

Environmental Science Under Siege: Fringe Science and the 104th Congress

A Report by

Rep. George E. Brown, Jr., Ranking Democratic Member
to
the Democratic Caucus of the Committee on Science
U.S. House of Representatives

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This report is being submitted by the Hon. George E. Brown, Jr., Ranking Democratic Member, House Committee on Science, for the information of and use by the Democratic Members of the Committee on Science. The report has not been reviewed or approved by the Democratic Caucus of the Committee and may therefore not necessarily reflect the views of all Members of the Caucus.

Transmittal Letter
Committee on Science
U.S. House of Representatives

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TO: Members, Democratic Caucus
Committee on Science

FROM: George E. Brown, Jr.
Ranking Democratic Member

During the 104th Congress, the Committee on Science launched a major initiative directed at the basic integrity of the science community. Three major hearings, entitled Scientific Integrity and the Public Trust, were convened by the Energy and Environment Subcommittee to showcase allegations that science had been distorted to promote an environmentalist agenda. The hearings focused on alleged abuses in the science on stratospheric ozone depletion, global climate change, and the health risks posed by dioxin.

This series of hearings did not occur in a vacuum. The new Republican Congress promised as part of its "Contract with America" to fundamentally change the way environmental regulations would be promulgated. With a new majority, dominated by what has been characterized as an inexperienced and ideological freshman class, the Republicans launched an attack on the basic methods by which environmental regulations could be established. In fact, this attack spread to encompass almost all forms of regulation—including those designed to insure public health, protect the environment, and guarantee workplace safety.

This radical effort in the House went too far even for a Republican-dominated Senate and regulatory reform legislation died in the 104th Congress. However, the two most prominent qualities of the effort to pass this legislation in the House were (!) the shameless use of industry lobbyists to draft the legislation and staff Committee mark-ups, and (2) the widespread reliance on anecdotal stories, usually apocryphal, of the stupid consequences of regulations or the weak scientific basis for regulation. Again and again, like a mantra, we heard calls for "sound science" from Members who had little or no experience of what science does and how it progresses.

This broader environment in the House set the context for the hearings in the Subcommittee on Energy and Environment. The Subcommittee effort was an extension of the themes of the regulatory reform debate and the line of criticism laid out by big industry

lobbyists. Widely quoted scientific critics of environmental regulation were cited for the proposition that federal researchers were merely wasting dollars on a politically driven agenda. But the hearings went beyond allegations of overzealous regulators. They implied that scientists themselves were part of a vast conspiracy with environmental regulators. The terms of the pact were that the scientists would exaggerate their certainty and consensus on environmental problems and the bureaucrats could use these statements, with help from their environmental activist allies, to push through ever more stringent regulations and ever greater funding for the researchers. Bureaucrats were funding science that justified their existence and scientists sold their integrity to the bureaucrats in exchange for steady funding.

At the conclusion of these hearings, I asked the minority staff to prepare a comprehensive report on the very serious allegations made by the Majority and their witnesses. My intent was to examine in more depth the specific charges leveled against the scientific community and the involved federal agencies, to ascertain whether or not these charges had merit, and to review the political and cultural factors that may have motivated these hearings. The staff produced case studies of the three Subcommittee hearings. I then synthesized those cases into basic themes or findings. My report follows with the staff case studies included in the appendix.

Reviewing the hearing record, the staff could find no credible evidence to support the claims that scientists distorted their research to serve political ends. In fact, the record shows that the science in question was carried out in the best tradition of objective, peer-reviewed science.

This report raises serious concerns regarding the approach to science and policymaking represented by the hearings themselves. Beyond the specific allegations of misconduct lurks a deep distrust of government-funded science and the scientific "establishment" represented by peer-review and the scientific assessment process. This distrust flies in the face of House Republican's oft-repeated affection for basic research and science.

Further, there seemed to be an assumption that Congressional hearings would be an appropriate forum for determining scientific "truth" and for resolving scientific disagreements. This was tied to a sometimes implicit, sometimes explicit, critique of publication of experimental methods and findings and peer review. By rejecting the time-tested tradition of scientific peer review and substituting an overtly political process for judging scientific truth, the Subcommittee hearings were an ominous portent for the future role of science in environmental policymaking.

The hearings also produced a clearer understanding of what some Members appeared to mean when they invoked the phrase "sound" science. Apparently, only some kinds of scientific knowledge qualify as "sound" science. Further, the Majority seems to equate sound science with absolute certainty regarding a particular problem. By this standard, a substance can only be regulated after we know with absolute certainty that the

substance is harmful. That is an unrealistic and inappropriate standard. Absolute, final certainty is a rare commodity in science. When dealing with complex scientific issues, we need to recognize that there will always be a range of uncertainty surrounding any scientific claim of understanding. Science cannot easily provide definitive answers to complex, real-world problems; problems of this kind provoke probabilistic statements from scientists, not cast-in-stone truths.

Scientific uncertainty is a constant that politicians and policymakers must have the courage to deal with. Coming to terms with the reality of scientific uncertainty does not, in itself, solve the issue of whether a particular situation demands action. The decision to act or not to act in a specific case is a policy choice. Whether we act or not, we need to remain open to further scientific work that may confirm the wisdom of the policy choice or may demonstrate that it was unnecessary. Science may be able to guide policymakers, but it cannot relieve policymakers of the obligation to make tough policy choices, choices that require a difficult balancing of competing interests. The Majority's demand for absolute and incontrovertible truth prior to action is a choice to ignore science rather than be counseled by it and an abdication of the responsibility to use the best knowledge available at any given time to serve the common good.

The real debates facing us are not about scientific issues, but about fundamental policy differences which reflect honest disagreements about the values of various competing social goals. I hope that the 105th Congress will engage these real issues in a more substantive and productive way.

I commend this valuable report to the Members' attention.

GEORGE E. BROWN, JR.
Ranking Democrat

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Executive Summary

One of the major claims asserted throughout the 104th Congress was that many environmental regulations were not based on "sound science," but instead on scare-mongering and gross exaggerations of environmental problems. In 1995, the Subcommittee on Energy and Environment convened hearings on the science relating to stratospheric ozone depletion, global climate change, and health risks of dioxin exposure. The hearings focused on claims by conservative think tanks, high profile "skeptical" scientists, and industry groups that these environmental problems had been systematically exaggerated for the purpose of promoting a regulatory agenda, and that scientific information and views inconsistent with this political agenda had been routinely ignored and even suppressed.

As detailed in the staff report attached as an appendix to this report, the hearings failed to produce credible substantiation for any of these claims of scientific misconduct. On the contrary, the hearings showed science being conducted in an objective and apolitical manner, consistent with the traditional norms of scientific integrity.

Although the hearings failed to substantiate these serious charges, they nevertheless displayed a number of disturbing beliefs about science and its relationship to policymaking which are detailed in this report:

1. Repudiating Peer Review. The hearings not only reflected a fundamental mistrust of government-funded science, but also a mistrust of the entire process of peer review as a means of ensuring the quality and integrity of science. Instead, the hearings exhibited the view that scientific truth is more likely to be found at the fringes of science rather than at the center. Such an assumption seriously distorts the history of science and reflects a disturbing repudiation of the scientific process and peer review. Such a view is inimical to a constructive role of science in policymaking and hinders the ability of science to build scientific consensus on matters relevant to both domestic and international policymaking.

2. Congress as Science Court. Presented as a contest between equally valid scientific views, the hearings were portrayed as a scientific court where the Subcommittee would determine scientific truth through testimony and questions. By substituting its own judgment for that of the scientific community, the Subcommittee achieved exactly what it purported to condemn: the politicization of science.

3. Policy Paralysis through "Sound Science". The hearings reflected a definition of "sound" science which would entirely preclude the consideration of certain types of scientific knowledge in favor of "empirical facts." In fact, this definition has nothing to do with the quality of science. It merely reflects a policy position which would require unrealistic scientific certainty before any regulations could be justified. The

definition would make it virtually impossible to pass regulations intended to prevent environmental harm before it occurs.

4. Hanging First, Trial Later. The hearings were an attempt to create an after-the-fact justification for efforts to cut environmental research budgets, particularly in areas unpopular with the Committee's Republican leadership.

5. Heat, not Light. The country faces complex environmental decisions that involve difficult policy choices and the consideration of important competing interests. These difficult decisions will not be made easier by diversionary attacks on illusory issues involving "scientific integrity."

The report recommends that the 105th Congress turn towards a more constructive debate on ways to reconcile the often sharply different value judgments that largely shape the political disagreements on environmental policy issues, and to turn scientific issues back to the scientific community and the time-tested process of peer-review as the best means of ensuring quality and objectivity. The report also recommends that Congress routinely require scientific witnesses to disclose funding sources, much as scientific journals already do. Finally, the report recommends that the scientific community take much more seriously the responsibility to educate the public and policymakers about the importance of the scientific process and peer review, and to respond to the arguments raised by the scientific "skeptics" who have taken a highly visible and public role in criticizing mainstream science on these issues.

The Assault on Environmental Science

I. Introduction

The last several years have seen an increasing chorus of charges, primarily from conservative think tanks and special interest groups, that costly environmental laws and regulations are often passed without “sound” scientific evidence of a “real” environmental problem. Such critics argue that environmental problems have been systematically exaggerated by an unholy alliance of scientists eager for increased federal research funding and environmentalists pushing a political agenda. They claim that scientific views which might undermine the environmentalists’ political agenda have been systematically suppressed. In short, these critics believe that science, particularly environmental science, has been distorted to serve political purposes.

These claims found a particularly receptive audience in the Republican majority of 104th Congress, which set as one of its primary goals the establishment of a new paradigm for environmental policy and environmental law.¹ Congressional critics of environmental regulations called for “sound” science as a basic element of regulatory reform.² Repeals, rollbacks, and research budget cuts were all asserted to be required by “sound” science. For example, proposed budget cuts to the global climate change research program were justified on the grounds that the program represented politicized science that was a “product of basically the Vice President of the United States’ zeal for this particular issue. Many of us believe that that zeal is what we would call environmental fanaticism.”³ The recent Republican platform reflects similar sentiments in its statement that proposals to reduce greenhouse gas emissions have “leapfrogged over reasoned scientific inquiry.”⁴

For its part, the Republican leadership of the Committee on Science indicated early in the 104th Congress its intention to oversee the “integrity of science” by promoting

¹ Reforming the regulatory process by requiring strict new risk assessments (“sound science”) and cost-benefit analyses was one of the Republican Contract with America provisions brought to an early vote in the House in the 104th Congress by the new Republican leadership. See, generally, legislative history of H.R. 9, the Job Creation and Wage Enhancement Act of 1995.

² *See, e.g.*, Rep. Tom Delay (“That is what regulatory reform is all about ... to make [agencies] do their jobs with a little common sense and with good science.” 141 Cong. Rec. H2416 (March 1, 1995)); Rep. Robert Walker (“We have regulations run amok ... we need to get the good science.” 141 Cong. Rec. H2268 (Feb. 27, 1995)); Rep. David McIntosh (protect “regulated community, average Americans, from the threat of ... regulations that do not meet the test of good science and cost-benefit analysis.” 141 Cong. Rec. H2327 (Feb. 28, 1995)).

³ Rep. Dana Rohrabacher, 141 Cong. Rec. H9942 (October 12, 1995).

⁴ Republican Platform on Science and Technology, *Power for Progress*, August, 1996.

reliance on "empirically sound data" and by protecting scientists from political influences on their scientific work.⁵ The Chairman of the Science Subcommittee on Energy and Environment, Mr. Rohrabacher, announced his intention to conduct an investigation of possible political pressure on the scientific process a few weeks into the session:

"We are looking into charges that political pressure was put on people to make scientific decisions. And we may have a hearing if we find evidence on that. We may be holding a hearing on that to expose that type of indefensible behavior on the part of certain government officials".⁶

This investigation culminated in 1995 in three Subcommittee hearings convened to showcase areas in which science had been allegedly distorted: the 1992 decision to accelerate the ban on chlorofluorocarbons (CFCs) to protect the stratospheric ozone layer⁷; proposals to reduce carbon dioxide and other greenhouse gas emissions to slow down global warming⁸; and proposals to regulate dioxin-containing chemicals to protect human health.⁹ The hearings focused on allegations that these environmental problems had been systematically exaggerated to the public, the media, and policymakers, and that contrary scientific data and views had been systematically ignored or even actively suppressed.

These charges are serious in themselves. But equally importantly, the way in which the Subcommittee pursued these allegations provides a valuable window into the

⁵ The Science Committee "Vision Statement," submitted by Chairman Robert Walker to the House Republican Conference during the 104th Congress, contained (among other things) the following "strategies to promote scientific integrity": "Science programs must seek and be guided by empirically sound data; The results of scientific research must be completely and accurately reported without fear or favor; Scientific research must be merit reviewed in an open and competitive process."

⁶ Interview with Dan Greenberg in *Science and Government Report*, February 15, 1995.

⁷ *Scientific Integrity and the Public Trust: The Science Behind Federal Policies and Mandates: Case Study 1--Stratospheric Ozone: Myths and Realities: Hearings Before the Subcomm. on Energy and Environment of the House Committee on Science*, 104th Cong., 1st Sess., No. 31 (Sept. 20, 1995)(hereinafter cited as "Ozone Hearings").

⁸ *Scientific Integrity and the Public Trust: The Science Behind Federal Policies and Mandates: Case Study 2 -- Climate Models and Projections of Potential Impacts of Global Climate Change: Hearings before the Subcomm. on Energy and Environment of the House Committee on Science*, 104th Cong., 1st Sess., No. 35 (Nov. 16, 1995) (Hereinafter cited as "Global Climate Change Hearings"). In addition, a panel also testified about global climate change science during full Committee hearings on NASA's Mission to Planet Earth: *U.S. Global Change Research Programs: Data Collection and Scientific Priorities: Hearings before the House Committee on Science*, 104th Cong., 2nd Sess. No. 49 (Mar. 6, 1996).

⁹ *Scientific Integrity and Federal Policies and Mandates: Case Study 3 -- EPA's Dioxin Risk Reassessment: Hearings before the Subcomm. on Energy and Environment of the House Committee on Science*, 104th Cong., 1st Sess., No. 39 (Dec. 13, 1995) (Hereinafter cited as "Dioxin Reassessment Hearings.")

many assumptions – hidden and overt – which underlie the Majority's views toward the conduct of science and the use of science in the formulation of policy.

This report first discusses the allegations that environmental science has been politically compromised, as well examining some of the unconventional views and assumptions held by the Majority on questions relating to the conduct of science and its use in policy formulation. The report then assesses whether any of the allegations of impropriety were actually substantiated during the hearings process. (The case studies prepared by the minority staff are appended to this report and contain a detailed discussion of the allegations and the actual evidence produced at the hearings.) The report next examines the effects that the Majority's views have had (and will continue to have, if unchecked) on science, science policy, and environmental policy. Finally, the report concludes with a series of recommendations on how Members of the Congress and the scientific community might strengthen environmental science and its link to the policy process.

This report shows that the three hearings were much more than a platform for critics to air charges which ultimately proved to be baseless. The hearings constituted an unprecedented assault on the peer review system and the scientific process itself. In the end, the hearings conducted by the Committee Majority demonstrated a lamentable lack of understanding of science and of policy, and a real danger to effective linkages between the two.

II. The Subcommittee's Allegations and Assertions

Allegation: Science Has Been Distorted to Serve Politics

The 104th Congress has been fertile ground for the allegations sown by conservative think tanks and special interest groups that science-based environmental policies have been systematically distorted and misrepresented for political purposes.¹⁰ The three Subcommittee hearings focused on allegations that researchers had deliberately overstated environmental problems to mislead policymakers, and had willfully ignored and even suppressed contrary scientific information and viewpoints. The Chairman and witnesses made a number of specific allegations, discussed in detail in the appended case studies, including the following claims:

- NASA and EPA deliberately overstated the risks of stratospheric ozone depletion;

¹⁰Conservative Washington think tanks have published a plethora of books and articles over the last few years criticizing environmental policy and the alleged manipulation of environmental science. See, e.g., Bailey, Ronald (ed.), The True State of the Planet, (New York, 1995) [a project of the Competitive Enterprise Institute]; Bast, Joseph et al. Eco-Sanity (Lanham, Md. 1994) [Heartland Institute]; Milloy, Steven, Science Without Sense: The Risky Business of Public Health Research, (Washington, D.C. 1995) [CATO Institute].

- Scientists presented testimony before Congress which deliberately understated inherent uncertainties in climate models;
- Scientists distorted research results to secure continued federal funding and EPA conspired to distort the risk of a regulated substance.
- Grant applications were inappropriately denied for ozone depletion research based on political convictions;
- Politically unpopular dissenters were systematically excluded from international scientific assessments of ozone depletion and global warming;
- A publication suppressed an article dealing with ozone depletion in the scientific literature because of biased editorial policy; and
- A scientist critical of global warming was denied data.

Assumption #1: Peer Review is Suspect and the Unconventional Scientific Fringe is Probably Right

The hearings displayed a fundamental distrust of government-funded science and the process by which scientific assessments are developed through open and peer-reviewed procedures.¹¹ A number of the witnesses attacked the traditional peer-review process as corrupt and politicized. The hearings appeared to bestow greater scientific credibility on the non-peer-reviewed views of individual scientists than on the peer-reviewed scientific assessments.¹² In that regard, the hearings reflected a fundamental disregard for the scientific process itself and undermined the very credibility of science as a basis for making policy decisions. In his testimony rejecting the international scientific assessment of ozone depletion science, for example, Rep. John Doolittle expressed contempt for the “mumbo-jumbo of peer-reviewed documents” and expressed his preference for the views of the few “skeptical” scientists.¹³

¹¹ As practiced today, the term “peer-review” refers to different things in different contexts. Most narrowly, peer review refers to the process by which an original article is circulated to independent knowledgeable reviewers to determine an article’s scientific quality before publication in a scientific journal. “Peer review” also refers to the process by which an assessment of scientific knowledge, which itself draws upon scientific peer-reviewed literature, is reviewed by an independent panel of experts to ensure that the assessment reasonably reflects the state of scientific knowledge on a subject.

¹² In the ozone hearing, Rep. Tom Delay admitted that he had not seen the WMO international assessment, but readily dismissed it anyway: “I haven’t seen this study, so I can’t comment on this particular study. But it’s been my experience that a selective group, in fact, is usually taken—well let me put it a different way. The conclusion is usually written before the study is even done.” Ozone Hearing, *supra*, at 28. Instead, he based his assessment that there was no scientific basis for ozone depletion on “reading people like Fred Singer....reading Arnie Goldback from Norway, reading others.” *Id.*, at 29.

¹³ When asked what peer-reviewed science he had relied upon for his conclusion that there was no scientific basis for ozone depletion, Rep. Doolittle responded “[w]ell you’re going to hear from one of the scientists today, Dr. Singer...I consulted Dr. Singer, who is a very authoritative source, and I will stand with the Doctor.” Ozone hearings, *supra*, at 19.

Indeed, the "skeptical" scientists¹⁴ were perceived to be all the more credible precisely *because* their views were contrary to the consensus of peer-reviewed science. Citing historical instances where unconventional theories successfully overturned conventional wisdom, some Members and witnesses suggested that scientific "truth" is usually more likely to be found at the scientific fringes than in the conventional center.¹⁵ As the Subcommittee chair stated, "I am not swayed by arguments that here's a big list of scientists that are on my side and you only have a smaller group of scientists on your side. I'm just not swayed by that at all."¹⁶ A similar sentiment was echoed by the Chairman of the Science Committee: "My experience in 18 years of watching science policy being made is it is often those small groups of scientists, though, who differ with conventional wisdom that in fact are always producing the scientific judgments of the future."¹⁷

¹⁴ All scientists are skeptics because the scientific process demands continuing questioning. In this report, however, the scientists we refer to as "skeptics" are those who have taken a highly visible public role in criticizing the scientific consensus on ozone depletion and climate change through publications and statements addressed more to the media and the public than to the scientific community.

¹⁵ See, e.g., Kuhn, Thomas S., *The Structure of Scientific Revolutions* (University of Chicago Press: Chicago, 1962) for a seminal discussion of the role of "paradigm shifts" in the history of science. Defenders of skeptical scientists frequently cite historical examples where unconventional theories were actively suppressed by the establishment. See, e.g., "George Miller, Meet Galileo Galilei", Dear Colleague circulated by Rep. John Doolittle (Sept. 26, 1995): "[I]t is [Rep. George Miller] and other supporters of the CFC ban who want to keep the scientific debate closed. Accept conventional wisdom or else, is what he seems to be saying. Can you imagine how Mr. Miller might have reacted to other dissenters in the scientific community? Consider Galileo Galilei...."

¹⁶ Ozone Hearings, *supra*, at 155. Contrast this view with the goal expressed in the 1996 Republican Platform which proposes, under *Restoring Justice to the Courts* to "eliminate the use of 'junk science' ...by requiring courts to verify that the science of those called as expert witnesses is reasonably acceptable within the scientific community..."

¹⁷ Rep. Robert Walker, *Cholesterol Measurement: Error and Variability: Hearing before the Technology Subcommittee of the Committee on Science*, 104th Cong., 1st Sess. (Feb. 14, 1995) at 125-126. Similar sentiments have been expressed by "skeptical" scientists to bolster their position that the scientific consensus is irrelevant. "[T]he most progress in science is made when researchers challenge existing paradigms, the most overarching of which is that we are doomed." Michaels, Patrick, "Free Markets, Free Science," *Washington Times* (Dec. 15, 1992, p. F2). In testimony before the Science Subcommittee on the Environment in 1992, Dr. Michaels expanded this view about scientific consensus: "The question you're asking implies that science by large consensus is, in fact, correct. And I don't think the history of science, in fact, argues that consensual statements, in fact, turn out to be correct in the long run." *U.S. Global Change Research Program: Hearings before the Environment Subcommittee of the House Committee on Science*, 102nd Cong., 2nd Sess (May 5, 1992), at 174. Dr. Michaels has also said, "The premise is that consensus defines truth in science. The pressure to conform then comes to outweigh the openness to challenge and debate." Michaels, Patrick, "Forging Consensus: Climate Change and the United Nations" (George C. Marshall Institute, Washington, D.C. 1996). Such sentiments may also explain the high funding priority placed by the majority on research on "revolutionary ideas and pioneering capabilities that make possible the 'impossible.'" See, e.g., Views and Estimates on the FY97 Budget submitted to the Committee on the Budget by the Committee on Science (1996).

Assumption #2: Sound Science is Empirical Science

One of the overall messages of the hearings – that Congress should act as the arbiter of scientific disputes – becomes extremely problematic if Members of Congress are consistently confused about the nature and the limitations of scientific knowledge. And, in fact, these hearings were a case study in confusion. One example was the oft-repeated view of “skeptical” witnesses and Republican Members that “sound” science is “empirical” science¹⁸. In both the ozone hearing and in the global change hearing, for example, “skeptical” witnesses rejected the use of statistical analysis and models in favor of *observational* data – even when the use of uncorrected raw data was highly misleading.¹⁹ The hearings reflected a systematic aversion to the use of theory, models, and other sources of scientific knowledge to provide a full understanding of observed data.

This inordinate reliance on a single source of scientific understanding is part of a broader view that the “sound science” needed before regulation can be justified is science which somehow proves a proposition to be “true.”²⁰ This is a totally unrealistic view both of science’s present capabilities and of the relationship between data and theory in the scientific method. Not coincidentally, as the report discusses in later sections, this approach to science can lead to near paralysis in policy-making.

Assumption #3: The Trial Can Follow the Hearing

As an exercise in the relationship between the hearings process and legislative action, the hearings were a prime example of “hearing first, trial later.” Months before the hearings, the Subcommittee Chairman had already proclaimed his belief that the global change issue was “liberal clap trap.”²¹ Without the benefit of hearings, the Science

¹⁸ Science Committee Vision Statement, *supra*. See, e.g., Singer, F., “Confusing Science with Speculation,” Washington Times, (Aug. 16, 1993) at E1.

¹⁹ For example, in the ozone hearing, Dr. Singer testified that the fact that there were no empirical data showing an actual increase in surface level UV radiation must mean that stratospheric ozone was not being depleted. See, e.g., Ozone Hearing, *supra*, at 51, 56-57. However, Dr. Albritton testified that there was a reason for the lack of data: detecting trends in surface level UV radiation is extremely difficult because of interference from clouds and pollution. See, e.g., Ozone Hearing, *supra*, at p. 39-40, 170. The fact that there is no empirical proof of increased surface radiation does not mean that stratospheric ozone depletion is not occurring. Other direct satellite observations do, however, provide evidence that such depletion is taking place. See, e.g., statement of Dr. Albritton, Ozone Hearing, *supra*, at 38. To be certain, predictive models have their own set of problems as described by the GAO in the global warming hearing. The scientific method, however, is intended to reconcile empirical observations and predictive models and unify a common framework of understanding. Neither constitutes “sound” science in isolation.

²⁰ “[B]efore there is something proven to be a health risk, passing regulations that will cost billions of dollars to the American people is not justified.” (emphasis added) Rep. Rohrabacher, Dioxin Reassessment Hearings, *supra*, at 78.

²¹ Rep. Dana Rohrabacher, “Statement at Press Conference Energy and Environment Authorization,” June 7, 1995. Mr. Rohrabacher also stated: “In another area of savings, trendy science that is proposed up by

Committee in June, 1995 approved legislation²², later passed by the House of Representatives, which included dramatic cuts in environmental research, particularly in climate change and energy research. Other Members introduced legislation to roll back the ban on CFCs based on their belief, unconfirmed by any open hearings process, that the scientific basis for the ban had been politically distorted.²³

III. Were the Allegations and Assumptions Proven?

As detailed in the appendices to this report, the hearings failed to produce credible substantiation for any of the allegations of scientific misconduct and made no coherent case to buttress the sweeping assumptions concerning science policy. On the contrary, the hearings showed that the integrity of the scientific process is sound.

Despite the central focus of this series of hearings and subsequent efforts to develop specific factual evidence, there was no substantive corroboration of any of these charges. Nor was it demonstrated that the alleged incidents leading to these charges had any influence on the interpretation of science for policy. In short, no actual cases of scientific fraud, unacceptable conduct by any individuals or institutions, or breakdown in the scientific process were documented.

In each of the cases considered, the record showed that environmental research was carried out in an objective manner, consistent with the traditional norms of scientific integrity, and without preconceived political or scientific outcomes. Moreover, the record also showed many efforts by those scientists to convey to policy makers the complexity, uncertainties, and limitations of their science. Rather than ignoring contrary data or suppressing dissenting views, the research programs reviewed in these hearings instead demonstrated a remarkably open and transparent process that relied heavily upon critical scientific peer review to ensure quality and integrity.

Clearly, a wide disparity in scientific opinion exists for many important issues having policy implications. Although there exists a high level of scientific consensus on ozone depletion and global climate change, *some* scientists do disagree. Beyond this observation, however, no instances of illegal, unlawful, unethical, or even inappropriate acts could be validated.

liberal/left politics rather than good science has cost us billions.... We will not permit scare mongers and chicken littles to successfully push federal policies that tax out people into lower standards of living, raise the price of products they buy and regulate them out of a job. No where is scientific nonsense more evident than in global warming programs that are sprinkled throughout the current year budget."

²² H.R. 1814, H.R. 1815, and H.R. 1816, later incorporated into H.R. 2405.

²³ Rep. John Doolittle introduced H.R. 2367 to repeal the accelerated phaseout of CFCs; Rep. Tom Delay introduced H.R. 475, repealing the entire section of the Clean Air Act providing for the authority to phase out ozone depleting chemicals.

These hearings were aimed at discrediting the environmental movement, the Federal Government, and the science community itself. At best, these assertions of lapses of integrity can be characterized as an investigation into the possible breakdown of scientific integrity (which could not in fact be shown). At worst, they were a mythical distortion with the potential to obscure honest and open debate, to compromise the scientific process, and to cause great damage to human health and the environment.

IV. Impacts of the Subcommittee's Allegations and Assertions on Science and Policy

The Subcommittee Demeaned Peer Review and Looked for Scientific Truth at the Fringes

The hearings contrasted remarkably different concepts of science and the role of scientists in public policy. On the one hand, the testimony of agency scientists reflected the results of extensive efforts to analyze and assess the scientific peer-reviewed literature through an open process.²⁴ Each of these assessments disclosed key uncertainties and assumptions, and, consistent with sound risk assessment principles, addressed only scientific issues – not policy recommendations.²⁵

²⁴ Dr. Albritton testified at the Ozone hearing that he and Dr. Watson were representing not their own work, but the peer-reviewed research of hundreds of international scientists conducted since 1981. The 1994 Scientific Assessment of Ozone Depletion, the seventh such international assessment, is the most authoritative source on ozone depletion science. Over 200 scientists were contributors, and another 147 were peer reviewers. The report was prepared in a thoroughly transparent, public, and open manner.

Similarly, in the Climate Change hearing Drs. Watson and Mahlman presented the scientific consensus of the Intergovernmental Panel on Climate Change (IPCC), created in 1988 by the World Meteorological Organization and the U.N. Environment Programme. At the time of the hearing, IPCC was about to approve its Second Assessment Report. The Summary for Policy-makers and Technical Summary, based on the work of hundreds of scientists, were drafted by 78 lead authors from 20 countries and reviewed by 500 reviewers from 40 countries. The Summary was approved, line-by-line, by the 177 delegates to IPCC Working Group I in November, 1995. Dr. Mahlman referred to the IPCC reports as "the most widely accepted statements ever on climate change." (Global Change Hearings, *supra*, at 17).

EPA's draft Dioxin Reassessment was begun in 1991 and involved extensive public outreach and peer review. In September 1994, EPA released for public comment a draft reassessment consisting of two thousand-page documents. A year later, EPA submitted the entire document and all public comments to its Science Advisory Board for independent peer review.

²⁵ The 1983 National Research Council report, Risk Assessment in the Federal Government: Managing the Process (National Academy Press, Washington, D.C., 1983) recommended that the scientific process of risk assessment should be "explicitly distinguished from the political, economic, and technical considerations that influence the design and choice of regulatory strategies." Page 7. With respect to the ozone assessment, Dr. Albritton testified, "They are a solid basis for decision-making, in contrast to anecdotal statements or privately published viewpoints. They are pure science. The community makes no policy recommendations. That's the job of others, like yourselves, that are entrusted with the public welfare." (Ozone Hearings, *supra*, at 65.) Similarly, in the global change research hearing, Dr. Mahlman, like Dr. Albritton in the earlier hearing, was careful to avoid policy pronouncements (Global Climate Change Hearing, *supra*, at 16): "... as a physical scientist, I do not offer personal opinions on what society should do about these predicted climate changes. Societal actions in response to greenhouse

In contrast, in the Ozone Hearing, the Subcommittee heard testimony from Dr. Fred Singer and Dr. Sallie Baliunas, the latter testifying in her capacity as the chair of the Science Advisory Board of the George C. Marshall Institute. The criticisms of the scientific consensus contained in Dr. Singer's²⁶ and Dr. Baliunas'²⁷ testimony have not to our knowledge been published in any original peer-reviewed research.

There is, of course, nothing wrong with scientists exercising their rights as citizens to advise Congress on what they believe to be appropriate policies. But such policy advice is nothing more than personal opinion which is entitled to no more deference than that which should be afforded to the opinions of other thoughtful citizens. Scientists have

warming involve value judgments that are beyond the realm of climate science. Indeed, I would invite your skepticism whenever you hear a climate scientist's prediction being accompanied by a policy opinion." Referring to EPA's draft dioxin reassessment, Dr. Farland also testified, "The reassessment is a scientific document and does not address regulatory policy or issues." (Dioxin Hearings, at 23.)

²⁶ A literature review revealed only one recent peer-reviewed article on ozone depletion by Dr. Singer. The article is not original research, but a technical comment in Science co-authored by Dr. Singer (Michaels, P.J.; Singer, S.F.; Knappenberger, P.C., "Analyzing Ultraviolet-B Radiation: Is there a trend?", 264 Science 1341, May 27, 1994). The article criticized statistical techniques in a study purporting to detect a trend in UVB radiation associated with ozone depletion (Kerr, J.B; McElroy, C.T., "Evidence for Large Upward Trends of Ultraviolet-B Radiation Linked to Ozone Depletion," 262 Science 1032, Nov. 12, 1993). Science also published a response by the original authors to the criticism by Singer and his co-authors.

Dr. Singer testified that he had also published peer-reviewed articles in EOS and Technology: The Journal of the Franklin Institute (Ozone Hearing, supra, at 165-166). EOS, the journal of the American Geophysical Union, is a weekly newsletter, not a traditional scientific journal. As its editor-in-chief wrote in a letter to Rep. Rivers, EOS "publishes commentary on scientific programs and their results, short reviews of research results and activity, and opinion intended to stimulate scientific debate." While such articles are reviewed by one or more active scientists for "interest, clarity, and soundness of the science," EOS does not publish new scientific results subject to the traditional peer-review process.

Technology, a new journal separate from its parent publication, The Journal of The Franklin Institute, has published only three issues with a very limited circulation (Ozone Hearing, supra, at 165, and letter submitted for the record, page 320 et seq). According to Technology's editorial guidelines, Dr. Singer's article is a "Commentary" which would not be not peer reviewed.

Dr. Singer has noted (Ozone Hearings, supra, page 307) that he has published in many peer-reviewed journals. Dr. Singer did publish actively in the 1970s scientific literature on ozone and other global environmental issues. He has also been a prolific writer of op-ed articles for the Washington Times and other conservative publications. The point here, however, is simply that Dr. Singer's current views on ozone depletion science have not been published in the scientific peer-reviewed literature.

²⁷ Dr. Baliunas has many peer-reviewed publications in her specialty, solar astrophysics, but her criticisms of ozone and global change science have been published only by the Marshall Institute, whose reports are not peer reviewed, according to published reports. In "Attacks on IPCC Report Heat Controversy Over Global Warming" (Physics Today, Aug. 1996 at 57), Toni Feder quotes Dr. Frederick Seitz, Chairman of the Marshall Institute, as saying that Marshall reports are not peer-reviewed and "represent opinion."

no special expertise to judge the many economic and political issues involved in any regulatory decision. Indeed, it is for that reason that scientists generally try to limit their advice to scientific issues within their expertise, or at least clearly distinguish between science and personal opinion. This is a standard which "skeptical" scientists frequently fail to meet in their publications.²⁸

As evidenced by earlier-cited comments, Subcommittee Members were quite comfortable both in enthusiastically accepting the policy pronouncements of "skeptical" scientists and in demeaning the careful peer-review efforts of traditional scientists. Peer review was almost flippantly dismissed as politically correct tyranny, as opposed to the true scientific breakthroughs generated by the unconventional and skeptical innovator.

The sentiment that the scientific fringe is more likely to be right than conventional scientific knowledge reflects a disturbing misunderstanding by some Members not only of the scientific process but of scientific history as well.

Skepticism is an inherent part of the scientific perspective; scientific knowledge grows only through a process of continual questioning. The central accepted core of our scientific knowledge is the cumulative result of centuries of resolving scientific questions through observation, testing, and open and rigorous scientific peer review. The consensus that has emerged from this process deserves respect as our best effort to understand and explain the physical world. Like Winston Churchill's democracy, peer-review is not a perfect process, but it is the best that we have.

While scientific breakthroughs that challenge conventional wisdom do occur, it is a perversion of scientific history to say that the conventional wisdom – the product of the peer review process – is more often than not wrong. Further, while "skeptical" scientists are unquestionably correct that their theories are not wrong simply because they are not popular, the burden must be on the challengers to show that the conventional wisdom is wrong, by the scientific process of developing and testing alternative hypotheses subject to open and rigorous peer review. Those who would wear Galileo's mantle must also meet Galileo's commitment to science's rigorous demands.

For the most part, "skeptical" scientists have failed to confront conventional wisdom in a valid scientific forum. Instead, they have chosen to present their views in opinion pieces aimed not at their fellow scientists but at policy-makers, the media, and the

²⁸ For example, Marshall Institute reports on ozone and climate change make policy recommendations based on the "scientific" conclusion that policy actions are not justified. As noted in the text, *infra*, such a conclusion is a policy, not a scientific, conclusion. Other policy matters are included in the Marshall reports as well. In "The Ozone Crisis," Dr. Baliunas extensively discusses the economic impacts of the CFC phase-out and the wisdom of the "precautionary principle" policy, concluding that the phase-out "appears both scientifically unjustified and unnecessarily costly." At the hearing, however, Dr. Baliunas was much more restrained about her policy qualifications. She declined to state her position on the CFC phaseout: "It's just that it involves a broader issue than the science. It involves the risk/benefits. And I can't comment on those, and the second panel shall. It involves an economic question as well."

general public. And because the skeptics often present subtle misinterpretations of results and undocumented analyses with each new hearing or op-ed piece, their arguments are difficult to rebut by the methods normally utilized by the scientific community.

In lionizing the methods of the skeptic community, the Subcommittee has damaged the peer-review process, displayed its ignorance of the history and conduct of science, and failed profoundly in its responsibility to educate and enlighten the 104th Congress on the contributions of science to society.

The Subcommittee's Embrace of Skeptic Science Is a Threat to Domestic and International Consensus Building and to a Constructive Role for Science in Policy Making

A key allegation throughout these hearings was that the link between the scientific process and the policy making process is flawed. For the climate change hearings, the testimony of skeptics was taken as proof that the peer review process has failed and that unsound science was being used for major decisions. The structure of these hearings and the selection of viewpoints to be heard were aimed at showcasing the skeptics' interests. Although mainstream science was represented, it was cast in a defensive posture²⁹ and the true link between the consensus process and policy making was obscured³⁰.

Through these hearings, there emerged the outlines of an alternative proposal for policy making. That is, rather than relying on the traditional consensus process that has characterized the IPCC, the Montreal Protocol process, and Federal regulatory review panels, the hearings profiled the "think tank" process in which scientific opinions can be developed unencumbered by the peer-review process. The hearing in fact gave equal weight to witnesses representing both processes.

Some have argued that high profile think tank and skeptical scientists, while they may not be an integral part of the science process, are a part of the public opinion process and should be afforded a platform. The issue of relevance is not whether skeptics should be heard but *how* such individuals and think tanks are used by Congress in developing policy and legislation.

In encouraging and supporting the views of skeptic scientists who do not participate constructively in peer review processes, the Subcommittee has undercut

²⁹ Witnesses who were part of the traditional scientific community stopped short of conveying personal opinions -- properly believing that policy matter were outside their expertise. Thus, throughout the hearings, many exchanges between witnesses seemed unbalanced -- strongly expressed policy opinions on the one hand versus highly qualified scientific responses on the other.

³⁰ For example, there was no representation from the critics at the opposite end of the spectrum, i.e. those who believe the consensus process is too conservative and more proactive policies are needed. The consensus represents a balance in this spectrum of viewpoints.

domestic and international consensus-building processes which aim to link science and environmental policy. If it is successful, the Subcommittee will have discredited the best available mechanism for establishing environmental policy, leaving nothing in its place except raw political influence.

By Turning Congress into a Science Court, the Subcommittee Has Politicized Science

Although skepticism has long been an essential part of the scientific process, the emerging role of skeptics within the policy making process has been confusing and counter-productive. The receptivity of the 104th Congress to their views has distorted the true cases of consensus where consensus exists and has led to a perception that science itself cannot be trusted for policy making.

A perception has been created that for any scientific issue, *there will always be some scientists in agreement and some in disagreement, scientists will invariably change their minds, and no reliable process exists to resolve scientific differences of opinion with any degree of integrity.* This cynical view in fact does undermine science-based policy-making. It leads to the conclusion that institutions such as Congress have been ceded the responsibility to define what is sound science and to act as a science court.

This emerging view, based on a fundamental mistrust of the process, establishes the science community as *just another interest group*. Large numbers of scientists subscribing to a consensus are simply a *large* interest group. Skeptics, on the other hand, are viewed as an equally credible, but smaller interest group. Within this new framework, policy making will be dominated by politics rather than science. That is, small interest groups with greater access have the potential to achieve more than larger interest groups with diminished access.

The idea that politicians rather than scientists should decide what constitutes "sound science" should be deeply disturbing to those concerned with the integrity of the scientific process. Yet in these hearings, the Subcommittee acted as a "science court", leaving to the judgment of Members which science to believe based on little more than the persuasiveness of five-minute presentations and question sessions.³¹ Science is not a political debating contest. Scientific "truth" is unlikely to emerge in such a legalistic, adversarial setting; it cannot, like policy options, be chosen from a menu of alternatives. Yet the Committee routinely dismissed the scientific viewpoint established through

³¹ "I came away [from the Ozone Hearing] thinking, well, the people who were talking about ozone certainly made their case. But when we had the people there talking about global warming, they didn't make their case at all. And they were, as far as I could see, they were shot down totally by the people presenting the other side of the argument." Rep. Dana Rohrabacher, statement made during Committee consideration of H.R. 3322, April 24, 1996. *Omnibus Civilian Science Authorization Act: Report of the Committee on Science on H.R. 3322, together with Dissenting Views*, 104th Cong., 2nd Sess., H. Rep. 104-550 (Part 1), page 541.

rigorous peer review in favor of an untested scientific viewpoint which had only the benefit of supporting a preferred policy outcome.³²

What are the implications of this new view of science for future Congressional decisions on the environment? There was a disturbing common theme to these hearings suggesting that research funded by the federal government is not sound science, since scientists have economic incentives to exaggerate the importance of their research.³³ In this view, "consensus" science derived from peer review is not sound science, since it merely reflects a conspiracy of the scientific establishment which suppresses dissenting views. Finally it was implied that science which has any uncertainty or which is not "empirical" is not sound science. What is left?

If we accept these propositions, science becomes something that policy makers can simply pick and choose depending upon their own personal political preferences and the persuasiveness of slick packaging. With the credibility of peer-reviewed science undermined by political attacks, the 104th Congress has signaled its intention to make its own decisions about what constitutes "sound" science, thereby ensuring precisely what it said it wanted to avoid: the politicization of science.

The deep-rooted distrust of science funded by government, the lack of respect for the scientific peer review process, and the lack of understanding of distinctions between science and policy matters displayed by the 104th Congress all but assures continuing attacks by special interest groups on the scientific basis of environmental regulations.

The Subcommittee's Definition of "Sound Science" Creates an Impossible Burden of Proof for Science, Thereby Undercutting All Environmental Regulation

The hearings illustrate a newly emerging theme (enunciated in the Republican vision statement for scientific integrity) equating *sound* science with *empirical* science. Throughout these hearings it was clear that although all Members advocated the use of "sound" science, there was no universally accepted definition of what it meant. Rep.

³² The complexity of science provides a further caution to the idea of Congress acting as a "science court", especially when politicians are generally ill-equipped to judge the merits of complex science. One of the key controversies in the EPA Dioxin Reassessment was EPA's assumption that dioxin could be considered to have a linear dose-response, which could mean that even relatively small increases in exposure could pose health risks -- an assumption opposed by the chemical industry. However, Chairman Rohrabacher expressed his frustration in understanding the testimony on this critical issue: "I don't know how many people on this panel understand it or this committee understand it, but I am sure that it's an important question, and we need to make sure that people are on the record even on issues that the committee doesn't understand." Dioxin Reassessment Hearing, *supra*, at 64.

³³ Part of the distrust of environmental science appears to stem from the fact that most environmental research is funded by the federal government. Some critics have questioned the inherent credibility of such research because of the potential self-interest of researchers in exaggerating the importance of their research -- or, as one witness wrote, to be "shills for the apocalypse." Michaels, Patrick, "Free Markets, Free Science," Washington Times, Dec. 15, 1992 (p. F2).

Doolittle, in his prepared statement for the Ozone Hearing, stated that "Sound science must be the basis for all future decisions we make on this important issue". In seeking to clarify the definition of sound science, Ms. Rivers asked "...what would you consider to be sufficient evidence for action to be taken in this area?" Mr. Doolittle responded "I think we need a clear scientific conclusion that there is a definite cause for the problem and that so-called problem is producing definite effects. Theories or speculation about it are not sufficient. We need science, not pseudo-science. I think we've been in an era of pseudo-science where these dire consequences are portrayed in order to achieve a certain political objective." Similar statements were made by other Members in the global change hearings with respect to projections from computer models and in the Dioxin Reassessment Hearings with respect to choices of models of dioxin receptor activity.³⁴

The emphasis on empirical science to the exclusion of modeling represents a fundamental misunderstanding of science itself. The classic scientific method involving observations, hypotheses, testing of hypotheses, and establishing and refining a theoretical construct is fundamental to scientific understanding. The emerging effort to truncate the scientific method at the initial observations stage endangers the ability of the scientific community to unify its understanding not only of environmental problems, but any phenomenon.

While it may be understandable that laymen like Members of Congress do not understand all the conceptual tools of modern science, we believe that the Subcommittee's oversight in this case was less accidental and more sinister than it may appear at first sight. *By equating sound science with empirical science, the Subcommittee has attempted to sever the link between peer-reviewed science and policy and to stop environmental regulation in its tracks.*

There are several components of this strategy.

First, limiting what is scientifically admissible to that which is "empirically true" eliminates much of the subtle evidence that both contributes to scientific understanding and supports environmental regulation. Scientific understanding of complex environmental and health problems evolves over time, drawing from different approaches and techniques for testing theories. By eliminating modeling, theoretical constructs, and process studies, the Subcommittee has imposed a totally unrealistic burden on science and has compromised the relationship between data and theory in the scientific method.

Secondly, by demanding empirical "truth", the Subcommittee has effectively severed the link between science and policy. There will always be scientific uncertainties, particularly in dealing with complex areas such as human health and global climate systems. The fact that science cannot always make statements with 100% certainty about a subject does not mean that scientists do not know anything about the subject. For example, even though science still lacks a precise understanding of the mechanisms by

³⁴ See note 20, supra.

which cigarette smoking causes lung cancer, the combined weight of scientific evidence, including clinical and epidemiological research, presents an overwhelming case for causation. Uncertainty is not the hallmark of bad science; it is the hallmark of honest science. The scientist professing absolute certainty is likely the least believable.

Further, no politician should be allowed to cut off a serious public policy debate on the basis that the underlying science is uncertain. Degree of scientific certainty is only one of many factors that enter into policy decisions. Even where there is substantial scientific uncertainty, a policy action might still be justified in a policy-maker's view depending on factors such as the nature, distribution, and significance of the possible harm to be avoided and the cost of implementing the policy to avoid the harm³⁵. This perennial question -- "Do we know enough to act?" -- is inherently a *policy* question, not a scientific one. There is no "scientific" way to decide how to make the difficult tradeoffs among uncertainties, costs, benefits, and risks inherent in any policy action. Policy choices invariably involve subjective values about which science has nothing to say. It is therefore meaningless to say, as some environmental policy critics have, that certain policy decisions are "unscientific."³⁶

In short, then, the term "sound" science as used by Subcommittee Members has very little to do with the quality of science. Instead, it is a policy position that a proposition should be "proven" before any regulatory action can be justified.³⁷ The three hearings examined here demonstrate that waiting for the kind of certain, unambiguous and

³⁵ Scientific uncertainty is certainly a factor to be considered, since the uncertainty creates the risk that any given regulatory response will be less than optimum. Either the actual risk can be overstated, in which case regulations may not have been necessary, or the actual risk can be understated, in which case regulations have not been sufficient to avoid all of the harm. Where regulatory costs are high, and the benefits uncertain, policymakers could reasonably insist on greater scientific certainty before deciding to regulate. On the other hand, if regulatory costs are low, and the benefits are high, policymakers may place less importance on scientific certainty. How any given policymaker wants to "gamble" on such outcomes will be heavily influenced by the other policy factors mentioned in the text.

³⁶ For this reasons, scientists try to distinguish between science issues, on which they are uniquely qualified to speak, and policy issues, on which they have no particular expertise. In regulatory language, these two issues are separated as risk assessment and risk management. While each of the mainstream peer-review assessments challenged in these hearings scrupulously avoided policy pronouncements, many of the "skeptical" scientists who testified at these hearings routinely mix science and policy judgments together in their writings. See, e.g., Baliunas, Sallie, "The Ozone Crisis" (George C. Marshall Institute, 1994) ("The Precautionary Principle, as a basis for the formulation of environmental policy, is the denial of science.")

³⁷ Congress could, of course, legally mandate agencies to meet such a high burden of proof to justify regulations. Given the practical difficulty of meeting such a burden, however, agencies would be unlikely to enact regulations intended to prevent harm from occurring. For that reason, environmental laws passed over the last 25 years generally do not require such a strict burden of proof, partly in recognition of high policy priority given to protecting public health and the environment from involuntary environmental risks.

empirical data called for by Subcommittee Members means waiting until irreversible and irreparable harm has already started happening. In the global change area, waiting for an unambiguous signal of global warming before taking any actions to reduce greenhouse gas emissions adds greenhouse gases to the atmosphere which could make the impacts of global warming worse and mitigation strategies more expensive. Similarly, the atmospheric lifetime of CFCs is so long that it would take centuries to reverse stratospheric ozone depletion if we waited for certain, unambiguous evidence of ozone depletion and increased skin cancer incidence. With respect to dioxin, as in public health in general, public policy is based on preventing adverse human health effects, not waiting for evidence that cancer or other adverse effects have already occurred.

By requiring an unrealistically high level of scientific proof, the Subcommittee has thrown a large roadblock in the path of sensible environmental regulation. Their obstructionism is aimed at reversing the "precautionary principle," which has been the basis for environmental and public health regulations for many decades.

The Subcommittee Has Obfuscated and Postponed Constructive Consideration of the Difficult Core Issues in Scientific and Environmental Policy

Congress and the Administration face policy decisions of staggering complexity in dealing with environmental problems and their economic, social and political implications. These decisions, which are inherently non-partisan, involve balancing important social goals such as environmental protection and economic growth. While these hearings could have provided a useful forum for exploring these critical issues, they instead featured a confusing array of scientific distortions, red herrings, false accusations, and vague charges of a breakdown in integrity. Rather than focusing on the real policy choices that need to be made, the Members were presented with a new view of "sound science" that is far different than is generally accepted by the scientific community.

The difficult environmental policy choices that this nation faces will not be made easier by the attacks on the scientific process launched by environmental critics, "skeptical" scientists or their sympathizers in Congress. By creating an illusory controversy over the "integrity" of science, these attacks have not only diverted attention from the real policy choices. They have also turned science into a political pawn, and demeaned its value as a unique and irreplaceable part of a rational decision making process.

The 104th Congress Was Unjustified in Cutting Funding for Environmental Research Programs

Well before this series of hearings was held, the Science Committee had been actively pursuing a legislative agenda that was unprecedented in its mistrust and hostility toward Federal environmental research programs. For example, the FY 96 Budget Resolution, which passed the House in May 1995, recommended a reduction of 20 percent

in FY 1996 for Federal environmental research and a steep decline in succeeding years.³⁸ The Science Committee also passed a series of authorization bills throughout 1995 to enact these reductions and to ensure that the Appropriations bills were constrained in their budget authority for environmental programs. Although the final appropriations bills were somewhat more moderate (an aggregate reduction of about 12%), compromise was achieved only after intense partisan fights, adverse public reaction, and direct threats of Presidential vetoes.

In addition to budget cuts, the Committee passed legislation to constrain NOAA's climate mission to natural phenomena only and to eliminate the environmental mission of NASA altogether.³⁹ All of these actions occurred prior to this series of hearings and without any actual public record.

It is ironic that the "skeptical" scientists called by the Majority did not in general endorse reductions in environmental R&D, particularly climate change R&D. Dr. Nierenberg, for example, noted:

"I have been advocating increased research in climate affairs ever since I have been in this business for reasons beyond global warming. Whether global warming is to escalate or not is a serious issue. Very little of what we are doing now in research is being wasted."⁴⁰

Other skeptic witnesses expressed similar sentiments, possibly because some of the most important issues highlighted in their arguments can be fully resolved only through continued research. These sentiments appear to be at odds with the views of the Subcommittee Chairman, who in April, 1995, characterized global change research as "money right down a rat hole".⁴¹

³⁸ AAAS, *AAAS Warns Budget Cuts Threaten Future Scientific Enterprise*, August 29, 1995; Hileman, Betty, "Administration Warns of Congress' Attack on Environmental Science," Chemical and Engineering News, (June 19, 1995) at 21; Johnson, Jeff, "Lean Times Ahead for Environmental R&D Funding," Environmental Science and Technology, Vol. 29, No. 4 (1995) at 180A.

³⁹ See for example House Report 104-237, Report accompanying H.R. 1815, National Oceanic and Atmospheric Administration Authorization Act of 1995, page 32,33. In addition, although later disputed, a legislative proposal was developed to alter the organic NASA Act which now spells out in section 102(d) "The expansion of human knowledge of the Earth and of phenomena in the atmosphere and space" as a fundamental agency mission. The proposal sought to remove the words "of the Earth".

⁴⁰ Global Climate Change Hearings, *supra*, at 239. Dr. Nierenberg's statement was echoed by Rep. Roemer, the Ranking Democratic Member, in his opening statement in the climate hearing: "Given the enormous costs and benefits (of global warming) it makes eminent sense to do the necessary research to find out as much as we can about global warming....The policy we have followed of targeting environmental research, belittling the possibility of any impacts and so on, will not make the problem go away, it will only put us on a slower track to understanding this problem".⁴⁰

⁴¹ Report of the Committee on Science on H.R. 3322, the Omnibus Civilian Science Authorization Act of 1996, 104th Cong., 2nd Sess., H. Rep. 104-550, Part 1 (April 24, 1996), at p 540.

The hearings developed no serious rationale for reductions in environmental R&D. For example, Chairman Rohrabacher claimed that EPA's Global Change Research Program could be eliminated because it wasn't really science:

"I am taking a look here out of \$111 million contract for global climate research EPA, and their account was used for brochures, posters, program logos, design for product awards, promotional pens, pencils, buttons, banners, displays, billboards, bus and train placards..."⁴²

Later, Ms. Rivers asked Mr. Gardiner of EPA about his budget for Global Change R&D:⁴³

"I have in front of me a list of programs that are being negatively affected by decisions here: The terrestrial carbon flux tracking program; developing predictive models; regional vulnerabilities; integrated assessment research; stratospheric ozone depletion. To your knowledge, are any of those programs engaging in any of the PR kinds of things that were mentioned by the chairman earlier today?"⁴⁴

After Mr. Gardiner responded negatively, Chairman Rohrabacher asserted that the projects listed by Ms. Rivers were fully funded and had not been cut. Notwithstanding this assertion, on July 21 1995, the Committee directed EPA to terminate its global climate change research program and reduced the budget for global change research from \$22.5 million to \$2.4 million.⁴⁵

If environmental R&D cuts were not supported by Committee oversight nor generally endorsed by hand-picked skeptic witnesses, why was the Committee was so aggressive in pursuing them? The answer may well lie in the Majority's desire to end the federal "monopoly" on research which some conservative critics have seen as the source of demands for environmental protection. Government scientists, such critics argue, have an incentive to exaggerate the importance of their research in order to keep Congressional funding.⁴⁶ The "real problem stems from the monopoly provision of science funding by

⁴² Global Climate Change Hearing. *supra.* at 53.

⁴³ Our Changing Planet—The FY 1996 U.S. Global Change Research Program (A supplement to the President's Fiscal Year 1996 Budget), p 140.

⁴⁴ Global Climate Change Hearing. *supra.* at 240.

⁴⁵ House Report 104-199, Report accompanying H.R. 1814 Environmental Research, Development and Demonstration Authorization Act of 1995, page 13 and 15. Note the confusion between the Global Change Research Program and the Climate Change Action Plan which does generate brochures and other public information items. As best can be determined, the former was cut in response to perceived abuse by the later.

⁴⁶ Dr. Patrick Michaels, who testified at the Global Change hearing, has written: "[A]gencies exist to perpetuate themselves ... The agency goals cannot be accomplished without the largesse of Congress.

the federal government.”⁴⁷ Since federally-funded research is tainted, the policy response is obvious – cut the budgets:

“Those who promote federally funded science as a solution to regulatory incompetence have a misplaced faith in bureaucrats. ... [P]ublic officials frequently use ‘junk science’ and fear-mongering to justify greater federal intervention. When bad science arouses the public’s fears, public officials stand ready to rescue us from the phony threat. ... In the world of policy-making, science is a servant to political interests, and when it doesn’t serve those interests it is easily cast aside ... The result of using science as a policy weapon will be the destruction of scientific credibility, not better regulation. In the long run, science will suffer because of federal involvement. ... More science funding is not the answer to America’s environmental policy problems.”⁴⁸

If severe reductions in Federal environmental R&D do occur, researchers will look to other avenues of support, such as industry. A key issue in this transformation will be the extent to which the traditional hallmarks of scientific integrity such as peer review and the free and open dissemination of information are maintained. Federally supported R&D, whatever faults it may possess, is generally open, peer-reviewed R&D. As the balance in support for environmental R&D shifts toward industry, there is a danger that external control over the quality or validity of what passes for science will disappear.

The Subcommittee Has Developed a New and Very Unhelpful Definition of Scientific Integrity

In an earlier discussion of Congress as a “science court”, we argued that the Committee routinely dismissed scientific viewpoints established through peer review in favor of untested assertions whose only value was that they supported a preferred policy outcome. The Committee’s approach in this regard was extremely troubling, but there is

Thus begins a peculiar back-scratching in which political patrons define a particular problem as The Most Important in History, and the agency responds by testifying that the end is near unless a few billion is spent pronto, and then it will probably be worse than we thought. Such issues and constituencies include the ozone hole (NASA/NSF/EPA), Global Warming (NASA/NSF/DOE/EPA), Sexually Transmitted Diseases (NIH/NSF), or Roughage Shortages (USDA/NIH) ... ” He called for increased industry funding of basic research so that “scientists will not longer be required to shill for the apocalypse in order to keep their jobs.” Michaels, Patrick, “Free Markets, Free Science,” *Washington Times* (Dec. 15, 1992). Similar sentiments were expressed by Dr. Stroup at the Ozone Hearing, where he testified that he didn’t expect any lab or agency which gets “better financed when the public and the Congress strongly have a concern” to admit that CFC’s are “not a problem.” Ozone Hearing, *supra*, at 265.

⁴⁷ Michaels, Patrick, “Forging Consensus: Climate Change and the United Nations” (George C. Marshall Institute, Washington D.C. 1996) at 24.

⁴⁸ Georgia, Paul, “When Science Yields to Subversion,” *Washington Times* (Nov. 22, 1995) [Mr. Georgia is a research analyst at the Competitive Enterprise Institute.]

an equally dangerous corollary – namely, the concept that scientific integrity is linked to the political popularity of the research itself.

The debates that have unfolded during the past several years over scientific integrity – including allegations of falsifying data, plagiarism, and fabrication of results – have presented formidable challenges to the scientific community and to sponsoring institutions. The conduct of science is inherently and intensely human and therefore dependent upon a staggeringly complex matrix of personal interactions. As such, it will remain vulnerable to human failings, and the issue of integrity will always be central to the scientific culture.

Scientists and scientific administrators are constantly grappling with these questions⁴⁹, along with conflict-of-interest issues related to the increasingly complex partnering arrangements involving domestic and foreign industries, universities, and domestic and foreign government agencies. Their discussions have been difficult and rancorous at times, but at no point has integrity been questioned simply because of the subject matter of the research in question. But that is exactly what transpired during this set of hearings.

It hardly seems coincidental that allegations concerning the conduct of research and the application of its results were directed only at research which supported policy options inimical to the Majority's point of view. The fact that none of the charges were remotely substantiated does not seem to have moderated either the rhetoric or the budgetary and policy choices selected by the Majority. The only logical conclusion that one can draw from these events is that certain types of research, and associated applications, were guilty of lapses of integrity simply because they led to unpopular conclusions. Were this attitude to become prevalent in the Congress, the stifling effect that it would have on free and open inquiry is at once obvious and frightening.

The Subcommittee Has Highlighted a New and Very Unhelpful Paradigm for Scientific Productivity

As described earlier, a pervasive theme in these hearings was that scientific truth is much more likely to be found at the fringes than in the scientific mainstream. Historical anecdotes in which the mainstream was in fact proven wrong and the dissenters correct were often cited to justify an air of contempt towards the peer review process, the scientific consensus and the traditional scientific method⁵⁰.

⁴⁹ The latest and one of the most extensive overviews of scientific integrity is currently being conducted by the Office of Science and Technology Policy in the White House.

⁵⁰ For the most part these anecdotes were inaccurate. For example Galileo's view was not aimed at upsetting mainstream science, it was aimed at the dogma established by the religious and political hierarchy. It can be argued that the global warming premise in fact represents the Galileo tradition since

As the scientific fringe has become institutionalized, professionalized, and lionized, it behooves us to take a closer look at its methods and beliefs. One finds that a fundamental difference between the traditional scientific establishment and the emerging “skeptical” establishment relates to their ultimate scientific goals. The former has traditionally emphasized the *generation of new knowledge* as a measure of productivity. That is, the collection of original data, construction of new mathematical techniques, and generation and validation of testable hypotheses have been the hallmarks of the traditional scientific community, and funding has been directly related to the ability to achieve these ends. On the other hand, the emerging culture profiled in these hearings emphasizes the *generation of new perspectives*. Productivity is measured on the ability to alter public opinion – through opinion pieces aimed not at their fellow scientists but at policy-makers, the media, and the general public – and funding flows accordingly.

If funding sources for environmental R&D do tilt increasingly away from government sources and toward private sources, there will be an increasing risk that this new paradigm for productivity will become widely established.

V. Recommendations for the Scientific Community and the Congress

Lessons for the Congress and An Agenda for the 105th Congress

The previous section of this report details a number of threats that these hearings posed to science, science policy, and environmental policy. With the convening of the 105th Congress, the Committee should resolve to be alert to these threats and to take seriously one of its most important functions – to educate other Members and the public about the function of the peer-review process in ensuring objective and high-quality science. The Committee should also educate policy-makers about the proper linkages between science and policy, neither imposing impossible burdens upon science, nor promoting for the Congress a role in arbitrating sound science.

A key lesson from these hearings relates less to what was discussed than to what was not discussed – how to deal with a range of value judgments that must be rationalized in a compatible policy framework. In particular, the climate change debate has illustrated three distinct viewpoints that represent equally valid value judgments regarding how science and policy can be rationalized. Each viewpoint in effect represents a differing judgment about one’s willingness to be wrong:

- 1) Someone who places the highest value on protecting the environment is more likely to be willing to act now to prevent harm and to take the chance that such actions will later turn out to have been unnecessary as further scientific information becomes available. In such a case, the actor is willing to risk incurring the costs of unnecessary action as the price for ensuring that harm is avoided. A

it aims to establish that mankind can in fact upset a major natural system such as the climate. It cannot be said that this has been a pre existing, generally accepted scientific belief.

high level of scientific certainty is not required for such a policy position. In other words, the value that one places on protecting the environment justifies the purchase of an "insurance policy" even if the probability of the event is uncertain.

2) On the other hand, one who places a higher value on economic issues, such as the dependency of the world's social and economic balance on fossil fuel availability, is more likely to wait and take the chance that the possible harm does not occur. This view implicitly states that it is more important to avoid the costs of unnecessary action than to prevent an uncertain harm. A high level of scientific certainty would be required under such a policy perspective to justify the economic costs. In effect, such a policy position states that it isn't worth it to purchase an insurance policy unless the risks are very certain and very high.

3) Finally, a third policy perspective that values "sustainability" posits that economic and environmental interests are compatible and can be accommodated within a common policy framework. Such a perspective attempts to value both economic and environmental goals and to find ways in which they both can be protected and preserved.

Although the hearings touched on these value judgments and policy issues only peripherally, the economic impact of phasing out chemical products that have demonstrably improved our quality of life, of transitioning to new energy sources that may upset the world's socio-political balance, and of confronting subtle health hazards that may have been overlooked in the past represent real concerns. The ethical and social issues associated with man's impact on the environment underlie some of the most important decisions we will make in this generation. The backdrop against which this debate will unfold is an emerging scientific capability to understand what was previously unintelligible, calculate what was previously beyond the state of the art, and generate new technologies for which the benefits can only be imagined.

These are not issues of integrity – that is a profoundly unjustified oversimplification. These are issues which the Congress, the public, and the world community must openly and honestly debate. At present there does not even exist a forum or mechanism for carrying out this debate. The 105th Congress will have an opportunity to contribute to this debate. The hearing process, despite its inherent drawbacks, remains a valuable avenue for promoting this discourse. It is recommended that the Committee address the need to more clearly frame the linkage between science and decision making in the public interest. Such hearings will be an enduring contribution to the policy process.

Financial Disclosure As an Imperative for Scientific Integrity

Throughout the hearings, various witnesses were represented as experts. Published reports have documented that some of these witnesses are funded at least in part by corporate interests with a stake in the outcome of the debate. Although this latter fact

does not necessarily affect the credibility of opinions expressed or the qualifications of the witnesses to make them, the Committee had little information at the time of these hearings with which to make such a judgment.

Emerging trends in science funding dictate that some safeguards be established to ensure the integrity of any scientific advice that is offered to Congress. First, expert witnesses should be required to provide a list of publications in their area of expertise, including both peer-reviewed and so-called "gray" publications. Secondly, sponsorship of scientific results and opinions offered to Congress is relevant. In these cases, the Committee should require, as a condition of presenting testimony, that witnesses provide a statement of financial support.

A New Responsibility for the Science Community

The scientific community must take seriously the challenge represented by the environmental critics by: (1) scrupulously ensuring that scientific assessments are open to all scientifically credible views; (2) educating policy-makers on the role of scientific peer review in ensuring integrity and quality, and (3) educating the public and policy-makers with clear and cogent responses to scientific and technical criticisms raised by "skeptical" scientists.

Over the past several years the nature of the skeptic has changed dramatically. No longer are scientific debates confined to the traditional academic seminars, professional scientific meetings, and technical journals. They have spilled over into the newspapers, talk shows, and other public fora. And the traditional burden of proof has shifted. Rather than the author proving that an idea is worthwhile and should be published, others will have the burden of proving that a published statement or idea is not meritorious. In short, peer review is no longer a passive activity for the science community.

The emerging responsibility for the scientific community that these trends suggest is based not on scientific imperative, but on civic duty. That is, the science community must directly and actively rebut any inaccurate, misleading, or distorted scientific claims which are made in the public arena.

All too often, the science community has taken the position that the charges of these skeptics are so lacking in legitimate scientific underpinning that they do not merit attention. As a result, there is an insufficient public record to dispute these charges. Lack of peer review, lack of participation in the scientific process, and lack of technically sound arguments do not, of themselves, disqualify the skeptics from commanding public and Congressional attention.

The findings of this report suggest that an adequate rebuttal to these charges simply cannot be made effectively within the rapid-fire political process in which Congressional oversight is carried out. The scientific community must develop new mechanisms to engage these arguments as a general and ongoing task, not one that is

carried out once or twice a year in a hearing. While this may disrupt or slow the traditional scientific process, it is seemingly an inevitable step. It is recognized that this requires an inordinate amount of time and energy on the part of the science community. There is little reward either scientifically or professionally. It is an unfortunate diversion. Yet this becomes an imperative in order to restructure the proper relationship between science and policy-making.

relying upon for key projections of global warming.¹⁰⁸ Essentially, he contended that the model response of the arctic region to increasing greenhouse gas and sulfate emissions provided a critical test of the validity of the model. Without the actual grid point data, Dr. Michaels argued, he was unable to provide critical review for the IPCC assessment.¹⁰⁹

Notwithstanding whether the request was reasonable by conventional standards or whether there was any real possibility that the analysis would have impacted the assessment, Dr. Michaels' argument raises a legitimate issue that posits the traditional rights of scientific investigators against the need for early and open access to research used in an international assessment.

From a science culture standpoint, tradition generally recognizes that originators of data must have sufficient time to explore their own data before releasing it especially, as was the case here, that the actual data was more extensive and detailed than that incorporated in the public paper.¹¹⁰ There is also a widely recognized standard that information gained in the peer review process should not be disclosed by the reviewer.

At the same time, the issue of sharing of environmental data is evolving rapidly in view of the perceived importance of global effects of global warming and ozone depletion. The international scientific assessment process is still a new and evolving process and such conflicts should not be unexpected. The issue is further complicated by a variety of cultural and legal differences in the views of various countries toward scientific data.

While the issue of access to data merits further discussion, Dr. Michaels' contention that there was a **legal** obligation for the United Kingdom Meteorological Office (UKMO), under whose auspices the model data were developed, to provide the data to him, is problematical. Dr. Michaels argued that, since the IPCC was presenting some results from the UKMO model, and U.S. taxpayer dollars in part supported the IPCC process, all such data should be treated as publicly available to U.S. researchers. Although a full review of this issue has not been carried out, it is not obvious that U.S. support for the administrative costs of the IPCC assessment process constitutes an adequate basis to assert public data rights with regard to research conducted by non-U.S. participants. U.S.

¹⁰⁸ "...I requested from the United Nations that they send me the data that went into that model, and I was denied. I wrote back and I said this is a horrible breach of scientific ethic. You must send me the data because I have been asked by the United Nations to review their own work. I was denied...Therefore, any policy statements or any impact statements that are made on these new, more reliable models are based on models that were not subject to review by those who were known to provide critical review in the process." Climate Change Hearing, *supra*, at p. 27.

¹⁰⁹ The Grid Point Data is the detailed, and voluminous, numerical output of the model. The data actually provided to the IPCC and normally exchanged by scientists is the refined version of this data which is interpretable in a physical way.

¹¹⁰ Subsequent to the Michaels request, the UKMO actually released this data to others collaborating in the research and the data are now intended to be available upon request.

Federal agencies as well as other countries have established data policies designed to ensure broad dissemination of knowledge while protecting the intellectual property rights of principal investigators. The proprietary nature of data generated by the U.K. model may be a fully valid concern¹¹¹.

From a purely scientific standpoint, Dr. Michaels request for UKMO data may be appropriate and access to such data could conceivably contribute to the review process. However, there is no evidence that the denial of such data was inconsistent with U.S. law or was part of an overall conspiracy to suppress dissenting views.

d) Have scientists ignored the benefits of global warming?

Critics of global climate change science have alleged that mainstream scientific efforts to quantify the impact of possible global warming invariably address only possible negative impacts of global warming, and consistently ignore potential benefits. Dr. Robert Watson, who co-chaired the IPCC Working Group II on impacts of global warming, testified on the efforts of that group to quantify impacts. The report, which was being finalized by the IPCC at the time of the Subcommittee's hearing, contained projections on the impacts of mid-range global warming estimate on terrestrial and aquatic ecosystems, hydrology and water resources management, food and fiber, human infrastructure, and human health. The Subcommittee chair and others were critical of such "dire predictions" and called them "misleading."¹¹²

In fact, the IPCC impact assessment does include consideration of benefits. The Summary for Policymakers prepared by the IPCC Working Group chaired by Dr. Watson, for example, discusses potential regional benefits of global warming for agriculture. The Summary notes that warmer temperatures and the fertilization effects of higher CO₂ levels would lead to increases in agricultural productivity in some areas, but that such increases would be offset in other areas. Overall, the Summary projects that current levels of agricultural production could probably be maintained.¹¹³ However, as the report also makes clear, all of the projections for regional changes are highly uncertain because of the very limited ability of models to assess changes from global warming at the regional scale.

Dr. Thomas Gale Moore testified on the general social and economic benefits realized in past societies by naturally-occurring warming episodes. While Dr. Moore's testimony was suggestive of ways that society could benefit from warmer temperatures, his testimony with respect to paleoclimatology and regional impacts of CO₂-induced climate

¹¹¹ Dr. Mitchell states that "the data does not belong to the IPCC, it belongs to Her Majesty's Government". Global Climate Change hearing, *supra*, at 1190.

¹¹² *Id.*, at 76.

¹¹³ International Panel on Climate Change, *Climate Change 1995: Impacts, Adaptations and Mitigation, Summary for Policymakers* (1995), p. 10.

change would certainly appear to go beyond his area of academic expertise in the economics of transportation regulation and appears to be at odds with the views of scientists with expertise in those areas.¹¹⁴

3. Science and Policy: Are Global Warming Models Adequate for Policy Making?

a.) "Uncertainty" vs. "Reliability"

As noted above, "skeptical" scientists have attacked GCMs as fatally flawed for their failure to replicate certain observed data. While the comparisons they make are not scientifically appropriate, the criticisms do raise a legitimate policy issue about reliance on models for predictions of the future which cannot, by their very nature, be verified until the future actually happens.

The arguments against models made by critics of global climate change science fundamentally confuse different concepts. Throughout the hearing, witnesses and Members utilized the terms "reliability", "uncertainty", and "accuracy" to describe the ability of models to characterize future global warming. In introducing the hearing topic the Chair stated that the Subcommittee would examine the "controversy over the reliability" of the computer models for climate change. Dr. Michaels, in characterizing older models which did not incorporate aerosols with newer models which do, uses the term "error" to describe model differences.

Clearly, a model known to be unreliable or erroneous would not likely be considered adequate to support policy decisions. A model known to be uncertain could well support policy decisions depending on the range of uncertainty and the consequences of erring either passively or actively. In this case, GCM models are believed to be accurate on a global scale but not definitive (i.e. uncertain) on regional scales. While "skeptics" focus on the potential of models to overestimate global warming, the models are in fact equally likely to underestimate global warming. As Dr. Mahlman noted, "...when you have made your best estimate of the way things are, it automatically says that

¹¹⁴ See statement of Dr. Thomas Gale Moore submitted for the record: Global Climate Change hearing, supra, at 147. As noted in the questions submitted for the record by Rep. George E. Brown, Jr., paleoclimatologists whose work Dr. Moore relied upon now question whether there was a global "Medieval Warm Period," casting doubt on Dr. Moore's effort to correlate social and economic development with past warming events. Global Climate Change Hearings, supra, at 1147. Moreover, some paleoclimatologists question the utility of comparing past naturally-occurring warming episodes with CO₂-forced climate change, which is likely to force temperature increases well beyond those realized in recorded human history. Such warmings may radically change precipitation patterns from those that occurred in past natural warming episodes, with obvious regional impacts on social and economic development. Crowley and North, *Climatology* (Oxford University Press), 1991, p. 89. In addition, it is questionable whether it is possible to quantify measures of "progress" for the purposes of correlating progress with past warming periods. For example, Rep. Rivers noted that other periods associated with "progress", such as the Roman Empire, the Renaissance, and the industrial revolution, all occurred in colder times. Global Climate Change Hearing, supra, at 241.

you do not know whether you are wrong on the high side or the low side.”¹¹⁵ Mr. Guerrero amplified this view saying “...that degree of uncertainty is expressed in the range. When scientists talk about a global surface temperature range by the year 2050 of one to 3.5 degrees Fahrenheit, embodied in that range is the sense that... it could be on the low side or on the high side.”¹¹⁶

Thus, it is clear that the science community has attempted to provide a measure of certainty associated with such assessments. This is, however, fundamentally a policy tool rather than a scientific imperative. The duty of the policy maker will be to ensure that a prudent policy accounts for consequences more severe, as well as less severe, than the central estimate.

b.) “Predictions” vs. “Projections”.

In another key line of questioning, Chairman Rohrabacher contrasted the use of the word “projection” used by the IPCC with the word “prediction” more popularly used in the media. Specifically he defined projections as being based on unvalidated assumptions, implying that these would thus be unsuitable for policy decisions. He said

“...I’ve been reading all kinds of predictions...that say...our coast lines are going to be inundated, that people are going to be dying of malaria. I mean these were dire predictions. After this testimony today, I am not leaving this hearing feeling that those predictions were justified.”¹¹⁷

In commenting on this issue, Dr. Mahlman submitted the following statement

“I do agree with Chairman Rohrabacher that the greenhouse gas projections are based on unvalidated assumptions about the future. They are based on unvalidated assumptions about, for example, population growth, policy decisions about fossil fuel use, maintenance of CFC phaseout protocols, and coal use in developing countries.”¹¹⁸

By their very nature, assumptions about the future cannot be validated. As the Chairman noted, assumptions about the future can turn out to be wrong.¹¹⁹ The policy question is whether it is better to try to make policy based on our best efforts to understand probable future trends, or simply to abdicate to random chance. Certainly, the

¹¹⁵ Global Climate Change hearings, *supra*. at 63.

¹¹⁶ *Id.*

¹¹⁷ *Id.*, at 76.

¹¹⁸ *Id.*, at 1075.

¹¹⁹ *Id.*, at 75.

widespread use of economic models for many policy purposes, despite their obvious limitations, suggests a consensus that efforts to understand the future effects of our actions are worthwhile. The fact that models must use unvalidated assumptions does not mean that models are an inherently **unreliable** policy tools, as implied by climate change critics.

In choosing terms to describe the ability of models to project the impact of increasing CO2 emissions, it must be acknowledged that the true answer is yet unknown. However without a completely analogous geophysical case to test the model, the "accuracy" of a model with respect to this projection cannot be defined unambiguously. In addition, as yet, fully comprehensive comparisons of model results with the historical temperature record cannot be made. Thus model "reliability" cannot be fully defined. The most appropriate way to describe the current state of models is to indicate the test cases that models have simulated and in so doing, to indicate their ability to meet these tests and the resulting shortcomings and qualifications to consider in evaluating model results¹²⁰. The current concept of uncertainty is intended to provide reasonable brackets around the range of results that encompass these shortcomings and qualifications.

This is a valid concept to support policy making as long as policy makers are cognizant of the sources of uncertainty, range of uncertainty, and consequences of making wrong decisions. In addition, the "uncertainty" in a model provides a rational basis for carrying out research to improve the models for policy purposes. Within their capabilities, GCM models can be useful as policy making tools, depending on value-based considerations concerning their findings.

4. Is there a scientific basis for the claim that humans are responsible for global warming?

The timing of this hearing was significant in that it took place immediately following the release by the IPCC of a scientific assessment stating for the first time that human activities have caused a discernible increase in global temperature over the past several decades. This finding is significant inasmuch as the natural variability of the Earth's climate, together with incomplete data on temperature measurements had, up to that time, frustrated attempts to extract a clear indication of human induced climate change from the record.

This state of affairs was characterized by Dr. Mahlman as follows

¹²⁰ Some of the tests that the science community rely on to assess the performance of models include: field and laboratory studies which allow the testing of short term chemical, physical and biogeochemical processes; day to day weather forecasting out to several days in advance; seasonal to inter-annual simulations out to one year in advance; biogeochemical cycles and atmospheric chemistry which are thought to be several years in cycle duration; and, paleoclimate studies which address century time scale processes comparable to the global warming phenomenon.

"Global surface warming over the past century (is) virtually certain. The observed warming in the surface temperature records of about one degree Fahrenheit cannot yet be unambiguously ascribed to greenhouse warming. However, no other hypothesis is nearly as credible."¹²¹

Thus, according to this view, there is no unequivocal "smoking gun" in the traditional sense for the gross aspects of the historical temperature record. Nonetheless, given the fact that there are no other credible hypotheses to explain the temperature increase over the past century, the consensus of the scientific community has settled on global warming as the likely cause.

Subsequent to these hearings, the IPCC finalized in the closing months of 1995 the conclusions of the fifth session of Working Group I dealing with the state of scientific consensus on global warming. Significantly, this assessment concluded that "the balance of evidence suggests a discernible human influence on global climate." This conclusion was based on pattern based work in which the "fingerprint" for a human induced effects was recognized. That is, some features of a human induced pattern of global change such as stratospheric cooling, Northern vs. Southern Hemisphere differences, and other large scale regional phenomena have been recognized to emerge with statistical significance over time. The striking similarity of modeled vs. observed patterns was deemed by the international scientific community to warrant a more conclusive finding than has been the case in past assessments.

It is also of significance that this more affirmative finding has been subject to a particularly focused attack by skeptics, not on substantive scientific grounds, but on procedural grounds. Specifically, the editorial process in which this new finding was developed has been criticized by the skeptics and the fossil fuel industry as flawed and failing to adequately incorporate contradictory statements. Although hearings on this issue have not yet been held by the Committee, a preliminary review of the documents in question fails to demonstrate anything other than customary editorial practice.

C. THE DIOXIN HEARING

The third hearing in the Scientific Integrity series was held on December 13, 1995. This hearing focused on the Environmental Protection Agency's (EPA) Dioxin Reassessment process. Two interrelated allegations of scientific misconduct were the focus of this third case study. First, they charged that the final chapter was composed without utilizing a peer review process to guarantee the scientific quality of the important summary chapter of the reassessment. Second, critics alleged that the final chapter was heavily slanted to exaggerate the risks of dioxin. In sum, the critics claimed that EPA had misused science to lay the groundwork for an unjustified regulatory assault on dioxin.

¹²¹ Global Climate Change hearings, *supra*. at 19.

In his opening statement Chairman Rohrabacher clearly stated the allegations which were the focus of the hearing:

"There is no question good science was produced in the EPA's document. The EPA issued an open call to the best scientists in the field to participate and many of them did. In many respects, the early stages of this process were a model of peer review and sound science and the EPA is to be commended for it. When it came time to write the critical portion of the Health Effects document, however, it appears the doors were closed and the EPA drew its own conclusions."¹²²

To make the case for EPA's systematic exaggeration of dioxin risks and abandonment of the peer review process, the majority relied upon the testimony of two witnesses, Dr. Michael Gough and Dr. Kay Jones. Although the report of the EPA's Science Advisory Board (SAB) and its peer review of the EPA assessment was a central focus of the hearing, the hearings included no witness to represent the Board.

The hearing resulted in no credible substantiation of any of the charges made by the Majority. As the analysis presented in the following sections will demonstrate, the dioxin reassessment process has been open and transparent. It afforded the public, affected industries, and scientists representing divergent views ample opportunities to participate in the development of the dioxin reassessment. Two of the authors of the Dioxin Reassessment, Dr. William Farland of the EPA and Dr. George Lucier of the National Institute of Environmental Health Sciences (NIEHS) testified at this hearing. They admitted to choosing options that were most protective to public health and the environment when presented with choices about how to fill in knowledge gaps about the biology of dioxin to estimate risk. However, no evidence was presented to substantiate the claim that these assumptions or interpretations were, in fact, not scientifically defensible.

EPA's Dioxin Reassessment

EPA completed two earlier risk assessments for dioxin in 1985 and 1988. The current reassessment of dioxin was initiated in 1991 by the Bush Administration.¹²³ In 1988, the SAB reviewed a draft exposure document and a draft health assessment document related to the determination of carcinogenicity of dioxin. At the time, the SAB recommended that EPA "follow up on this excellent start" by developing new methods to estimate human exposure to dioxin and to estimate the dose-response relationship for this chemical.¹²⁴ Reports of a study funded by the paper industry and of a conference

¹²²Opening statement of Chairman Dana Rohrabacher, Dioxin Reassessment Hearing, *supra*, at p. 5.

¹²³The CRS report: "Dioxin Reassessing the Risk" provides a summary of the history of the reassessment and the current issues associated with it. CRS 95-1059, Oct. 25, 1995.

¹²⁴EPA Science Advisory Board. "Resolution on the Use of Mathematical Models by EPA for Regulatory Assessment and Decision-Making." EPA-SAB-EC-90-003, 1989.

sponsored by the chlorine industry also played a role in initiating the reassessment. The paper industry's request that EPA reconsider the assumption of "no safe level of dioxin" as the basis for setting regulatory standards may also have contributed to the Agency's decision to initiate the reassessment.¹²⁵ The reassessment is not expected to be completed until sometime next year.

1. Did EPA Abandon the Use of the Peer Review Process in Developing the Dioxin Risk Characterization?

Chairman Rohrabacher's comment to the effect that EPA had closed the doors and drew its own conclusions when they composed the risk characterization portion of the health effects assessment echoed criticisms of EPA made in the press and by some in the scientific community. Critics charged that EPA had written the risk characterization chapter (Chapter 9) without input from outside scientists and had submitted that chapter to the Science Advisory Board for review rather than bringing together a panel of outside experts for review as they had with each of the other chapters. Implicit in the Chairman's comment was a charge that EPA had deliberately evaded peer review on Chapter 9.

The charge, however, is incorrect. While EPA's process of drafting the risk characterization chapter was different for the reasons discussed below, it was always EPA's intention to have the Science Advisory Board conduct the peer review of the entire report, including the risk characterization chapter.

The first eight chapters of the Dioxin health reassessment summarized the state of scientific knowledge on different aspects of dioxin. Each of these chapters was drafted by a team of authors which consisted of between 2 and 14 authors, at least one of whom was an EPA scientist. In the case of chapters 6 and 7, the outside author was also a government scientist but not from EPA. Of the thirty authors who worked on Chapters 1-8, sixteen were scientists from outside the government. The majority of the government scientists who authored these chapters were from the EPA, two scientists were from different institutes of the National Institutes of Health. EPA also convened an outside panel of thirteen scientists to review those eight chapters. Chapter 7 received additional review by a second panel of eight scientists. Of the twenty reviewers selected, two were government scientists. Neither were from the EPA.

The procedure followed for drafting and reviewing the risk characterization chapter (Chapter nine) of the reassessment differed from that of the other eight chapters of

¹²⁵Bailey, Jeff. "Dueling Studies: How Two Industries Created a Fresh Spin on the Dioxin Debate," Wall Street Journal (Feb. 20, 1992.) The article states: "...paper company executives called on Mr. Reilly in January 1991 with their version of the Banbury meeting. "Despite the emergence of a consensus in the international health community that the risks of dioxin have been seriously overestimated, none of these developments has received positive acknowledgment by Agency staff," they said in a letter to Mr. Reilly recapping the meeting. They asked again for a reassessment of the EPA's strict dioxin regulations-- and suggested "accelerated efforts."

the document. The risk characterization chapter¹²⁶ was prepared by Dr. William Farland of EPA, and was not reviewed by a panel of government and non-governmental scientists as the previous eight chapters were. However, Chapter Nine was reviewed by an interagency panel of scientists which included representatives from five Departments and three sections of the Executive Office of the President prior to its review by the SAB.¹²⁷

Following this review, Chapter Nine was made public in September, 1994, and EPA solicited public comments on the report for 120 days.¹²⁸ In addition, the agency held eight public meetings in December 1994 to receive oral comments on the document. A summary of the risk characterization conclusions were also presented by Agency staff at scientific conferences early in 1995 including meetings of the Society of Toxicologists and the American Association of Cancer Research. The entire report, including Chapter Nine, was submitted to the EPA SAB for review in December, 1994. The SAB held a public meeting to receive additional comments and draft their findings in May, 1995.

Clearly, the risk characterization document was not a closely kept secret from the public or the scientific community prior to its submission to the SAB in December 1994. In sum, the risk characterization chapter underwent extensive scientific review inside EPA and by the SAB.

EPA created a different drafting and review process for the risk characterization chapter because the chapter had a different purpose than the first eight chapters which summarized scientific knowledge on hazard identification, dose-response factors, and exposure information. The task of a risk characterization is to integrate all of the preceding information to provide an estimate of the risk to humans from actual exposure to the chemical, and a discussion of uncertainties and assumptions. As has been noted by the National Academy of Sciences, risk characterization often involves the use of scientific assumptions in the face of scientific uncertainty.¹²⁹ The choice of such assumptions is

¹²⁶Chapter 9, "Risk Characterization of 2,3,7,8-Tetrachlorodibenzo-p-Dioxin (TCDD) and Related Compounds" U.S. EPA, Office of Research and Development, Washington, DC. EPA/600/BP-92/001c, August 1994, External Review Draft

¹²⁷ The five departments were the Department of Agriculture, the Department of Defense, the Department of Health and Human Services, the Department of Labor, and the Department of Veterans Affairs. The sections of the EOP included the Office of Science and Technology Policy, the Council of Economic Advisors, and the Domestic Policy Council

¹²⁸The process of developing and releasing the risk characterization chapter was laid out by Dr. Farland for the Science Advisory Board at the May meeting. His full description of the process is included in the transcript of the May 1995 meeting

¹²⁹ In its 1983 report, the National Research Council discussed the use of "inference guidelines," which it defined as "an explicit statement of a predetermined choice among alternative methods (inference options) that might be used to infer human risk from data that are not fully adequate or are not drawn directly from human experience." An example of such an inference guideline would be the choice of mathematical models to estimate the effects of low doses on the basis of high-dose exposures. National Research

guided in part by policy considerations and therefore are appropriately made by the agency, not by outside scientists. In addition, while risk characterizations do not make risk management recommendations, the risk characterization is written in the context of policy decisions to be made by the risk managers, a task also appropriately left to the agency.

Critics seem to have equated the fact that the review process was different for the risk characterization chapter with a conclusion that the process was inadequate. Similarly, the Chairman apparently did not believe review by the SAB constituted an outside scientific review. Following Dr. Farland's explanation of the review process, Chairman Rohrabacher asked: "... but your contention is that this is your strategy all along...not to have the outside peer review for the final conclusions?"¹³⁰ Dr. Farland reiterated that the SAB review was the outside peer review. He further explained that one of the reasons for asking the SAB to review the risk characterization document was because of the independent nature of the Board. "... one of the issues I think is important here, Mr. Chairman, is that when we [EPA] do these peer panels, we actually decide who the peer reviewers are going to be, and the SAB process is an independent process."¹³¹

In the case of a review done by the SAB, EPA does not select the reviewers. The reviewers are selected by the SAB. It is ironic, that in an attempt to subject their risk characterization to a more independent process for review, the Agency was accused of attempting to avoid the peer review process.

The result of the peer review by the SAB has not been a simple rubber-stamping of the Agency's efforts, a result that would have been expected if the review process had failed or been a whitewash. Plans for revision of the document were underway at the time of the hearing. The revision of the draft is now proceeding with input from scientists both inside and outside the government, and it will be resubmitted to the SAB for a second review when the revision is complete. Contrary to the picture the Majority tried to paint, the dioxin reassessment process has been an extraordinarily open and transparent one and has included scientists with a variety of expertise and opinion. The hearing record provides no evidence that the EPA attempted to avoid outside criticism and review of its work or that the process followed was inadequate to ensure that Chapter Nine will be a scientifically-based risk characterization.

2. Did EPA Selectively Interpret Scientific Evidence to Exaggerate the Risk of Dioxin?

Council, Risk Assessment in the Federal Government: Managing the Process (National Academy Press, Washington, D.C. 1983) at 4.

¹³⁰"Dioxin Reassessment Hearing, *supra*, at p. 64.

¹³¹*Id*

There is a long history of allegations from interest groups on all sides that the health assessment of dioxin has been dominated more by politics than by science. Interest groups have accused government agencies of either exaggerating or underestimating the risks to human health of exposure to this chemical. Sen. Tom Daschle (SD) noted as much in his statement submitted to the hearing record.

- "For too long, the process of assessing the health effects of dioxin has been politicized. Charges of government and chemical manufacturer attempts to hide or control scientific information about the harmful effects of dioxin began over a decade ago, and there is much evidence to support those charges."¹³²

His comments reflect views similar to those held by many in the Vietnam veterans' and environmental community. Chairman Rohrabacher reflected the opposite view, that the risks of dioxin have been greatly exaggerated.

Linear vs. Non-Linear Models: Science or Policy?

One of the most frequently cited examples used to demonstrate EPA's systematic exaggeration of risk is its use of linear dose-response models to relate exposure to a toxin to the probability of experiencing adverse health effects.¹³³ There are two common models used to define the relationship between exposure to a toxin (dose) and the probability of experiencing an adverse health effect as a result of that exposure (response). One is a linear model, the other is a non-linear, threshold model.

In the case of the linear model, there is no dose at which a person would not experience an adverse health effect. In the case of the non-linear, threshold model, there are no adverse health effects at low doses, but at some point the amount of the dose reaches a threshold which triggers an adverse effect. The choice of which model to use has significant implications for risk management. If the exact nature of the dose-response curve is unknown (which is usually the case), the use of a linear model results in greater protection from potentially adverse health effects. Therefore, the selection of a dose-response model is a scientific issue that has profound policy implications. Because it is charged with protecting public health and environmental quality, EPA errs on the side of caution and currently uses a linear dose-response model to set regulatory limits for dioxin.

¹³²Testimony of Sen. Tom Daschle submitted to the Dec. 13, 1995 hearing record.

¹³³Other EPA risk assessment practices have also been criticized as unduly inflating risk estimates. One is the use of high-dose, animal experiments to determine low-dose, human responses. The other is EPA's failure to consider epidemiological studies that indicate no adverse health effects from exposure to toxins. These two issues were raised at the hearing but did not generate as lengthy an exchange between the witnesses. These issues did arise at the SAB review meeting and there were lengthy discussions of these issues as they pertain to the dioxin reassessment. See, generally, EPA Science Advisory Board, Transcript of Meeting of Dioxin Health and Exposure Review Panels, May 1995.

There was an extensive discussion of this topic at this hearing. However, testimony presented at the hearing did little to resolve the issue of which is the most appropriate model. There are gaps in knowledge about the mechanistic biology of dioxin which do not allow either type of model to be definitively selected or ruled out. Critics have claimed that such models are "unproven," and therefore should not be used. Under a standard requiring that human data display the identical relationship between exposure and response displayed by the model, this criticism is valid. Therefore, neither the linear nor the non-linear, threshold model should be used because neither is "proven" for low-level exposures. However, in the area of human health, obtaining empirical proof of harm would present considerable ethical dilemmas. Scientists cannot and would not conduct experiments on humans to derive the precise dose-response relationship because it would require deliberately exposing human subjects, including children, to toxic substances over long time periods. Models are chosen precisely to avoid this type of experimentation. Although the models are not proven that does not mean they are **untested**. Models are continuously re-evaluated as new data become available. The relevant question is not whether a model has been proven, but whether its description of the system is scientifically defensible. Both the linear and non-linear threshold models meet this criteria.

Dr. Gough indicated his belief that a non-linear, dose-response model was more appropriate. He testified that "...if you consider the biology that is involved in dioxin, it seems inappropriate now to use this model [linear] which associates ... a direct relationship between exposure and risk."¹³⁴ The aspect of dioxin biology Dr. Gough refers to is the mediation of dioxin response by a specific receptor in cells, the Ah receptor.¹³⁵ However, both Dr. Farland and Dr. Lucier disagreed with Dr. Gough's assertion that a receptor-mediated response indicated that the use of a non-linear, threshold model was more appropriate. They both defended the use of a linear model, citing the fact that dioxin accumulates in human fat tissues which assures that no one receives a zero-level exposure. Dr. Farland explained:

"...our assumption is that because of the biology that is available on dioxin and because we are adding to a background of dioxin that we all carry around, ... an incremental exposure to dioxin should be modeled in a linear way, not using a default, but modeled in a linear way."¹³⁶

Dr. Lucier also indicated that "... receptor modeling doesn't necessarily imply any particular shape to the dose-response curve. No dose-response can be ruled in or out based solely on the knowledge that a response is receptor-mediated."¹³⁷

¹³⁴Dioxin Reassessment Hearing, *supra*, at 65. When a linear model is used, there is no dosage that does not produce a negative effect on human health.

¹³⁵The Ah receptor is a receptor in cells associated with protecting cells from the effects of toxins. Dioxin has been shown to bind to this receptor.

¹³⁶Dioxin Reassessment Hearing, *supra*, at 66.

¹³⁷*Id.* at 67

Dr. Gough stated that his appreciation for Dr. Farland's clarification about the use of a linear model, but he remained unpersuaded and he characterized Dr. Farland's position as exhibiting "an incredible bias." He further indicated, "Most people regard the idea that it's a linear response to be very, very improbable;..."¹³⁸

The SAB report on the dioxin reassessment provided no definitive guidance to the choice of model. Reviewers did indicate that a non-linear, threshold model would also fit the available scientific data, but did not invalidate the EPA's use of a linear model as unscientific. The report noted:

"EPA must describe its analysis in sufficient detail to allow the reader to understand how EPA arrived at its preferred model and how robust those results are -- i.e., to what extent would other assumptions be reasonable, adequately fit the data, and lead to different levels of risk. ... This is the most important issue in the dose response modeling and should be thoroughly explored in EPA's analysis."¹³⁹

Although in this hearing the debate over linear vs. non-linear threshold models was conducted as a scientific discussion, this debate is a lively one in the regulatory arena as well. As previously stated, the choice of model has substantial policy implications. Dr. Gough noted this in a chapter he co-authored on estimating cancer risks from dioxin.

"Manufacturers, faced with reducing exposures to carcinogens to comply with regulatory limits, would favor the use of threshold models for assessing the risks from nongenotoxic compounds. Similarly, people faced with cleaning up waste sites would welcome the lower risk levels predicted from threshold models. Alternately, people who are convinced of the risk of environmental carcinogens are likely to oppose any relaxation of use of the nonthreshold models."¹⁴⁰

The tendency for industry and environmental groups to favor one or the other model has been reported as well:

"Paper and chlorine makers say dioxin has no adverse human health effects below a certain threshold, ... Of course environmental groups and some plaintiff's lawyers argue the opposite side of the dioxin issue --that it's dangerous even at low levels of exposure..."¹⁴¹

¹³⁸Id. at 80.

¹³⁹SAB Draft Report p. 76 and 77.

¹⁴⁰Gough, M and Turnbull, D. "Estimating the Cancer Risks of Exposure to 2,3,7,8-Tetrachlorodibenzo-p-Dioxin" Chapter 7 In: Health Effects of Municipal Waste Incineration, p. 142.

¹⁴¹Bailey, supra note 125.

Others have claimed, as Dr. Gough did in this hearing, that most scientists do not subscribe to the use of a linear model for dioxin. The chemical industry has reportedly tried to portray the acceptance of the non-linear, threshold model as an emerging scientific consensus based upon their characterization of the results of a meeting of dioxin researchers they sponsored in 1990.

"...the Chlorine Institute also said the scientists had agreed that the receptor acts as a sort of biological switch--one that can't be thrown unless dioxin exposure reaches a certain level, or threshold. ... The Institute's statements, however, didn't accurately reflect what had happened at the conference. There had been discussion about the possibility...of such a threshold, but no general agreement that one exists. ...subsequent research by Dr. Lucier indicates that for two of three important yardsticks...there is no threshold at all..."¹⁴²

The entire discussion about dose-response models was initiated when Chairman Rohrabacher asked if Dr. Gough had any questions for Dr. Farland.¹⁴³ While everyone can understand the policy argument over the selection of a dose-response model, the scientific argument is difficult for lay persons to follow or participate in. When Dr. Gough had finished with his question about the use of the linear dose-response model, Chairman Rohrabacher said:

"Now, the reason why I had Dr. Gough ask that question is because I am sure there are people in the scientific community that understand that question. I don't know how many people on this panel understand it or this committee understand it, but I am sure it's an important question, and we need to make sure that people are on the record on even issues that the committee doesn't understand."¹⁴⁴

What the Chairman's statement illustrates is the difficulty of having Members of Congress preside over a scientific debate. Senator Rockefeller noted as much in a recent Senate Hearing on Agent Orange.¹⁴⁵

¹⁴² Id

¹⁴³ Dioxin Reassessment hearings, *supra*, at p. 64. Dr. Gough responded that he had a couple of questions for Dr. Farland. "I was surprised when you said they were minor, because one of the criticisms of Chapter 9 is its reliance on the default assumption of a linearized, no-threshold model for carcinogenicity whereas chapters 1 through 7 develop a great deal of information about receptors. And at least a majority of the people on the committee would think that the linearized multistage dose-response model is not appropriate for a receptor-mediated toxic event. And it seems to me that since this is a deviation from long-standing policy within the agency, this is not a minor change."

¹⁴⁴ Dioxin Reassessment Hearing, *supra*, at 64.

¹⁴⁵ Opening Statement of Senator John D. Rockefeller IV, September 19, 1996, Hearing of the Senate Committee on Veterans' Affairs "Implementation of Public Law 102-4: The Agent Orange Act of 1991."

"... what I believe even more is that a political forum is particularly ill-suited to analyze the correctness of such scientific undertakings.

"Several years ago, some very learned men urged that we should exercise extreme caution before the Senate should step into such issues; they warned that involving the Senate in Agent Orange decisionmaking would 'place difficult scientific and epidemiological questions in a political forum for resolution at a time when these questions are being revisited in the forum originally intended by the Congress. Irrespective of our individual views on the scientific merits of the case, we believe these are questions the Senate is poorly qualified to resolve.'"¹⁴⁶

As the National Academy of Sciences and other experts in risk assessment have repeatedly noted, the development of risk assessments involves the use of both scientific facts and scientific judgments. The use of models is required to describe the complex system interactions which are the focus of risk assessments because we do not have complete, scientific information. The use of models unquestionably has policy implications, as we saw in this hearing in the debate over linear vs. non-linear, threshold models. The Republican demand for empirical proof requires eliminating the use of assumptions and models since, by definition, they are used when definitive scientific information is lacking. Without such assumptions, it would be impossible to conduct risk assessments. By adhering to a rigid empirical standard while simultaneously insisting that risk assessments be conducted as a precondition for issuing regulations,¹⁴⁷ the Republicans have created a definition of "sound science" which would never permit agencies to regulate or demands an approach to human testing our society has judged to be unethical.

EPA and other regulatory agencies have been accused of using "biased" assumptions.¹⁴⁸ However, *all* assumptions have a bias. If an agency chooses a threshold model, it chooses to err on the side of under-regulating and under-protecting. If an agency chooses a linear model, it chooses to err on the side of over-protecting and over-regulating. The question is not whether an agency should use assumptions, but which assumptions it should use. The answer to that question is obviously one that depends on subjective value judgments and policy perspectives, not on science. As Dr. David Ozonoff, one of the reviewers on the SAB health assessment panel, stated:

¹⁴⁶ The quotation used by Sen. Rockefeller is from the Additional Views of Senators Murkowski, Simpson, and Thurmond on the proposed Agent Orange Act, July 24, 1989, Senate Rept. 101-82, p. 60.

¹⁴⁷ H.R. 9 and other regulatory reform proposals considered in the 104th Congress all required the use of risk assessments and cost-benefit analyses by federal agencies prior to the issuance of regulations.

¹⁴⁸ See, e.g., debate on H.R. 9, the Job Creation and Wage Enhancement Act of 1995; Report of the Committee on Science on H.R. 9, 104th Cong., 1st Sess., H. Rep. 104-33, Part 2 (Dissenting Views, p. 249) "Statistically unbiased estimates simply do not exist for the models that are generally employed in cancer risk assessment...Further, as noted by the National Research Council, all assumptions have inherent biases")

"... This is a health assessment. Assessment carries with it some implication and connotation of judgment, not just a literature review and , you know, a listing of some people think this and some people think that, on the one hand, but on the other hand. ... I'm troubled by the discussion here because people have a variety of ways to interpret this, and I take that as a given. ... It's obvious that there's disagreement around this table, and when we talk about the public mis-interpreting what's said in this document, all we have to listen to is the amount of disagreement about interpretation around this table to see that it's not just the public that's got this problem."¹⁴⁹

The hearing revealed no conspiracy on the part of EPA scientists to manipulate scientific information to exaggerate the risk of dioxin. However, the hearing did reveal the policy preference of the EPA versus that of its critics. There are both legitimate scientific debates and policy debates about dioxin, but these should not be confused. Science will never provide all the definitive, detailed knowledge necessary to make the regulatory policy decisions about dioxin a purely objective, scientific one. Members of Congress will continue to have to make these policy choices in an environment of scientific uncertainty.

¹⁴⁹Dr. David Ozonoff, SAB Health Panel, May 1995 meeting.

APPENDIX

Case Studies: Ozone Depletion, Climate Change, and Dioxin Risks

A Report to George E. Brown, Jr.
Ranking Democratic Member, Committee on Science
prepared by the Democratic Staff
of the Committee on Science

A. The Ozone Hearing

The first of the "case study" hearings, relating to the 1992 Bush Administration decision to accelerate the phase-out of chlorofluorocarbons (CFCs) and other ozone-depleting substances, was held on September 20, 1995.

In his opening statement, the Chairman questioned whether the public and the Congress were "getting objective science from our regulatory agencies" and whether scientists with "unconventional views" were being "shut out of the process." He charged that government officials had portrayed the ozone depletion issue in "largely emotional terms" and decried the use of "scare tactics" designed to "intimidate and repress rational discussion." As an example, he cited a 1992 Senate floor statement made by then-Senator Gore concerning a just-released NASA study finding possible ozone depletion in the Arctic and portions of the northern United States. Dismissing Senator Gore's statement as "bunk" and "scare-mongering," the Chairman concluded that "This whole episode ... turned out to be another basically 'the-sky-is-falling cry from an American Chicken Little...' He accused the 'scare mongers' of 'stamped[ing] Congress and the President of the United States' into phasing out CFCs.

Other witnesses quickly picked up similar themes. Rep. John T. Doolittle (R-CA) complained, "Instead of responding with scientific facts, some NASA scientists, EPA officials, and extreme environmental organizations have forced this imminent CFC phase-out on the American people using fear and doomsaying."¹ He went on, "[W]e've been in an era of pseudo-science where dire consequences are portrayed in order to achieve a certain political objective."² Dr. Fred Singer, one of the scientists called by the majority, testified that "There are cases where the science was twisted, shaped, in order to gain certain ideological objectives. There was never a case where the actual facts were, shall we say, misstated, where there was actual wrong information presented. But it was

¹ Ozone Hearing, *supra*, at 15.

² *Id.* at 19.

presented in such a way as to give a misleading impression. You .. are being today misled, bamboozled, and otherwise manipulated.”³

Witnesses also charged that dissenting scientific views had been suppressed. Rep. Doolittle, for example, stated that “There’s politics within the scientific community, where they’re all intimidated to speak out once someone has staked out a position.”⁴ Dr. Singer noted, “The problem is that there are many, many scientists who do not speak up. And the reason they do not speak up is because they do not want to lose their research funding.”⁵ Dr. Singer also claimed that his work had been ignored.⁶ Dr. Sallie Baliunas, another scientist called by the majority, also alleged that she had been badgered by an environmental group and told by federal officials not to submit her research for funding grants.⁷

As discussed below, however, the hearing record is in fact devoid of any credible substantiation for these serious allegations. To the contrary, the science upon which the CFC ban was based is sound. In developing an assessment of ozone depletion science for policymakers, hundreds of scientists went through an extensive, rigorous, and open international scientific peer review process. The assessment drew on hundreds of articles published in the peer-reviewed scientific literature and represents a comprehensive and objective analysis of the scientific knowledge on ozone depletion. Contrary to the witnesses’ claims, the scientific assessment process was a model of scientific integrity and an excellent example of the use of sound science in policymaking.

Did Federal Scientists Exaggerate the Risks of Ozone Depletion?

1. The NASA Press Release Allegations

Both the Subcommittee Chairman and Rep. Doolittle charged during the hearing that a flawed NASA study was used to “stampede” Congress and the President in 1992 to accelerate the phase-out of CFCs. The story is a common staple in conservative literature.⁸ The story goes that NASA, in a public relations effort to build political support

³ *Id.* at 50.

⁴ *Id.* at 19.

⁵ *Id.* at 168.

⁶ *Id.* at 167.

⁷ *Id.* at 169.

⁸ See, e.g. “The Ozone Scare,” *Insight* April 6, 1992, (vol 8, No. 14) p 6-35 [a publication of the Washington Times]; Smith, Kenneth, “Whispering the Ozone Hole Truth”, *Washington Times*, May 18, 1992; Michaels, Patrick, “NASA, Gore, Environment, Lift-off”, *Washington Times*, February 21, 1992, Page F1; Ronald Bailey, *Eco-Scam: The False Prophets of Ecological Apocalypse*, 1993, pp. 119-120, (Competitive Enterprise Institute); Bast et al, *Eco-Sanity: A Common Sense Guide to Environmentalism*, 1994 (The Heartland

for a bigger budget, prematurely rushed out a press release announcing evidence of an Arctic ozone hole covering portions of populated areas of the United States.⁹ Fanned by intense media coverage, Congress and the White House immediately accelerated the CFC phaseout. However, the story continues, the NASA report turned out to be wrong, and NASA quietly admitted that there had in fact been no ozone hole -- and therefore no basis for accelerating the CFC phaseout. This story has long been cited by critics as a prime example of "policy by press release."¹⁰

The story, however, is completely false. There was nothing wrong with the scientific findings announced in NASA's press release; there was no retraction. Indeed,

Institute), p 67; Paul Craig Roberts, "Quietly, Now, Let's Rethink the Ozone Apocalypse," *Business Week*, June 19, 1995.

Much of the initial pseudo-scientific skepticism about the depletion of the ozone layer by CFCs comes from Rogelio Maduro, a bachelor of science in geology, and associate editor of *21st Century Science and Technology*, a publication of the Lyndon LaRouche organization. Maduro's book, *The Holes in the Ozone Scare: The Scientific Evidence that the Sky Isn't Falling*, was cited by Dixy Lee Ray in her book, *Trashing the Planet*, and by radio talk show commentator Rush Limbaugh. The numerous scientific errors in Maduro's book have been well documented. See, e.g. "The Ozone Backlash," *Science*, Vol. 260, 11 June 1993, p 1580-1583; F. Sherwood Rowland, "The Need for Scientific Communication with the Public," *Science*, Vol 260, 11 June 1993, p 1571-1576.

⁹ Critics have claimed that concern about shrinking budgets and declining public support for the space program in the post Cold War era was the motivating factor in NASA's "premature" release of the study to support its budget request. See, e.g. Morrison, Micah, "The Ozone Scare," *Insight*, Vol 8, No. 14, April 6, 1992, p. 13, 34; Michaels, Patrick, "NASA, Gore, environment, liftoff," *Washington Times*, Feb. 21, 1992 (F-2). As Rush Limbaugh explained, "They always want more funding, and today that means government funding. What could be more natural than for ... [NASA], with the space program winding down, to say that because we have this unusual amount of chlorine in the atmosphere we need funding? Obviously, we have to research this. But first we have to 'inform' the public." Quoted from Taubes, "The Ozone Backlash," *Science*, Vol 260, p 1581, (June 11 1993).

The argument that the press release was rushed to influence NASA's budget is not plausible. While the President's budget is submitted to Congress in February, the budget process lasts virtually all year long. The House does not actually begin voting on Appropriation bills until May at the earliest, and bills are often not completed until September or longer -- well after NASA had issued the second press release on its ozone study, as discussed in the text. Indeed, it is difficult to find a time of year when any press release could not be accused of being an attempt to build public support for a budget request. A release in the fall could be accused of attempting to influence the OMB preparation of the following year's budget; a release in the winter or spring could be accused of influencing Congressional mark-ups; and a release in the summer can be accused of attempting to influence Congressional floor debate.

In any event, attempting to bolster NASA's budget by publicizing its ozone research is like trying to lighten an airplane by emptying the ashtrays. Far and away, the largest part of NASA's budget deals with the space shuttle (\$5.5 billion) and the space station (\$2.1 billion); NASA's ozone research is a relatively small program in the agency.

¹⁰ See, e.g., testimony of Dr. Fred Singer, Ozone Hearing, *supra*, at 181, lamenting the "deplorable way in which policy is being made by press release."

NASA's predictions of future Arctic stratospheric ozone depletion has proved to be correct. Further, NASA's press release had little, if any, relation to the decision, supported by both the Bush Administration and the chemical industry, to accelerate the CFC phaseout.

a.) Was NASA's science wrong?

In early February, 1992, NASA issued a press release announcing that researchers had measured record high levels of the chemical precursors of stratospheric ozone depletion in the Arctic region.¹¹ NASA's key finding -- that levels of stratospheric chlorine monoxide were unusually high -- was confirmed by multiple measurement techniques. Under the right meteorological conditions, such chemicals could cause rapid ozone depletion in the Arctic region, reaching as far south as northern portions of the United States. But the NASA release also cautioned that the actual amount of ozone loss would depend on "how long these chemical perturbations persist." Nevertheless, the study raises "concern that significant ozone loss will occur during any given winter over the Arctic in the next ten years." In April, at the conclusion of the research program, NASA issued a second press release announcing that because stratospheric temperatures had remained above normal, the expected extent of ozone depletion had failed to materialize.¹² But nothing in this later release changed NASA's key initial finding that the Arctic was chemically primed for rapid ozone depletion under the right meteorological conditions.¹³

More significantly, NASA's concern about the potential for Arctic ozone depletion has turned out to be well-founded. In the following winter of 1992-1993, stratospheric temperatures remained low, with a resulting 20 percent decline in ozone in the lower Arctic stratosphere.¹⁴ Similar levels of ozone depletion were detected in the winters of

¹¹ NASA News, "Ozone Depletion a Possibility over Northern Populated Areas", (Feb. 3, 1992).

¹² NASA News, "NASA Spacecraft Finds Large Arctic Ozone Depletion Averted." (Apr. 30, 1992).

¹³ A number of media stories erroneously reported that NASA had actually found an arctic ozone hole. Some critics seem to blame scientists for the mistakes and excesses of the media. Scientists, they argue, hope that the media will generate exaggerated horror stories that will build public support for their programs. For example, on this particular NASA press release, Dr. Patrick Michaels has written, "Do you really believe that an organization that sent men to the moon didn't precalculate the downstream trajectory of a press release?" Michaels, Patrick, "NASA, Gore, environment, lift-off," Washington Times, Feb 21, 1992 (F-2). Similarly, Dr. Michaels testified in the Global Change hearings that scientists knew that various "projections" of adverse impacts of climate change, such as sea level change, would be turned into apocalyptic "predictions" by the media. "[E]verybody who wrote the word 'projection' knew that it would be turned into the word 'prediction.' I don't think people are that naïve." Global Change Hearings, supra, at 76.

¹⁴ "Chemical Depletion of Ozone in the Arctic Lower Stratosphere during Winter 1992-1993," G.L. Manney et al, Nature 370, 429-434, 11 August 1994.

Satellite 'Thermometers' Are Quite Accurate

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Satellite 'Thermometers' Are Quite Accurate

Lower tropospheric temperatures from satellites have excellent long-term stability as demonstrated by comparisons with independent atmospheric measurements from weather balloons. These results contradict Hurrell and Trenberth (1997) who claimed the satellite data have significant discontinuities.

How does one measure the temperature of the atmospheric layer we label as the lower troposphere (surface to 7 km)?

Two direct and independent methods are used today: (1) balloon-borne instrument packages (radiosondes) that rise through the atmosphere and, (2) satellite-measured intensities of microwave emissions from atmospheric oxygen, which are proportional to temperature.¹ The latter method relies on polar-orbiting microwave sounding units. We analyze the lower tropospheric temperature identified here as T_{2R} .

Recently, Hurrell and Trenberth (1997, hereafter H&T) estimated the lower tropospheric temperature indirectly using variations of sea water (or "sea surface") temperatures (SSTs).² When comparing their SST-based estimates with T_{2R} in the tropics (20°S-20°N), they found two relative temperature jumps, one in September 1981 (0.25°C) and one in late 1991 (0.10°C). They claimed the jumps were due to problems with the satellite measurements.

To check the claim for 1981, we compare T_{2R} against temperatures measured independently at tropical radiosonde stations. We compute the average tropospheric temperature at each location for both radiosondes and satellites for the two years before September 1981 and the two years after. (Using only 4

years of radiosonde data assures instrumental inconsistencies are essentially non-existent.)

For stations in three latitude bands ($\pm 15^\circ$, $\pm 20^\circ$ and $\pm 25^\circ$) the latter 2-year average temperatures minus those for the earlier period are -0.04 , 0.00 and -0.02°C respectively. The same differences for T_{2R} are -0.04 , -0.03 and -0.03°C .³ These two independent, direct measurements of tropical tropospheric temperatures before and after the alleged jump agree within $\pm 0.03^\circ\text{C}$, indicating no "spurious" jump of 0.25°C .⁴

If the "spurious" jumps claimed in H&T are real, trends over the period since 1979 should show clear differences of 0.1 to 0.2°C/decade between T_{2R} and radiosondes. Trends from several multi-station radiosonde datasets (one which used over 300 stations worldwide and three datasets which had no changes in instrumentation) all agreed with T_{2R} to within $\pm 0.03^\circ\text{C/decade}$, the level of uncertainty we had previously ascribed to the satellite data.^{5,6,7,8}

H&T proposed the idea that merging NOAA-07 data into the time series caused the "spurious" jump in late 1981. Figure 1 disproves this claim by displaying the independent anomalies of tropical T_{2R} from NOAA-06 and NOAA-07 separately. A displacement of 0.25°C would be clearly evident, but nothing of that magnitude is found. Note also the intersatellite agreement of anomalies, indicating a level of intersatellite precision, which is 5 to 10 times better than H&T's approximation.

Additional speculations about the "spurious" jumps (i.e. surface emissivity variations or disagreements with the rigid SST/troposphere linkage found in climate models) are not supported by any observational evidence. Other studies have shown that surface emission variations do not significantly impact tropical averages⁹ and that multi-decadal variations in the surface/troposphere relationship do occur.^{5,10,11}

In summary, claims of large and spurious jumps in the T_{2R} satellite dataset are not supported by either of two direct and independent measures of tropospheric temperatures.

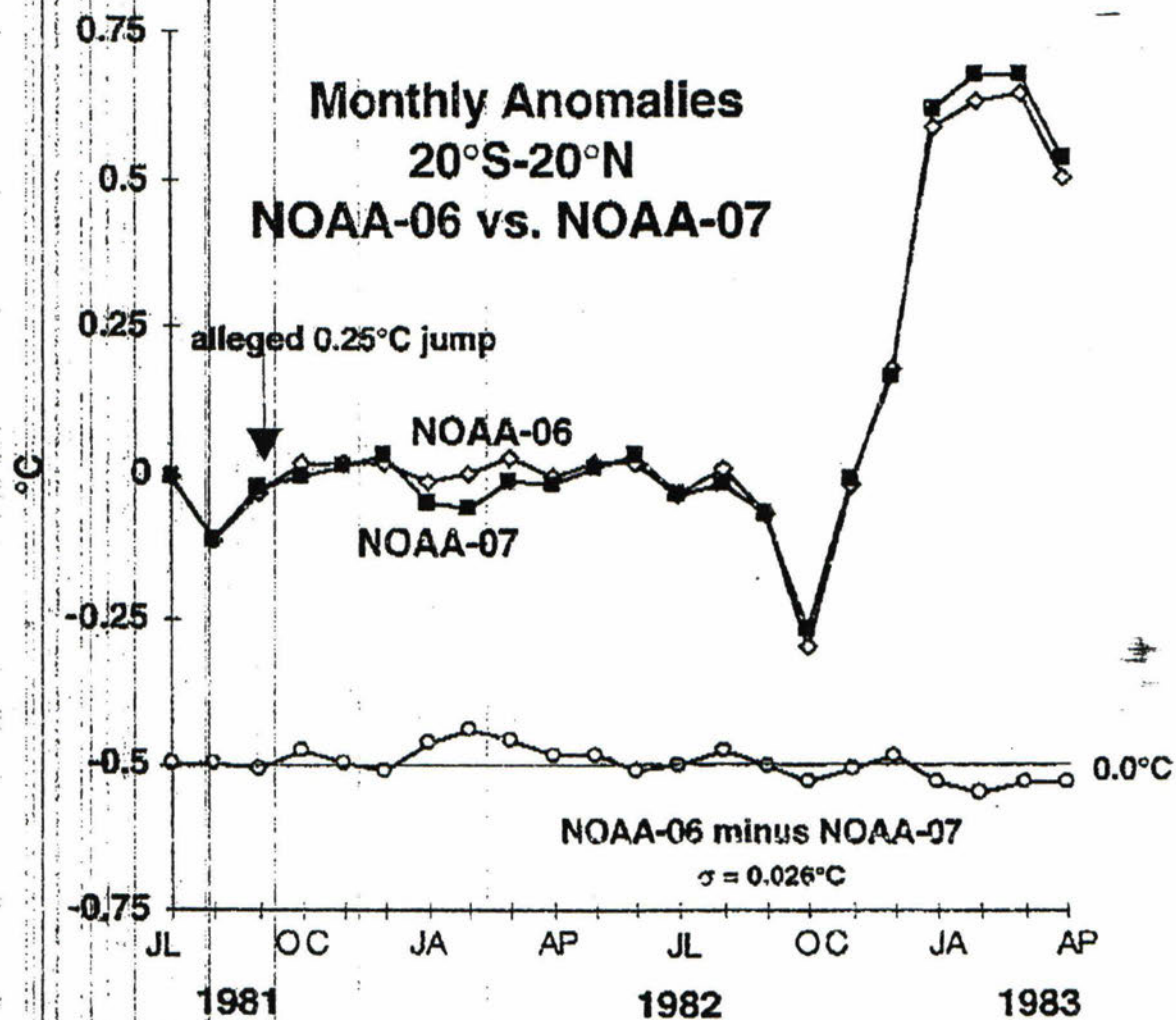
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Figure 1 Monthly temperature anomalies ($^{\circ}\text{C}$) for the tropics (20°S - 20°N) computed independently from two satellites, NOAA-06 and NOAA-07 for July 1981 to April 1983.



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**RESEARCH
EXPERIENCE:**

Climate dynamics, Global-scale processes, Satellite temperatures

EDUCATION:

1987-Ph.D. Atmospheric Sciences, University of Illinois
1984-M.S. Atmospheric Sciences, University of Illinois
1982-1987 Graduate Research Assistant
University of Illinois (summer 1985 at NCAR)
1978-M.Div. Golden Gate Baptist Theological Seminary, Mill Valley
1973-B.A. Mathematics, California State University, Fresno

**PROFESSIONAL
EXPERIENCE:**

1994 - Associate Professor of Atmospheric Science, (tenure-95), UAH
1991-1994 Assistant Professor of Atmospheric Science, UAH
1989-1991 Research Scientist, UAH
Instructor in Atmospheric Science, UAH
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1987-1989 Senior Research Associate, UAH
Instructor in Atmospheric Science, UAH
1983-1987 Instructor of Mathematics
Parkland College, Champaign IL
1981-1982 Instructor of Mathematical Sciences
University of South Dakota, Vermillion SD
1980-1981 Instructor of Mathematics
Yankton College, Yankton SD
1978-1982 Pastor: Grace Baptist Church, Vermillion SD
1973-1975 Science Master: Baptist High School, Nyeri, Kenya

**PROFESSIONAL
SOCIETIES:**

American Meteorological Society
American Geophysical Union
National Center for Science Education

HONORS

- 1996 Special Award, American Meteorological Society "for developing a global, precise record of earth's temperature from operational polar-orbiting satellites, fundamentally advancing our ability to monitor climate."
1994 Award for Research in Physical and Mathematical Sciences, UAH Foundation
1993 Distinguished Research Award, UAH Alumni Association
1991 Medal for Exceptional Scientific Achievement
NASA Headquarters
1991 NASA Technical Innovation Award, MSFC
1983 Departmental Fellow, University of Illinois Urbana-Champaign
1978 Outstanding Young Men of America
1973 Summa Cum Laude, Phi Kappa Phi, California State University, Fresno

SERVICE

Congressional:

House Committee on Science, 9 March 1996
Senate Committee on the Environment and Public Works, 10 July 1997

Peer Review:

Nature
Science
Journal of Climate
Climatic Change
Global and Planetary Change
Geophysical Research Letters
Journal of Atmospheric Research
Journal of Geophysical Research
Quarterly Journal of the Royal Meteorological Society
International Journal of Climatology

Proposal Review

National Science Foundation
NOAA/Global Change Program, Pathfinder Program
DOE/NIGEC Southeastern Regional Review
NASA/Earth Science and Applications Division
NASA/Earth Observing System TRMM
California Space Institute
Australian Research Council

Program Review

NOAA/National Evaluation Panel: Regional Climate Centers 1991-4
NOAA/National Review Panel: National Climatic Data Center 1993-6
NOAA/Pathfinder Review Panel 1995-96

Committees

Chairman: Atmospheric Circulation Requirements Panel, NPOESS (1996)
Chairman: Temperature above surface layer, GCOS (1995)
Ala. Academy of Sciences, Panel on Environmental Concerns (1995-)
Greenhouse Detection Experiment (GEDEX/NASA - 1991)
UAH Graduate Council (1991-3, Alternate 1993-5)
UAH Graduate Curriculum Committee (1993-5)
Southeast Regional Climate Center: Research and Technical Committee
Aspen Institute for Global Change, 1989

Expert Review

Intergovernmental Panel on Climate Change (IPCC, Invited Key Contributor)
1995 Scientific Assessment of Climate Change
National Academy of Sciences, Climate Observations (1995)
IPCC (Invited Contributor) 1994 Radiative Forcing of Climate
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PUBLICATIONS

Reviewed:

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- Christy, J. R., "Monitoring Global Temperature Changes from Satellites" *Global Climate Change: Implications, Challenges and Mitigation Measures*, S.K. Majumdar, L.S. Kalkstein, B. Yarnel, E.W. Miller and L.M. Rosenfeld Eds. Pennsylvania Academy of Science, 1992, 566 pp.

Popular Press

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Invited Presentations:

- Christy, J.R., 1997: Global atmospheric temperatures from Microwave Sounding Units since 1979. American Geophysical Union, Spring Meeting. 26-30 May 1997, Baltimore MD.
- Christy, J.R., 1997: Assessing the long-term stability of the MSU 18-year global temperature time series. Proceedings, Eighth Symposium on Global Change Studies, American Meteorological Society, 2 - 7 Feb. 1997, Long Beach CA.

- Christy, J.R., 1996: Global atmospheric temperatures from satellites since 1979. American Geophysical Union, Fall Meeting. 15-19 Dec. 1996, San Francisco CA.
- Christy, J.R. 1996: The satellite temperature record. US Global Change Research Program, National Seminar. 20 May 1996, Washington DC.
- Christy, J.R. 1993: Global warming not found in high precision satellite temperatures. *Proc. Changing Environments: How vulnerable are we?* 14-15 October 1993, Indiana University.
- Christy, J.R., 1992: The uncertainties of global temperatures in the global warming context. *Proc. Technical and Business Exposition/Symposium*. 12-14 May 1992, Huntsville AL.
- Christy, J.R., 1991: The MSU data, 1979 to the present. *Proceedings, First Demetra Meeting on Global Change*. 28 October - 1 November 1991, Chianciano, Italy.
- Christy, J. R., 1991: The uncertainties of global temperatures in the global warming context. *Conference Proceedings, Pittsburgh Coal Conference*, 14-18 October 1991, Pittsburgh PA.
- Spencer, R.W. and J.R. Christy, 1991: A physical interpretation of brightness temperatures from Microwave Spounding Units. *Proceedings of the 5th Symposium on Climate Variations*, 14-18 October 1991. Denver CO.

Nonreviewed (Abstract review only) Conference Publications:

- Christy, J.R., 1996: An upper tropospheric retrieval of the tropical atmosphere. *Proc., AMS 7th Symposium on Global Change*. 29 Jan. - 2 Feb 1996, Atlanta GA.
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- Christy, J.R., 1995: Forcing factors on the global lower tropospheric and stratospheric temperatures. *Proc. AMS 6th Symposium of Global Change*, 16-20 January 1995, Dallas, TX.
- Allen, M.R., J.R. Christy, M.J. Murray and C.T. Muttow, 1994: Potential impact of satellite-derived data sets on global change detection. *Proc. 19th Climate Diagnostics Workshop*, 15-19 November 1994, College Park, MD.
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- Christy, J.R. and J.J. Hnilo, 1994: Comparison of GCM and MSU temperatures for the AMIP experiment (1979-88). *Proc. Sixth Conf. Climate Variations*, 24-28 January 1994, Nashville, TN.
- Christy, J.R., and R.T. McNider, 1994. Detecting Global Warming using a Precise But Short (15-years) Satellite Data Set. *Proc. 5th Symposium Global Change*. 24-28 January, Nashville TN.
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- Christy, J.R., 1993: Regional to Global Scale Temperature and Precipitation Inferred from the Microwave Sounders. *Tenth Pacific Climate Workshop*. 5 April 1993, Asilomar: Pacific Grove CA.
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- Reddy, R.S. and J. R. Christy, 1993: On the relationship between Indian rainfall and tropospheric and stratospheric temperatures. *Proc. International Conf. on Sustainable Development*. 25-29 January, 1993. New Delhi, India.
- Christy, J.R. and J.D. Goodridge, 1993: Homogeneous time series from sequentially launched polar orbiters, MSU channels. *Proc. Eighth Conf. Applied Climatology*. 17-22 January, 1993. Anaheim, CA.
- Robertson, F.R., E. Barron, S.J. Goodman, D. Fitzjarrald, E. Bishop, J.R. Christy, S. Thompson, D. Pollard, 1993: Genesis climate model: Intercomparison with multiple climate data bases. *Proc. Fourth AMS Symposium on Global Change Studies*, 17-22 January, 1993. Anaheim, CA.
- Christy, J.R., 1992: Impacts on global temperatures due to Mt. Pinatubo and the 91-92 ENSO. *Proc. 17th Climate Diagnostics Workshop*. 19-23 October 1992, Norman OK.
- Christy, J.R., R.T. McNider and F.R. Robertson, 1991: A comparison of CCM1 and MSU temperatures for 1979-1986. *Proc. Fifth Symposium on Climate Variations*. 14-18 October 1991. Denver CO.
- Christy, J.R., and K.E. Trenberth, 1991: Monitoring global monthly surface temperatures. *Proc Fifth Symposium on Climate Variations*. 14-18 October 1991. Denver CO.
- Christy, J.R., and R.W. Spencer, 1990: Global temperatures from Microwave Sounding Units. *Proc. Fifteenth Climate Diagnostics Workshop*. 29 Oct.-2 Nov. 1990. Asheville NC.
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- Christy, J. R., and K. E. Trenberth, 1985: Interannual variability in the distribution of atmospheric mass. *Third Conf. Climate Variations and Symposium on Contemporary Climate: 1850-2100*. 8-11 January 1985, Los Angeles CA. 46-47.
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PRESENTATIONS

- Christy, J.R. 1996: The Uncertainty in the Climate of Global Change. National Mining Association. National Press Club. 30 September 1996, Washington DC.
- Christy, J.R. 1995: Temperature above the surface layer. Global Climate and Observing System Workshop, Asheville NC, 9-11 January 1995.
- Christy, J.R. 1993: Precision global temperatures from satellites. Electric Power Research Institute workshop, 27-28 September 1993, La Jolla CA.
- Christy, J.R. 1993: Introduction to microwave temperature measurements. Univ. Kyoto, Univ. Tokyo, Japan Satellite Agency (Tokyo), Environ. Res. Inst. (Tsukuba). 30 Aug. - 3 Sep 1993, Japan.
- Christy, J.R. 1993: Data products from the microwave sounders. National Climatic Data Center, 24 June 1993, Asheville NC.
- Christy, J.R. 1993: Global Temperature Measurements and Their Importance for Government Regulation. Alabama Dept. Env. Management Conf. Clean Air Act. 25 March 1993. Montgomery AL.
- Christy, J.R., 1993: Global Temperatures from Satellite Measurements and Climate Change Through Geologic History. Birmingham Astronomical Society. 23 Feb. 1993, Hoover AL.
- Christy, J.R. 1992: The uncertainty of global temperatures in the global warming context. Tri-State High School Science Teacher Conference. 12 October 1992. Pittsburgh, PA.
- Christy, J.R., 1992: The uncertainty of global temperatures in the global warming context. University of Alabama, Birmingham, 25 September 1992. Birmingham AL.
- Christy, J.R., 1992: The uncertainty of global temperatures in the global warming context. Visiting Scholars Colloquium, Moorhead State University, 4 May 1992, Moorhead MN.
- Christy, J.R. 1992: Global climate model validation using MSU temperatures. AMIP LLNL Workshop. 19-21 February 1992, Berkeley, CA.
- Christy, J.R., 1991: Validation of Microwave temperatures. *The Global Hydrologic Cycle*. 22-25 July, 1991. The Pennsylvania State University, University Park PA.
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Corporation, Good Morning America, Today Show, network television news. Secretary of Energy James Watkins met R.W. Spencer and Christy for a 90 minute private briefing at the university to assess the impact these results would have on the national energy policy.

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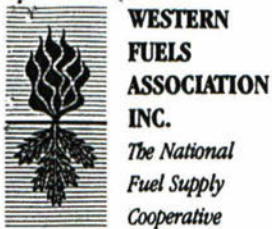
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**PRESS
MATERIAL**

**CLIMATE CHANGE PRECAUTIONARY PRINCIPLE:
RISK OF CATASTOPHIC COOLING GREATER
THAN CATASTROPHIC WARMING**

(Arlington, VA — May 19, 1997) Western Fuels announces release of a new scientific paper from the Office of Climatology at Arizona State University examining future climate in the context of "the precautionary principle." The paper's author, Craig D. Idso, concludes:

Many people are predicting imminent catastrophe from a few degrees of potential global warming. For this scenario, however, there is little historical precedent. Ice ages, on the other hand, are a regularly-recurring feature of the current geologic epoch of earth's history, with up to 20 of them having occurred at 100,000 year intervals over the past two million years; and based upon the record of their past periodicity, many scientists believe we can expect the next one to commence any time now. As a result, the *precautionary principle* suggests we do nothing to prevent any minor to moderate tendencies for warming in the near future, especially when such warming would actually improve the "living standard" of the biosphere and when we face a real and present danger from the next "scheduled" glaciation. If anything, it suggests we should *encourage* activities that tend to warm the planet, or, at the very least, refrain from adopting policies designed to arbitrarily discourage the utilization of coal, natural gas and oil as modern industrial fuels.

Western Fuels Association general manager and chief executive officer Fred Palmer says Idso's work is provocative because those who are concerned about the potential for apocalyptic climate change themselves invoke the "precautionary principle" in arguing for policies to limit emissions of carbon dioxide. "With increasing real-world evidence suggesting that any anticipated warming of climate will be benign, a rational person would examine the very real potential of another ice age against that backdrop and conclude concern for climate catastrophe from greenhouse warming is misplaced, at best."

(more)

Idso's paper (Climatological Publications Scientific Paper #26, "Future Climate and the Precautionary Principle: The Other Side of the Story") sets out to determine what constitutes an "adverse climate" in the context of applying the precautionary principle as a reasonable approach to decision-making. The precautionary principle seeks to minimize or avoid unnecessary risks. He writes, "Like Goldilock's assessment of the thermal state of the Three Bears' porridge, we can safely say that an adverse climate is one that is either too hot or too cold. But how hot or cold is *too* hot or cold? What is the 'temperature of neutrality' from which such climatic deviations are measured? And what is the probability of either extreme occurring?"

Idso's paper considers the consequences of real-world temporary weather fluctuations, moderate climatic excursions of the last thousand years, and full-fledged climate disasters either experienced in the past or predicted to occur in the future.

In examining the consequences of extreme weather events, he concludes, "Many negative consequences can and do result from typical real-world heat waves and cold-air outbreaks. For the most part, however, society has learned to live with the effects of these temporary weather fluctuations. What is more, they will *always* be a feature of our climate, even if earth's mean temperature were to coincide with the ideal temperature of neutrality."

Idso then examines the record of the consequences of two historic shifts in the earth's mean climate state – the Medieval Warm Period between the 10th and 14th centuries, and the Little Ice Age which persisted between the 16th and 19th centuries – and their impact on earth's plant and animal life. He concludes, "It would appear that earth's flora and fauna, including mankind, fared far better during the former period. Indeed, there is an acute absence of negative literature regarding climate conditions experienced during the Medieval Warm Period. Hence, the observational evidence seems to suggest that earth's 'temperature of neutrality,' *i.e.* the mean global

temperature that minimizes adverse consequences, may well be somewhat higher than that of the planet's current average temperature. And with atmospheric CO₂ concentrations on the rise, this 'ideal' temperature could go even higher; for it is one of the better-established facts of science that the optimum temperature for plant growth in almost all species actually *rise* with an increase in the air's CO₂ content."

Idso then examines full-fledged climate disasters, either extreme global warming or extreme global cooling. In the case of global warming, he assesses its theoretical basis in the context of the published work of the Intergovernmental Panel on Climate Change (IPCC) Working Group I ("The Science of Climate Change") and Working Group II ("Impacts, Adaptations and Mitigation of Climate Change"). On the other extreme – extreme global cooling – Idso notes, "We have no need to consult the predictions of theoretical models to obtain the insights we seek; for the earth has much to tell us, as it has revisited this state repeatedly. And where the predictions of global warming are uncertain, and its consequences dubious, the reality of earth's repeated ice ages and their many ramifications are literally 'etched in stone' in the geologic record of the planet."

"It should be obvious that the biosphere is much more capable of withstanding the results of severe heat than it is of coping with the consequences of extreme cold. A meter's rise in sea level would indeed pose problems for many of earth's coastal areas and some islands; but in contemplating the prospect of having an entire third of the planet's land area covered by a mile of ice, it pales in comparison, barely meriting mention in the same breath," Idso concludes.

As to the relative likelihood of either of the two extremes occurring, Idso admits the prospect of extreme warming has no track record from which to make predictions and notes that in the case of extreme cooling, the present inter-glacial (time between ice ages) is already 10,000 years old and that the next full-fledged ice age is due to appear (geologically speaking) any day now.

(more)

"In applying the precautionary principle to the subject of future climate, it is clear that the most likely adverse state we may shortly have to deal with is another of the recurring ice ages that have plagued the planet for most of the past two millennia," he writes. "And how does one combat cold? By turning up the temperature. Or, at the very least, by not doing anything to prevent a minor amount of global warming, especially *highly questionable* global warming. And one surely does not implement incredibly expensive anti-warming programs to prevent what could well be purely *hypothetical* warming. Reality and logic therefore attest to the fact that it is the height of irresponsibility to attempt to reduce the burning of fossil fuels – in the face of the very real and present danger posed by the next full-fledged ice age that is looming on the geologic horizon. And when it is remembered that earth's 'optimum' climate is one that may well be *significantly* warming than it is now, that regulatory medicine begins to look more and more like the poison it truly is. Carbon dioxide, on the other hand, is the elixir of life, comprising the primary molecular link between the animate and inanimate world. Any amount of it that humanity could possibly put into the air by the burning of fossil fuels will only amplify the totality of earth's life processes and enhance the robustness of the biosphere."

NOTE: A copy of Craig D. Idso's "Future Climate and the Precautionary Principle: The Other Side of the Story" can be obtained through Western Fuels Association, Inc., of the Arizona State University Office of Climatology. Contact Western Fuels at 4301 Wilson Boulevard, Suite #805, Arlington, Virginia 22203-4193 or by calling (703) 907-6160. Western Fuels' E-mail address is wfa@cais.com.

Western Fuels Association is a cooperative enterprise operating on a not-for-profit basis to provide coal for the generation of electricity by consumer-owned electric utilities throughout the Great Plains, Rocky Mountain and Southwest states, and in Louisiana. Western Fuels' 23 member/owners are rural electric generation and transmission cooperatives, municipal utilities, and other public power entities.



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**PRESS
MATERIAL**

**CANCEL THE APOCALYPSE?
SATELLITES SHOW GLOBAL COOLING
NOW STATISTICALLY SIGNIFICANT**

(Arlington, VA — April 17, 1997) Earth's temperature history, as measured by orbiting satellites, reached an important milestone on March 31: the overall record now shows a *statistically significant global cooling* of -0.048°C per decade.

The orbiters, called Microwave Sounding Units, are now in their 19th year of operation. The accuracy with which they measure the temperature of the lower atmosphere, according to NASA researcher Roy Spencer, is $\pm 0.01^{\circ}\text{C}$. Scientists have shown that they are so sensitive that they detect the monthly 0.02°C warming and cooling of the earth as the moon waxes and wanes, something that has never been measured by ground-based thermometers.

Scientists who study this record have known for a long time that the southern half of the planet has been cooling significantly, but the behavior of the northern half was sufficiently different so that the global trend (or the average between the two) never crossed the threshold of statistical significance. Now it has.

Straightforward analysis shows that the decline in global temperature is now so large that there is only a 5% probability that it is due to chance, and a 95% probability that it is real. This is the significance level that many jurists have ruled separates "junk science" from acceptable truth. It is noteworthy that many of the indices of climate change that make it into news reports — such as increases in flooding rains — do not meet this same criterion.

These findings come on the heels of other reports that the satellite data must be in error. But further analyses show that a completely independent set of

(more)

temperature measurements – from weather balloons – finds exactly what the satellites do on a global scale. "It's hard to believe that two completely independent measures of temperature, both taken twice a day, would conspire to lie in precisely the same fashion over 13,350 twice-daily observations," says Dr. Patrick J. Michaels, professor of environmental sciences at the University of Virginia and one of the nation's most prominent climatologists.

"The fact is," Michaels notes, "that none of the three measures of temperature – satellites, weather balloons, or ground-based thermometers – show any warming trend in the past decade." During that period, seemingly everyone agreed that the planet should have warmed rapidly because of changes in the greenhouse effect. "This new finding that the lower atmosphere is cooling *globally* in a statistically significant fashion is going to make people sit up and take notice that something was very, very wrong with the forecasts of rapid global warming," he concludes.

It was those forecasts of rapid *warming* which served as the basis for the United Nations' Framework Convention and Climate Change. Representatives of the U.S. State Department have recently called for a change in that treaty to make binding upon the people of the United States reductions in emissions of greenhouse gases, such as carbon dioxide from fossil fuel combustion and methane from farm animals.

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NOTE: This press release is based upon information provided to Western Fuels Association, Inc., under contract with New Hope Environmental Services, inc.

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SEVERE FLOOD/DROUGHT IDEA ALL WASHED UP

Talk about covering your bases. "Warmer temperatures will lead to a more vigorous hydrological cycle; this translates into prospects for more severe droughts and/or floods in some places and less severe droughts and/or floods in other places."

So said the notorious Intergovernmental Panel on Climate Change in its 1995 report—one of our favorite passages simply because of its complete lack of content.

Recently, however, the Consensus of Scientists which authored the report has shifted to a more extreme position. On the February 26 segment of Dateline NBC, for example, Stanford professor Stephen Schneider said that with greenhouse warming, "You'd see increases in intense storms, you'd see very intense droughts and floods..."

Here's the logic behind their argument. As the atmosphere warms from increased greenhouse gases, evaporation of surface water will increase the amount of water vapor in the air. The warmer air coupled with a more moist atmosphere will produce conditions ripe for the development of heavy precipitation. Simultaneously, dry places (which add little moisture to the air)

will remain dry or get drier. Thus, greenhouse gases will generate a climate with more extreme droughts and more floods.

This scenario is so filled with illogic, scientific leaps, and a lack of understanding of atmospheric processes that we could flood several *WCR* issues. But let's take the proposition at face value and test the validity of the hypothesis that we're experiencing more simultaneous rainfall extremes (wetness and dryness) over time.

To examine these trends over the United States, we looked at the Palmer Drought Severity Index (PDSI). This measure is commonly used to examine the severity and extent of drought conditions at particular locales. Based on precipitation and temperature, the PDSI estimates the supply of water compared with the climatic demand for water, or the evapotranspiration (ET). When ET is greater than rainfall over some period of time, the soil dries out and drought conditions begin to set in. This situation is characterized by negative PDSI values. In contrast, when the soil is saturated and rainfall continues, the excess water flows overland into streams and rivers, and in some cases can produce flooding (excess precipitation is indicated by positive PDSI values). The index is standardized by site and typically varies from -6 to +6. In general, positive PDSI values are associated with increased crop yields, and negative ones with crop failures.

In our analysis, we examined the percent area of severe and extreme drought (PDSI less than -3) and severe and extreme wetness (PDSI greater than +3) for the United States since 1895. According to the Consensus of Scientists, we should be seeing simultaneous increases in each (more severe flooding and more severe drought).

Figure 1 (top) shows the area of the country under severe or extreme wetness for each month since January 1895. While the overall mean value is about 11 percent, the wet areas are sufficiently extensive over the past three decades to produce a statistically significant upward trend. However, there is no long-term trend in severe or extreme

dryness (Figure 1, bottom), as values have averaged about 10 percent over the past century.

But is there a simultaneous correlation? In other words, do months with severe drought in one region also see heavy precipitation in another region? Such evidence would support their hypothesis of extremes. Each point on Figure 2 shows the percentage of the United States experiencing severe or extreme wet conditions vs. the percentage experiencing severe or extreme dry conditions for each month since 1895. Notice that the correlation is markedly (and statistically significantly) inverse. When a higher percentage of the country is experiencing severe drought, the percentage classified under extreme wetness is low.

("Of course, any idiot knows that!" you may be thinking. Well, that may be the case, but with that attitude, you'll never make it as an apocalyptic.)

Note in Figure 2 how few points occur above the mean in both severe/extreme dry and wet categories (the unshaded portion of the graph). This is where the Consensus of Scientists expect most of the points to fall.

So the bottom line is that there is no evidence of increasing extremes in precipitation and drought. Perhaps before the next IPCC report is written, the Consensus should ask a few more people what they know rather than relying solely on the predictions from fundamentally flawed climate models.

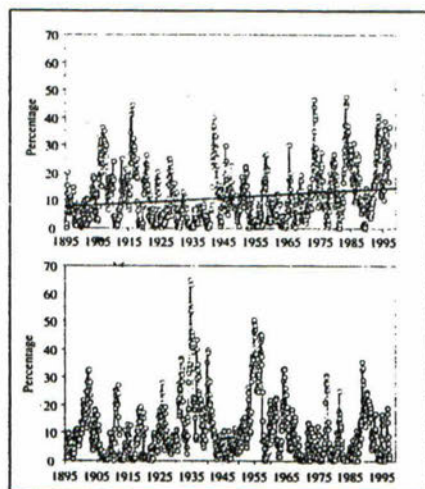


Figure 1. Percentage of the United States experiencing severe or extreme drought conditions (top) and severe or extreme wetness (bottom).

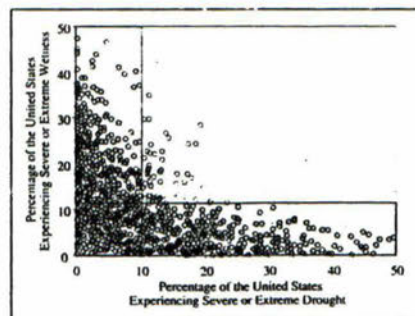


Figure 2. Relationship between areas of severe/extreme drought and areas of severe/extreme wetness. Points in the shaded area are below the mean in both categories.

WHAT'S HOT

DEBATE OVER SATELLITE DATA HEATS UP!

All but the most naïve followers of the global warming fray know that there is big pressure on federal science to do everything in its (considerable) power to try to disprove the global satellite data. That the satellites show no warming in their 18.25-year history has continually created great consternation in the apocalyst community.

One of the fig leaves used to cover this problem was the assertion that there really is "warming" in the satellite record, but it just happens to be "hidden" by the two volcanoes—El Chichon (1982) and Mount Pinatubo (1991)—that exploded at convenient times. But, five years after Pinatubo blasted stratosphereward, global temperatures have remained below the long-term average, casting serious doubt on the volcanic excuse.

Another explanation is that the big "El Niño" events—periodic warmings of the Tropical Pacific Ocean—also compromise the record. But, according to Kevin Trenberth, one of the most prominent federal climatologists, the relatively long one that persisted through the early 1990s was a sign of global warming anyway. (For some dispute on this, see "What's Hot" in our last issue.) This logic clearly indicates that the satellite record should be warming, even though it is not.

In order to preserve the internal consistency of this argument, James Hurrell and Kevin Trenberth have just published a paper in *Nature* arguing that there are two "discontinuities" in the satellite record, in 1981 and 1991 (remarkably convenient to those volcanoes, no?) that were missed by the keepers of the history, Roy Spencer and John Christy.

The problem arises, they say, because we don't have one "continuous" satellite. The temperature sensors, called Microwave Sounding Units, have a service lifetime of less than a decade. Consequently, when a new one comes on-line, it is calibrated against an existing one, and it is at this point that Hurrell and Trenberth argue that an error has crept in. When they adjust for

this, they get a warming of 0.12°C/decade, rather than the *cooling* of 0.05°C that exists in the record as it stands.

The media cheerleaders for climate apocalypse are sure to ballyhoo this contention in a big way. Yet no one seems to realize that even if it were true, the warming rate would be only about 33 percent of the value predicted by the models that serve as the basis for the Rio Treaty. Nor does it bode well for those who argue that this reduced warming is caused by sulfate aerosols. Hurrell and Trenberth cannot argue away the fact that the satellite data still must show a relative cooling of the Southern Hemisphere, which, being sulfate-free, should be warming like too much plutonium.

The problem is that it's probably not true. What Hurrell and Trenberth did was to somehow throw away not only the satellite data, but also all of the weather balloon data that are taken twice every day by highly calibrated instruments around the planet. In the layer from 5,000 to 30,000 feet, these data, predicted to warm by every computer model, just happen to match up perfectly, year by year by year, with the satellite temperatures. Needless to say, both histories show no warming.

What is the chance that this happy coincidence of two completely independent measures of temperature just happens by chance? Here's one way to estimate this likelihood: Both the satellite and weather balloon records have a 50-50 chance of being above or below average in a given year. This is the same as your local penny landing heads or tails. Now, the probability that both records are simultaneously above or below normal in each and every one of their 18 concurrent years is the same as the probability of throwing 18 heads or tails in a row. It *can* be done, but you'll have to, on the average, flip that penny about 262,000 times in order to achieve this result just once!

The chance you'll get hit by an asteroid during this exercise, assuming it takes about a year to execute all these flips, is about 10 times greater than your getting 18 consecutive têtes or derrières. But if you

believe your television, asteroids seem pretty likely these days...and isn't it amusing how TV's convinced of the global warming apocalypse, too?

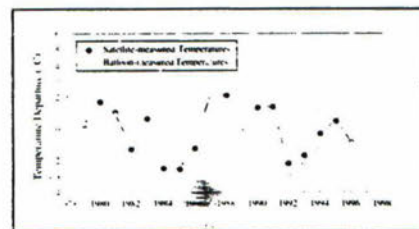
According to satellite guru Roy Spencer, what Hurrell and Trenberth did was to estimate the difference between surface temperatures and those measured by the satellite by using a general circulation climate model to calculate the bias by forcing the computer model with observed temperatures. That's right, readers! Throw away two independent sets of data and substitute a computer climate model to "prove" the satellite is wrong.

Global warming is a strange scientific world, indeed. It's one where computer models—which are not doing a good job of estimating observed temperature changes—are used to correct observed data. Somehow this seems counter to the rules of basic science—in which data are used to correct the models, not vice versa.

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Trenberth, K.E., and T.J. Hoar, 1996. The 1990-1995 El Niño-Southern Oscillation Event: Longest on record. *Geophysical Research Letters*, 23, 57.



Temperatures measured by the MSU satellites (closed circles) match up nearly perfectly with temperatures measured by weather balloons in the atmospheric layer from 5,000 to 30,000 feet (open circles). The correspondence between these two datasets is remarkable considering that they represent two completely independent measures of temperature.

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Reducing Noise in the MSU Daily Lower-Tropospheric Global Temperature Dataset

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ABSTRACT

The daily global-mean values of the lower-tropospheric temperature determined from microwave emissions measured by satellites are examined in terms of their signal, noise, and signal-to-noise ratio. Daily and 30-day average noise estimates are reduced by almost 50% and 35%, respectively, by analyzing and adjusting (if necessary) for errors due to 1) missing data, 2) residual harmonics of the annual cycle unique to particular satellites, 3) lack of filtering, and 4) spurious trends. After adjustments, the decadal trend of the lower-tropospheric global temperature from January 1979 through February 1994 becomes -0.058°C , or about 0.03°C per decade cooler than previously calculated.

1. Introduction

Microwave Sounding Units (MSUs) onboard NOAA polar orbiting satellites have provided temperatures of deep layers of the global atmosphere since 1979 [Spencer and Christy (1992a,b, 1993) (hereafter SC92a, SC92b, and SC93)]. These studies have demonstrated the high quality of the MSU data and their value in addressing global climate issues [see also Hurrell and Trenberth (1992), Basist et al. (1995)]. In general, such studies have used MSU data averaged into monthly timescales. In this paper, we shall examine the signal and noise characteristics of the MSU channel 2 retrieval of the lower-tropospheric temperature, known as MSU 2R, for daily global-mean values. Our goal is to provide a dataset of daily global temperatures for which errors, or noise, have been reduced as much as possible while preserving the magnitude of the signal variability.

The time series of daily zonal-mean temperatures through February 1994 has utilized measurements from instruments on seven different satellites (TIROS-N, NOAA-6, -7, -9, -10, -11, and -12). How these data were generated and merged into a single time series will be explained in the following two sections. To as-

sess changes made to the original data, we shall begin our analysis from the point where no quality control has been applied. We shall examine the impacts of missing data, unique satellite characteristics, filtering, and spurious trends on the global-mean values and determine how to enhance the quality of the time series. Users who have performed research on current editions of the MSU 2R data should realize that some quality control was applied to those data and that the final results of this study do not alter the earlier monthly versions in a significant manner.

2. MSU temperatures

Temperatures are produced from the raw MSU data in the following way. The radiance counts observed by the MSUs are converted into brightness temperatures by an interpolation scheme, which is anchored on the warm side by an onboard hot target (measured by a set of redundant platinum resistance thermometers) and on the cold side by the temperature of cold space (2.7 K). On each scan, the sensor obtains radiance counts for these two targets of known temperature as well as 11 footprints over the earth. The counts observed in the earth views are converted to temperatures using the interpolation scheme derived from the cold and hot targets (Spencer et al. 1990).

As described in SC92b, a limb-retrieval technique is applied to the scan-line data that results in a vertical temperature profile of the lower troposphere. For this

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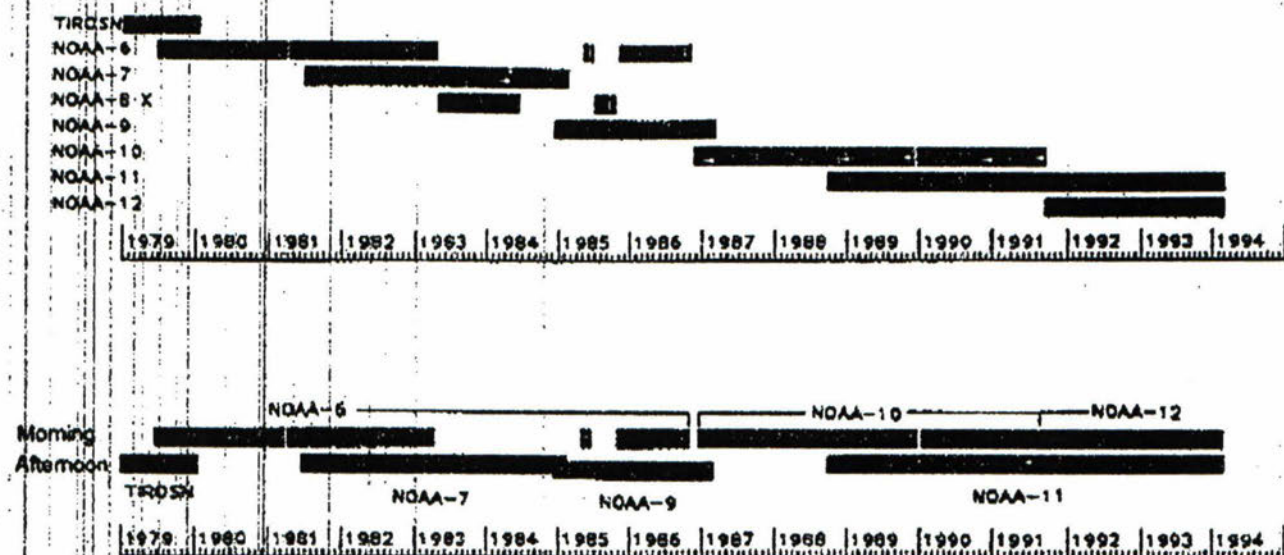


FIG. 1. (Top) Data availability from the operational NOAA polar orbiters, which carried Microwave Sounding Units. (Bottom) As above but categorized by crossing time: morning or afternoon.

study, the daily data are binned into 2.5° latitude bands that are then averaged into zonal-mean temperatures. Global-mean values are calculated from these zonal quantities. Comparisons with individual radiosonde locations indicate the MSU 2R monthly temperature anomalies correlate most highly with the 1000–500- or 1000–400-hPa thickness anomalies (SC92b). The use of daily zonal means provides a robust dataset from which to calculate global means relative to daily gridded data that have coarser resolution and much greater noise.

The time period examined here is 1 January 1979–28 February 1994. For this 15+ year period, over 97% of the possible days had at least 85% of the possible observations recorded by at least one satellite. Most of the days below the 85% daily data rate occurred between 1979 and 1981 (inclusive).

3. Merging method

A brief description of the method by which the data from seven satellites were merged is contained in the appendix of SC92a. In the following discussion, we shall provide background information and an update of that method.

There are basically two sun-synchronous satellite orbits that meet the operational requirements of the National Weather Service. One is the “terminator” orbit in which the satellite monitors the earth at local time (LT) near sunrise and sunset, crossing the equator at about 0730 LT (descending or southbound) and 1930 LT (ascending or northbound). A platform in this orbit is commonly called the “morning” satellite. The second or “afternoon” orbit crosses the equator at about 1330 LT (ascending) and 0130 LT (descending). The crossing times for the morning satellites have

been very stable through the years, while those of the afternoon orbiters have tended to degrade, ascending later in the day as length of service increases. In particular, the most recent platform, *NOAA-11*, has drifted by 3 hours, creating potentially serious consequences as described later.

Since 1979 there have been three reliable MSUs on the morning satellites: *NOAA-6*, *-10*, and *-12*. The *NOAA-8* data proved to be too noisy for necessary measurements, so the older morning satellite already in orbit (*NOAA-6*) was returned to operational activities until *NOAA-10* was launched. None of the *NOAA-8* measurements were used in any of our previous studies nor will they be used here. The four afternoon satellites are *TIROS-N*, *NOAA-7*, *-9*, and *-11*.

The National Weather Service has generally launched a replacement satellite every 2 years or so, alternating between the morning and afternoon orbits. As such, the operational instruments onboard are nominally anticipated to provide information over a 4-year period. This schedule has been interrupted due to such circumstances as *NOAA-8*'s instability, a malfunctioning oscillator in the MSU on *NOAA-9*, and loss of an entire satellite, as in the August 1993 attempted replacement of *NOAA-11* with *NOAA-13*. As a result, some instruments have been used for at least 6 years (*NOAA-6* and *-11*). Figure 1 indicates the sequence of launches and the data used in construction of the 15+ year MSU time series (*NOAA-8* included for display purposes). Note that there are some periods prior to 1988 in which only one MSU was providing data for the time series.

The instruments are also arranged by crossing time category in Fig. 1, revealing the opportunities where simultaneous comparisons between MSUs on different satellites can be performed. It is in these overlapping

periods where a robust measurement of precision can be made because the instruments on different satellites are completely independent.

To combine the entire record into a single time series of daily anomalies, two forms of biases were calculated and then removed from each MSU's data in sequence. The first bias is due to differences in the mean annual cycle as observed by the morning orbiters versus that viewed by the afternoon orbiters because they each sample the local diurnal cycle at different times. The greatest morning/afternoon satellite differences occur where surface emissions have large diurnal variations, since the total emission observed by the MSUs includes some emission from the surface. This is especially true over elevated terrain where the fraction of surface emission becomes larger, as viewed from the satellite, because in such locations there is less atmospheric mass to produce emissions. Factors that determine the amount of surface emission are surface skin temperature and to a lesser extent, wetness, snow cover, and vegetation. Variations in these parameters, particularly skin temperature, will disproportionately influence the MSU-observed brightness temperature over the course of a 24-hour day.

In general, the ascending node of the afternoon satellite (about 1330 local time) views sun-exposed land and the overlying atmosphere as being warmer than the other passes because of the increase in surface emission (warmer skin temperature) relative to atmospheric emission. This is most apparent over dry regions with considerable sun exposure (Sahara desert) or over high terrain (Tibetan Plateau) because day-to-night differences in surface skin temperature are much larger than those of the troposphere as a whole. This is a systematic effect and must be treated separately for the afternoon versus morning satellites. [The differences in emission from water surfaces (i.e., oceans) between day and night is not a factor.] Therefore, to calculate anomalies of atmospheric temperature, we must determine the systematic biases of the afternoon MSUs versus those of the morning MSUs due to diurnal effects such as surface emissions.

We calculate a reference annual cycle based on September 1981–August 1982, a period in which the morning (NOAA-6) and afternoon (NOAA-7) contain adequate data on nearly every day. Daily temperatures for this period are smoothed with a cosine filter (half-power frequency of 30 days) for each satellite, and the result is defined as the "preliminary" mean annual cycle. Because interannual variability exists, we are required to utilize a period common to both an afternoon and morning satellite that is at least 12 months long (i.e., we cannot use a different 12-month period for the morning than for the afternoon satellite). Due to serious problems (to be discussed later), NOAA-11 is unavailable to serve as the afternoon satellite and only NOAA-7 contains a period of overlap longer than 1 year with a morning satellite (Fig. 1). Hence, the period

defined above is chosen for the preliminary mean annual cycle. As noted below, a longer base period will be selected for the final product so that peculiarities of September 1981–August 1982 will not unduly affect the data.

We standardize all of the satellite data by subtracting the morning mean annual cycle from NOAA-6, -10, and -12 and the afternoon mean annual cycle from TIROS-N, NOAA-7, -9, and -11. In this way, we eliminate the diurnal effects peculiar to morning or afternoon orbits from all satellite data. (The reader should keep in mind, however, that what has been removed are annual cycles as observed by only NOAA-6 and -7. These may differ in slight ways from the other instruments had they operated during the 1981–82 period.) At this point, the total time series is a set of anomalies from the mean annual cycle as defined above.

The second bias to be removed arises from the systematic offset of one instrument versus another. Though the daily global anomalies of two simultaneous MSUs may correlate at 0.99+, each instrument has a relative temperature bias of as much as 1 K (SC92a, SC92b, SC93). We determine these systematic biases as the average difference between temperatures of the MSUs at each latitude during common periods of observation. The bias is sequentially accumulated and removed for each MSU so that all anomalies then are relative to NOAA-6/7 for September 1981–August 1982, our preliminary mean annual cycle.

The final step is to select a representative period as the base annual cycle and calculate anomalies relative to this. We selected 1982–91 as the base because there were several missing-day periods prior to 1982 and a length of 10 years seemed appropriate, though of course it is arbitrary. We then determined the residual annual cycle in those 10 years and subtracted this from the entire record. The result is 15+ years of daily anomalies relative to the 1982–91 period.

4. Precision during overlap periods

Because the atmosphere is being observed by two independent instruments during the overlap periods, we may determine the signal and noise characteristics of the instruments. In Fig. 2 we show results of the mean and mean difference of the global anomalies of the NOAA-11 and -12 overlap (hereafter 11/12). We shall define noise (N) as the variance of the anomaly difference divided by 2, $N = (\sigma_{\Delta/2})^2$, and the signal (S) as the variance of the anomaly sum divided by 2, $S = (\sigma_{\Sigma/2})^2$. The daily N of 11/12 is 0.005565 K², while the daily S is 0.032184 K², giving a signal-to-noise ratio (S/N) of only 5.8. The noise, signal, and S/N for 30-day averages are 0.001211 K², 0.016512 K², and 13.6, respectively. These are the lowest (worst) S/N values of the six overlaps that are used in merging the dataset into a single time series. Improvements in S/N will be most evident in this example.

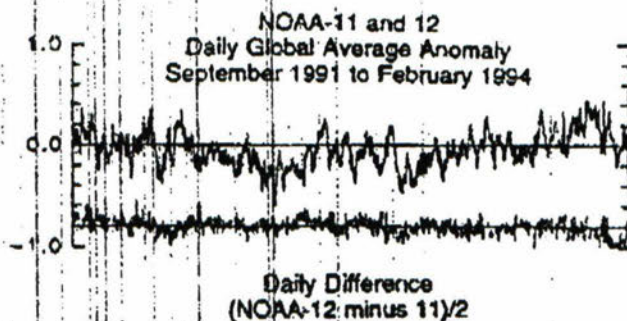


FIG. 2. (Top) The average of the daily global-mean anomalies for NOAA-11 and -12. (Bottom) The difference of the global-mean daily anomalies (offset by -0.8°C for clarity) divided by 2. This was the worst case of the six overlap comparisons.

Our goal is to reduce the noise without compromising or smoothing the signal. We note that the MSU datasets previously provided to the scientific community contain some quality control aspects, and in reality, the final result of this present study will not materially alter any conclusions one may have deduced using older versions of the MSU 2R data. We are showing here the results of data analysis for which no quality control was performed, and then we shall introduce measures that will optimize the S/N for both daily and 30-day mean statistics. The effects that relate to noise reduction are 1) variations in the amount of missing data allowed, 2) mean annual cycle differences between NOAA-6 or -7 and the other satellites, 3) median latitudinal filtering, and 4) removal of NOAA-11's spurious warming trend.

a. Impact of data availability

The information for the statistics presented above for 11/12 were derived from MSU 2R data for which at least 20 000 observations per day were available from both satellites. For this section, we use as our "number of observations per day," the total number of footprint observations from which the MSU 2R retrieval is derived. There are about 3000 useful scan lines per day, each of which provides 11 footprint observations. The MSU 2R retrieval scheme utilizes only 8 of these observations for the scan-line retrieval; hence, the maximum number of distinct observations on a given day is about 24 000 (SC92b). The 20 000 value then represents about 85% of the total number of observations that are possible.

Since one complete orbit provides 7% of a day's data, errors are introduced by subsampling the earth using daily data amounts that represent fewer than 14 orbits. This is especially true where the surface emissions are strong. These areas require systematic sampling each day so as not to introduce biases into the global mean. Even missing only the part of the orbit that views these "hot spots" can lead to greatly increased noise.

We first attempt to reduce N by assessing how missing data impact global-mean temperature values. We have calculated $\sqrt{N} = (\sigma_{A/2})$ for 19 000, 20 000, 21 000, 22 000, and 23 000 per day data rates for daily variations and 30-day average variations (Fig. 3). The values plotted are those of a weighted mean of $\sqrt{N}$ for all six overlaps based on the number of days in each overlap period (recall we have mentioned the statistics of the worst overlap example earlier). The total number of days on which both of the intercompared MSUs reached acceptable data rates were 3009, 2895, 2697, 2133, and 1436 for 19 000 through 23 000, respectively.

The results of the daily comparisons indicate that the noise is reduced as the number of observations required for comparison is increased, as would be expected. The reduction is noticeable but relatively slight with daily $\sqrt{N}$ decreasing from 0.068 K to 0.064 K for 19 000–22 000 data rates. There seems to be no significant difference in $\sqrt{N}$ due to data availability for 30-day averages, all being about 0.026 K. Of all the characteristics we shall examine in this study, data availability has the weakest impact on N . From this result, there is no compelling reason to limit the acceptable data rate beyond 20 000, which is the rate currently used in monthly reports (e.g., NOAA, *Climate Diagnostics Bulletin*).

b. Residual annual cycle differences

We have indicated that the morning and afternoon instruments observe the earth under differing local solar conditions, leading to different mean annual cycles. It was assumed that all morning satellites would have the identical mean annual variations observed in NOAA-6, and all afternoon satellites those of NOAA-7. Careful examination of Fig. 2 reveals a series of undulations in the difference time series, which happen to be phase locked with the annual period. Because Fig. 2 represents the last overlap period in which the MSU data were

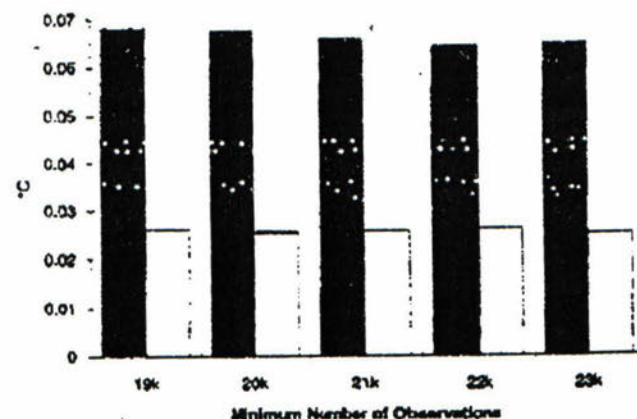


FIG. 3. Solid (open) columns represent $\sqrt{N}$ for daily (30-day mean) statistics. The left-to-right progression indicates results for minimum daily observation rates of 19 k, 20 k, 21 k, 22 k, and 23 k.

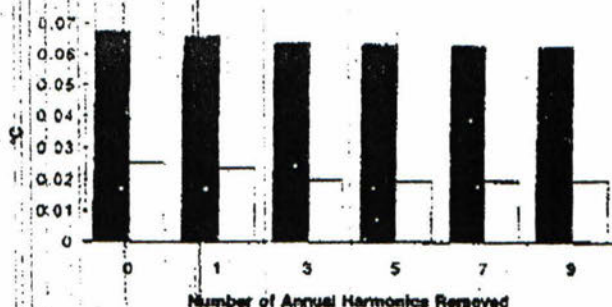


FIG. 4. Solid (open) columns represent $\sqrt{N}$ for daily (30-day mean) statistics. The left to right progression indicates results for removal of Fourier components of the annual period up to the wavenumber indicated below the columns.

adjusted with the accumulations of all previous adjustments, any systematic errors should be most visible here. Inspection of all overlap examples indicates that the 11/12 is clearly the only period with such obvious periodicity in the difference time series.

Upon closer study we found that for a given latitude, the NOAA-12 MSU generates warmer than expected temperatures in local winter and colder than expected in local summer. In other words, the annual range of temperatures in the NOAA-12 MSU was only about 98% of the other MSUs. This observation might be related to the fact that the dynamic range of the NOAA-12 MSU channel 2 was reduced due to much reduced gain (Mo 1994).

To account for this effect, that is, adjust the dynamic range of the NOAA-12 and possibly other MSUs, we decompose, latitude by latitude, the annual cycle of the difference time series into Fourier components for those overlap cases longer than 1 year (NOAA 6/7, 6/9, 10/11, 11/12). Once these Fourier components of the residual are removed, the time series is reconstructed as before. The results for daily and 30-day means are shown in Fig. 4 for various Fourier-component wavenumbers removed (e.g., "5" indicates removal of components 1 to 5).

The removal of Fourier components 0, 1, 1-3, 1-5, 1-7, and 1-9, based on the difference time series, produces S/N values for daily anomalies of 8.7, 9.2, 9.8, 9.9, 10.0, and 10.0, respectively. For 30-day averages, these values are 26.2, 30.6, 43.3, 45.2, 45.1, and 45.1. This adjustment impacts the 30-day S/N substantially more than the daily, reducing $\sqrt{N}$ by over 20% in the case of waves 1-5. The daily $\sqrt{N}$ is also reduced, but less than 10% because its fluctuations occur more on a day-to-day basis. There is no significant reduction of N beyond wave 1-5 removal. Given this magnitude of noise reduction we believe this procedure should be applied (up to annual harmonic 5) to the data supplied to the users. The process of removing Fourier components of the annual period does not affect the overall trend of the time series at the 0.002°C per decade level and has its primary impact on NOAA-12.

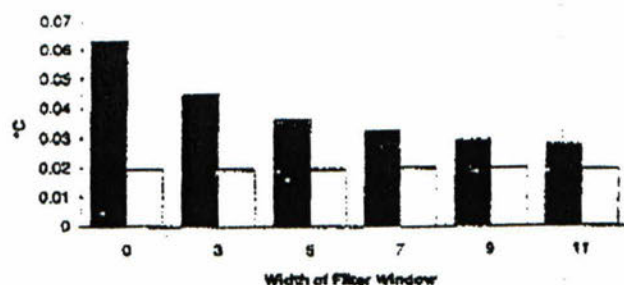


FIG. 5. Solid (open) columns represent $\sqrt{N}$ for daily (30-day mean) statistics due to median filtering with window width $2n + 1$ indicated below.

c. Median filtering

The northern midlatitudes tend to have a large influence on the global-mean anomaly because of the large temperature variations that are observed over the continental regions. When an MSU undersamples this area relative to other areas, there is a potential for dramatically increased noise in the difference between two observing satellites. The spikiness of the time series in Fig. 2 is strongly related to this. Rather than averaging each zonal anomaly across a few days to reduce the noise, we shall use the technique of median filtering in which the outliers or spikes are essentially eliminated from the dataset.

For a given latitude and given day, the median is determined from the current value ranked with n days previous and following. The median window is then $2n + 1$ days in length. Data will be set to missing if the $2n + 1$ window finds less than $n + 1$ days of data. In Fig. 5 we show the result of noise reduction to the daily global-mean anomaly for no median filtering through an 11-day window ($n = 5$) once the annual harmonics have been removed as described above. We notice a substantial reduction in daily $\sqrt{N}$ for $n = 1$ and 2, with lesser reductions thereafter. However, reducing N is only one component of the goal, the other being a preservation of the signal magnitude S . For the same categories of median filtering, in Fig. 6 we display the values of $\sqrt{S}$ where reductions are also apparent in the daily variance. A portion of the reduction in both N and S is due to the removal of the errors in the time

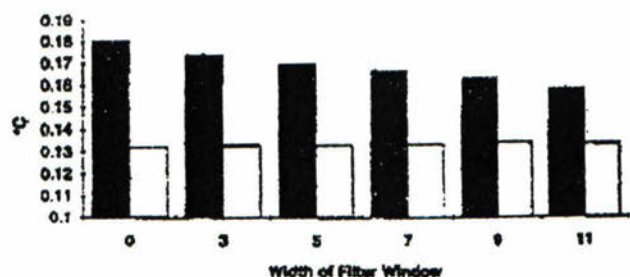


FIG. 6. As above for $\sqrt{S}$.

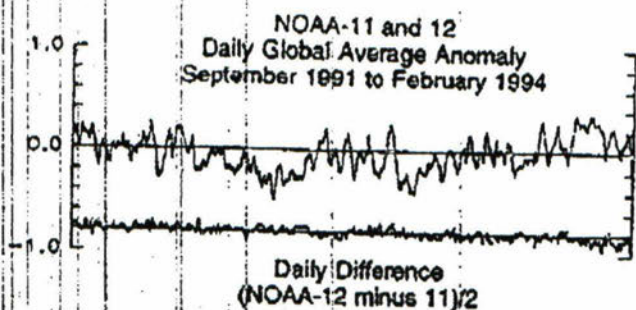


FIG. 7. As in Fig. 2 for the NOAA-11 and NOAA-12 overlap comparison after removal of five Fourier components of the annual period and inclusion of 5-point median filtering. Note the trend in the difference time series.

series. However, the natural smoothing characteristic of median filtering is also a factor.

We believe it is desirable to include median filtering of the latitudinal anomalies because of the obvious reduction of N . The selection of the width of the window is somewhat arbitrary since the level of signal smoothing one might accept varies according to research requirements. We have chosen $n = 2$ for a width of 5, which reduces VS by only 5.6% while reducing VN by 38%. The S/N ratios of daily global anomalies for the median filter windows shown in Figs. 5 and 6 (width: $2n + 1 = 0, 3, 5, 7, 9$, and 11) are 9.9, 18.1, 26.2, 31.8, 38.1, and 41.1, respectively. Reductions in VS for the same sequence of values are 0%, 3.8%, 5.6%, 7.0%, 8.4%, and 9.8%. The S/N ratios for 30-day averages were 45 ± 1.5 with no discernible relationship between window width and S/N .

A median filter of width 5 would *not* be expected to replace the center or current value with the calculated median one time out of five (20%) for a random distribution. In other words, the time-centered value would be the actual median 20% of the time. For processes that have discernible variations on time spans longer than 5 days, the percentage of nonreplacement would be greater as the current value would have a higher probability of being the actual median value if there were a trend over the 5-day period.

Analysis of the 5-day median replacement rate of the latitudinal anomalies indicates that about 35% are *not* replaced at high latitudes, with that percentage decreasing to slightly more than 20% at the equator. This implies that tropical variations of zonal-mean temperature are so slow as to represent essentially random distributions on 5-day intervals. Concerning the almost 80% that are replaced in the Tropics, the difference between the current and median (i.e., replacement) value produces a σ of about 0.2°C . In higher latitudes, the 65% current and median values differ with a σ of about 0.4°C . The effect of the latitudinal median filter is rather slight on the global mean as compensation between latitude bands occurs so that the VS is reduced by only 5.6%.

The reduction of VN from a combination of har-

monic removal and median filtering is over 45% for daily observations and over 20% for the 30-day averages. Figure 7 shows the same overlap of 11/12 as shown in Fig. 2 after these two procedures are applied. For this particular overlap example, the S/N for daily and 30-day averages are now 18.4 and 36.8, respectively, up from 5.8 and 13.6. Using the various window widths, we calculated the trend of the entire time series and found variations of the trend are less than 0.002°C per decade from that of the selected ($2n + 1 = 5$) filter.

d. The issue of trends in the differences

What is now apparent in the 11/12 overlap time series of differences (Fig. 7) is the disturbing presence of an obvious trend. In actuality, the trend began in 1990 when the temperatures of the 10/11 overlap began to diverge. During the first 2 years of the 10/11 overlap, there was no trend in the difference time series greater than 0.01°C per year (Christy and Goodridge 1994). Since 1990, NOAA-11 observes a global temperature trend that is $0.03^\circ\text{--}0.04^\circ\text{C}$ per year warmer than that of post-1989 NOAA-10 and all of NOAA-12.

Because NOAA-11 is in disagreement with two other satellites, our first assumption is that NOAA-11 is the source of the error. This suspicion is substantiated by NOAA-11's orbital drift from the initial equatorial crossing time of 0130/1330 to 0430/1630 as of February 1994 (Fig. 8). The question now becomes how does the global tropospheric temperature relate to the changing time of observation (i.e., diurnal cycle). The troposphere is generally warmer at 1630 than at 1330 but is this warming entirely offset by the cooling that would be expected in the nighttime pass as it drifted from 0130 to 0430?

To provide further insight into this issue we calculated the trend latitude-by-latitude for the difference between NOAA-11 and the two morning orbiters, NOAA-10 and -12 (Fig. 9). We see that the subtropical

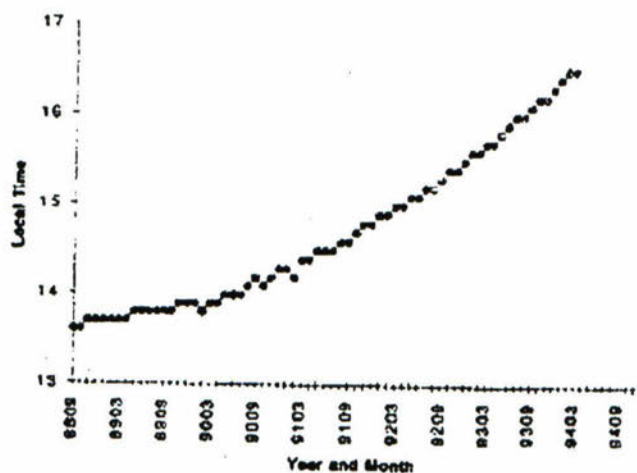


FIG. 8. Ascending pass crossing time at the equator for NOAA-11 from September 1988 to February 1994.

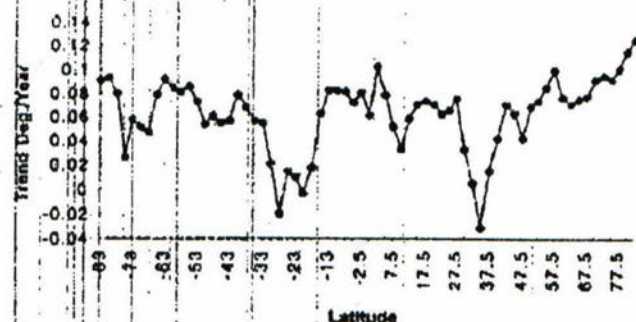


FIG. 9. Relative trend ($^{\circ}\text{C}$ per year) between NOAA-11 versus NOAA-10 and NOAA-12 determined from 1 January 1990 to 28 February 1994 as a function of latitude.

latitudes show slight positive to negative trends for the relative difference, while at all other latitudes the sign is positive. The notion that the MSU on NOAA-11 is contributing a spurious warming trend related to its orbit time decay seems confirmed by this figure. In those regions with strong convection, in which surface heat is transferred to the free atmosphere throughout the afternoon, the warming measured from 1330 to 1630 would be greater than cooling during the stable period from 0130 to 0430. The Northern Hemisphere, with its greater proportion of land surface relative to the Southern Hemisphere, seems to have a greater propensity for vertical mixing and, therefore, generally supports more positive trends during the 0130/1330–0430/1630 drift. Even over those oceanic regions, which are subject to frequent precipitating systems (i.e., tropics and midlatitudes), it has been shown that the tropospheric temperature peaks at about 1600 local time (Randall et al. 1991).

However, in the subtropical latitudes there is considerable subsidence and, thus, decoupling between the boundary layer (most often a marine boundary layer in the Southern Hemisphere) and the free atmosphere (Trenberth et al. 1992). The diurnal cycle in the troposphere would more closely follow the solar cycle, peaking in the early afternoon and cooling until dawn. Tropospheric temperatures at 0430 would certainly be cooler than those at 0130, while in the afternoon the 1630 observation would most likely be equal to or cooler than the 1330 observation.

The latitude bands in the 32.5° – 40°N region have a peculiar character in that they are somewhat affected by the typical subtropical atmospheric processes and also by pronounced surface emissivity effects. The highlands from Iran eastward to China penetrate the MSU weighting function, “shining through” the atmosphere to some extent. The diurnal cycle of the MSU 2R in these areas is very closely tied to the surface skin temperature, so that the MSU brightness temperature reaches its maximum earlier (near solar noon) than does the physical temperature of the air above. By viewing at 1630 rather than 1330, NOAA-11 observes a cooler brightness temperature due to the cooler skin

temperature even though the atmosphere there may be warmer. The removal of a negative trend in those bands is, therefore, necessary.

The effect of the satellite orbit decay would be greater during summer, when convection (dry and moist) is more vigorous, than during winter. As such, one would expect an annual cycle in the time-drift effect on the difference time series. This is not seen in our data at this point because such oscillations, which are anchored to the annual period, have already been removed (section 4b). In fact, that these harmonics were present to begin with seems related to this orbit-drift problem as well as instrument differences.

The trends of Fig. 9 are removed from the NOAA-11 data, beginning with 1 January 1990. This process further reduces the noise of the last two overlap pairs and, thus, the overall noise levels. The final $\sqrt{N}$ and S/N for all overlapping comparisons are 0.0348 K (0.0167 K) and 29.5 (63.4) for daily (30 day) averages respectively. The reductions of noise for the procedures described in this paper are summarized in Fig. 10.

Our definition of noise, as the variance of the difference time series divided by 2, is not a traditional quantity but did suit our purposes for the visual comparison of signal (the sum divided by two) and noise for intercompared satellite data. The standard error of measurement, as another representation of noise, requires that our $\sqrt{N}$ be multiplied by 1.414 (i.e., $2/\sqrt{2}$). We therefore compute the daily (30 day average) value of the standard error of measurement as 0.0492 K (0.0236 K).

In Fig. 11 we show the 11/12 overlap in which now there is no trend in the difference time series. We note here that the latitudinal trends removed in NOAA-11 are linear functions of best fit. We assumed that the actual warming/cooling rates due to time drift are linear over the 3-hour drift observed in NOAA-11. As it continues to drift, we expect that the instrument will eventually observe temperatures at their local maximum (globally speaking) of the diurnal cycle and then the temperatures will begin to decline. Since NOAA-



FIG. 10. Solid (open) columns represent $\sqrt{N}$ for daily (30-day) averages for A: unaltered data for 20 k observations; B: as in A with removal of five Fourier components; C: as in B with 5-point median filtering; and D: as in C after removal of NOAA-11 trend.

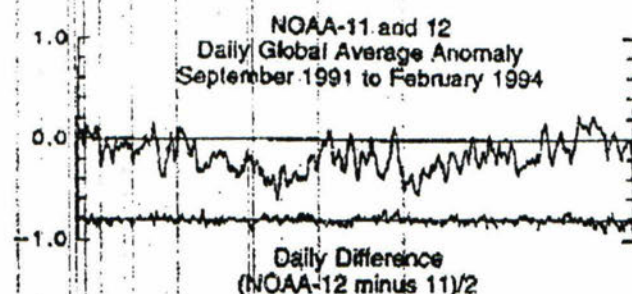


FIG. 11. As in Fig. 7 for the NOAA-11 and -12 overlap after latitudinal trends of NOAA-11 are removed.

11 is degrading at 6 minutes per month, we suspect that the usefulness of the linear adjustments made here may have already reached their limit.

The orbital drift in the afternoon satellites is not detectable in the temperature data until the third year of orbit, as in the case of NOAA-11. For TIROS-N, there was a sudden drop in the MSU data rate after only 14 months (January 1980), so drifting had no impact. The oscillator on NOAA-9's MSU failed after only 27 months, rendering the instrument inoperative for channel 2. We should note that other instruments remained in operation on NOAA-9, and researchers using those data will certainly have to deal with the problem of drift. The MSU on NOAA-7 was in operation for 3.5 years, and as such, there may be a slight warming effect late in its term of service (about 1984, Fig. 1) when it was the only MSU in operation. We should note, however, that the subsequent MSU on NOAA-9 was calibrated directly against NOAA-6, and so did not require NOAA-7 data. The long time series of NOAA-6 was rigorously checked by radiosonde data from mid-1979 through

1986 and found to have no temperature drift over the 7.5 years (Spencer et al. 1990). Therefore, the MSU time series after NOAA-7 is independent from any temperature drift that might have occurred between the first shutdown of NOAA-6 (April 1983) and its restart in April 1985.

5. Conclusions

Careful examination of the daily global-mean anomalies of the lower-tropospheric temperature through the comparison of simultaneously operating satellites has allowed a direct determination of signal and noise of the data. From this, we have determined which characteristics are important in noise reduction. In the case of missing data, there was little impact found between the 19 000 and 22 000 per day data rates, so the value of 20 000 was retained.

There were significant impacts due to residual annual cycle differences between the various instruments and the lack of latitudinal/temporal filtering. By removing the residual annual cycle to five Fourier components and applying a median filter of width 5 days for each latitude, the daily and monthly noise were reduced by over 40% and 25%, respectively, while leaving the signal with over 90% of its original variance.

The time drift of NOAA-11 was shown to produce, since 1990, a spurious warming trend in the time series as it observed the atmosphere at warmer local times (globally averaged) during its degradation. Once calculated and removed, the resultant total time series produces a decadal trend for the 15+ year time series of -0.058°C (Fig. 12). This is 0.03°C per decade cooler than calculated under the assumption that NOAA-11 was in a stable orbit. Also in Fig. 12 is the time series of the differences between previously reported global

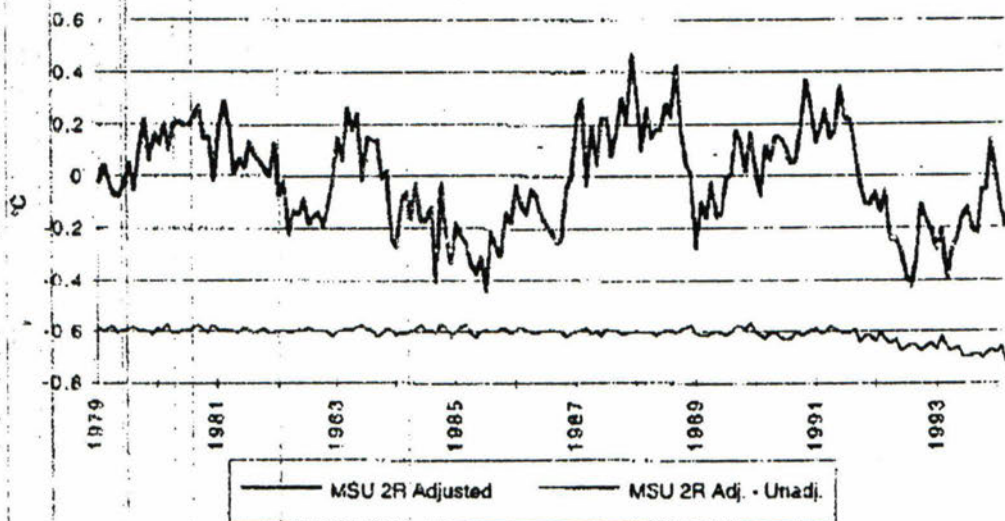


FIG. 12. Time series of monthly global anomalies (thick line) relative to 1982-91 annual cycle after removal of effects noted in this paper. Difference (thin line, offset by -0.6°C for clarity) relative to MSU 2R values reported prior to adjustments given in this paper. The time series here includes March 1994.

temperatures and those using the adjustments applied from this current research. Monthly differences are very minor (within 0.03°C) until the last 3 years when the impact of the *NOAA-11* drift is apparent.

In a recent report, Christy and McNider (1994) estimated the magnitude of the global MSU 2R temperature trend once the effects of volcanoes and El Niños were removed. The goal was to isolate a possible warming signal due to the enhanced greenhouse effect. Their resultant 15-year trend was about $+0.09^{\circ}\text{C}$ per decade. Using the MSU 2R data, as adjusted in this study, the volcanic impact was reevaluated because the impact of Pinatubo (June 1991) occurred entirely within the period affected by the *NOAA-11* orbital drift. The global temperatures since 1991, now cooler than previously thought, imply that Pinatubo had an even stronger impact on the global temperature than estimated in Christy and McNider. However, after reevaluating the volcanic effect on the now-cooler post-1990 global temperatures and then removing that effect we find the "global warming" trend remains at about $+0.09^{\circ}\text{C}$ per decade as of July 1994.

An opportunity is now available to assess the diurnal cycle of temperature of the global- (and zonal) free atmosphere due to the inadvertent drift of *NOAA-11*. With the morning satellites well anchored to the terminator orbit, we can compare global and zonal temperatures in *NOAA-11* with the morning orbiter data throughout the 3-hour drift as was done in this paper. From this, we may determine average changes between the drifting observations and those of the morning orbiters to assess part of the diurnal cycle. Investigations concerning the diurnal cycle, as well as correcting MSU channel 4 (lower stratosphere), will be addressed in future work.

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The Heated Debate: Greenhouse Predictions Versus Climate Reality. Robert C. Balling, Jr. 1992. 195 pp. \$21.95. Hardbound. Pacific Research Institute. ISBN 0-936488-47-6.

Robert Balling has produced a book that is both interesting and frustrating to this reviewer. The book is interesting in that it contains a great many thoughtful analyses of observational data presented in a manner to critically test and evaluate model predictions of the climatic change to be expected from the increasing concentrations of greenhouse gases. That Balling pursues this empirical approach with great vigor and talent should not be surprising. He is director of the Office of Climatology and associate professor of geography at Arizona State University. In addition to analyzing a range of other climatic questions, he has devoted considerable time and effort to looking critically at the claims and projections for climatic and environmental change in response to human activities.

The book contains nine chapters and an epilogue (in addition to an introduction). Within each chapter Balling lays out what he refers to as the "popular

vision" of the projected global warming and then presents an array of observational evidence intended to test the validity of these perceptions and interpretations. This is carried through in an eminently readable text, with more than 50 figures. There are very few editorial and typographical errors, although a few that do occur are in surprisingly obvious places [e.g., an approximately equals sign instead of fourth root sign in Eq. (2), mislabeling a curve in Fig. 20, referring to "decade" instead of "century" in describing past warming on page 139]. One hidden error I found came when he noted that there is more carbon ("by far") in the oceans than in geological formations (p.19); actually, geological formations contain several orders of magnitude more carbon. It would also help if the word "Earth" (capitalized) were used consistently to mean the atmosphere-ocean-land system (i.e., the planet) and not also to mean only the surface (which is earth and water).

... while the focus on data analysis is helpful, one must be careful in accepting some of the comparisons he does make that are central to his arguments, because other explanations may be as, or even more, plausible.

In addition to these few shortcomings, there are also questions of scientific interpretation. One example is his attempt to determine the contribution that desertification is making to global warming. To develop an estimate, Balling compares temperature changes for desert areas (primarily the Sahel) and contrasts them to changes in nearby nondesertified areas (for the Sahel grid points, primarily tropical rain forest). He attributes the greater warming in the desert areas all to desertification (and not to greenhouse warming), whereas global-scale climate change (including greenhouse warming) would be expected both to warm dry areas more than moist areas and, as is predicted by models to be the case for the midcontinental United States, to make marginally wet areas drier and to warm them more than fully moist areas. Thus, while the focus on data analysis is helpful, one must be careful in accepting some of the comparisons he does make that are central to his arguments, because other explanations may be as, or even more, plausible.

Overall, however, the book has much to offer. Its strength is the core set of chapters, which look in succession at the exponential increase in greenhouse gases, numerical models of global climate, observed

global-scale climate change, the observed hemispheric and latitudinal patterns of climate change, and greenhouse effects in the United States. Given the title of the book, I am giving away no secrets in saying that the popular vision and Balling's empirical analyses generally diverge. While Balling finds that some aspects of what models predict is reflected in the record, many shortcomings are identified. The summaries at the end of each chapter leave little doubt that, while he agrees atmospheric composition is changing and that some warming will occur, what is happening is nowhere near as severe as the popular vision.

But the book is also frustrating. Despite its title, the book is clearly not a documentary of the debate that is taking place. The popular vision he describes is neither well referenced nor responsibly filtered, with Balling picking and choosing from the most dire consequences put forth by activist environmentalist groups (and some scientists in their public statements) to

make up the apocalyptic future. There is no effort made to provide the rationale, explanations, justifications, or contexts that these groups offer for basing their conclusions on worst-case scenarios (e.g., taking a precautionary approach that assumes the knowns plus uncertainties will occur in that the effects are long term and irreversible, and there is only one "spaceship Earth" on which life is known to be able to survive). Thus,

Balling sets up a "strawman" catastrophist vision in which it is rather easy to punch holes. It would have been much more of a challenge had he taken on the more authoritative report of the Intergovernmental Panel on Climate Change (IPCC).

A second frustration is that all the while he is critiquing the greenhouse effect in chapters 2 to 6, Balling holds in reserve what is likely part of the explanation for the discrepancies he sees between model predictions and climate reality. Balling waits until chapter 7 to introduce increasing concentrations of sulfate aerosol as a possible cooling influence, and more generally to explain that climate is affected by factors in addition to greenhouse gases. Environmental literature may be slow in getting to this point as well, but from a climate empiricist it is somewhat surprising that development of the perspective is so delayed, especially when the conclusion is that "we found that the models were simulating a doubling of CO₂ and producing results that were largely consistent with the observations of the past century, with the obvious problem of overestimating the rise in temperature. The addition of the sulfates helps to resolve the unusual trends in the industrialized Northern Hemisphere, the lack of warming in many industrialized areas, the higher than expected precipitation totals

and cloud coverage, and the increasing soil moisture levels" (130–131). In later analyses, when he may be also inclined to include the climatic effects of ozone depletion, Balling may even become a greenhouse convert.

In the last chapter, Balling draws several implications for responsible policy. Some of his points are well taken (e.g., leveling greenhouse emissions will not be enough to stop the temperatures from warming; there will be both beneficial and detrimental impacts). What is frustrating, however, is that Balling seems to have forgotten what he had just described in the preceding chapter; namely, that the climate is indeed about as sensitive as the models are indicating (their problems are mainly that they have not been including sulfates—and, it is becoming realized, ozone depletion effects) and so, with sulfates having a short atmospheric lifetime and greenhouse gases a long lifetime, the greenhouse effect will prevail over time, and at an accelerating rate. In considering these implications in the final epilogue, Balling eschews use of the "crystal ball," relying instead on conclusions from the past. He criticizes the global warming catastrophists of having a religious attachment to the issue and of not accepting lessons from the climate past; yet Balling seems to be as tightly attached philosophically to future changes being limited to those in the past, even as population growth proceeds exponentially.

Richard Lindzen of MIT is quoted on the back cover as saying the book "is most assuredly not a polemic." For Balling's text, while being put forth with a definite perspective, I can agree—Balling seems to be searching and testing for the truth, albeit very critically and even if very reluctant to depart from a linear trend. For the Introduction by Aaron Wildavsky, Lindzen's quotation is most assuredly not the case: the Introduction is indeed a polemic against environmentalism and any actions to impede the carbon economy. Balling strives to avoid "theoretical predictions and the purely speculative"; in contrast, Wildavsky supports Lindzen's postulated but unproven negative feedback, the Marshall Institute's postulated but unproven solar connection, all the beneficial consequences of warming, and on and on, believing every critic of the greenhouse effect and no supporter. Whereas one is tempted to ask if anything could change Wildavsky's mind, Balling's book focuses on data and testing and, while a skeptic, he comes across as one who may be open to considering new evidence and new analyses. The book is ill-served by its Introduction, but in spite of this, well worth the reading.—*Michael C. MacCracken.*

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ELECTRIC CONSUMERS AND THE RIO TREATY – GOVERNMENT'S GREEN THUMB

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Presentation to:

"Beyond Business – Global Climatic Change" Seminar
Employers Reinsurance Corporation

Coral Gables, Florida
April 23, 1997

Today, I am proud to stand before you representing millions of electric consumers in our nation's heartland who rely on coal-fired electricity for their health and wealth, indeed for their very existence. These consumers, and the American economy itself, are at risk from a powerful combination of government, professional environmentalists both at home and abroad, and energy producers who compete with coal in the electricity marketplace. I stand today in opposition to this coalition.

Of all fossil fuels, coal is the fuel of choice for the common man. It is cheap to produce and burn. It can be – and is – burned cleanly and efficiently. It can't be monopolized by foreign governments or powerful energy companies since it is located in so many places. Coal is electricity and electricity is key to our country's environmental and economic future.

Of all the fossil fuels, coal also has the greatest carbon content. When it is burned, carbon dioxide (CO₂) emissions result. Since CO₂ is a greenhouse gas, professional environmentalists raise speculative fear of apocalyptic global warming from our utilization of coal for electricity generation. Environmentalists are the opponents of low cost and abundant electric supply and they now argue, together with other members of their anti-coal coalition, that our nation should shut in domestic coal plants.

But carbon dioxide (CO₂) is not a pollutant. Since 1988, when a century-old argument over apocalyptic global warming went public, environmentalists in true Orwellian fashion have quite successfully convinced people that CO₂ is a pollutant even though it is a benign gas required for life on earth and a building block of nature because of its role in photosynthesis.

When plant biologists, agronomists, horticulturists, and foresters gather, you won't hear much discussion about a looming apocalypse due to ever increasing atmospheric CO₂ content.

Instead, these scientists, who work in the real world, speak optimistically about aerial CO₂ fertilization of plants, a better environment for food production, more robust forest growth, longer growing seasons, modest nighttime winter warming, and the greening of planet earth. In short, they speak of a better world for humans and all living things.

Unfortunately, the real-world voices of scientific optimism on global change are seldom heard. Instead, the scientific pessimists, who live in a virtual-world of computers, have captured the attention and backing of both the national media and important politicians. In a spectacular abuse of computer technology, they have projected a world of apocalyptic global warming, melting polar ice caps, drought, flooding, blizzards, disease, famine, and pestilence. These pessimists have made arbitrary assumptions, ignored key areas of inquiry, and changed known physical properties of the climate in creating computer models that forecast apocalypse 100 years from now. That is why the models can't hindcast and why it is that the models predict future climate that has no bearing on the real world in which we live.

As Twentieth Century promoters of Malthusian economics, the pessimists have seized on the forecast of apocalypse to prescribe massive government intervention in our lives in an attempt to lower living standards for the industrialized West – particularly the United States – while denying the human community the free and open use of the natural resources the Lord has given to us for our human family to succeed. The present day successors of Malthus are easily identified. They are the professional environmental community both here and abroad who work in government, in private environmental groups, and in respected universities.

Unfortunately for the American people, the Clinton Administration, through Vice President Al Gore, has embraced this pessimistic view of the future of the human community. Vice President Gore's approach, after all is said and done, is not to raise all of the people of the earth to Americans' living standard, but to roll back American living standards to some vague, ever changing notion of "sustainability" defined by those whose view of the world is driven by Malthus's economic thinking. As a result, American electric consumers, working men and women, poor people, people on fixed income, and the American economy itself are all in peril from proposed action by our own government. The Clinton Administration, acting in concert with foreign interests and governments, currently plans to take steps to limit energy production and consumption in the United States under the United Nation's Framework Convention on Climate Change (or the Rio Treaty, as it has come to be known).

This conclusion can no longer be characterized as a predictable pleading by industrial special interests. This is, in fact, the bottom line of a draft report prepared by Argonne National Laboratory for the U.S. Department of Energy as part of the Administration's promise to evaluate the effect of its proposals.

As summarized in the April 18, 1997 edition of *Inside EPA Weekly Report*, the study suggests that potential increases in energy costs driven by an international agreement to control global warming would lay waste to such major industrial sectors as iron and steel manufacturing, petroleum refining, aluminum production, cement production, paper and allied products, and chemical manufacturing. This would happen – according to the draft's authors – without

producing a reduction in global emissions and while, in fact, causing such emissions to increase. Why? Because manufacturing capacity in these six sectors would move out of the U.S. to developing countries which are not subject to the terms of the Rio Treaty.

In Article II, the Rio Treaty sets forth as its ultimate objective the *stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous, human interference with the world's climate system*. The speculation, based on flawed computer models, is that greenhouse gas emissions from humans will cause catastrophic global warming. Carbon dioxide (CO₂) is the primary greenhouse gas caused by human activity and is created when we burn fossil fuels. Since fossil fuels are burned by some humans somewhere all of the time, the Rio Treaty represents an initial step by government to massively regulate almost all human activity everywhere all of the time. The Rio Treaty thus represents government's Green Thumb.

Even though relevant scientific bodies in the U.S. and abroad have not determined (and cannot determine) what level of atmospheric CO₂ content would constitute dangerous interference with the climate, the Clinton Administration, under the leadership of Vice President Gore, seems ready to commit the U.S. to a dramatic change in the Treaty that would try to prevent *climate change* (as opposed to dangerous interference with climate) through binding U.S. CO₂ emission restraints.

It apparently has never occurred to the Vice President that government has as much chance at preventing climate change as preventing the moon from turning full. It also apparently has never occurred to the Vice President that human-induced environmental change could be good for humans and the planet, and not bad. The evidence of change we have today indicates such change will in fact be good.

According to most reports, the Administration favors an emissions trading allowance system as the mechanism for limiting energy production and consumption in the United States. Under such a system, American electric consumers will be charged money to burn American coal in American power plants for the purpose of paying that money to foreign interests in countries like China and Indonesia. These countries will sell us the "right" to run our own power plants.

Characterize the science however you want on climate change. The fact of the matter is the remedy for the problem, as perceived by the Clinton Administration, will result in a transfer of American wealth abroad and hurt the most those of us who can afford it the least. It is respectfully submitted that there is no science that justifies this kind of punishment of our citizens.

The Rio Treaty is aimed at Americans. Americans represent 4.5% of the world's population, but we consume close to 25% of all energy. Americans consume almost three times as much energy as the Chinese and over four times as much as the Japanese. If you want to restrict energy use in the world, you have to start with the United States.

Why would any American want to restrict energy utilization in the United States? Is it wrong for Americans to use the natural resources of our great land to raise living standards in this

greatest of all countries? Is it wrong that American households enjoy a lifestyle keyed to the use of more and more electricity as their affluence grows? Has it never occurred to the environmental community that you need cheap energy to make people's lives better; that using low-cost electricity enables all of us to lead fuller and more productive lives?

In the last 15 years, household use of electricity has grown by over 20%. Household use of electricity grew because electric consumers installed:

- | | | |
|-----------------------------|----------------------|------------------------|
| ✓ Microwave ovens | ✓ Video recorders | ✓ Second refrigerators |
| ✓ Second televisions | ✓ Personal computers | ✓ Electric typewriters |
| ✓ Electric air conditioners | ✓ Electric printers | |

Is this bad? Electricity improves people's lives and will continue to do so. Are we now going to punish people for wanting to live better?

In Vice President Gore's book *Earth in the Balance* he characterizes America's affluence and our citizens' lifestyle as "dysfunctional." He characterizes emissions from our industrial activity as "Buddha's breath." In the Orwellian fashion of professional environmentalists, the Vice President refers to CO₂ as a pollutant in several places. He calls for reduction in our country's energy consumption to less than half of 1992 levels. His book identifies with European thinking on American consumption patterns which are deemed by Europe's intellectual elite to be harmful to the future of the earth and, therefore, all people of the earth.

I would like to invite Vice President Gore and scientists in the European community who think Americans use too much energy to a townhall meeting with the citizens of Bismarck, North Dakota in the dead of winter, in the middle of a blizzard when the wind chill is -50°F, and have them tell North Dakotans they use too much electricity and don't pay enough for it. I also invite Vice President Gore and his European friends to meet with citizens of Sun City, Arizona at summer's peak when it's 115°F in the shade to deliver the message to elderly people who live on fixed incomes that they use too much electricity and don't pay enough for it.

The Vice President would have our government use its Green Thumb to radically change our lifestyle while choking off the lifeblood of industrial activity by transferring abroad jobs in America's carbon-intensive industries. Our manufacturing jobs remain high paying jobs. Base wages average \$45,000 per year. With benefits, these jobs are worth \$60,000 to \$70,000 per year. Auto assembly workers in Michigan, longshoremen in Maryland, copper miners in Arizona, union workers in the coal fields of Illinois, and the men and women who drive freight trucks on the Interstate highways are just some who will face loss of their jobs as America de-carbonizes its economy through restraint of fossil fuel use and in making energy expensive.

Politicians who support binding CO₂ constraints under the Rio Treaty purport to act in the interests of working people and families. In reality, these politicians promote an agenda designed to further the interests of an international bureaucracy, special energy interests seeking government access to consumers' pocketbooks, and the professional environmentalist class of lawyers, economists, scientists, and consultants who live in big cities, jet to conference after

conference in order to continually discuss global warming, who are sustained by government and foundation grants in all of this activity, and who seek to control our lives and futures by preying on fears of apocalypse a hundred years from now even without scientific observations to support such claims.

If as a society we buy into the nonsense of apocalyptic global warming, expect more Draconian measures in the years to come. In the Fall of 1994, the President's Commission on Sustainable Development met to consider our energy future in the context of concern over greenhouse gas emissions. Newspaper accounts at the time reported that the Commission was considering the following policy options:

- Restricting how many cars a family can own
- Forcing elderly drivers to give up their drivers licenses
- Increasing gasoline taxes by \$1 a gallon
- Increasing the age for teenage driving
- Requiring commuters to use public transportation every other day
- Restricting industrial activity based on energy use
- Requiring states to charge motor vehicle fees based on miles driven
- Requiring states to charge motor vehicle fees based on vehicle fuel efficiency
- Increasing the tax burden on personal use of cars by taxing parking spaces
- Requiring bicycle use in designated urban areas
- Imposing toll charges for interstate highway use and requiring states to charge for the use of city streets
- Surcharging the price of electricity by over 30% to force people to use less. This is known as the *caviar theory of energy*; only rich people can afford it.

Is this the kind of society in which we want to live? Is there any science justifying the kind of government tyranny that would so dramatically impact the lives of us all? I think not.

But there's an even more important reason for rejecting the vision of apocalypse advanced by the Vice President and by the environmental community under the Rio Treaty. ~~The~~ environmental community vilifies the fact that our economy is fossil based. The environmental community vilifies our reliance on coal-fired electricity. The fact is, however, that instead of vilifying coal we ought to get on our knees and thank the Lord we have it.

I'm going to show you a series of graphs from a recent report by Mills-McCarthy & Associates for Western Fuels, National Mining Association and CEED which tells this story in detail. These graphs from *Coal: Cornerstone of America's Competitive Advantage in World Markets* paint a picture of robust economic growth, international competitive advantage, and a bright future for all of us based on coal-fired electricity.

Before I do, let me briefly describe the wonderful and uniquely American success story that our domestic coal chain industry represents. In the United States today, there are 417 coal-fired electric power plants annually burning 900,000,000 tons of coal. Even if another coal plant never is built, existing units have the capacity to burn another 200,000,000 to 300,000,000 tons of

coal per year to provide low-cost electricity to the American people and our growing economy. Coal's competitors in the electricity marketplace want government to use its Green Thumb to choke off coal's growth in order to divert the business to higher-cost natural gas and renewable energy plants.

These coal plants did not come from some evil conspiracy of committed polluters, as the environmental community continually alleges. They were the result of a concerted federal energy policy commenced in the 1970s under President Jimmy Carter, a Democrat. President Carter commenced Project Energy Independence out of his firm belief that the best energy policy we could have in the United States is one based on our domestic fossil fuel resources and based on low-cost electricity for our people.

President Carter and the federal government embarked on this program with full knowledge of the theory of catastrophic global warming, no doubt secure in the view that visions of apocalypse are always just that and while recognizing that a growing economy needs low-cost electricity. President Carter recognized that America has been blessed with the hundreds of billions of tons of recoverable coal available to us in widely-dispersed coal fields all over the country and ready to be used in electric power plants to provide power for our people.

It was the Democratic Party in the 1970s and early 1980s that mandated the use of coal as our nation's favored fuel source. This mandate, by the Democrats, led to an enormous investment in coal chain industries – including coal mines, coal-fired power plants, and rail transportation. A major part of the mandate was the Powerplant and Industrial Fuel Use Act of 1978 which mandated the conversion of industrial boilers to coal and *prohibited* the use of oil or gas in new electric generating plants.

As a result, America made a direct investment of over \$200 billion dollars in coal chain industry power plants, coal mines, railroads, and barge facilities. Western Fuels calculates that the hundreds of coal plants and related facilities that are now operating in our country have a present value to our society of close to \$1 trillion.

Western Fuels itself was born in this environment. We are a creature of federal policies, policies designed to help working men and women by bringing the benefits of our country's natural resources to society. Western Fuels is a not-for-profit coal cooperative. We are owned by generation and transmission cooperatives and by municipal electric utilities. All of public power operates on a not-for-profit basis and all of us are ultimately owned by the consumers we serve. All of public power has democratically-elected boards. All of us participated in building billions of dollars worth of coal mines and coal-fired electric generating facilities utilizing federal loan guarantees from the Rural Electrification Administration or tax-exempt financing in the municipal sector. Most of the coal burned in these huge electric generating complexes is clean western coal from Wyoming and Montana, coal that is owned by the federal government and leased to coal companies pursuant to a federal law, the Mineral Leasing Act of 1976.

In public power's case, the coal plants were the direct result of a request from the United States that customers, who were utilizing federal hydroelectric power from federal dams which

were running out of capacity, put in matching thermal generation to meet the growing needs of the middle part of our country in the 1970s and 1980s. The public power coal plants are the direct result of inducements made by the United States to its citizens that they make the huge investments required to provide electricity to our vital agricultural economy, to defense industries and installations in the Rocky Mountain West and the Plains states, to the synthetic fuel plants that were to be built by the federally-established Synfuel Corporation, and to lead our country away from its reliance on imported oil. These inducements came from the elected federal officials who were the leaders of the Democratic Party and successors to FDR and his New Deal.

The government today at the Executive Branch level is led by Democrats who reject the FDR model of an activist federal government committed to the well-being of working men and women. Their energy policies seem designed to benefit a select few at the expense of the many. The Executive Branch today is repudiating the commitments to our organizations and to the people we represent in the middle part of the country who, in good faith, made huge investments at the request and at the behest of the federal government. The government today is telling us that we will not be allowed to operate these plants at their full-rated capacity for their natural life, as opposed to their accounting life.

What is the natural life of a coal plant? Fifty years from whenever you ask. This is so because they can be re-engineered on the ground even as they operate, and because our country's coal reserves will last for well over another 200 years. The true pay-off from these facilities will come when the debt is gone. The government today is getting ready to tell us that we cannot operate these facilities any longer than their accounting life and that they must be shut-in within 15 years.

Such action represents a breach of faith by the United States. I stand before you today on behalf of the millions of electric consumers in the middle part of the country who put in these coal-fired facilities in good faith and state that we reject the vision of apocalypse that forms the Rio Treaty. We reject the notion that energy policy in the United States should be set based on the CO₂ content of emissions that come from utilizing coal-fired power plants.

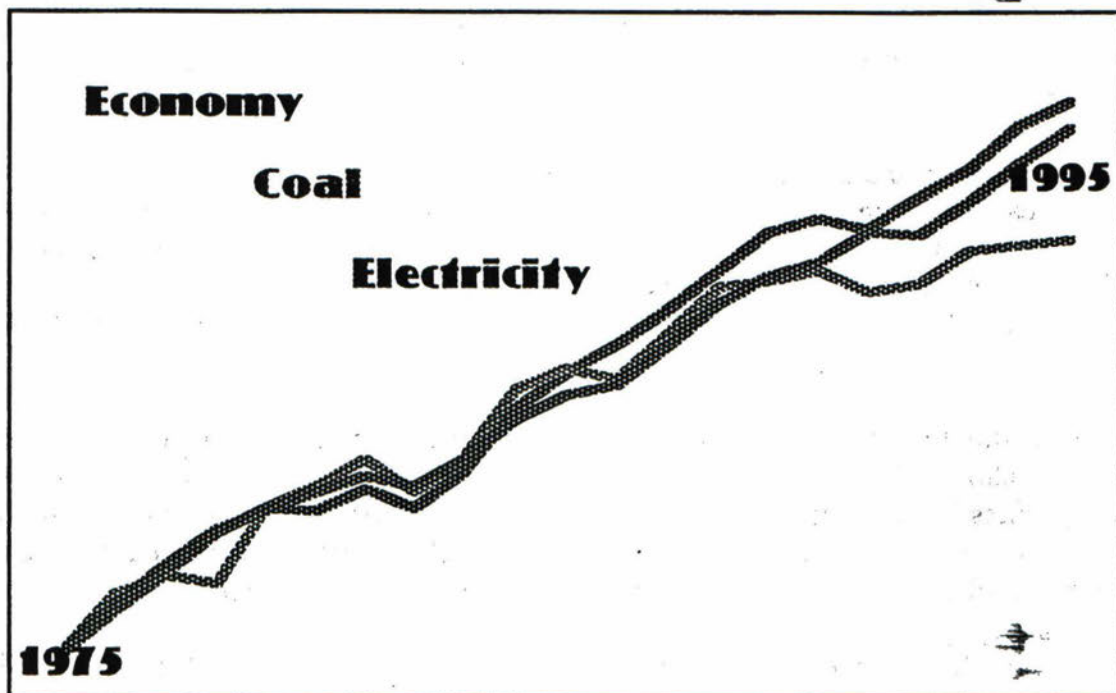
We reject this vision of apocalypse because, as you will hear from Dr. Robert C. Balling, Jr. and Dr. Patrick J. Michaels later in this seminar, scientific support for the vision of apocalypse does not exist. No science exists that justifies artificially limiting the United States' coal-fired electric generating base, a base which has provided us with tremendous benefits and will continue to do so for as long as we are alive and as long as our children are alive, and probably as long as their children are alive. Now let's go to the graphs and the slides.

Note: The following pages reproduce in black-and-white a series of color slides. Color copies are available upon request. Please contact Ned Leonard at Western Fuels Association by telephone at (703) 907-6163, by fax at (703) 907-6161, or by E-mail at wfa@cais.com.

Electricity, Coal & The Economy

Relationships, Trends & Realities

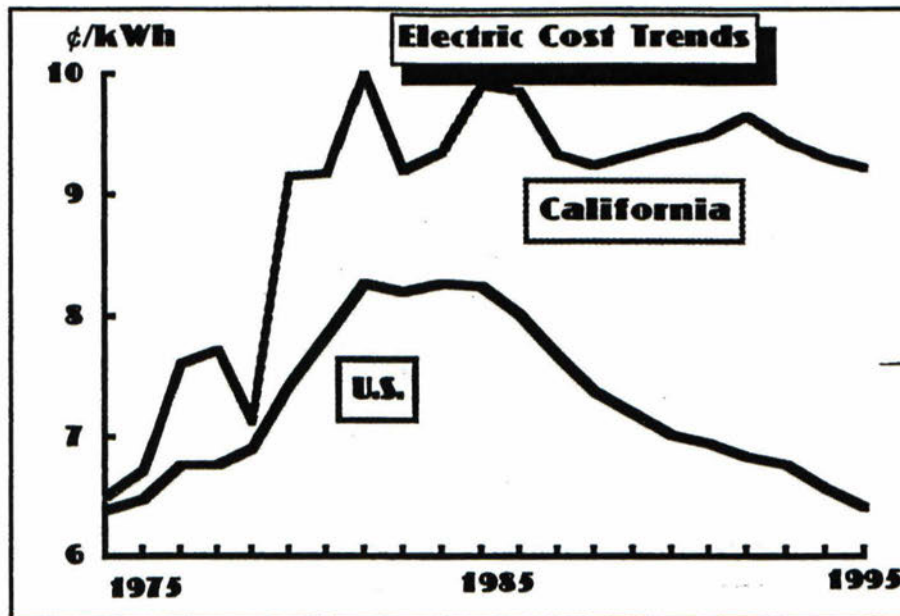
SUMMARIZED IN GRAPHICS



BY
MILLS • MCCARTHY & ASSOCIATES INC.
FOR
WESTERN FUELS ASSOCIATION

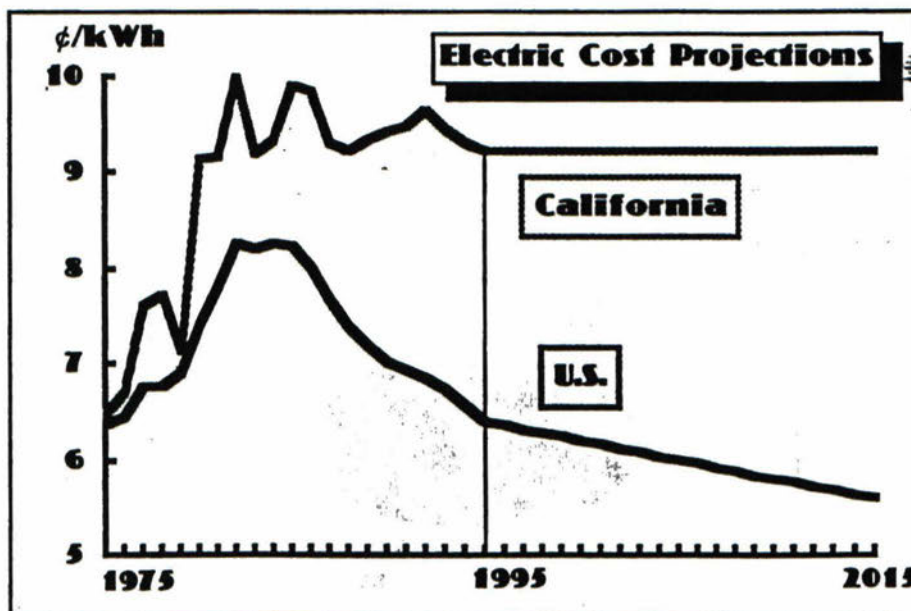
APRIL 1997

- POLICY APPROACHES TO ELECTRICITY REGULATION IMPACT THE PRICE OF ELECTRICITY FOR CONSUMERS.
- CALIFORNIA CONSUMERS PAY OVER \$3.5 BILLION/YEAR MORE FOR ELECTRICITY THAN IF THAT STATE'S ELECTRIC RATES HAD STAYED AT THE NATIONAL AVERAGE.



DATA FROM DOE/EIA, AND EEI
PRICES IN CONSTANT 1992\$

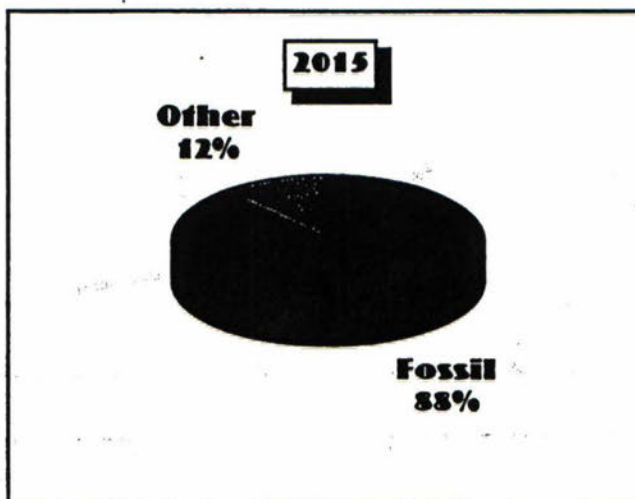
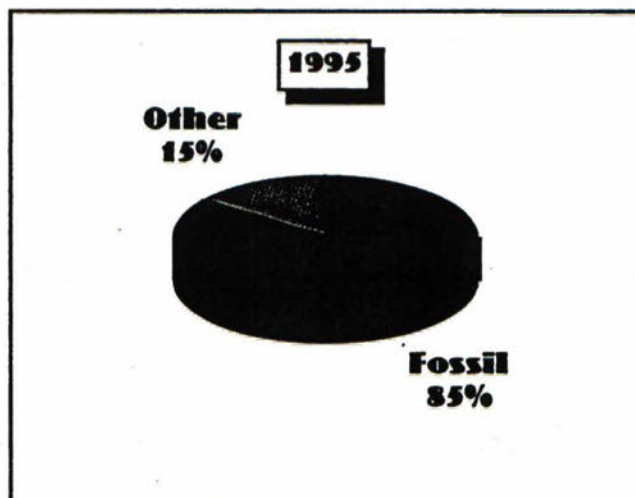
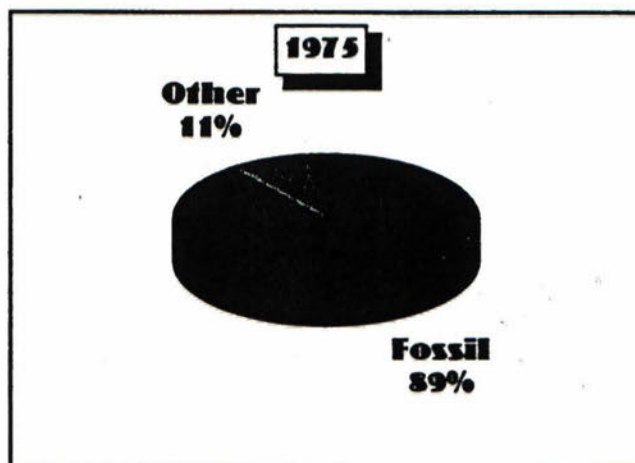
- CURRENT ENERGY INFORMATION ADMINISTRATION PROJECTIONS ANTICIPATE A SLOW, CONTINUED DECLINE IN AVERAGE NATIONAL ELECTRIC RATES DUE TO TECHNOLOGY PROGRESS AND INCREASED COMPETITION. WILL CALIFORNIA'S ENERGY POLICIES PERPETUATE THAT STATE'S ELECTRIC PENALTY?



DATA FROM DOE/EIA, EEI; DOE 1997 ANNUAL ENERGY OUTLOOK.
PRICES IN CONSTANT 1992\$

Electricity, Coal & The Economy

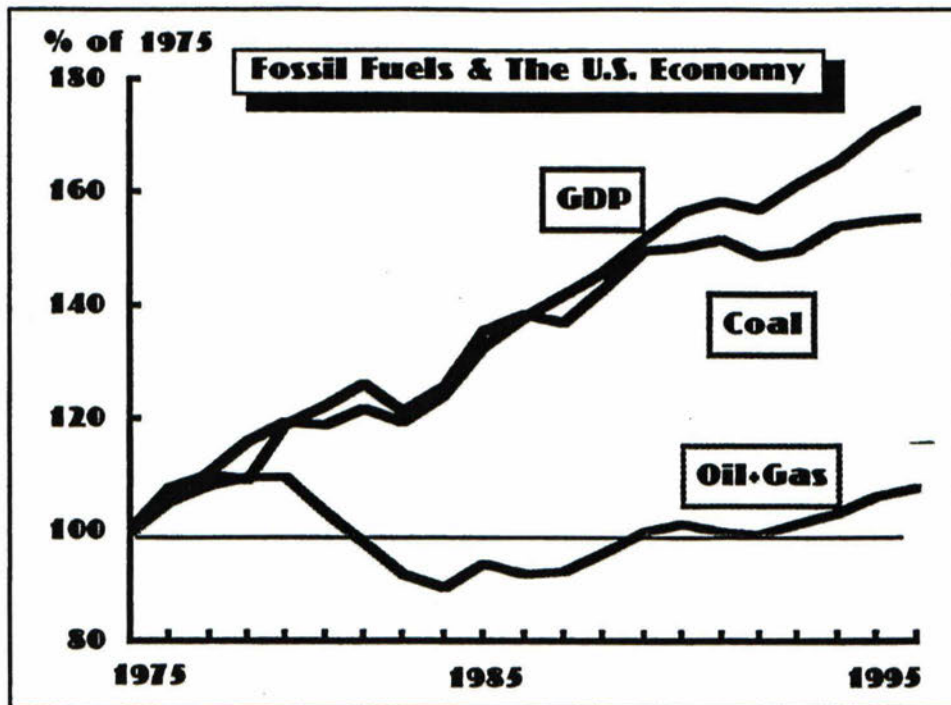
- FOSSIL FUELS WERE, ARE AND WILL CONTINUE TO BE THE PRIMARY SOURCE OF ENERGY FOR THE U.S. ECONOMY.
- THE FOSSIL SHARE OF TOTAL ENERGY NEEDS HAS BEEN, IS AND IS EXPECTED TO BE ABOUT 90%.
- THIS CONSTANT SHARE REPRESENTS A SIGNIFICANT GROWTH IN TOTAL ENERGY FROM FOSSIL FUELS. IN 1975, THE ECONOMY REQUIRED A TOTAL OF 73 QUADS, BY 1995 CONSUMPTION WAS 89 QUADS AND IS PROJECTED TO GROW TO 111 QUADS BY 2015.



DATA FROM DOE/EIA, EEI: DOE 1997 ANNUAL ENERGY OUTLOOK.

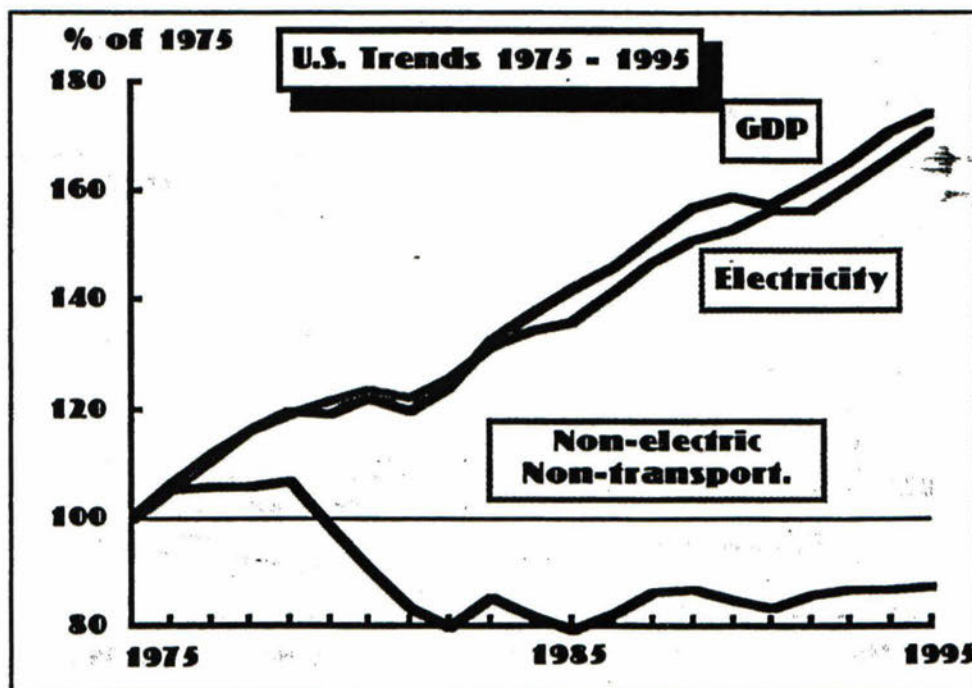
Electricity, Coal & The Economy

- ECONOMIC GROWTH IS CLOSELY LINKED TO GROWTH IN THE USE OF COAL.
- FOR TWO DECADES, THERE HAS BEEN NO LINKAGE BETWEEN ECONOMIC GROWTH AND INCREASED USE OF OIL AND NATURAL GAS.



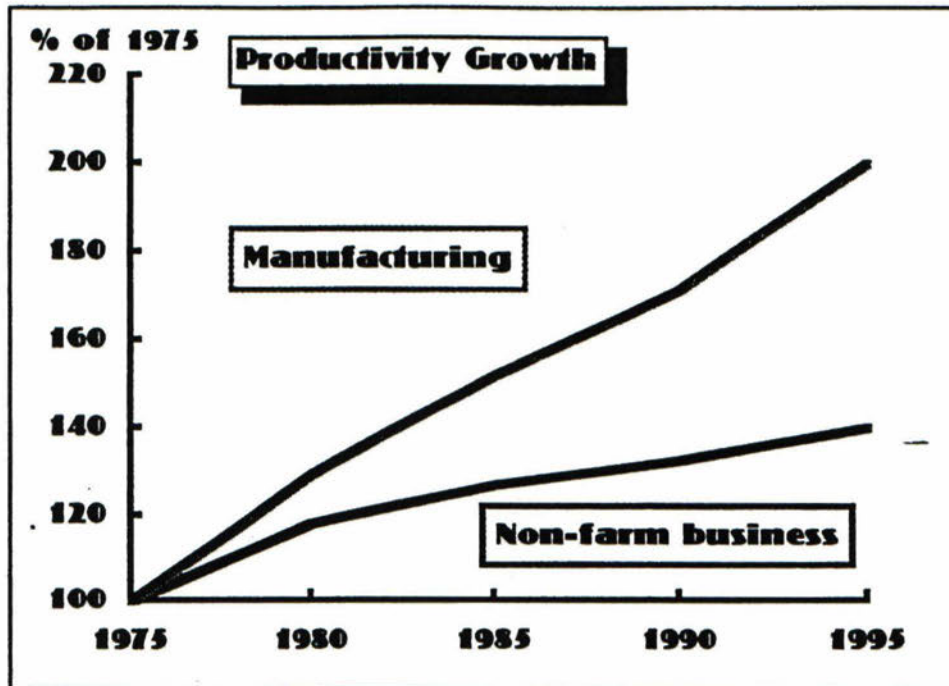
DATA FROM DOE/EIA

- THE LINKAGE BETWEEN COAL AND THE ECONOMY IS A DIRECT REFLECTION OF THE TIGHT INTER-RELATIONSHIP BETWEEN ECONOMIC GROWTH AND INCREASED ELECTRICITY USE. NO OTHER ENERGY FORMS TRACK ECONOMIC GROWTH SO CLOSELY.



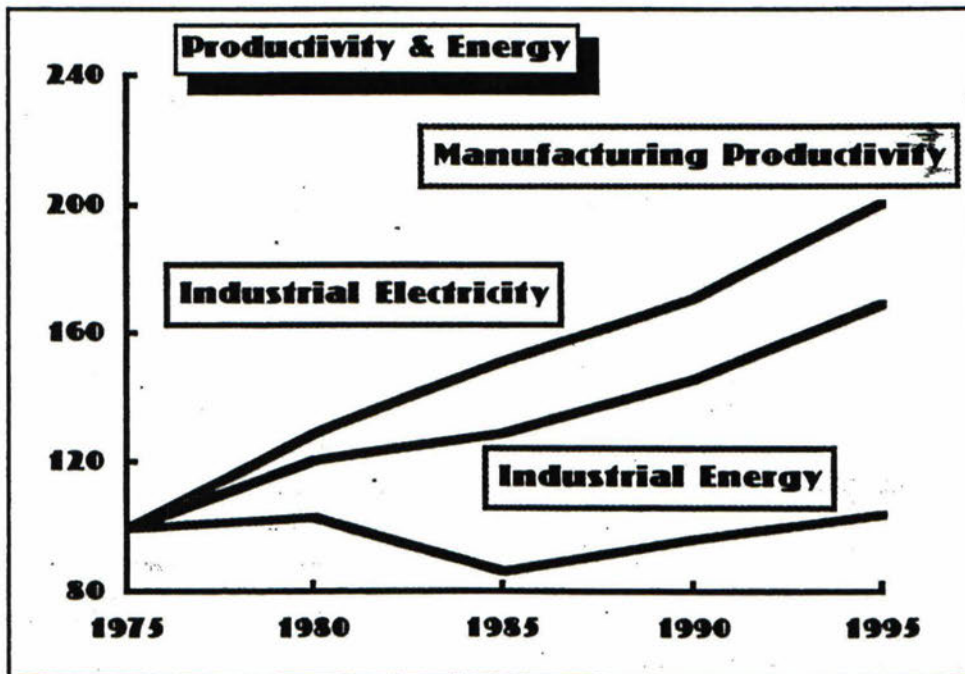
DATA FROM DOE/EIA

- PRODUCTIVITY IS ONE OF THE MOST IMPORTANT MEASURES OF THE HEALTH OF AN ECONOMY. U.S. MANUFACTURING PRODUCTIVITY HAS NEARLY DOUBLED IN THE PAST TWO DECADES.



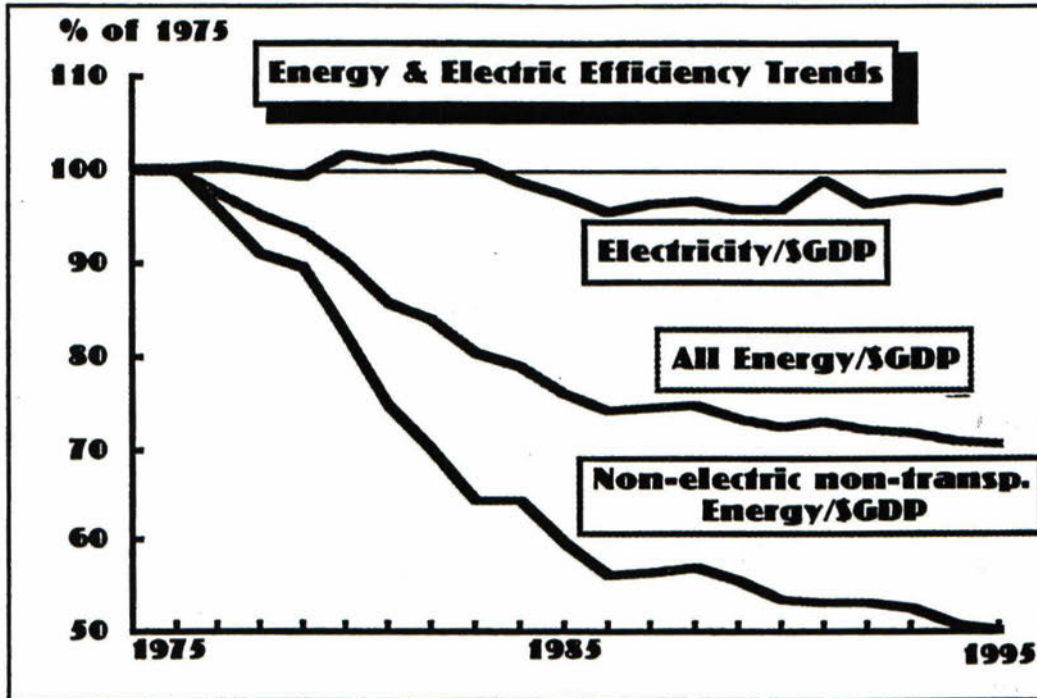
DATA FROM STATISTICAL ABSTRACT OF THE UNITED STATES

- THE STRONGEST PREDICTOR OF PRODUCTIVITY GROWTH IS INVESTMENT IN NEW EQUIPMENT & TECHNOLOGY. INDUSTRIAL ENERGY TRENDS SHOW THAT ELECTRIC TECHNOLOGIES HAVE BEEN THE DOMINANT SOURCE OF NEW EQUIPMENT IN MANUFACTURING.



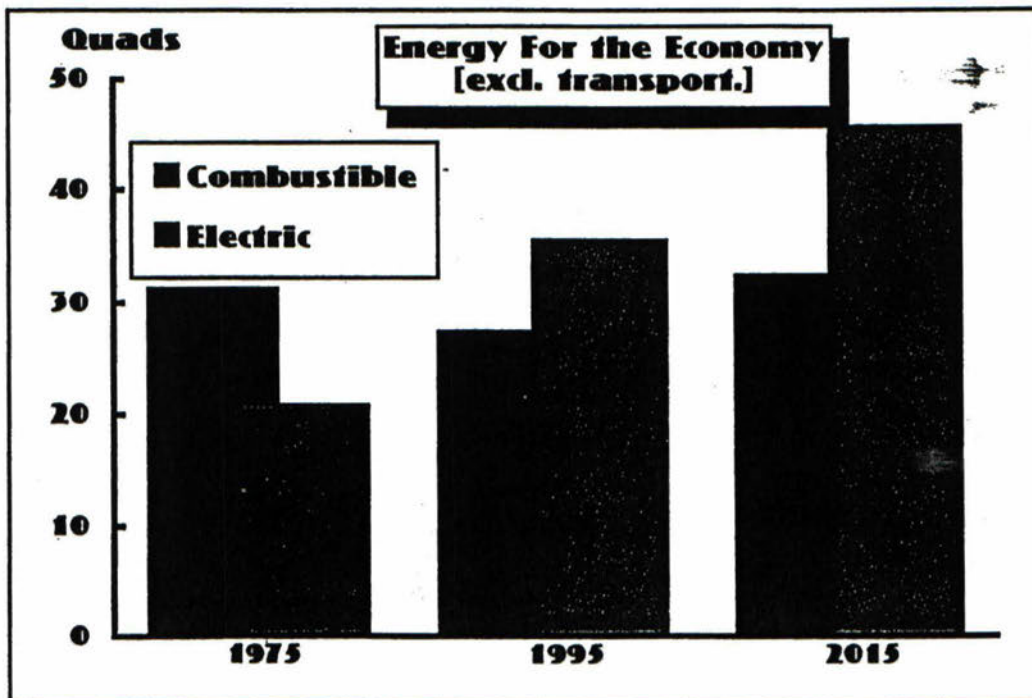
DATA FROM STATISTICAL ABSTRACT OF THE UNITED STATES & DOE/EIA

THE AMOUNT OF ELECTRICITY NEEDED TO-SUPPORT THE ECONOMY HAS REMAINED NEARLY CONSTANT FOR TWO DECADES. THE USE OF ENERGY OVERALL, AND NON-TRANSPORTATION NON-ELECTRIC ENERGY SOURCES (PRIMARILY NATURAL GAS) HAVE DECLINED IN IMPORTANCE TO THE ECONOMY.



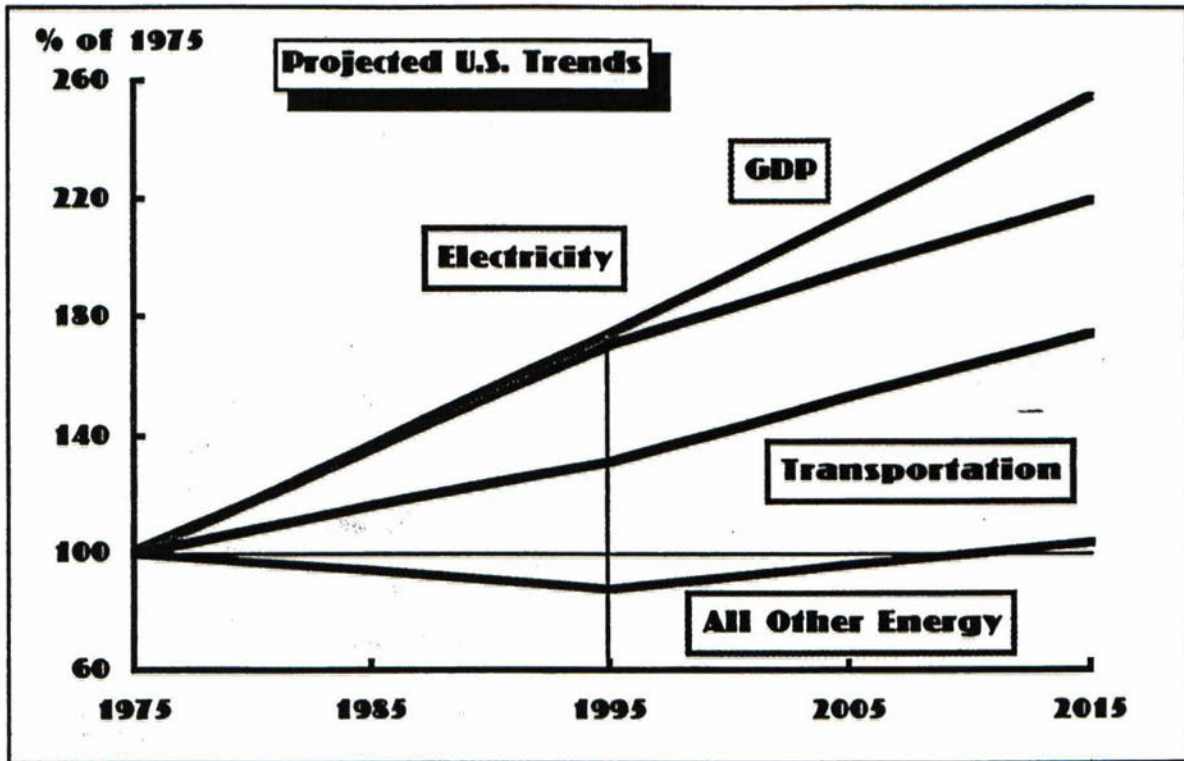
DATA FROM DOE/EIA
PRICES IN CONSTANT 1992\$

ENERGY USED BY THE INDUSTRIAL, COMMERCIAL AND RESIDENTIAL SECTORS (WHICH COMPRISE 90% OF THE GDP) ARE NOW PRIMARILY DELIVERED IN ELECTRIC FORM. THE DEMAND FOR COMBUSTION ENERGY SOURCES AT THE POINT-OF-USE HAS REMAINED LARGELY FLAT, EVEN AS THE ECONOMY HAS GROWN.



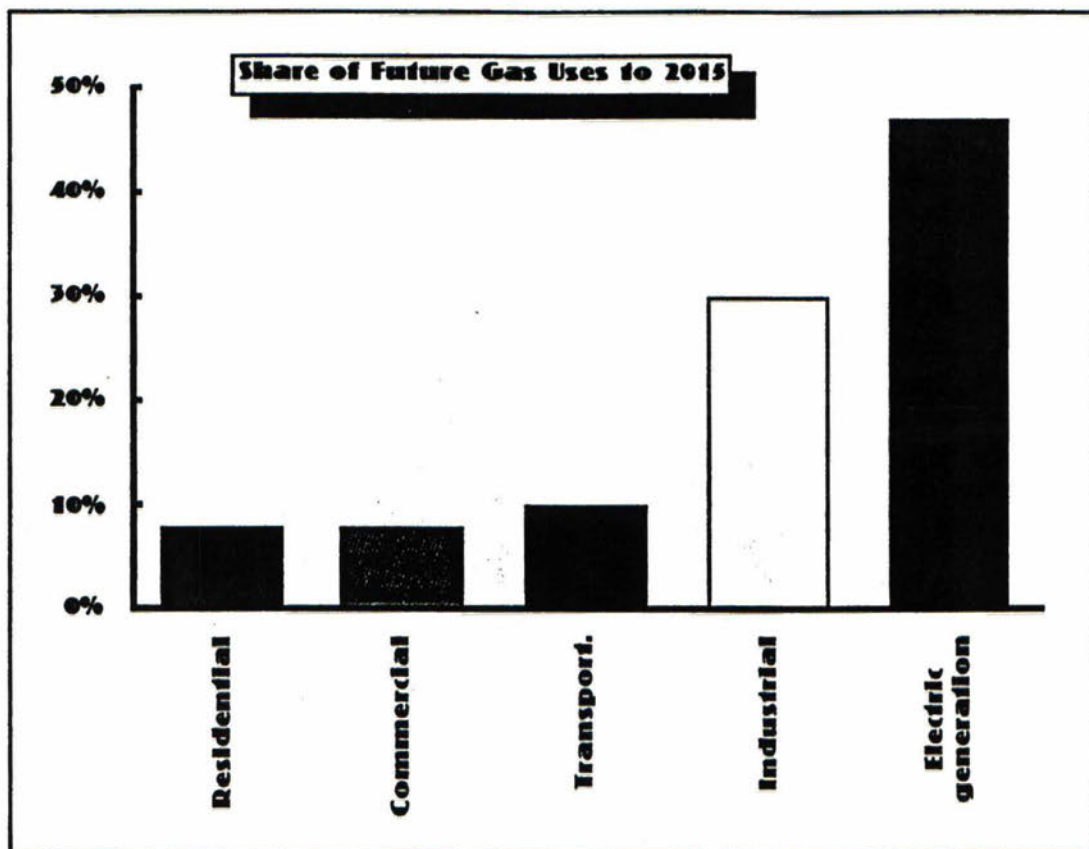
DATA FROM DOE/EIA
Page [6]

- PROJECTED GROWTH IN THE U.S. ECONOMY WILL BE ACCOMPANIED BY CONTINUED GROWTH IN ELECTRIC USE -- I.E., RISING USE OF ELECTROTECHNOLOGIES. NO SIGNIFICANT GROWTH IN ENERGY FOR COMBUSTION TECHNOLOGIES (EXCLUDING PLANES, TRAINS & AUTOS) IS EXPECTED.



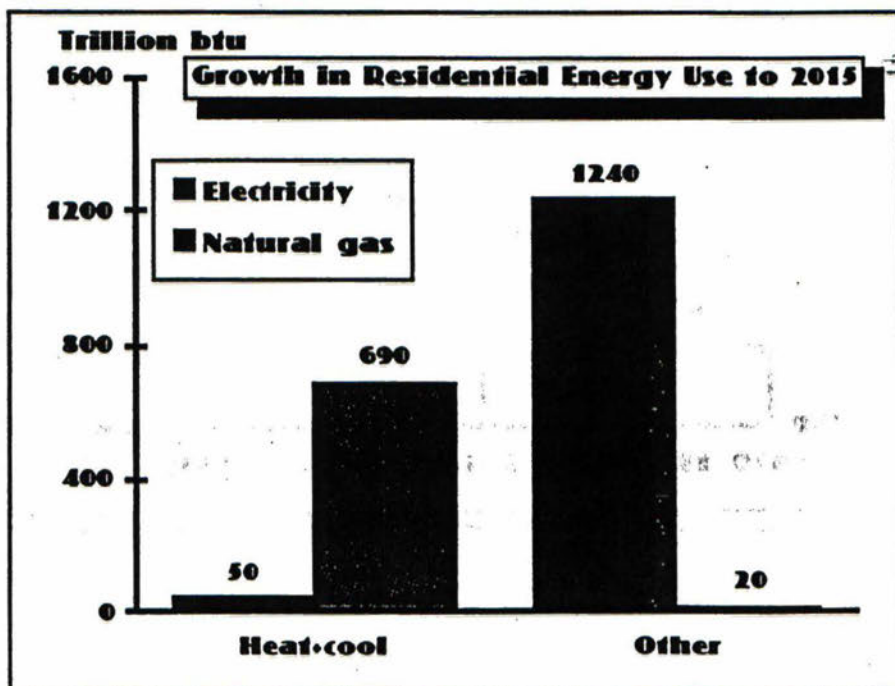
DATA FROM DOE/EIA 1997 ANNUAL ENERGY OUTLOOK TO 2015

- THE GAS RESEARCH INSTITUTE PROJECTS NEARLY ONE-HALF OF ALL THE INCREASED USE FOR NATURAL GAS TO 2015 WILL BE FOR MAKING ELECTRICITY. IN OTHER WORDS, GROWTH IN ELECTRIC TECHNOLOGIES WILL BE THE PRIMARY DRIVER FOR INCREASED USE OF GAS.



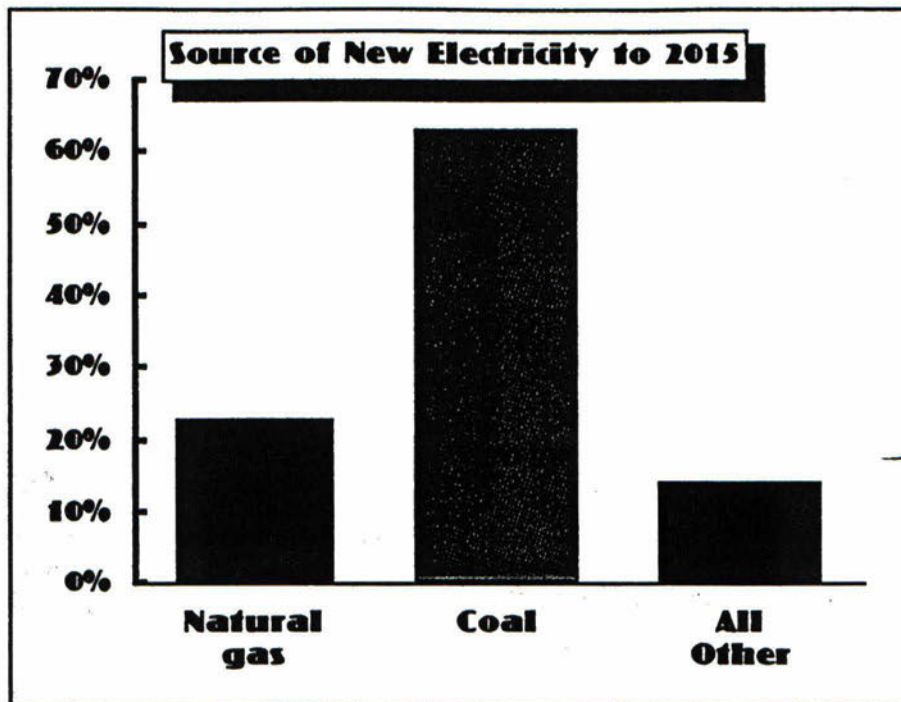
DATA FROM GRI BASELINE PROJECTIONS TO 2015

- GROWTH IN RESIDENTIAL ENERGY TO 2015 IS DOMINATED BY THE "OTHER" CATEGORY -- EVERYTHING OTHER THAN HEATING WATER, AIR, & CLOTHES, OR COOLING AIR & FOOD.



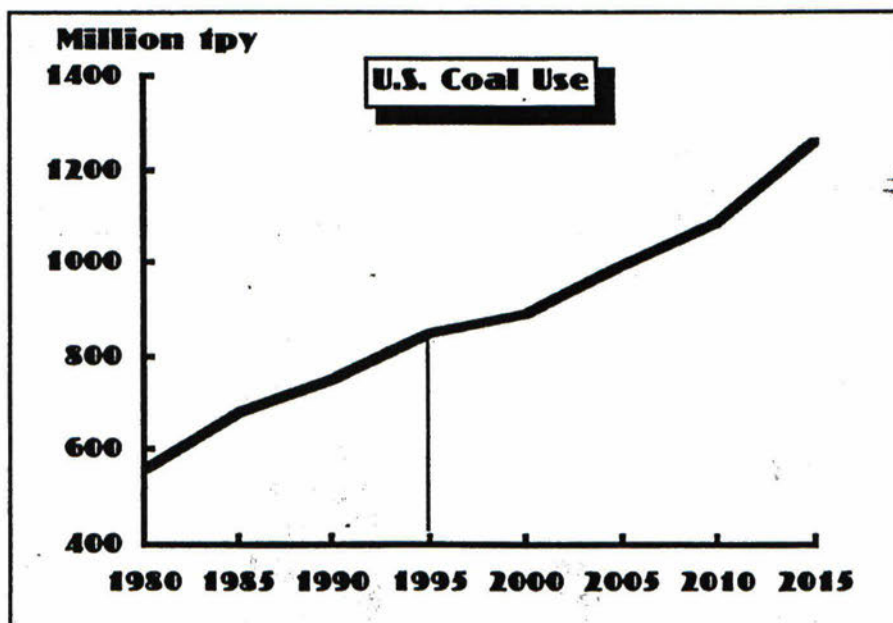
DATA FROM GRI BASELINE PROJECTIONS TO 2015

- THE GAS RESEARCH INSTITUTE PROJECTS THAT NEARLY TWO-THIRDS OF ALL ADDITIONAL ELECTRICITY SUPPLIED TO 2015 WILL COME FROM COAL.



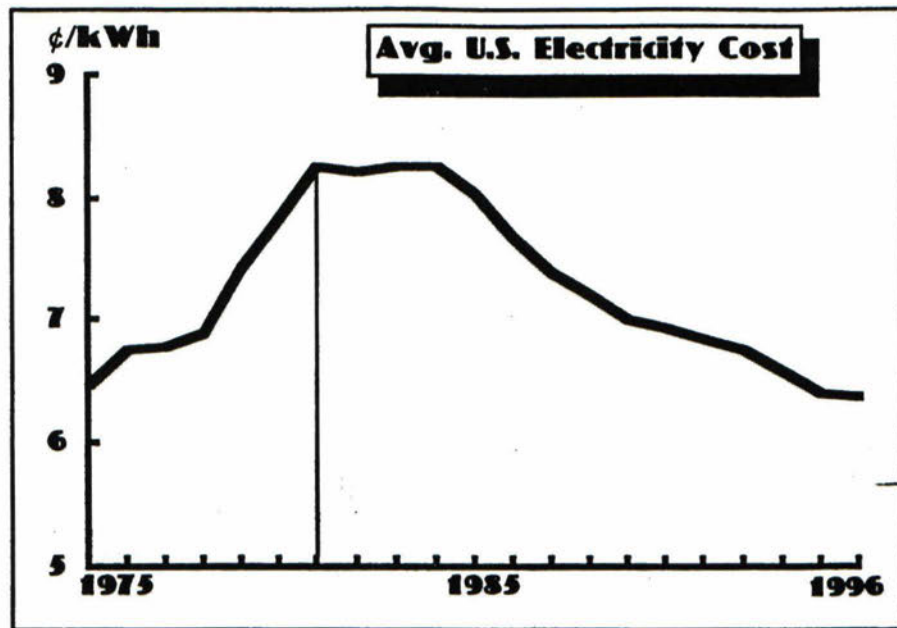
DATA FROM GRI BASELINE PROJECTIONS TO 2015

- INCREASED CONSUMPTION OF COAL, THE NATION'S LARGEST SOURCE OF LOW-COST ENERGY, IS EXPECTED TO GROW ALONG WITH THE ECONOMY AND ELECTRICITY.



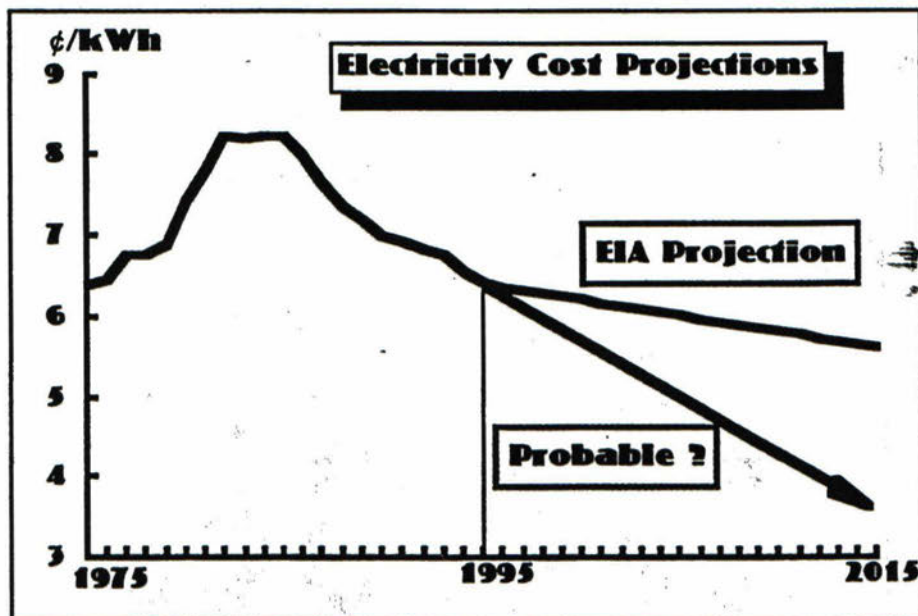
DATA FROM GRI BASELINE PROJECTIONS TO 2015 & U.S. DOE/EIA ANNUAL ENERGY OUTLOOK 1997

- THE AVERAGE COST OF ELECTRICITY IN THE UNITED STATES HAS BEEN DECLINING FOR 15 YEARS AS A RESULT OF IMPROVING TECHNOLOGY & LOW COST (COAL) FUELS.



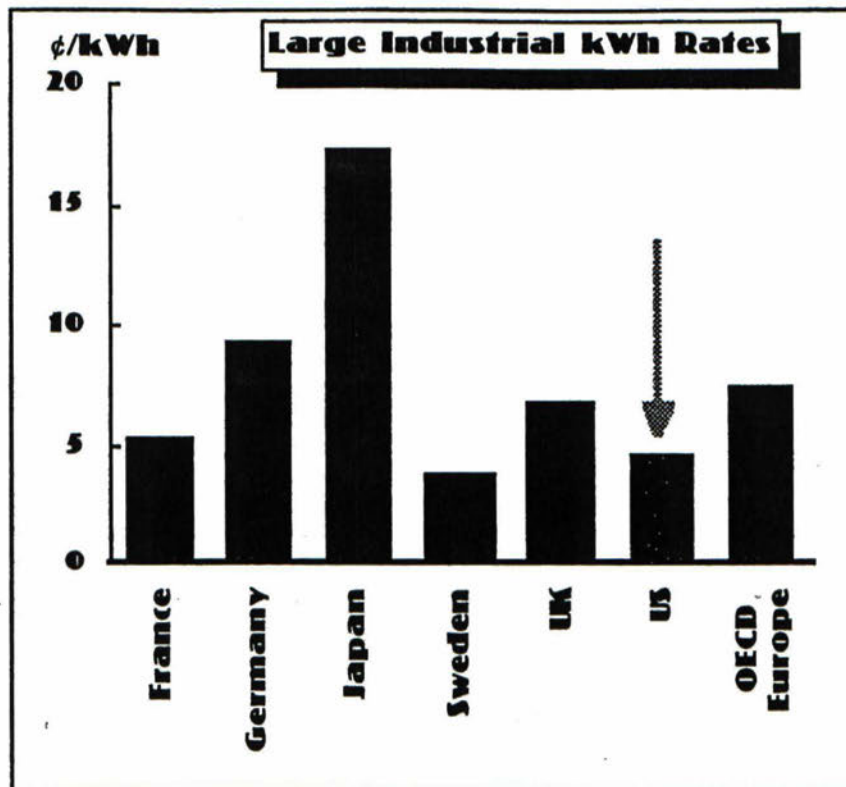
DATA FROM EEI STATISTICAL YEARBOOK
PRICES IN 1992\$

- THE AVERAGE COST OF U.S. ELECTRICITY IS EXPECTED TO CONTINUE TO DECLINE WITH COMPETITION, TECHNOLOGY PROGRESS & THE EXPANDED USE OF LOW COST (COAL) GENERATION.



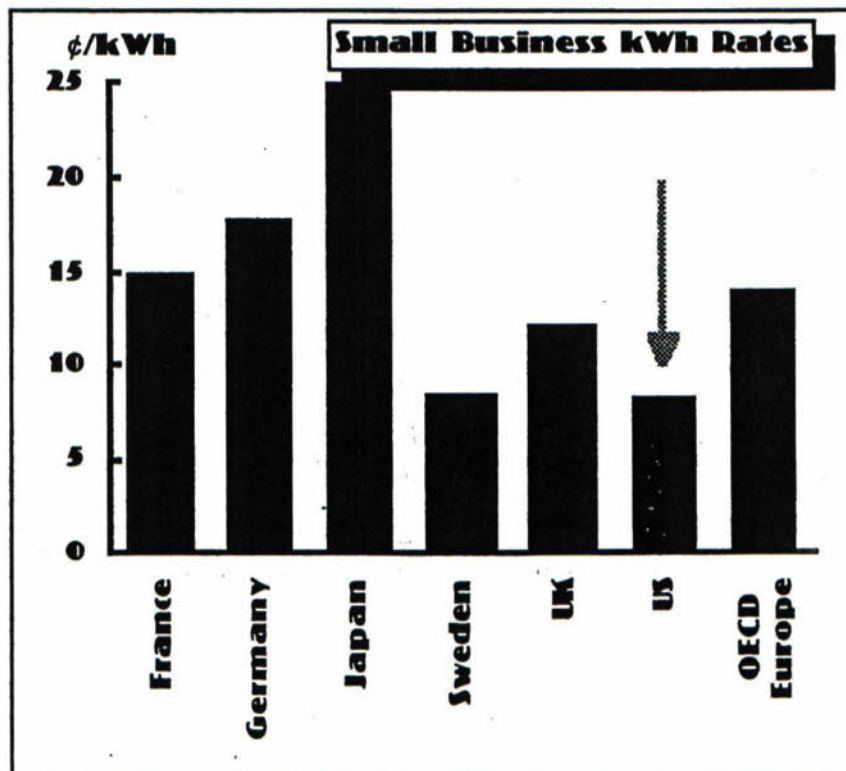
DATA FROM EEI STATISTICAL YEARBOOK & DOE/EIA ANNUAL ENERGY OUTLOOK 1997
COAL: CORNERSTONE OF AMERICA'S COMPETITIVE ADVANTAGE, MILLS *MC CARTHY & ASSOCIATES 1997
PRICES IN 1992\$

- U.S. INDUSTRY ENJOYS AN ADVANTAGE (AN AVERAGE OF 40% LOWER RATES) OVER RIVALS IN OTHER NATIONS IN TERMS OF THE COST OF ELECTRICITY -- A CRITICAL FACTOR IN SUPPORTING & ENCOURAGING INCREASED USE OF ELECTRIC TECHNOLOGIES.



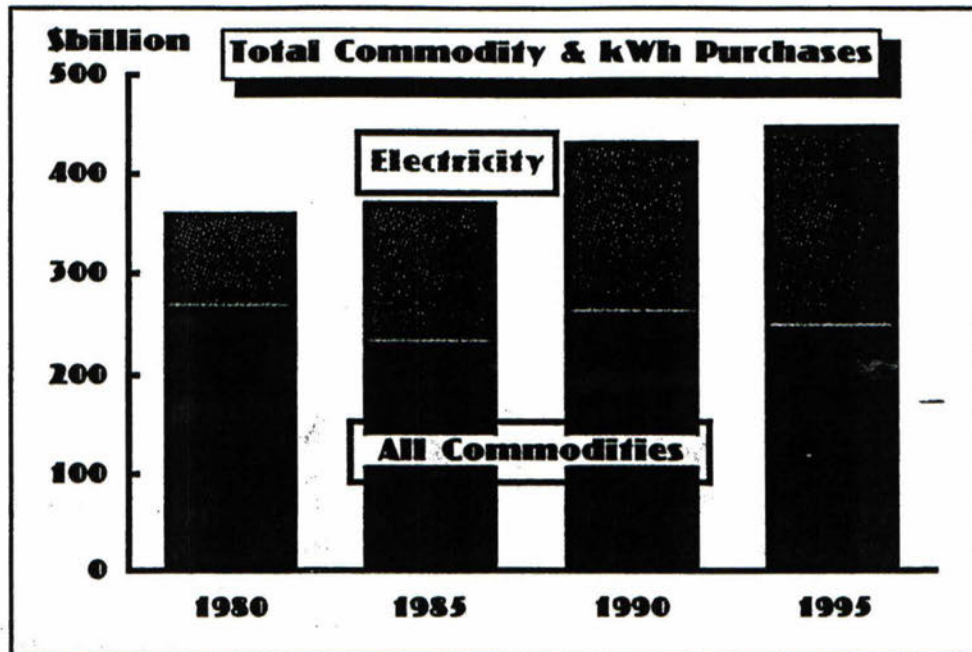
DATA FROM OECD IEA

- SMALL U.S. INDUSTRY -- SOURCE OF AT LEAST 50% OF ALL NEW JOBS -- HAS AN EVEN GREATER ELECTRIC COST ADVANTAGE COMPARED TO OTHER INDUSTRIAL NATIONS.



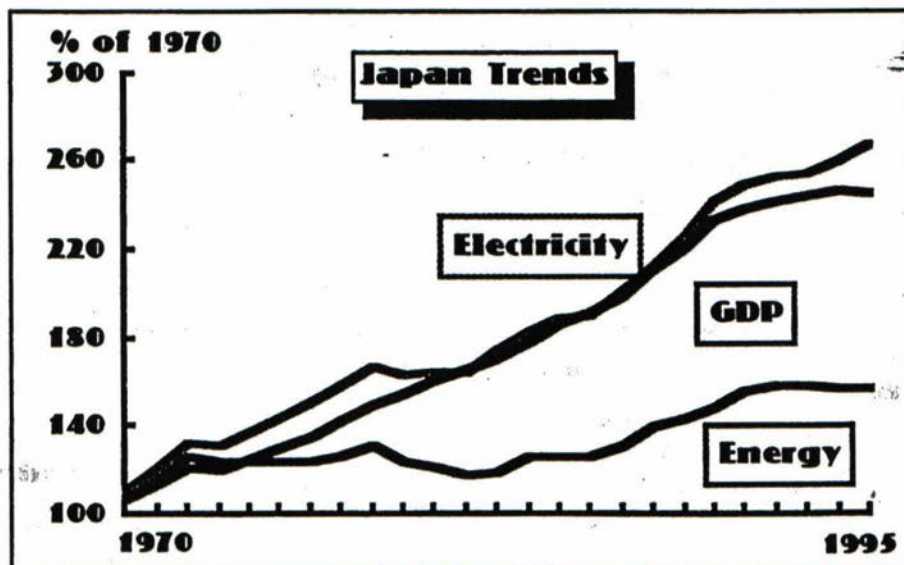
DATA FROM OECD IEA

KILOWATT-HOURS CONSTITUTE THE LARGEST SINGLE COMMODITY IN THE U.S. ECONOMY — ANNUAL KWH PURCHASES ARE NEARLY EQUAL TO THE ANNUAL PURCHASES OF ALL OTHER COMMODITIES COMBINED. (NOTE: DATA BASED ON 21 COMMODITIES INCLUDED IN CRB.)



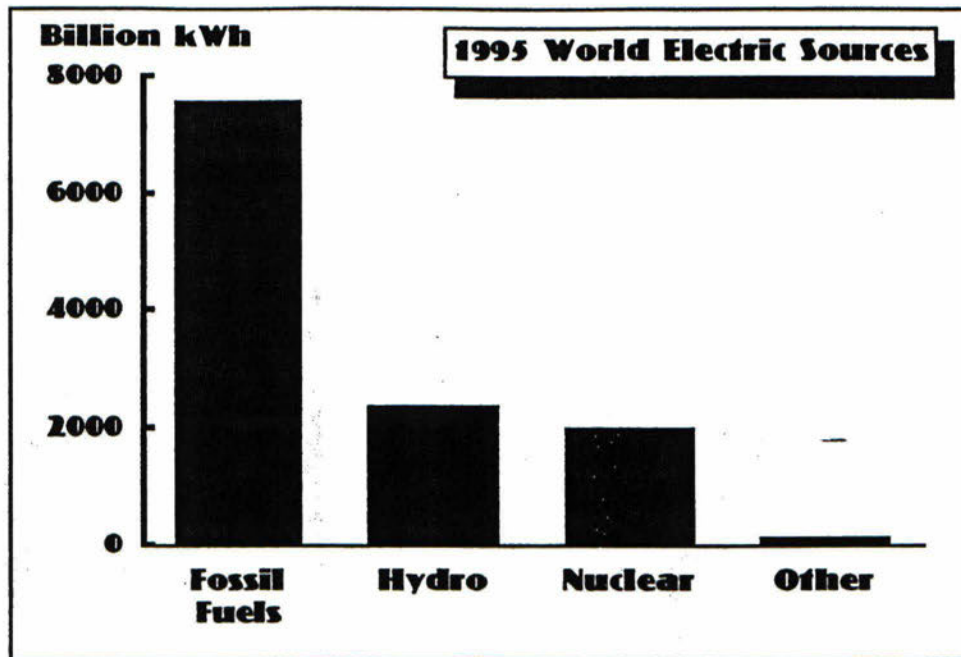
DATA FROM STATISTICAL ABSTRACT OF THE UNITED STATES

ELECTRICITY AND ECONOMIC TRENDS IN THE UNITED STATES ARE SEEN IN EVERY OTHER NATION. ECONOMIC GROWTH IS TIGHTLY LINKED TO INCREASED USE OF ELECTRICITY — BUT ONLY LOOSELY RELATED TO OVERALL GROWTH IN ENERGY USE. THIS ILLUSTRATES THE DOMINANT ROLE OF NEW ELECTRIC TECHNOLOGIES IN FUELING GROWTH.



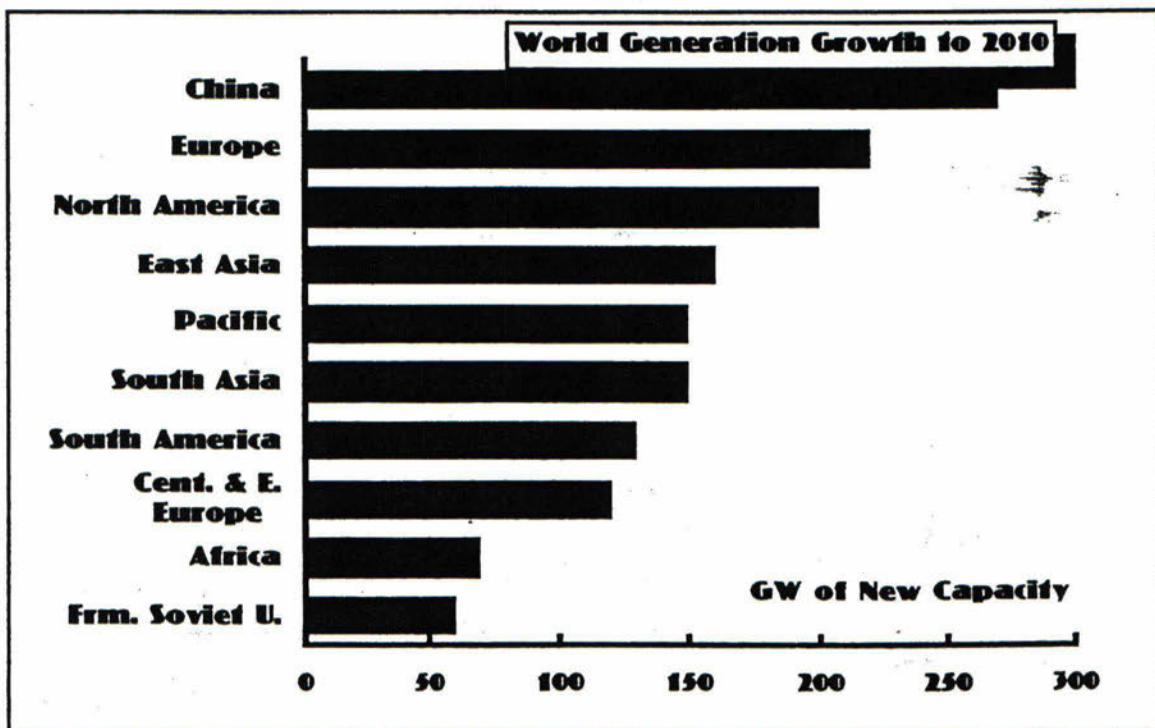
DATA FROM OECD/IEA

- FOSSIL FUELS ARE THE PRIMARY SOURCE OF ELECTRICITY FOR THE WORLD TODAY. COAL ACCOUNTS FOR 75% OF ALL THE FOSSIL FUELS PRODUCING ELECTRICITY.



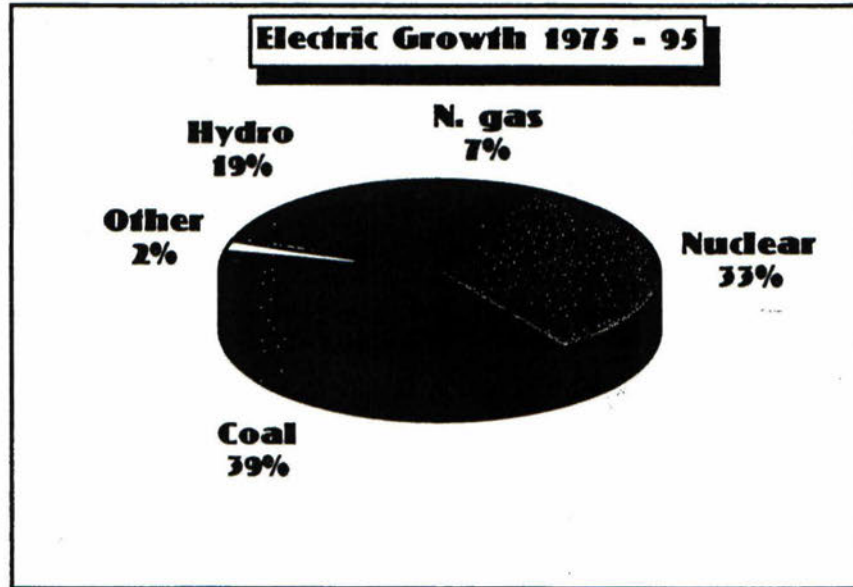
DATA FROM OECD/IEA, DOE ANNUAL ENERGY REVIEW

- CONTINUED GROWTH IN THE ECONOMIES OF THE WORLD WILL SUBSTANTIALLY INCREASE THE NEED FOR NEW ELECTRIC GENERATION — ESPECIALLY LOW-COST FUELS. OVER 1,500 GW OF NEW CAPACITY IS EXPECTED TO BE REQUIRED BY 2010.



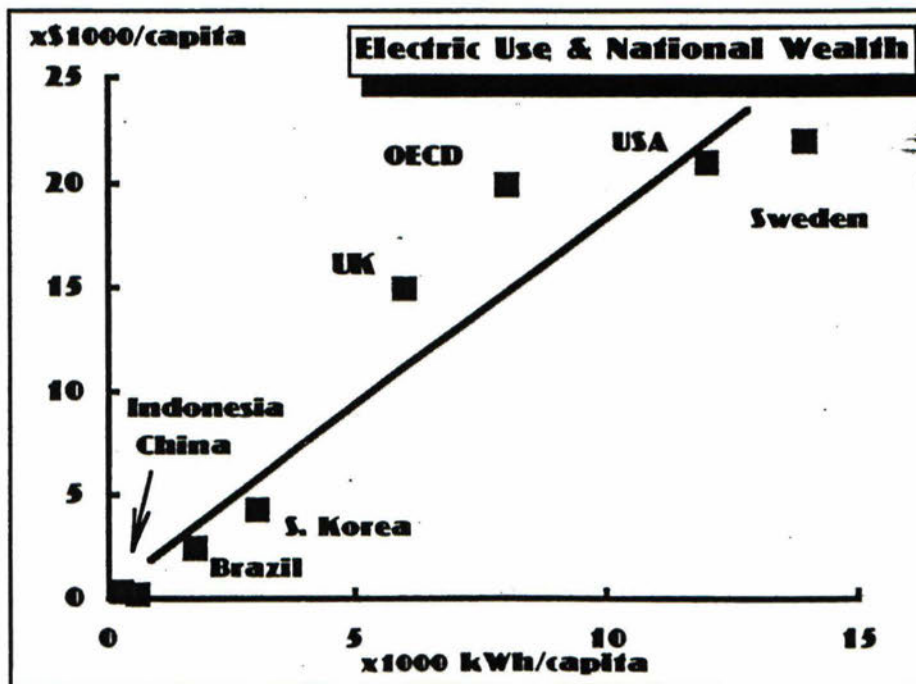
PROJECTION FROM SHELL OIL

- WHAT CAN MEET THE WORLD'S FUTURE ELECTRICITY NEEDS? OVER THE PAST TWO DECADES, 40% OF ALL INCREASED SUPPLY CAME FROM COAL. MOST OF THE REST CAME FROM HYDRO (19%) AND NUCLEAR (33%); THE FORMER IS SEVERELY LIMITED IN MOST NATIONS WITH THE LARGEST NEEDS; THE LATTER HAS BEEN RENDERED UNAVAILABLE FOR GROWTH.



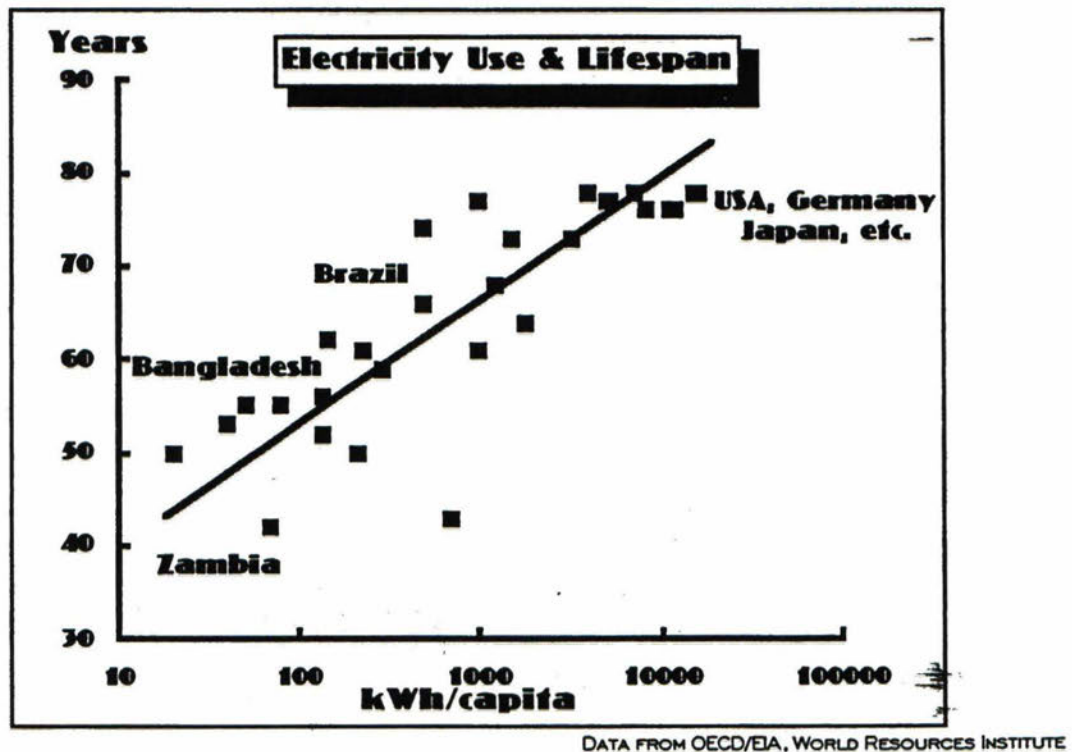
DATA FROM DOE ANNUAL ENERGY REVIEW, BP, OECD/EIA

- ELECTRICITY (AS A MEASURE OF THE USE OF ELECTRIC TECHNOLOGIES) IS CLOSELY CORRELATED WITH NATIONAL WEALTH. THE HIGHER THE PER CAPITA ELECTRIC CONSUMPTION, THE GREATER THE PER CAPITA SIZE OF A NATION'S ECONOMY.



DATA FROM OECD/EIA, WORLD RESOURCES INSTITUTE

INCREASED USE OF ELECTRICITY (AS A MEASURE OF THE USE OF ELECTRIC TECHNOLOGIES) IS CLOSELY CORRELATED WITH INCREASED AVERAGE LIFESPAN OF PEOPLE IN VARIOUS COUNTRIES. THE HIGHER THE PER CAPITA ELECTRIC USE, THE LONGER THE AVERAGE LIFESPAN. THIS CORRELATION, IN THE EARLY PHASES OF INCREASED ELECTRIFICATION REFLECTS INCREASED USE OF ELECTRIC EQUIPMENT FOR WATER, SEWAGE, REFRIGERATION. AS ECONOMIES MATURE, ELECTRIC TECHNOLOGY USE RISES LEADING TO DIRECT HEALTH BENEFITS (EG., REDUCED COMBUSTION POLLUTION IN THE WORKPLACE FROM ADVANCED TECHNOLOGIES), AS WELL AS INDIRECT HEALTH BENEFITS. INDIRECT BENEFITS COME FROM THE OVERALL ECONOMIC EFFECT OF ELECTRIFICATION. ELECTRIFICATION BOOSTS THE ECONOMY, WHICH IN TURN MAKES IMPROVED HEALTH CARE AFFORDABLE.



WORLD Climate Report

A BI-WEEKLY REPORT ON GLOBAL CLIMATE CHANGE

Volume 2, No. 23
August 4, 1997

GLOBAL WARMING: SLOUCHING TOWARDS MODERATION

Despite the Administration's campaign to rally public support for legally binding reductions in the use of fossil fuels, the science of global warming has taken a dramatic turn in recent weeks with the publication of three paradigm-shifting articles in the professional literature.

Last issue, we reported on one of these—Roy Spencer's article in the June *Bulletin of the American Meteorological Society*—that provided dramatic evidence for the "skeptics" who said that global warming was being muted by processes far above the earth's surface. It provided strong support for the hypotheses of MIT scientist Richard Lindzen, who has argued that climate models were predicting too much warming because they assumed that vast regions of the subtropics were wetter than they actually are.

It did seem a bit cheeky on the modelers' part to make such assumptions in the absence of much data, but that's what happened. And when Spencer finally found some real numbers—from a Defense Department satellite—they showed this region to be much drier than any model had assumed. The bottom line is that global warming's torpid pace is not likely to accelerate from water vapor effects in the high altitudes.

Since then, two more blockbusters have appeared. The July 18 issue of *Science* showcases an extensive analysis of global temperature trends by David Easterling and several other scientists that demonstrates a continued tendency for climate change to be primarily expressed as a warming of night temperature. For years, those who maintain that the effects of man on the atmosphere would be neutral (or perhaps even beneficial) have said that greenhouse effect changes should take place primarily at night and in the very cold winter airmasses.

Easterling's extensive review of global data in *Science* shoots down the long-held idea that night (vs. day) warming was simply a peculiarity of the United States record. It is truly global, and therefore likely to be a product of some truly global phenomenon. This knocks out sulfate aerosols (which are

primarily in the Northern Hemisphere) as a major influent and argues that it is more likely to be related to greenhouse changes that models did not anticipate. Sulfates may modulate some slight differences between the hemispheres, but they are minor in relation to the overall changes.

The numbers are striking. By far the largest warming since 1950 is in the winter nights in the Northern Hemisphere (1.18°C), when we obviously have the coldest temperatures to begin with. *But there is no significant warming of the summer days—* when we have the warmest temperatures. In the Southern Hemisphere, the overall warming is muted.

The total warming of both hemispheres is about 0.60°C. These are land temperatures only, and should warm more than the global average; in fact, old greenhouse models that didn't include cooling sulfates said the land should have warmed 1.4°C since 1950.

The other blockbuster is an extensive review article by Fred Pearce called "Greenhouse Wars" in the July 19 *New Scientist*. Its teaser? "They're among the world's top scientists. They don't believe in global warming. And they think their time has come."

Well, we actually *do* believe in global warming, just not so much of it and that it will be primarily in winter and at night, and that maybe people will actually like it (plants already do). Anyway, after the usual name-calling (this Editor is "belligerent" and writes "violent verbal attacks"—fancy that) and the standard allusion to "lucrative lecturing fees" (we "skeptics" believe in free speech, but don't give free speeches), the critics' critics have little to say.

Pearce does his darndest to find someone to counter the skeptics. Modeler David Parker said there is no good explanation for why the middle atmosphere stopped warming. "If we don't get tropospheric [surface to 50,000 ft.] heating right, we are in trouble." That's putting it mildly.

The big criticism of MIT's Richard Lindzen (who salves after the U.N.'s Intergovernmental Panel on Climate Change (IPCC) by calling them "geographers") from John

Houghton, the former science chief of the IPCC, is that Lindzen is "painfully clever." NASA's James Hansen says the old greenhouse models predicted twice as much warming as was observed, and NASA's John Christy says three times.

These new reports come fast on the heels of Richard Kerr's May 16 slam dunk in *Science*, which challenged the entire notion that the—now admitted—lack of predicted warming is the result of cooling from competing sulfate aerosols, and, for the first time, noted that climate models free of "fudge factors" (Kerr's words), if they are in fact capable of correctly simulating the behavior of this century, just don't predict much future warming.

References

Easterling, D.R. et al. (1997). Maximum and Minimum Temperature Trends for the Globe. *Science*, 277, 364–367.

DUMB FARMERS

One common trick greenhouse hypesters use has been characterized by Paul Waggoner, who chaired a National Academy of Sciences report on adaptation to climate change, as the "dumb people scenario." It assumes climate does change and people are too stupid to change with it.

One of the global-warmers' greatest media allies is *Science News*' Richard Monastersky. In trying to find something horrific about Easterling's article on night and winter warming, he dialed up Cynthia Rosensweig of NASA, the agency's expert on global warming and agriculture. She said such climate change will limit the areas where farmers can grow winter wheat.

The thing is, south of the winter wheat region, where it's a bit warmer, farmers grow corn, soybeans, and (where it's dry) sorghum—all of which bring in more money than wheat. Will farmers in newly warmer regions learn to dig these cash crops? "Naah!" say the hypesters. They'll just sit frowning dumbly at their fallow fields.

Kerr, R.A. (1997). Greenhouse Forecasting Still Cloudy. *Science*, 276, 1040-1042.

Pearce, F. (1997) Greenhouse Wars. *New Scientist*, 139, 38-43.

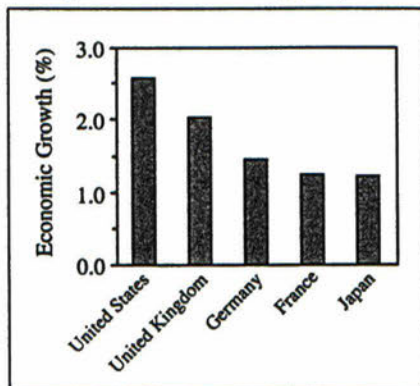
Spencer, R.W. and W.D. Braswell (1997). How Dry is the Tropical Free Tropical? Implications for Global Warming Theory. *Bulletin of the American Meteorological Society*, 78, 1097-1106.

SUMMITRY: POSTURING AND POLITICS

Last month world leaders gathered in New York for what was dubbed "Rio +Five" but soon became known as "Rio -Five." At the conference, some of the closest U.S. allies charged President Clinton with failing to lead the world. Although the President gave a rousing speech, painting a fearsome picture of a world full of storms, rising seas, and spreading diseases in the wake of global warming, he feared more the wrath of the voters than the wrath of nature or his colleagues.

U.K. Prime Minister Tony Blair, German Chancellor Helmut Kohl, and President Jacques Chirac of France took the United States to task for failing to adopt stringent goals on greenhouse gas emissions. The Australian government, on the other hand, was pleased that the United States did not endorse the European Union's (EU) plan to cut greenhouse gas emissions over the next 12 years by more than 15 percent. The Japanese were motivated mainly by the desire to see some agreement, any agreement, signed at Kyoto in December. The Canadians and Scandinavians sat on the fence. What's going on?

Why should the British and the Germans be pushing for such drastic steps when, as we've pointed out in these pages, the result would be devastating to their energy-intensive industries? In part because their politicians can pose as "Greens," knowing full well that the United States will never (one hopes) agree to such restrictions. Moreover, they may not face the same pressures. As the chart shows, Germany, France, and Japan have grown much more slowly than the United States during the past five years. Slow growth means less energy use, hence



Economic growth over the last five years. (Economic Report of the President, February 1997)

reduced CO₂ emissions.

Because both Germany and the United Kingdom have cut their emissions of greenhouse gases in the 1990s, they feel morally superior, able to lecture the wasteful Americans. What gives them such standing? Germany took over the Communist East, a landscape populated with inefficient industry that could not compete with the West's modern facilities. Even though the Bonn government tried to keep Eastern plants producing, primarily to protect jobs, many were eventually shut down. The resulting reduction in CO₂ emissions allows the Federal Republic to argue that, since it has managed to meet the obligations of Rio, the United States should too. German opposition parties, however, have pointed out that the former West Germany has in fact increased its greenhouse gas emissions: Were it not for the halving of East German emissions, the EU has admitted, Europe's total CO₂ would actually rise 9 percent by the year 2000.

The United Kingdom's "reduction" is also less than meets the eye. The Conservative government instituted a privatization program for its inefficient, money-losing coal industry. As a consequence, many mines were forced to shut down, reducing the burning of fossil fuels for power. The resulting substitution of natural gas for coal in the United Kingdom reduced greenhouse gas emissions sharply, allowing Prime Minister Blair to reproach President Clinton for the U.S. failure to curb its greenhouse gases.

Although the French might have to make significant reductions in carbon dioxide emissions to meet the European goal, they joined the other EU countries in attacking the United States. Anything that might slow the U.S. boom, reflected in a 5.0 percent unemployment rate—less than half the level for France and Germany—is worth the cost to the anti-American Gaullists. Meeting the European proposal would reduce U.S. competitiveness. Moreover, as President Chirac remarked pointedly at the recent summit meeting in Denver, "The average American is responsible for emitting three times the amount of greenhouse gas as the average Frenchman." The relatively low French emissions result from the country's reliance on nuclear energy for over 80 percent of its power and the taxing of gasoline at rates that, if imposed in the United States, would produce contention on the streets of American cities and towns.

On the other side of the issue are the Australians, who rely exclusively on fossil fuels for energy while exporting large quantities of coal. Prime Minister John Howard has asserted that a flat-rate reduction in emissions would devastate the Australian economy. He said recently, "We're a net exporter of energy and we're a highly developed country and if the current European and American proposals go through, it will

damage Australia, cost Australian jobs, reduce our GDP...." He would like any agreement to provide "differentiated" goals that take into account each country's special circumstances, particularly its reliance on fossil fuels.

Stateside, politicians, experts, and academics are split on the issue. Pushing the Administration to agree to the European standards or at least to propose rigid limits, are environmentalists, a handful of politicians, and some well-meaning, if poorly informed commentators. On the other side are those concerned about the impact of an agreement on economic growth, employment, and trade; those skeptical about the significance of any climate change; and those who find evidence that a warmer world would not in general be harmful. More than 60 senators have come out against any treaty that limits the United States while giving a free ride to much of the rest of the world. Rep. John Dingell, a senior Democrat member of the House Commerce Committee, has repeatedly requested that the Administration provide an economic analysis of the effects of any agreement. Dingell is particularly skeptical about the exemption from stringent controls of developing countries like China and India. This powerful Michigan representative fears, with some justification, that a Kyoto agreement would be costly, resulting in an "economic fiasco."

The possibility of an agreement on a treaty that can pass muster in the United States while capping U.S. emissions at a level significantly below 1990 appears to be remote. Clinton and Gore, however, have been politically astute in past bargaining with the Congress and usually get their way in international meetings. Al Gore, who boasts a reputation as a dedicated environmentalist, must deliver or lose his credibility.

Because the Europeans are unlikely to be serious about their proposal, which would put their industry through the wringer, some compromise, such as postponing any significant reductions well into the next century, might produce an agreement in Kyoto. Stricter CAFE standards and a tax on fuel used for international air travel seem likely to form part of the package. At that point Congress would have to face rejecting a treaty and supposedly losing the U.S. leadership on the environment, or going along with Clinton and the environmentalists, knowing that a distant future Congress would have to legislate the onerous energy taxes and stringent regulations necessary to meet the protocol's mandates. Let us hope that both Congress and the public can see through this charade.

Reference

Alexander Downer, "Australia and Climate Change," address given to the "Global Emissions Agreements and Australian Business" seminar, Melbourne, July 7, 1997.



GLOBAL WARMING TO CAUSE HELL TO FREEZE OVER

Our first reaction to this article was to check the publication date.

Somehow, our April 1 issue of the *Transactions of the American Geophysical Union* had to have arrived in July.

But, noooo....

The lead article of the July 8 issue says that global warming will accelerate an imminent ice age, and that the first evidence will be the onset of ice sheet growth in northern Canada "in coming decades." The primary cause of the glaciation will be Aswan High Dam on the Nile River. But it will occur anyway, dam or no dam, because of global warming. Is this clear?

According to R. G. Johnson, the Aswan Dam, which has been in service for three decades, dramatically reduces the flow of fresh water into the Mediterranean Sea, making it saltier. The resultant change in the density of water flowing into the Atlantic through the Straits of Gibraltar ultimately changes ocean currents, resulting in cooling of the Nordic Seas, warming of the Labrador Sea, more transport of moisture into Canada, and, presto, a big glacier.

Global warming will make this even worse because the heat will cause more evaporation from the Mediterranean, making it even saltier. Atlantic... Straits of Gibraltar... Nordic Seas... Labrador Sea... faster than presto, a bigger glacier.

So we can't stop the next ice age unless we stop global warming and blow up the Aswan High Dam or we could just keep on burning fossil fuel and build another dam across the Straits of Gibraltar to hold the water in. (Anybody want to write the Environmental Impact Statement?) This last solution is what Johnson recommends.

"The costs of the dam would be minor compared to...the prevention of widespread new ice sheets in Canada." And, just like the global warmers, don't forget to invoke the "Precautionary Principle" to silence debate: The dam "would probably generate controversy that might delay a decision...until climate deterioration becomes a reality in Canada and Europe."

So we're damned if we do, damned if we don't. The biggest problem is that too much human delay will make it impossible to build the dam because of the "scarcity of petroleum supplies that will probably develop in the next century," which will cause wars and divert people's attention from the dam. Better, he says, to build the dam

quickly, before the wars start.

We did not make this up. It was published as the lead article in an extremely prestigious journal in the refereed scientific literature. We can allow for the author's wild streak, but what does this say about the basic common sense of the reviewers in this climate of hysteria?

Reference

Johnson, R.G. (1997) Climate Control Requires a Dam at the Strait of Gibraltar. *EOS, Transactions, American Geophysical Union*, 78(27), 277-281.

DEATH BY ANOMALY

Two years ago last month, several hundred Chicagoans died in an unprecedented weekend heat surge. This event, covered in our inaugural *WCR* issue, was noteworthy not only for the incredibly high minimum temperatures, but also for the overreporting of the death statistics which, despite the error, have nevertheless become part of '95 Heat Wave lore.

But let's face it—that July 15–16 weekend was hot and a lot of people died. And just like your mother, who blamed every bout of childhood sniffles on your not taking her advice and wearing earmuffs to school, our maternal administration couldn't pass up the opportunity to link these deaths to global warming. Just last month, during the President's Rio +5 speech, he declared that "we can expect more deaths from heat stress [due to greenhouse enhanced climate change]—just two years ago in Chicago, we saw the tragedy of more than 400 of our citizens dying during a severe heat wave."

A newly published analysis cools the rhetoric. Federal climatologists Tom Karl and Richard Knight looked at trends in apparent temperature in Chicago and the Midwest from 1948–1995. Apparent temperature, a measure used to estimate the degree of heat stress on the human body, is a combination of temperature and humidity (and to a much lesser degree, wind speed, which was not included in their analysis). They found increasing trends in apparent temperature, particularly when the 1995 summer data are included, since this ratchets up the end of the trend line.

But there are several complicating factors in this case. First, there is an urban heat island influence, which induces artificial warming trends in thermometers as cities and concrete pop up around them. Second, there was a change in instruments—the newer thermometers tend to read higher maximum

and minimum temperatures. Third, the surrounding Midwestern stations do not have the same increasing apparent temperature trend. So in a nutshell, according to the authors, "If the [instrument change] bias is taken into account, the trends are essentially close to zero, and the trends of the [apparent temperature] for both the maximum and minimum would be negligible."

Since we doubt the latest issue of the *Bulletin of the American Meteorological Society* is part of the President's and Vice President's bedtime reading, we suggest that someone might want to tell Karl's Boss and Vice Boss to stop using the Chicago Heat Wave as an example of the kind of havoc global warming will wreak if the citizens don't buy into their upcoming tax increase.

Reference

Karl, T.R. and R.W. Knight. (1997). The 1995 Chicago Heat Wave: How Likely is a Recurrence? *Bulletin of the American Meteorological Society*, 78(6), 1107–1119.

WEATHERING THE STORM

Probably the most common enviromyth is that global warming will cause weather to be more extreme. This myth certainly includes low pressure systems (extratropical cyclones) which are responsible for most of the rain in the middle and high latitudes. Does our global warming future portend more and stronger cyclones?

Not according to a recent modeling study by J. Beersma and his colleagues. They compared cyclone intensity and frequencies over the North Atlantic region by running a computer model for background conditions and then with double the atmospheric CO₂ concentration.

They concluded that, in the future, "...there is a shift in the distribution of depression strength towards weaker depressions [cyclones]. As a result, the number of storm events decreases in most areas." They also noted that "It is not possible to conclude that these differences are the result of the CO₂ doubling because they are small with respect to the natural variability."

So how does a tax increase, the premise of which is to prevent a future climate that has a longer growing season, warmer winters, and fewer intense storms, sound to you?

Reference

Beersma, J., et al. (1997). An analysis of extra-tropical storms in the North Atlantic region as simulated in a control and 2xCO₂ time-slice experiment with a high-resolution atmospheric model. *Tellus*, 49A, 347–361.

TEMPERATURE UPDATE

World Climate Report provides monthly updates of satellite-measured temperatures around the globe. These figures are measured by a series of platforms that sense mean temperatures of various layers in the atmosphere. The one we routinely display is the lowest level, which matches nearly perfectly with the mean temperatures measured by weather balloons between 5,000 and 28,000 feet. The measurement is thought to be accurate to within 0.01°C.

We compare these temperatures with surface values projected by the climate models that based the 1992 Framework Convention on Climate Change (the "Rio Treaty"). Although it is difficult to strictly compare surface projections and mean layer temperatures, the satellite provides great improvement over the surface record by supplying data over the entire planet.

We note that newer climate models produce less current warming, but they are still the subject of considerable debate. The fact remains that the old models served as the basis for the present Rio Treaty.

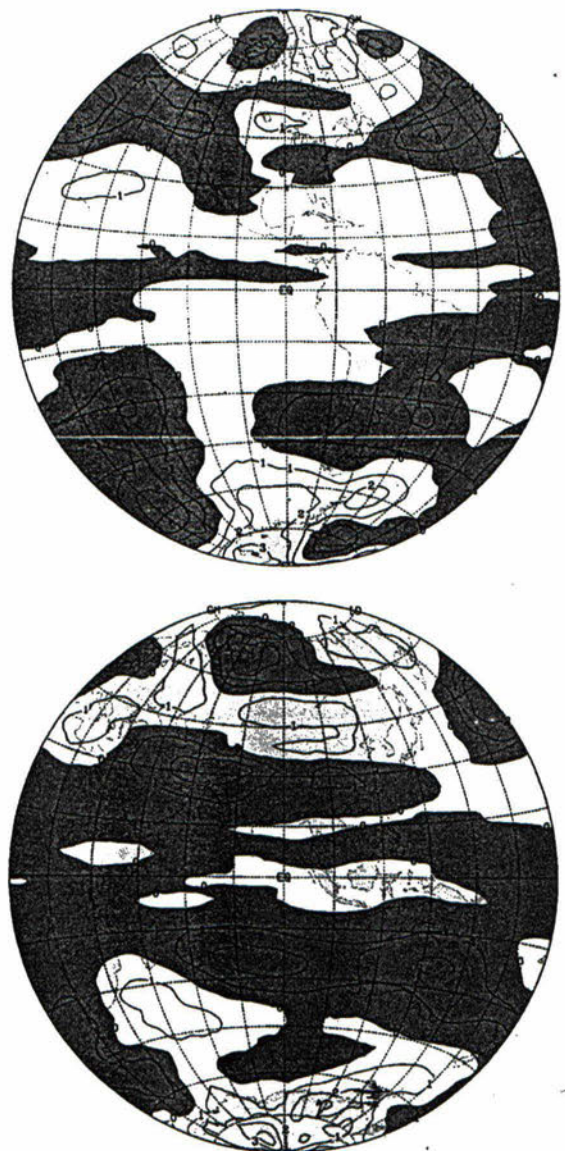
June 1997: A rather normal month. The global temperature departure of -0.07°C is just a few hundredths of

a degree colder than last month's departure and is very near the long-term (1982-to-1991) average. The Northern Hemisphere and the Southern Hemisphere contributed rather equally to the normality, by posting rather meager departures of -0.04°C and -0.10°C, respectively.

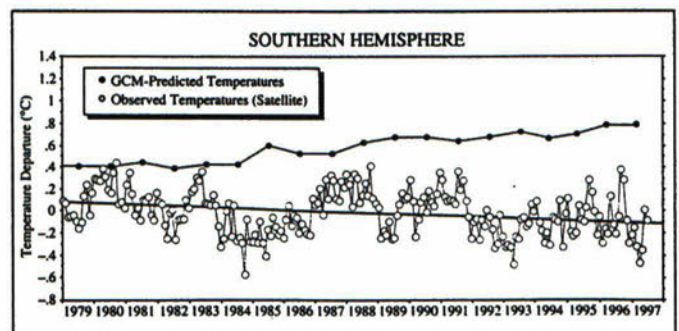
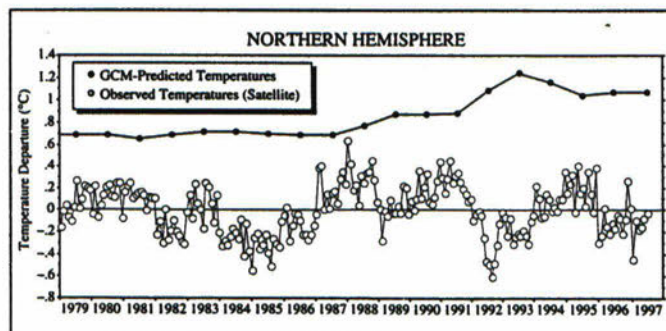
Not only were the hemisphere average temperatures very close to the long-term mean, but also the regional temperature anomalies typically did not stray too far to the extreme. In the Northern Hemisphere, the slightly warmer than normal central latitudes of Eurasia were sandwiched between regions of slightly cooler than normal conditions to the north and south. Another cool area stretched across the central Pacific and into western North America, while the eastern portions of the continent were a tad warm.

In the Southern Hemisphere, while Australia was a few degrees colder than normal, the temperatures across Antarctica were several degrees warmer than those typically expected during the onset of the winter season.

Right: Satellite-sensed temperatures for the Western Hemisphere (above) and Eastern Hemisphere (below). Areas of below-normal temperature are shaded.



Below: Satellite (open circles) and predicted temperatures (closed circles) by the model that based the United Nations' treaty on Climate Change. The negative trend in Southern Hemisphere temperatures is statistically significant.



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WORLD Report Climate

Volume 2, No. 17
May 12, 1997

A BI-WEEKLY REPORT ON GLOBAL CLIMATE CHANGE

ADMINISTRATION SNOW JOB IN NORTH DAKOTA

In the world of politics, often there is no shame. On Earth Day (April 22), in a series of carefully worded statements, the President and other administration officials preyed on the misfortune and misery of thousands of flood-ravaged North Dakotans to propel the administration's global warming agenda. Here is a smattering of the day's hyperbole:

Vice President Gore: Our research effort is continuing to pin down what many scientists have said is a link between extreme weather events...*that have long been predicted* [emphasis added] to become more common in a world where temperatures are rising even slightly...They [the scientific community] do say and have said for two decades that the probability that [extreme floods] will occur increases along with climate change.

President Clinton: We do not know for sure that the warming of the earth is responsible for what seems to be a substantial increase in highly disruptive weather events; but many people believe that it is...I think every American has noticed a substantial increase in the last few years of the kind of thing we're going to see in North Dakota today.

Asst. Secretary of State Eileen Claussen: While we cannot say with certainty that the flooding that is now occurring along the Red River signals the onset of climate change, it is entirely consistent with the predicted effects. We can expect that a continued warming of the Earth's atmosphere is likely to result in much more of such occurrences of extremely severe weather...I think we can say, with some confidence, that there will be more cases like [the Red River flooding] as the Earth starts to warm.

While in the midst of shoveling muck, the last thing these flood victims want to hear from the President is, "Yeah, we told you this was going to happen—not only that, but it's likely to happen again soon, and, by the way, to stop it we're going to raise

your taxes." Now, even though we can't be sure that any *given* president will want to raise your taxes to combat a nonexistent or benign global warming, or that any *given* tax increase will do a lick to change the future climate, many, many people have been saying for many, many years that it's a great ideal!

These remarks also imply that scientists have been warning us about greenhouse warming causing weather extremes for decades. In fact, only a few climatologists have jumped on this bandwagon, and only recently (over the past year or two), when it became clear that the model-projected warming wasn't happening as quickly or as intensely as predicted. But when extremes (cold, floods, blizzards) bought media play and bureaucratic capital, then extremes became the issue.

Let's look at the science. What is the hypothesized connection between Red River flooding—waters borne almost entirely from spring snow melt—and increased greenhouse gases? By now you know the drill: Warmer air evaporates more water, a moister atmosphere produces more clouds and precipitation, more precipitation yields more blizzards...yadda, yadda, yadda...pay more taxes.

In this case the "logic" is not off a little—it's completely backwards. In the extreme high latitudes (say, poleward of 70 degrees), the cold air is so dry that you simply can't squeeze much snowfall out of it. That's why the South Pole averages less than two feet of snow each year. But as you move into the warmer middle latitudes, moisture is no longer the limiting factor—temperature is.

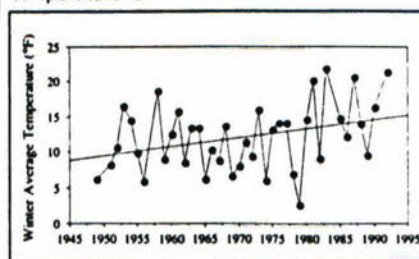


Figure 1. Winter average temperatures (°F) in Grand Forks, N.D., have been increasing since the late 1940s.

Let's examine the climate data for Grand Forks, N.D. Since 1949, winter (December through March) temperatures have shown a statistically significant increase, from a nippy 8.5°F to a balmy 13.5°F (Figure 1). Finally, a location that supports the global warming theory! So, snowfall there should be increasing, right?

In Figure 2, we plot the relationship between snowfall and temperature. Their correlation is negative and statistically significant. In this region, *warm winters have less snow than cold winters.*

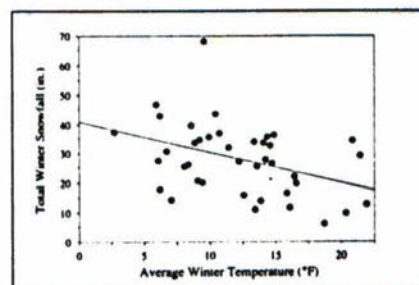


Figure 2. Relationship between snowfall and winter temperatures in Grand Forks, N.D.

Why hasn't this scientific fact worked its way into the administration's Earth Day press blitzkrieg? There are two possibilities, both of them grim:

- 1) Federal climatologists advising the administration on global warming matters either don't know this basic fact, and/or
- 2) Scientific facts only matter when they support the administration's prevailing policy, and federal climatologists don't want to get yelled at for telling the truth.

As this winter's Kyoto summit to amend the Rio Treaty and foist a binding carbon tax on U.S. citizens approaches, every global weather blip, which in more reasoned times would be characterized as simple natural variability, will portend our climatic fate and be used to build the body of evidence for global action against industrialized nations.

The people of North Dakota have suffered enough; they didn't need to be exploited in an Earth Day propaganda campaign.

NORTH ATLANTIC BLOW-HARDS

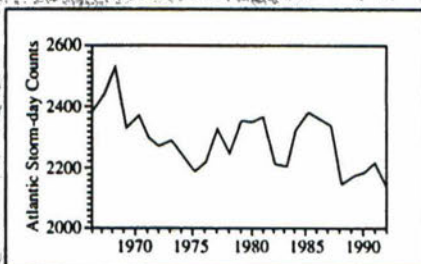
When a couple of strong low pressure systems blew through the British Isles recently, apocalysts were quick to point out that, for an enhanced greenhouse effect, climate models predicted "increasing storminess" in the sea that separates us.

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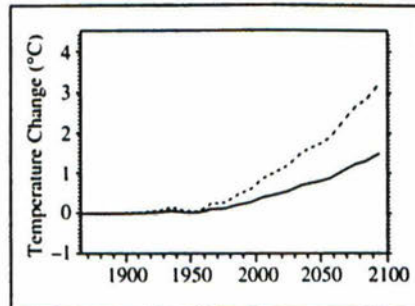
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TRUTH MELTDOWN IN ANTARCTICA

Check the facts" is the guideline of responsible journalism. But the March 31 Reuters story, on the warming of Antarctica is yet another sign of how, when reporting on the environment, the facts are sometimes a minor inconvenience in an otherwise great story.

"Global warming," reports Roger Atwood, "has sent many [penguins] searching for colder climes. ...Receding glaciers, milder winters, dramatic changes in seal and penguin populations—they are all signs that the warming of Antarctica, once a vague prediction by researchers, is a reality."

Vol. 1, No. 1, of this *Report* detailed the Antarctic temperature history, published by Phil Jones of the University of East Anglia. Using data through 1993, Jones noted that all of the warming of Antarctica "occurred before the early 1970s." Jones' record forms the basis for the temperature histories for the United Nations Intergovernmental Panel on Climate Change (IPCC), often

cited as the Consensus of Scientists. In fact, Jones' data show no trend since the early 1960s.

Here we present the IPCC record, now updated through 1996, and the satellite record that begins in 1979. The first shows the surface-based history for all areas poleward of 60°S (Figure 1). There is no statistically significant warming averaged around the entire bottom of the planet for the last 31 years.

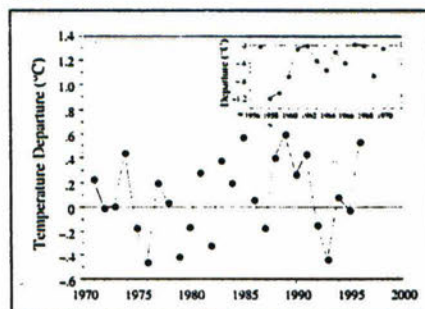


Figure 1. Antarctic temperature departures (°C) from the 1961 to 1990 mean, back to 1971 (from the IPCC record). Inset: Temperature departures from 1957 to 1970.

Satellite-measured temperatures show the same thing, although the orbiters do not measure the five degrees of latitude surrounding the South Pole, and the record only begins in 1979 (Figure 2).

Atwood goes on to note that "heavier snow, possibly caused by warming, seems to be cutting into some penguin populations" and then later quotes a U.S. scientist who says that "Retreat of glaciers seems to be happening all over the west coast of the Peninsula." We don't doubt that both

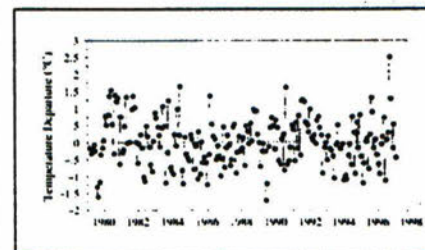


Figure 2. Satellite temperature departures (°C) also show no warming across Antarctica.

statements are true. But it is also true that some 4,000 to 7,000 years ago, when Antarctica (and the planet) was warmer than it is now, the Antarctic glaciers were expanded, probably by heavier snow that can occur in a warmer (but still very cold) atmosphere.

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Jones, P.D., (1995). Recent variations in mean temperature and the diurnal temperature range in the Antarctic. *Geophysical Research Letters*, 20, 1345-1348.

Washington Times, March 31, 1997.

SCIENCE FICTION

* While many of the claims of Roger Atwood in his Reuters piece are simply exaggerations—claiming, for example, that the warming of the Antarctic Peninsula is synonymous with an overall Antarctic warming—at least one piece of true fiction says everything a critic needs to know.

"In the 1950s," Atwood writes, "about four out of five winters experienced extensive seasonal pack ice, according to various studies using U.S. satellite data."

The United States had no satellites in polar orbit, no satellites that could have sensed pack ice, and no space-sensed data about Antarctica that was worth anything until the late 1960s. In fact, with the exception of a few satellites that only fell around the midlatitudes simply bleeping happy radio signals, we had no satellites at all.

RIO RUMORS

An occasional feature that turns speculations about the United Nations Framework Convention on Climate Change (also known as the "Rio Treaty") into facts...

We hear that Vice President Gore has received a letter from a big higher-up from the U.S. National Center for Atmospheric Research, arguing that it really isn't time, climactically and scientifically, for a carbon tax after all. *World Climate Report* says thank you and hopes for no reprisals. We also note that such a missive may sit well with those who dispose of our tax money (i.e., the Republican Congress) for global change research.



NORTH ATLANTIC BLOW-HARDS

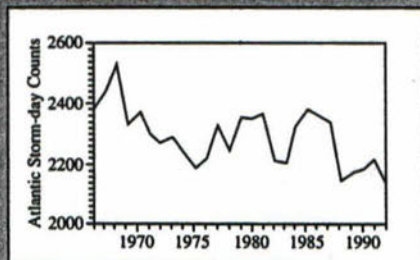
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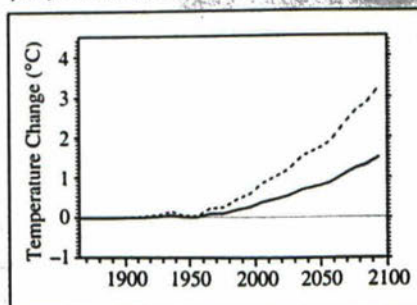
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**PRESS
MATERIAL**

**REPORT URGES
GREENING OF PLANET EARTH MOVE
FROM HYPOTHESIS TO THEORY**

(Arlington, VA — January 24, 1997) In a January 1997 report from the Office of Climatology at Arizona State University, researcher Craig D. Idso proposes an elevation in the status of the "greening of planet Earth" *hypothesis* to that of scientific *theory*.

Idso's report (Climatological Publications Scientific Paper #25, *The Greening of Planet Earth: It's Progression from Hypothesis to Theory*) reviews several challenges to "greening" — a hypothesis which suggests (1) the productivity of the planet's vegetation will be greatly enhanced by the aerial fertilization effect of elevated levels of atmospheric carbon dioxide, (2) that increased atmospheric CO₂ concentration will enhance the efficiency with which plants utilize light, water and nutrients, and (3) the existence of a natural CO₂-induced impediment to CO₂-induced global warming. Idso not only dismisses challenges to the greening hypothesis as "unsubstantiated by data obtained from long-term CO₂ enrichment experiments," he also tests a number of predictions which would logically flow from the hypothesis and concludes that real-world data reveal such predictions to be correct.

According to Idso, the idea that an increase in the air's CO₂ content might be of benefit to the biosphere can be traced back nearly 200 years. By the early 1980s, the results of nearly 600 scientific studies dealing with CO₂'s effects on vegetation contributed to a conclusion by a 1982 International Conference on Rising Atmospheric Carbon Dioxide and Plant Productivity that a doubling of the atmospheric CO₂ concentration would likely lead to (1) a 50% increase in the photosynthetic fixation of CO₂ by C₃ plants, (2) a doubling of the water use efficiency of both C₃ and C₄ plants,

After citing the body of research which verifies these four predictions, Idso concludes, "The greening hypothesis may validly be considered to have achieved the status of a theory — a theory that must surely play a major role in determining the course we will take as we confront the future in a world of conflicting concepts of impending global change."

According to Western Fuels Association general manager and chief executive officer Fred Palmer, who announces availability of Craig Idso's study, this work builds on that of Craig's father, Dr. Sherwood B. Idso, and his brother, Keith E. Idso. "In 1991, Western Fuels Association arranged for production of a videotape called *The Greening of Planet Earth*, which was based on Sherwood Idso's book *Carbon Dioxide and Global Change: Earth In Transition*," Palmer explains. "With nearly 20,000 copies of that tape in circulation worldwide, much was done to assure this compelling body of science not be overlooked as world governments wrestled with climate change policy. In 1992, Keith Idso compiled and analyzed the results of a decade of international research into the direct biological effects of atmospheric CO₂ enrichment in his report *Plant Responses to Rising Levels of Atmospheric Carbon Dioxide* for the Office of Climatology at Arizona State University. In 1995, Dr. Idso revisited the science of greening in his Kuehnast Lecture at the University of Minnesota, *CO₂ and the Biosphere: The Incredible Legacy of the Industrial Revolution*. Now, Craig Idso has weighed in with his analysis. They each are providing valuable service to the army of scientists at work in this important, though often overlooked, field of inquiry."

According to Palmer, seemingly more glamorous research activities involving super computers, intricate models of climate physics, and satellite observations attract media attention and substantial research dollars while less attention and fewer financial resources are afforded seemingly more mundane research such as that which upholds the theory of the greening of planet Earth.



Holes in the Greenhouse Effect?

By Patrick J. Michaels

Sunday, June 22, 1997; Page C02
The Washington Post

Global warming is about to heat up and enter the presidential sweepstakes for the year 2000. The fun starts in December, when the United States is going to agree to an amendment to the United Nations Framework Convention on Climate Change, also known as the "Rio Treaty," that requires the signatories to reduce carbon dioxide emissions.

That's the end of the easy part. Then the administration (read: Vice President Gore) is going to have to sell it to the Senate, which must approve treaties by a two-thirds majority. The amendment, which is likely to mandate a reduction of current emissions of between 10 percent and 20 percent by the year 2020, will carry an impressive price tag, perhaps several percent of gross national product per year by the time reductions become serious, according to several economists. It will first go to the Senate Foreign Relations Committee, chaired by Jesse Helms, the senior senator from North Carolina. Think it's going to get out of there alive?

Along the way, Gore is going to have to confront a growing contingent of scientists who are increasingly unhappy with the glib forecasts of gloom and doom. Once dismissed as "a small but vocal band of skeptics," usually supported by industry, the critics of the global warming thesis now have a rather formidable armada of facts.

As pointed out by Ross Gelbspan in these pages four weeks ago, some of these scientists, myself included, enjoy industry research support. (In my case, 84 percent of my university research is funded by taxpayers.) His figures show an average of \$35,000 per year to a few people. The U.S. government spends \$2.1 billion per year on global

change research, and it's hard to believe so much would be spent on researchers who would say "no problem." Accepting Gelbspan's contention that there are 2,000 climate scientists (there are actually about 60 PhDs in climatology in the entire United States), that's a cool million dollars per scientist, every year. How could the vice president lose the global warming argument with these odds?

Easily. Arguments against highly deleterious global warming have a charm and internal consistency that the arguments of the critics – who emphasize caution and uncertainty – lack. It's worthwhile to review the way the global warming thesis evolved. In 1990, the first Scientific Assessment of the United Nations Intergovernmental Panel on Climate Change (IPCC), a document that is the underpinning for the Rio Treaty, stated, "When the latest atmospheric models are run with the present atmospheric concentrations of greenhouse gases, their simulation of climate is generally realistic on large scales."

Several critics cried foul. The "largest scale" of simulation of planetary climate is surely the average surface temperature, and it was apparent, even back in 1990, that the computer models used to simulate global warming were predicting much more warming than had been observed. Since then, it has become generally accepted that the "generally realistic" models were saying that it should have already warmed between 1.3 degrees and 2.3 degrees Celsius, globally, with the higher figure for the Northern Hemisphere. The observed warming of the earth's surface temperature since the late 19th century is about one and a half of a degree. The first IPCC assessment is a busted forecast.

Why it took the U.N. five years to realize this is anyone's guess, but it sure did generate a lot of frequent flier miles for skeptics like me. Finally, in their second Assessment, published in 1995, the IPCC admitted the skeptics had a point: "When increases in greenhouse gases only are taken into account . . . most [climate models] produce a greater mean warming than has been observed to date, unless a lower climate sensitivity [to the greenhouse effect changes] is used There is growing evidence that increases in sulfate aerosols are partially counteracting the [warming] due to increases in greenhouse gases."

Sulfate aerosols are tiny bits of dust also emitted during the combustion of fossil fuel that cool global warming by reflecting away the sun's radiation.

Translation of the 1995 report: Either it's not going to warm up as much as we said it was, or something (like sulfate aerosol) is reducing the warming. I bet that many in my profession will do everything in their power to prove the latter and disparage the former, because no one wants to write the letter, "Dear Mr. Vice President: We are sorry but we goofed. Thanks for the \$\$\$. Hope you get your carbon tax. Yours truly, the Consensus of Scientists."

Thus began a frantic effort to save face. Ben Santer, a fine and aggressive scientist from the Lawrence Livermore Laboratory, published an article in Nature magazine last year that seemed to show a remarkable correspondence between the evolution of planetary temperature patterns and a model that included both the warming from the greenhouse gases and the cooling from sulfates. This result argued against the skeptics' proposition that our planet was simply not prone to big-time warming. Santer's study period began in 1962 and ended in 1987.

The critics immediately pointed out that the model he relied on had only half of the known changes in the greenhouse effect. The fact is critics and proponents of the global warming thesis agree that human activities like driving cars and burning coal have changed the amount of warming radiation in the atmosphere only about 2.5 watts (or about one-quarter the power of a good flashlight). The central issue is how much this affects the world's climate.

Santer's model had attempted to answer that question based on the assumption that the "change" in the amount of warming radiation was only 1.25 watts.

When the right number is put in to Santer's model, things get even hotter than in the old models that were already abandoned. Worst of all, from Santer's point of view, when all of the available data, which ran from 1958 through 1995, are used, the correspondence between the model and reality vanishes.

Then there's the problem of the satellite-measured temperatures. These measurements, accurate to .01 degree Celsius, find a statistically significant cooling trend in the lower atmosphere since they started taking measurements in 1979. The old models, which the U.N. said in 1990 were "generally realistic," predicted a warming of about .6 degrees Celsius since the satellite measuring started, and even newer models predict warming of .35 degrees of Celsius. This warming simply isn't happening according to

the satellite data.

 The satellite data also match up perfectly, on a year-to-year basis, with temperatures measured in the lower atmosphere by weather balloons. This is a completely independent corroboration of the lack of predicted warming.

Then there's the problem of identifying the type of warming that is going on. Warming up the planet's coldest air masses clearly creates little harm, because no plant or animal can feel the difference between -40 degrees and -35 degrees. Greenhouse physics predicts that warming is more likely in the coldest, air masses. Indeed, there is some evidence that this is already occurring in Siberia and northwestern North America in winter. But it's no threat. It's pretty hard to melt ice caps at temperatures that are way below freezing.

 Conversely, a warm, humid air mass, where things are living and growing, doesn't respond much at all to greenhouse changes. So we expect to see less change in the summer. In fact, most observed summer changes are either small or insignificant, even in Siberia. All totaled, the effects of winter warming and little summer change lengthens the growing season, costs less energy and is, in general, hard to label as a big negative.

Some people have made careers out of labeling what I just wrote as the carpings of that "small band of vocal skeptics." I hope they read the May 16 issue of Science magazine. There, senior environmental reporter Richard Kerr found widespread discontent over the magnitude and even the detection of global warming. Kerr found, as predicted by the skeptics for 15 years now, that when climate models are cleansed of their "fudge factors" (his words) that they will produce precious little greenhouse warming in the next century.

Do this, and put in the most likely changes in the greenhouse effect for the next century, and you get 1.2 degrees Celsius of warming in a new climate model from the U.S. National Center for Atmospheric Research. From the new model of the United Kingdom Meteorological Organization, the same exercise will give you 1.3 degrees Celsius of warming. Or look at Tom Wigley's completely independent calculation in Nature last year. Same number: 1.3 degrees.

The message is that this is less than half of the warming predicted by the U.N.'s "Consensus of Scientists" in 1990. And further, it's now appreciated that most of this has to be

in winter, as the rising temperature in Siberia is now informing us.

So the vice president is going to have to defend expensive and disruptive measures in the face of a very modest climate change whose most noticed effect will be to lengthen the growing season and reduce energy demand. The Senate will use the strength of the skeptics' arguments to turn down any amendment to the Rio Treaty -- which may actually be a blessing for Gore.

Defeat will enable the vice president to campaign in 1998 and 2000 on the attractive but spurious claim that Helms and the Republican leadership are going to kill our children because they won't stop global warming. With global warming, as with Gore's presidential ambitions, losing is winning.

Patrick Michaels is professor of environmental sciences at the University of Virginia and senior fellow in environmental studies at the Cato Institute.

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THE GREENING OF PLANET EARTH

ITS PROGRESSION FROM HYPOTHESIS TO THEORY

A Report Prepared by

CRAIG D. IDSO

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Office of Climatology
Arizona State University
Tempe, Arizona

Summary

Over the course of the Industrial Revolution, society's burning of coal, gas and oil has significantly increased the carbon dioxide content of earth's atmosphere. This change in the global environment has elicited the development of a number of hypotheses relative to its consequences, the most well-known of which is probably the CO₂-induced global warming hypothesis. Presenting a rather bleak view of the future, this negative concept of global change is the complete antithesis of a much more optimistic concept that is based upon the results of numerous laboratory and field experiments. This latter concept suggests that the productivity of the planet's vegetation will be greatly enhanced by the aerial fertilization effect of elevated levels of atmospheric CO₂, as will the efficiency with which plants utilize light, water and nutrients. Hence, as the CO₂ content of the atmosphere continues to climb, what may be referred to as the *greening hypothesis* bodes well for the biosphere, as it portends a great "greening of the earth" and envisions a natural CO₂-induced impediment to CO₂-induced global warming.

Several challenges to this concept are briefly reviewed and found to be unsubstantiated by data obtained from long-term CO₂ enrichment experiments. A number of predictions that logically flow from the hypothesis are then put forth as refining tests that have the power to raise it to the level of a theory. Real-world data reveal these predictions to be correct, suggesting that the *Greening Hypothesis* should henceforth be considered the *Greening Theory*.

The Greening of Planet Earth

In progressing from hypothesis to theory, an important concept comes of age.

Throughout enlightened periods of earth's history, the scientific enterprise has been a productive and effective means for discovering, describing and predicting various phenomena. So great has been its success, in fact, that science has become the primary vehicle of advancement in humanity's unending search for truth, the ultimate goal of which is a correct understanding of the natural laws that govern the universe.

Discovering the principles by which nature operates, and correctly inferring their consequences, begins with the act of observation and the synthesis of the acquired data into a meaningful scientific statement called an *hypothesis*. Such conjectures, often crude and imperfect at first, are generally refined over time, as additional research is conducted. Throughout this process, more accurate concepts often replace original ideas that are found to be inadequate, until an intellectual edifice is finally erected that harmonizes sufficiently well with a broad enough base of evidence that it can be elevated to the level of a *theory*.

Over the past few years, much time, money and effort have been expended in developing a concept of climate change known as the *CO₂-induced global warming hypothesis*, a corollary of which suggests that the copious quantities of carbon dioxide that are emitted into the atmosphere by the world-wide consumption of coal, gas and oil constitute the greatest environmental threat ever to be faced by the biosphere.¹

Proponents of this hypothesis claim that the continued burning of fossil fuels at today's high rates will result in warmer global temperatures,² as well as "many adverse consequences for human health, ecosystems and the economies of both developed and developing countries".³ Specifically, they contend that as the CO₂ content of the air continues to rise, large portions of earth's polar ice caps will melt, coastal lowlands will be inundated by rising sea levels, crop-threatening droughts will devastate agriculture, and super-hurricanes will ravage large areas of the planet,^{3,4} all of which scenarios are offered as compelling reasons for immediate and unprecedented governmental actions to avert the predicted catastrophes.

As with almost all hypotheses regarding subjects as complex as global weather and climate change, however, there is definitely another side to this story. In fact, there is an opposing hypothesis which suggests that the rising carbon dioxide content of the atmosphere may well be a blessing in disguise. The well-known *aerial fertilization effect* of atmospheric CO₂ enrichment, for example, tends to increase the productivity of nearly all of earth's plant life; and this response sets in motion an important process that acts to counter the impetus for warming caused by the extra CO₂, a phenomenon that could actually render the CO₂-induced global warming hypothesis moot. In the pages that follow, the origins of this lesser-known *positive* view of the ongoing rise in the air's CO₂ concentration -- the "greening of the earth" scenario -- are briefly reviewed, along with the history of its progression from hypothesis to theory.

Development of the Greening Hypothesis

The idea that an increase in the air's CO₂ content might be of benefit to the biosphere may be traced back in time nearly 200 years. As early as 1804, for example, de Saussure demonstrated that peas exposed to high CO₂ concentrations grew better than control plants in ambient air;⁵ and work conducted in the early 1900s significantly increased the number of species for which this growth-enhancing effect of atmospheric CO₂ enrichment was observed.^{6,7} In fact, by the time that a group of scientists met at Duke University in 1977 for a workshop on Anticipated Plant Responses to Global Carbon Dioxide Enrichment, an annotated bibliography of 590 scientific studies dealing with CO₂ effects on vegetation had been prepared.⁸ This body of research demonstrated that increased levels of atmospheric CO₂ generally produce increases in plant photosynthesis, decreases in plant water loss by transpiration, increases in leaf area, and increases in plant branch and fruit numbers, to name but a few of the most commonly reported benefits. And five years later, at the International Conference on Rising Atmospheric Carbon Dioxide and Plant Productivity, it was also concluded that a doubling of the atmospheric CO₂ concentration would likely lead to a 50% increase in the photosynthetic fixation of CO₂ by C₃ plants, a doubling of the water use efficiency of both C₃ and C₄ plants, significant increases in biological nitrogen fixation for almost all biological systems, and an increase in the ability of plants to adapt to a variety of growth-retarding conditions.⁹

In the face of this vast array of experimental evidence, it was easy to realize the obvious -- that carbon dioxide emissions from the burning of coal, gas and oil are

extremely beneficial to plant life -- and a number of scientists began to openly acknowledge that fact. In a study of Australian wheat yields from 1958 to 1977, for example, Gifford¹⁰ suggested that a large part of the upward yield trend over that period may have been due to the concomitant rise in atmospheric CO₂. Wittwer¹¹ likewise noted that "the 'green revolution' has coincided with the period of recorded rapid increase in concentration of atmospheric carbon dioxide, and it seems likely that some credit for the improved yields should be laid at the door of the CO₂ buildup;" while in a detailed analysis of this phenomenon, Allen *et al.*¹² concluded that yields of soybeans may have been rising since at least 1800 "due to global carbon dioxide increases."

With respect to the unmanaged biosphere, La Marche *et al.*¹³ reported in the fall of 1984 "the first direct evidence of CO₂-related growth enhancement in natural vegetation: increased widths of annual rings of trees in subalpine habitats in the western United States during recent decades." Four years later Hari and Arovaara¹⁴ reported similar findings in pine trees in northern Finland, noting that the increase in growth could not be explained by anything other than the increasing CO₂ content of the atmosphere. And as increasingly frequent studies of this nature began to appear,¹⁵ it became evident to an ever expanding number of scientists that as more and more countries increase their fossil fuel consumption in pursuit of a higher standard of living, CO₂ effects on both the managed and unmanaged biosphere will likely be overwhelmingly positive.

More detailed aspects of this concept were developed in a 1984 study that evaluated the consequences of a CO₂-induced doubling of plant water use efficiency for a number of different biotic communities.¹⁶ The basis of this analysis was the assumption

that if the water use efficiency of a plant is doubled, it should be able to survive with only half of the precipitation it currently receives at the water-limiting edge of its present range of occurrence. Calculations based upon this assumption indicated that in response to the ever-increasing carbon dioxide content of earth's atmosphere, all types of vegetation should gradually expand into areas of the planet that receive less rainfall than those areas to which they are currently restricted. What is more, the analysis revealed a general tendency for forests to expand their ranges at the expense of shrubs, for shrubs to encroach upon grasslands, and for grasslands to replace deserts.

This predicted expansion of vegetation into previously less-habitable and uninhabitable areas of the globe, along with the ubiquitous enhancement of plant growth rates expected to result from the aerial fertilization effect of elevated CO₂, prompted Idso¹⁷ to suggest that the ongoing industrialization of the planet was producing a remarkable "greening of the earth." Citing results of studies that indicated a recent increase in the metabolic activity of the global land biota, he additionally suggested that this ecological transformation of the planet was already in progress.

The climate-related portion of this positive view of the rising CO₂ content of earth's atmosphere grew out of the identification of a biologically modulated feedback mechanism that may reasonably be expected to offset any initial impetus for CO₂-induced global warming. The formulation of this aspect of the greening scenario drew heavily upon the pioneering work of Charlson *et al.*,¹⁸ who developed the key conceptual linkages of what may be described as a "global thermostat."

In developing this concept, Charlson *et al.* had noted that an increase in the reflectance, or albedo, of low to medium-level clouds over the world's oceans would have a powerful cooling effect on earth's climate, and that a significant albedo increase could be brought about by a moderate increase in the number of cloud condensation nuclei, or CCN, in the marine atmosphere. Hence, as marine CCN are believed to be primarily produced from gas-to-particle conversions of oceanic dimethylsulfide, or DMS -- which is a by-product of the photosynthetic activity of marine phytoplankton -- Charlson and his colleagues reasoned that if global temperatures were to rise in response to some initial impetus for warming, the productivity of marine phytoplankton would rise in response to the increase in water temperature, resulting in a greater production of oceanic DMS and its release to the atmosphere, where greater gas-to-particle conversions would increase the air's CCN population and, ultimately, the albedos of low and mid-level marine clouds. This phenomenon would then cause a greater percentage of the incoming solar radiation from the sun to be reflected back to space, thereby countering the initial impetus for warming. In fact, Lovelock¹⁹ has noted that the ultimate cooling effect of this phenomenon "is comparable in magnitude with that of the carbon dioxide greenhouse, but in opposition to it."

Within a year of its development, the generality of this concept was expanded beyond the shores of the world's oceans to the land itself with the discovery that the volatilization of reduced sulfur gases from soils may be just as important as marine DMS emissions in enhancing cloud albedo.²⁰ On the basis of experiments that showed soil DMS emissions to be positively correlated with soil organic matter content, and noting that

additions of organic matter to a soil tend to increase the amount of sulfur gases emitted therefrom, Idso²⁰ thus once again stated the obvious: "because atmospheric CO₂ is an effective aerial 'fertilizer,' ... augmenting its aerial concentration [and thereby increasing vegetative inputs of organic matter to earth's soils] should produce a second independent impetus for cooling *even in the absence of [initial] surface warming.*"

Two years later, Idso²¹ expanded the concept even more. First, he noted that since carbonyl sulfide is another biologically-produced sulfur gas that is emitted from soils, it too is likely to be emitted in ever greater quantities as earth's vegetation responds to the aerial fertilization effect of the ongoing rise in the air's CO₂ content. Then, he noted that carbonyl sulfide is relatively inert in the troposphere, but that it eventually makes its way into the stratosphere, where it is transformed into solar-radiation-reflecting sulfate aerosol particles. Consequently, he concluded, the CO₂-induced augmentation of carbonyl sulfide emissions constitutes a mechanism that can cool the globe's surface *even in the absence of clouds.*

With this last development, the "greening of the earth" scenario -- which posits great CO₂-induced biospheric benefits *with little or no adverse global warming* -- became a fully testable concept that is referred to hereafter as the *Greening Hypothesis.*

Challenges to the Greening Hypothesis

Every review of the scientific literature dealing with the aerial fertilization effect of atmospheric CO₂ enrichment has confirmed the reality of the growth-promoting effects of elevated levels of atmospheric carbon dioxide.²²⁻³⁸ In spite of this impressive empirical

foundation, however, the Greening Hypothesis has faced a number of challenges from the time of its inception, the foremost of which is the concern that natural ecosystems may not be able to take full advantage of extra CO₂ in the face of real-world resource limitations and environmental stresses.³⁹⁻⁴²

This issue has now been resolved by a review⁴³ of several hundred experiments of the preceding decade that reported growth responses to atmospheric CO₂ enrichment in identical sets of plants that were grown simultaneously under both ideal and less-than-ideal growing conditions. In the case of inadequate soil fertility, there was indeed a drop in the percentage growth enhancement caused by a 300 to 600 ppm doubling of the air's CO₂ content when a lack of soil nutrients limited growth, but it was very minor, reducing the CO₂-induced stimulation of plant productivity from 51% to 45%. When lack of water posed a limitation to plant productivity, however, the results were considerably more dramatic and in the opposite direction: the relative plant growth enhancement caused by a 300 ppm increase in atmospheric CO₂ jumped from 31% when soil water content was optimal to 63% when it was less than optimal. And a similar enhancement of the growth-promoting effects of atmospheric CO₂ enrichment was found when light intensity was reduced below its optimum.

In the case of environmental stresses, soil salinity was found to have no significant effect on the percentage growth enhancement caused by an increase in atmospheric CO₂. And when air pollution was the source of stress, again it was the stressed vegetation that exhibited the greater percentage increase in CO₂-induced growth enhancement.

The projected stress of global warming was also revealed to be a non-problem. In fact, for the vast majority of plants studied, the warmer it became, the greater was the percentage growth enhancement produced by higher levels of atmospheric CO₂. In addition, it was found that the optimum temperature for leaf photosynthesis actually *rose* in the face of atmospheric CO₂ enrichment, climbing by an average of 6 °C for a 300 ppm increase in the air's CO₂ content, which is even greater than the degree of global warming that is typically predicted to occur for such a rise in CO₂. What is more, the absolute rates of plant photosynthesis at the CO₂-induced optimum temperatures were nearly *twice as great* as the rates experienced at optimum temperatures under ambient CO₂ concentrations. Hence, it would appear that resource insufficiencies and environmental stresses will not impede the planet's vegetation from reaping the many biological benefits that may logically be expected to result from the rising CO₂ content of the atmosphere.

There is another phenomenon that has been mentioned as a potential problem in this regard, however, and that is the gradual "acclimation" or "down regulation" of photosynthesis and growth, where the initial stimulation provided by atmospheric CO₂ enrichment slowly erodes over long periods of time. This challenge to the Greening Hypothesis has its origin in a number of experiments that have indeed documented such behavior in several plants. But nearly all of these studies were conducted in controlled-environment chambers or greenhouses, where the experimental plants were grown in root-restricting containers, which have been demonstrated to typically prevent the full expression of atmospheric CO₂ enrichment effects.⁴⁴⁻⁴⁷

In field-grown plants the story is quite different. There is, for example, almost no evidence of down regulation of either photosynthesis or growth when plant roots are free to explore the soil profile when exposed to elevated CO₂ over long periods of time;⁴⁸⁻⁵⁴ and there are a number of reports where actual *increases* in photosynthesis and growth were measured under such conditions.⁵⁵⁻⁶⁵ Likewise, in the longest (and still on-going) CO₂ enrichment experiment ever conducted, Idso and Kimball⁶⁶ continue to report a cumulative productivity enhancement in excess of 100% in sour orange trees that have been grown out-of-doors since the seedling stage (they are now mature) and exposed to an extra 300 ppm of CO₂ in clear-plastic-wall open-top enclosures for over eight years. Hence, the laboratory and greenhouse-based challenge of the potential slow decline of growth in plants exposed to long-term atmospheric CO₂ enrichment would not appear to be a problem for earth's natural ecosystems.

Tests of the Greening Hypothesis

Standing up to the intellectual challenges that should rightfully be leveled against a concept as sweeping in scope as the Greening Hypothesis is obviously an important and necessary aspect of its ultimate elevation to the level of a theory. Of ~~even~~ greater importance, however, are observational confirmations of predictions that may be derived from the concept; and in this regard, the most fundamental testable prediction of the Greening Hypothesis is that the annual vegetative productivity of the entire biosphere should be rising in response to the yearly-increasing CO₂ content of earth's atmosphere.

So how does one measure changes in the total productivity of the plant life of an entire planet? Consider the recurring seasonal cycle of the air's CO_2 content. Each spring, when the Northern Hemisphere's thin veneer of vegetation awakens from the dormancy of winter and begins to grow again, it removes enough carbon dioxide from the atmosphere to reduce its CO_2 content by several parts per million. Then, in the fall, when much of this vegetation dies and decays, it releases huge quantities of carbon dioxide back to the atmosphere, raising the air's CO_2 content by a small amount. Taken together, these two phenomena produce a seasonal oscillation that is superimposed upon the yearly incremental rise in the air's mean CO_2 concentration; and the greater the yearly growth of the planet's vegetation, the greater are the yearly down- and up-swings in the amount of carbon dioxide in the air. Consequently, the *amplitude* of the seasonal CO_2 oscillation serves as an accurate relative measure of the planet's total vegetative productivity in any given year.

Nearly every group of scientists that has studied this phenomenon has come to the same conclusion, namely, that over the period of time for which accurate and detailed CO_2 measurements are available (1958 - present), there has indeed been a significant increase in the annual amplitude of the atmosphere's seasonal CO_2 cycle, which all of the studies primarily attribute to the ever-increasing aerial fertilization effect of the steadily rising mean value of the air's CO_2 content.⁶⁷⁻⁷² This conclusion has recently been reaffirmed by the study of Keeling *et al.*⁷³ and is further substantiated by (1) detailed analyses of the seasonal atmospheric oxygen cycle,⁷⁴⁻⁷⁷ (2) meticulous measurements of the carbon isotope composition of atmospheric CO_2 ,^{78,79} and (3) the mystery of the "missing

nitrogen,"⁸⁰ the lion's share of which is believed by many ecologists to be locked up with the extra carbon that is being sequestered by the biosphere as it responds to the rising CO₂ content of the atmosphere.⁸⁰⁻⁸⁴ These observations all point to the photosynthetic response of the terrestrial biosphere to atmospheric CO₂ enrichment as the major cause of the 18.7% increase in the amplitude of the seasonal atmospheric CO₂ oscillation that occurred between 1958 and 1994; and they clearly establish the validity of the first major prediction of the Greening Hypothesis.

Now the only way the terrestrial biosphere can be responsible for this CO₂-induced stimulation of global vegetative productivity is if woody plants are highly responsive to increases in the air's CO₂ content; for trees and shrubs account for close to 75% of terrestrial photosynthesis.^{85,86} Hence, a *second* testable prediction of the Greening Hypothesis is that the growth rates of earth's forests must be rising in response to the yearly-increasing CO₂ content of the atmosphere.

Idso¹⁵ has reviewed this subject in detail, reporting results from over 30 different studies documenting substantial increases in forest productivity that coincide in time with the progression of the Industrial Revolution and the contemporaneous increase in the air's CO₂ content. One of these studies -- that of Phillips and Gentry⁸⁷ -- was particularly impressive in this regard, as they had obtained and analyzed long-term data from 40 tropical forests from all around the world. Not only did these investigators clearly demonstrate the global extent of the phenomenon, they also showed that it has been growing greater and greater with time, much like the temporal pattern in the historical record of atmospheric CO₂ concentration.

With this second prediction of the Greening Hypothesis thus vindicated by a wide array of real-world data, a *third* prediction can be made; for if trees and shrubs are as responsive to atmospheric CO₂ enrichment as recent forest growth rate data demonstrate, the world should be experiencing a significant expansion in the ranges of occurrence of woody plants ... and so it is. In the review of Idso,¹⁵ for example, one finds over seventy reports of this phenomenon occurring on every continent of the globe except Antarctica.

We come at last, then, to the *fourth* and final major prediction of the Greening Hypothesis, specifically, that a CO₂-induced increase in global vegetative productivity will lead to an increase in biogenic DMS emissions that will ultimately produce a cooling effect of approximately the same magnitude as the global warming predicted to result from the CO₂-induced enhancement of the atmosphere's natural "greenhouse effect."

In support of this prediction, consider the results of the impressive IronEx II study.⁸⁸ This multi-faceted experiment was designed to test the idea that lack of iron limits the productivity of high-nitrate low-chlorophyll regions of the world's oceans.^{89,90} It was initiated by adding dissolved iron to the surface layers of two "patches" of seawater in the equatorial Pacific. Immediately thereafter, phytoplanktonic productivity began to rise dramatically within the patches, attaining a new equilibrium level 24 hours later that was maintained throughout the remainder of the experiment.⁹¹

This increased level of marine productivity drew a larger-than-normal amount of dissolved CO₂ out of the surface waters of the iron-infused patches,⁹² just as enhanced terrestrial productivity draws gaseous CO₂ out of the atmosphere. In addition, DMS concentrations in the surface waters of the patches rose by a factor of 3.5, providing -- in

the words of the study's authors⁹³ -- "direct support for an important link in the iron-DMS-climate hypothesis," which they also reported to produce a cooling effect of about the same magnitude as typically-predicted CO₂ induced global warming.

Viewed as a surrogate for the CO₂-induced stimulation of plant productivity, this iron-induced enhancement of plant growth and development, along with its contemporaneous stimulation of DMS production, provides as good a set of evidence for the veracity of the fourth prediction of the Greening Hypothesis as can reasonably be expected to be found, especially when considered in conjunction with the impressive observational studies of Saxena *et al.*,⁹⁴ who by many meticulous measurements have conclusively demonstrated that cloud albedo increases with an increase in air mass sulfate content. Hence, in paraphrasing the words of Coale *et al.*,⁸⁸ who felt compelled to conclude that "it is now time to regard the 'iron hypothesis' as the 'iron theory'," it is probably also time to regard the Greening Hypothesis as the Greening Theory.

Conclusions

Science works. It works because it is a logical, methodical means of acquiring knowledge based upon observations of nature. Hence, science is the primary tool that society employs (or should employ) in resolving important issues related to the environmental impacts of its activities, the most significant of which is currently regarded to be the large-scale utilization of fossil fuels.

Based upon the results of literally thousands of experiments employing the scientific method, a positive picture of the response of earth's biosphere to the increase in

the air's CO₂ content caused by the burning of coal, gas and oil has recently emerged as a bright alternative to the "gloom and doom" predictions associated with the speculative threat of global warming. This new view of the future is bright with promise, portraying an expanded and invigorated biota that thrives on the carbon dioxide emitted to the atmosphere as a natural consequence of humanity's increasing utilization of fossil fuels in its quest for a better life.

This CO₂-induced rejuvenation of the biosphere -- often described as "the greening of planet earth" -- is a multi-faceted hypothesis that has successfully withstood many challenges. Now, with the verification of four important predictions that may be derived from it, the hypothesis may validly be considered to have achieved the status of a theory -- a theory that must surely play a major role in determining the course we will take as we confront the future in a world of conflicting concepts of impending global change.

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COMMENTARY

PATRICK MICHAELS

Extremism in pursuit of green

Later this spring — after the termination of our interminable winter — the Clinton-Gore administration is going to announce that the U.S. supports legally binding reductions in emissions of the greenhouse gases forecast to cause dreaded global warming. This significant change in policy will be pronounced by the vice president, most likely in an address at George Washington University.

Vice President Al Gore knows this is going to be the sell of his life, because something is very wrong with the sureshot forecasts of climate apocalypse that cored his best-selling 1992 book "Earth in the Balance." There, he made great political hay out of an apparent "scientific consensus" of dramatic warming, supported by a United Nations report stating that the climate models projecting gloom and doom were "generally realistic." Mr. Gore labeled anyone with a Ph.D. in Climatology (there are fewer than 50 such individuals in the world) who might disagree as a member of "a small but vocal band of skeptics."

It turns out these "skeptics" were right, and Mr. Gore can't ignore it. What was heresy four years ago — that the climate models were forecasting way too much warming — is now "consensus." Scientists who

said satellites were finding no warming whatsoever were ridiculed, and journalists were remonstrated by Mr. Gore to ignore them. Now they're being lionized because they saw what was happening first. After nearly two full decades, the satellites find nothing but a statistically significant cooling averaged over the entire southern half of the planet.

The currently fashionable explanation is that the warming is being "hidden" by other industrial compounds, namely finely divided sulfate aerosols that screen the sun and brighten the clouds. They are almost exclusively found in the industrial Northern Hemisphere, and they rain out before they head south of the equator.

Obviously, the fashionable explanation is pretty darned wrong. Otherwise the Southern Hemisphere would be warming up with apocalyptic abandon. When this was pointed out in a densely written article in the Dec. 12 edition of *Nature*, proponents of the current fashion were forced to agree.

You never read about that because of Mr. Gore's deal with the environmental journalists: Don't report any good news and I'll treat you right when I become president. Just report (or construe, make up, whatever) bad news.

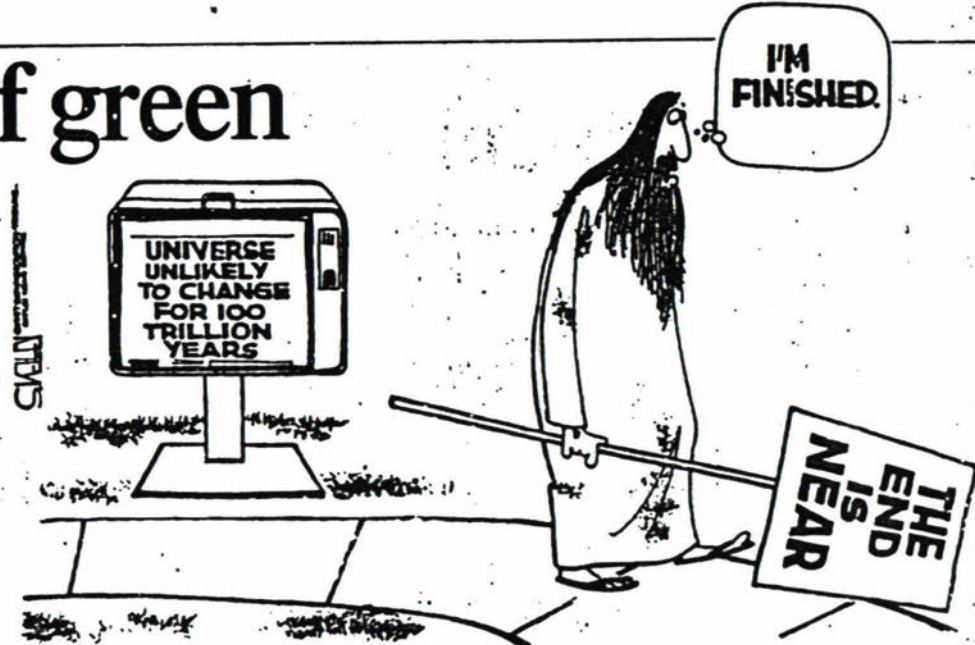
Need proof? The press was all over an article, in the very same

issue of *Nature* stating that fossil records from 1,000 years ago show more frequent droughts in the Upper Midwest. It just happened to be warmer then, so global warming must make more droughts there in the future. Nobody mentioned that the droughts of AD 1200 occurred without any assistance from mankind and were as natural as floods, hurricanes, normal rainfall, and frozen Washington.

So how is Mr. Gore going to sell his commitment to the greatest economic intervention in the history of man? Extremism! OK, the planet isn't as warm as I said it would be, but there are more "extreme" events. He is already on record as saying that "intense rainfalls have increased in summer over agricultural regions."

Here he uses the work of federal climatologist Tom Karl, who recently put out a press release, which just happened to be concurrent with the California floods, saying "extreme" rains are increasing, and that other "extreme" indicators are going along. Mr. Karl informed us there was no pressure to report these results or exaggerate.

What Mr. Karl actually found is that there has been an increase, averaged across the country of one day in every 730 in which it rains 2 inches or more. That's right — one in every two years — something that neither you or I would notice unless we had been stunned into true belief by our beneficent government. Three inch rains are just too infrequent to show a significant trend averaged across the



United States, according to Mr. Karl.

Mr. Karl and Mr. Gore call two-inchers "extreme" and "torrential," respectively. More likely, they're "beneficial," because a full 70 percent of all rainstorms that are greater than 2 inches are less than 3. Find me a Midwestern farmer who generally would rather not have that rain, given the fact that our average summer puts the Corn Belt in moisture stress.

Mr. Karl also has looked at what should be the most obvious sign of Apocalypse Soon — the percent of the United States that is experiencing much-above-normal temperatures. No significant change is detectable since 1910, the start of

his study. What about extreme cold? Indeed: there has been a significant reduction in the percent of the country covered by extremely cold temperatures since 1910. This is consistent with other work that shows that the air mass that most reflects climate change is the dreaded Siberian Express, which has warmed from -40 degrees C to -38 degrees C. Talk about change in extremes!

Expect to see an increasing volume of misleading climate hype over the coming year, to justify to the American people the destruction of their current way of energy life. For Mr. Gore, winning this argument is going to be a lot more difficult than winning the presi-

dency in the year 2000.

Just for the sake of extremists let's set the record straight. Stuck indicate that agriculturally beneficial rains are increasing in the breadbasket of the world. The extreme cold temperatures of winter have moderated a bit (not enough, in my mind), while the extreme heat of summer hasn't changed in a detectable fashion. If this was caused by people, God Bless 'em, we've got to write laws to stop it.

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WORLD Climate Report

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A BI-WEEKLY REPORT ON GLOBAL CLIMATE CHANGE

GLOBAL WARMING'S TRAVELING CIRCUS

Everyone knows that it's just not going to be very popular to reduce U.S. fossil fuel consumption the 60 percent that is required to stabilize atmospheric carbon dioxide concentrations. Nonetheless this is the road that the Clinton Administration will embark upon when it proposes legally binding reductions at the U.N. global warming 'crat-o-fest in Kyoto in December.

Anticipating a bit of upcoming political turbulence (see our "Big Rumor"), the Administration is busy selling its version of an elixir to save the planet via a series of traveling roadshows:

Oyez, Oyez! Coming soon to a lecture hall near you! It's hot! It's persistent! It's highly variable! And it can't be stopped (without a significant monetary contribution from you). Yes, it's Global Warming!

These State Department "discussions" about global warming are modeled after the "town meeting" format popularized by ABC's *Nightline* in the 1980s. The only towns that meet are correct-thinking communities (i.e., those with big universities) with large memberships in co-sponsoring environmental groups.

Opening night took place Aug. 13 on the University of Texas campus in Austin, a prosperous, liberal town that surely represents the State Department's America. Act I was a video—a four-part news series about global warming in which the research of several prominent scientists is taken out of context (we know, since we know them and have studied and reported on their research in this *Report*).

The playbill:

- Scene I—Global warming is caused by evil industry.
- Scene II—Long-term climate records show warming.
- Scene III—Sophisticated computer climate models show it, too!
- Scene IV—Many people will die from massive flooding, starvation, heat stroke, and spreading tropical diseases if we don't act now.

With the necessary facts out, Act II included a panel of scientists—an atmospheric chemist, an agricultural economist, and a coastal geomorphologist. Note that none of the panelists was in the video, so those analyses and conclusions were unassailable. Climatologists need not apply at this point. The one atmospheric scientist, Dr. Kenneth Bowman from Texas A&M, is a stratospheric ozone expert, and he used most of his time talking about—what else?—stratospheric ozone, rather than global warming.

After the presentations, audience members had an opportunity to question the experts. Fortunately (and much to the surprise of meeting organizers), the audience included some climatologists who, through pointed questions about some of the assumptions and analyses presented, provided some interesting perspective to the "debate."

A short while later came the big production number. Under Secretary of State for Global Affairs Timothy Wirth, fresh from announcing in Europe that the United States is for legally binding emission reductions, charmed the onlookers with his exposition on global science and global governance. But the usually unflappable ex-Senator's feathers ruffled when several citizens questioned his authority to negotiate a treaty and the bases for his conclusions. Throughout the show, about half of the audience questions opposed the party line. This is one government production that opened to bad reviews.

The tent revival then traveled to the University of North Carolina in Chapel Hill, another town-just-like-America, (hey, doesn't every college basketball team have a whining coach?), and this time the State Department gushed moderation, so as not to stir up any of the industry shills (read: PhD climatologists) that might be in the crowd. They did, however, somehow conflate the damage caused by Hurricane Fran—as average a hurricane as has ever hit a crowded beach—as the product of global warming, rather than the product of gee-isn't-a-sand-dune-a-bad-place-to-sink-all-your-money.

After a major rewrite, a substantial rehearsal period, and some recasting, the national tour reopened at the University of Minnesota on Dec. 11. This event, portrayed as politically neutral, was sponsored by the Hubert H. Humphrey Institute, the Minnesota Environmental Initiative, and the Sierra Club. The leading role was now played by a big-time climatologist, Dr. Stephen Schneider of Stanford University, who actually appeared (surprise!) as a climatologist in the made-for-TV movie *The Fire Next Time*. Audience members submitted their questions in advance; the last thing the State Department wanted was a repeat of the Austin fiasco.

THE BIG, BIG RUMOR

BORN TO LOSE

Does the Clinton/Gore Administration really believe that the U.S. Congress (particularly the Senate) will simply agree to the legally binding emission reductions that it proposes in Kyoto next December—knowing full well that it's going to entail some type of taxation, hidden or otherwise?

Of course not. The Kyoto Agreement is designed to lose in the current Congress. Then Clinton/Gore will finger a handful of Congressmen as tools of industry who are killing the planet's children. An especial amount of environmental money will go into an attempt to defeat these Congressmen and return a Democratic majority (the Senate will remain hopelessly Republican).

In fact, it is only by losing the Congressional vote in 1998 that the Vice President will be able to muster the amount of self-righteousness (he has some potential here) sufficient to require him as leader for the next millennium. If the Senate somehow ratifies the new global warming "tax" in 1998, Mr. Gore won't have an issue to stand on in the year 2000.

Weather satellites have been measuring global temperatures since 1979, but have shown no climate warming — contrary to all expectations. According to computer models cited by the U.N.-sponsored science advisory body, the Intergovernmental Panel on Climate Change (IPCC), a substantial warming of nearly 1 degree Fahrenheit, should have occurred during this 18-year period.

If the models cannot be supported by actual observations of the atmosphere, however, then we cannot and should not rely on their predictions of a future warming. Therefore, all the elaborate international machinery that's being constructed around the Global Climate Treaty is a complete waste of time and money. Policies are being developed to ration and tax carbon dioxide emissions from fuel burning, and thereby throttle energy use. Such policies would cause grave economic damage, not only to industrialized nations, but also to developing countries that depend on trade and global prosperity.

In contrast to the satellite results, data collected from thermometers at weather stations around the world do show a warming — but only about half that predicted by the models. But these surface data do not cover the oceans, almost 70 percent of the Earth's surface, and large gaps exist elsewhere. Besides, such observations are subject to all kinds of local disturbances and interferences that can change over time, and thereby confuse measurement of temperature trends; for example, construction of a nearby building or even a growing tree will change wind patterns and affect the thermometer reading. But the biggest disturbing influence is the local warming from urban growth around the weather stations, which are usually located at airports.

This well-studied "urban heat island effect" produces a fictitious warming that is hard to eliminate from the surface temperature readings. Everyone knows this is so, but few will admit it. Instead, the attack has been focused on the satellite data. The fact they have reported a slight cooling since 1979 has been an embarrassing problem for global warming enthusiasts. (When corrected for the strong cooling effects of the two major volcanic eruptions in recent years, the satellite data suggest a slight warming trend — albeit very much smaller than that derived from surface observations or predicted by computer models). The divergence between satellite-derived temperature trends and surface thermometer trends has been growing larger year by year.

Satellite weather data under siege

The campaign to discredit the satellite observations has been gathering momentum as it became more widely known that they demonstrate the inadequacy of the computer models. The objection at first was that the satellite record is too short; but after a decade or so, this excuse no longer works. The second approach has been to state that the surface thermometers and the satellite-borne instruments are both correct but that they measure different quantities. It is true the satellite instrument derives a temperature of the lower atmosphere rather than of the surface itself, but the two trends cannot be expected to diverge for very long. Both records cannot be right; at least one of them must be wrong.

The most recent attack, published in the March 13 issue of the international journal *Nature*, accuses the satellite experimenters of technical errors in constructing the record that shows a cooling trend. The satellite experimenters will shortly reply with technical arguments that will be equally incomprehensible to the general

public and even to non-specialist scientists.

The scientific debate is being conducted at a high professional level and will no doubt shed some light; but it hardly affects the fact the computer models are not being validated.

Personally, I believe the satellite data, although not perfect, are more nearly correct. The easiest way to demonstrate this is to appeal to a completely independent set of measurements for verification; instruments launched around the world by weather balloons show exactly the same temperature trends as the satellite instruments.

Further support for the satellite results comes from the actual demonstration of an urban heat island effect on surface thermometers. An article published in the July 1996 issue of the *Bulletin of the American Meteorological Society* graphically shows temperature readings from highly populated California counties exhibit a strong warming trend during this century while less populated coun-

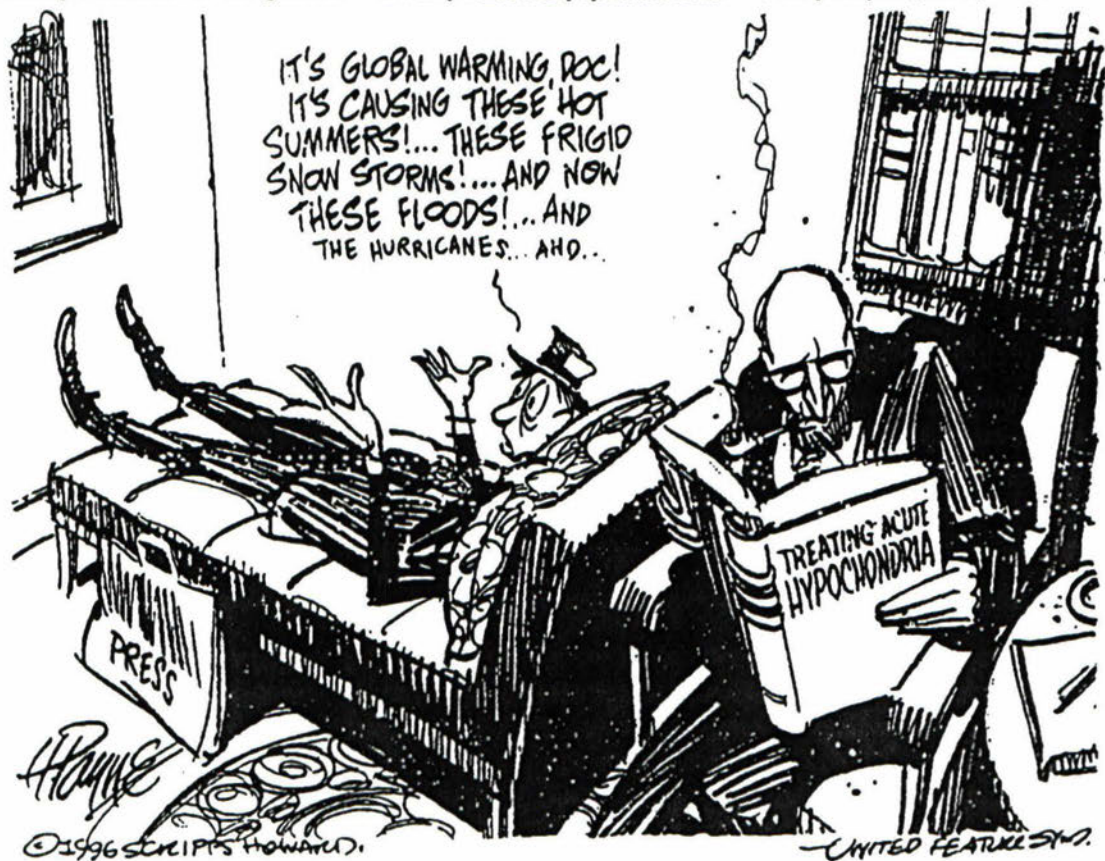
ties show a zero trend. Solar results have now been obtained, comparing cities and rural stations in Australia and in South Africa. It is evident that cities have become warmer as population grows and releases more heat into the atmosphere.

So we're back to Square One. It is clear the computer models are not validated by observations and need more work before we can trust their predictions. But now a scientific attack on the satellite data has been published in a respected journal, we can — regrettably — expect to see efforts to discredit the satellite results and obfuscate the true situation.

And what about future warming? When all is said and done, we can conclude there will be some warming as a result of the growth in atmospheric greenhouse gases, perhaps not more than 1 degree F by the year 2100, which would be barely measurable and completely inconsequential.

But long before then, a few more years of satellite data will make it obvious that global warming is a non-problem.

S. Fred Singer, professor (emeritus) of environmental sciences at the University of Virginia, is the founding president of the Fairfax-based Science & Environmental Policy Project (SEPP).





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**PRESS
MATERIAL**

**RECENT IPCC DATA, SATELLITES, WEATHER
BALLOONS AGREE NO WARMING IN LAST DECADE:
REBUTTING MARCH 13 *NATURE* ARTICLE**

(Arlington, VA — March 11, 1997) In response to a paper to be published in the March 13, 1997 edition of *Nature*, Western Fuels Association, Inc., releases the following statement.

Despite a spate of recent reports conflating floods, rainstorms, blizzards and hurricanes with global climate change, the earth's mean temperature hasn't budged a bit in the last decade according to every independent measure of temperature. The most recent data available from the UN Intergovernmental Panel on Climate Change indicates no warming trend in the ground-based temperature record during the period 1987-1996.

Therefore the IPCC, NASA scientists, and the global weather balloon network now are in agreement that **there has been no warming trend in the last decade**, which is precisely the period during which greenhouse warming was predicted to become extreme. The climate models which were the basis for the Framework Convention on Climate Change forecast a rise in global mean temperature of more than 0.3°C per decade by now.

While the scientific community now seems to agree that the early models have been discredited, newer models which simultaneously incorporate the cooling effects of sulfate aerosols and greenhouse warming continue to predict nearly as much warming (0.2°C) over the same period. According to Dr. Benjamin Santer in work recently presented to the American Geophysical Union, greenhouse warming should have overwhelmed any sulfate cooling in the last decade. It hasn't.

Despite independent sources of data showing the failure of the warming forecast, a paper to be published in the March 13, 1997 edition of *Nature* by J.W. Hurrell and Kevin Trenberth will argue that there was a "hidden" warming trend in the satellite record — a record which begins in 1979 and is well known to show a net *cooling* of the very atmospheric layers which are predicted to have warmed by nearly 0.4°C in that time. Hurrell and Trenberth reach their conclusion using climate models of middle atmosphere **rather than records of observed temperature.**

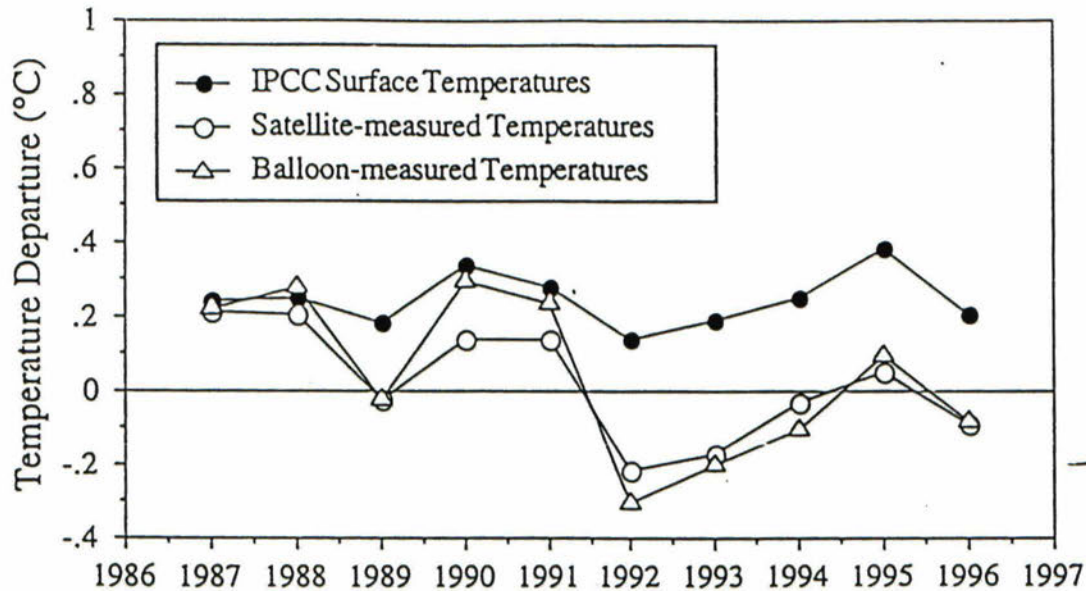
Hurrell and Trenberth's assertion requires scientists to ignore weather balloon temperatures recorded twice daily using highly-calibrated instruments sent skyward from locations blanketing the planet. On a year-to-year basis these data perfectly match the satellite temperature data taken in the atmospheric layers where substantial warming has been predicted. As illustrated in the accompanying graphs (see page 3), the match between the balloons and satellites is impressively precise.

What are the odds that these two independent measures of temperature could coincide over their 18-year simultaneous history? It's less than the odds of flipping a coin and getting 18 heads in a row — or one in 262,000 chances. According to NASA scientists, the chance of the earth being hit by an asteroid in a given year is ten times greater.

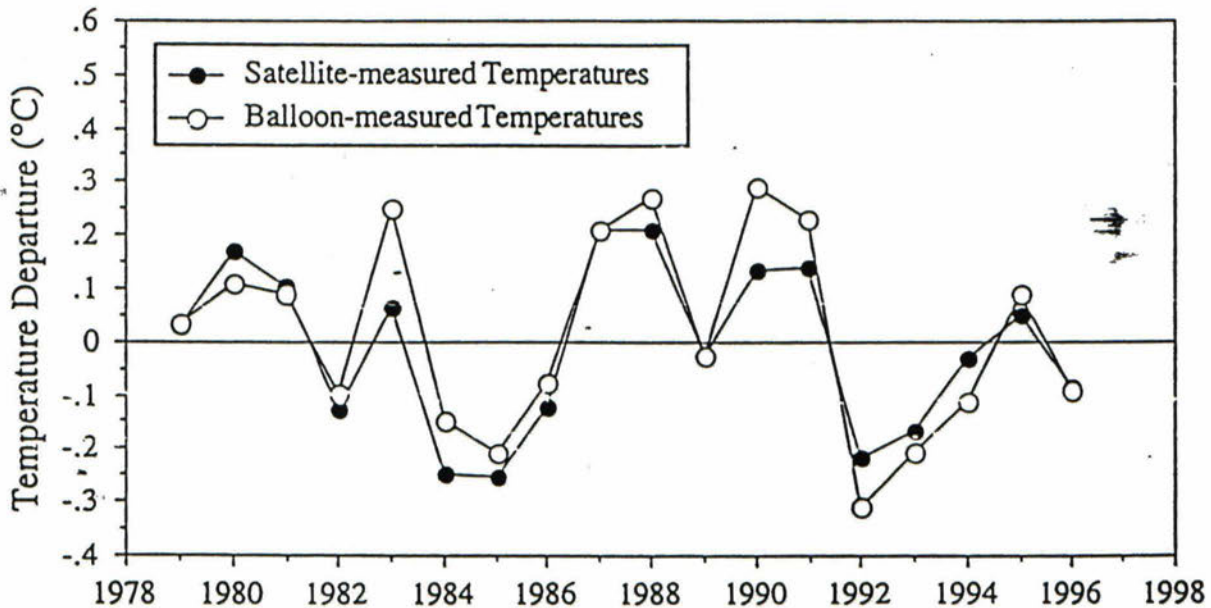
This statement is based upon information provided by New Hope Environmental Services, Inc.

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Western Fuels Association is a non-profit, consumer-owned cooperative company. Its member-owners are municipally- and cooperatively-owned electric utilities throughout the Midwest, West and Louisiana. Western Fuels supplies approximately 20 million tons of coal per year to its member-owners' 11 power plants and is one of the largest shippers of coal from the Powder River Basin in Wyoming and Montana.



Temperature trends over the last decade from the IPCC (filled circles), satellites (open circles), and weather balloons (triangles). IPCC data is from surface thermometers; satellite from Microwave Sounding Units (MSU) orbiting the planet; and balloon from instruments that ascend through the atmosphere simultaneously twice every day.



Temperature measured by the MSU satellites (closed circles) match up perfectly with those measured by weather balloons (open circles) between 5,000 and 30,000 feet.