with international trading to support discussion. Trading in goods, services, currencies, debt-for-nature, under the Montreal Protocol, etc.

10. Documenting and predicting the advantages to international trading. The advantages mentioned under national trading must be considered in the international context.

11. Relationship to other international law and international institutions.

III. Common issues:

1. What would be the likely environmental and economic benefits for the U.S. and the world of employing (a) the comprehensive approach, (b) the trading approach, or (c) both? A preliminary calculation could be undertaken to confirm that these are likely to be desirable approaches. Then a more in-depth study could be pursued, perhaps through an independent think tank.

2. Although the benefits from these approaches are probably greatest when they are universally adopted, universal adoption is not absolutely necessary. For example, if full adoption of the comprehensive and emissions trading approaches is not forthcoming, an international target could be written in terms of "net CO2 equivalent emissions," and then could allow emitters to demonstrate compliance however they wished -- reducing other gases, enhancing sinks, purchasing extra reductions abroad, innovating CO2 scrubbers, etc. -- so long as the emitter demonstrated the efficacy of its chosen approach. This would authorize both the comprehensive and emissions trading approaches, but put the burden of proof on -- and gives incentives to -- the emitter to demonstrate the alternative approaches. Emitters would be influenced by the forum and the process chosen for deciding whether an emitter has satisfactorily demonstrated the efficacy of its approach.

IV. Possible subgroup tasks:

1. Collect current information on measuring sources and sinks of greenhouse gases; identify next steps needed to measure and to monitor net emissions; estimate the costs (in time and money) of achieving needed capabilities.

2. Design a comparative index of environmental impacts of greenhouse gases, including warming and non-warming impacts.

3. Begin work on a model of greenhouse gas limits, for the United States and selected other national (domestic) applications, which apply only to CO₂, or to several gases. Assess economic and environmental results.

4. Begin work on models of trading: (a) Model of greenhouse gas limits, with and without trading, for the United States and selected other national (domestic) applications. Scenarios: limits apply only to CO₂, or to several gases; trading is informal, or formal; trading involves sinks, or not; sales or leases; expiration of allowances; etc. Assess economic and environmental results. (b) Model of greenhouse gas limits, with and without international trading. Scenarios: limits apply only to CO₂, or to several gases; nations trade, or private entities trade; trading is informal, or formal; trading involves sinks, or not; sales or leases; expiration of allowances; etc. Assess economic and environmental results.

5. Develop the institutional underpinnings of international trading: identify international entities that could assist in monitoring and facilitating trading (e.g. stock exchanges, agencies with relevant information (IEA? TFAP?)), and international instruments that might apply to such trading (e.g. GATT). Identify who would trade. Issues of monitoring and assuring compliance.



COUNCIL OF ECONOMIC ADVISERS
EXECUTIVE OFFICE OF THE PRESIDENT
WASHINGTON

September 14, 1990

MEMBER OF THE COUNCIL

MEMORANDUM FOR TASK FORCE ON ECONOMICS OF THE
DPC WORKING GROUP ON GLOBAL CHANGE

FROM: RICHARD SCHMALENSEE 

SUBJECT: Enclosed Draft

Here, at last, is what I hope will almost be the final version of our report. We have tried to do justice to the (relatively few) comments we received as well as to changes in the literature and context of which we are independently aware. I apologize for missing our own deadline so badly -- the weeks after we received your comments were rather busier than we had anticipated.

To facilitate your reacting to our (relatively few) changes, we have used WordPerfect's red-line/strikeout capability. Please concentrate on the changes we made and on the changes you think should have been made in light of developments since March -- we simply do not have time to fight any old fights again. If we are to have a prayer of meeting our goal of publication near the start of October, we'll need your major, substantive comments by COB Thursday, September 20. This will enable us to make calls on Friday to set up a principals-only meeting for the following Monday (September 24) if serious disputes need to be resolved at that level. We'll need the remainder of your comments by COB Friday, September 21. Please supply suggested language whenever possible. With your cooperation, we should be able to turn a draft over to DOE on Tuesday, September 25.