
**The Need For Action To Reduce Greenhouse Gasses:
A Clear Consensus Among Scientists, Economists And Other Leaders**

Over 2600 American Scientists Agree On The Need For Action:

"We are scientists who are familiar with the causes and effects of climatic change as summarized recently by the Intergovernmental Panel on Climate Change (IPCC). We endorse those reports and observe that the further accumulation of greenhouse gases commits the earth irreversibly to further global climate change and consequent ecological, economic and social disruption. The risks associated with such changes justify preventive action through reductions in emissions of greenhouse gases."

-- Statement signed by over 2600 American Scientists on Global Climate Disruption, June 18, 1997 (emphasis added)

More Than 2000 Economists, Including Eight Nobel Laureates, Agree On The Need For Action:

"As economists, we believe that global climate change carries with it significant environmental, economic, social, and geopolitical risks, and that preventive steps are justified. Economic studies have found that there are many potential policies to reduce greenhouse-gas emissions for which the total benefits outweigh the total costs. For the United States in particular, sound economic analysis shows that there are policy options that would slow climate change without harming American living standards, and these measures may in fact improve U.S. productivity in the longer run."

-- Economists' Statement on Climate Change, January 1997, Endorsed by over 2000 Economists, including eight Nobel Laureates (emphasis added)

Many In The Business Community Agree On The Need For Action:

"[T]here is now an effective consensus among the world's leading scientists and serious and well-informed people outside the scientific community that there is a discernible human influence on the climate and a link between the concentration of carbon dioxide and the increase in temperature. ...[T]here is mounting concern about two stark facts. The concentration of carbon dioxide is rising, and the temperature of the earth's surface is increasing. If we are all to take responsibility for the future of our planet, then it falls to us to begin to take precautionary action now."

-- John Browne, Group Chief Executive, British Petroleum from a May 19, 1997 address at Stanford University (emphasis added)

"[International Climate Change Partnership] ICCP continues to recognize the climate change issue as an important matter with which governments should be concerned.... Our companies have determined that the current state of scientific understanding requires a prudent long-term approach to address this issue."

-- Prepared Statement of Kevin J. Fay, Executive Director International Climate Change Partnership Before the Senate Committee on Foreign Relations Subcommittee on International Economic Policy on June 19, 1997 (NOTE: Among the member of the ICCP are companies including British Petroleum, Chevron, Dupont, Enron and AT&T)

John Christy, University of Alabama

Excerpts from Articles referring to John Christy:

The atmosphere is cooling. Dr. John Christy of the University of Alabama, Huntsville, and Dr. Roy Spencer of NASA have been conducting the most accurate and complete atmospheric temperature study known to man. For the past 18 years they have used nine dedicated satellites covering 98 percent of Earth's surface to study the temperature of the atmosphere from the surface to about 28,000 feet. This ongoing study is not industry-sponsored. [Sacramento Bee, July 26, 1997]

"In the greenhouse wars, the battle is bloody and many a good scientist has been conscripted by both sides. Take **John Christy**. For ten years he was a Baptist minister in Kenya before he took up science. Now, as professor of atmospheric science at the Global Hydrology and Climate Center, part of the University of Alabama in Huntsville, he catalogues data from satellite instruments operated by the US government's National Oceanic and Atmospheric Administration (NOAA).

Since 1979, long before global warming was an issue, NOAA's instruments have been measuring microwave radiation released by the atmosphere. The radiation comes largely from oxygen molecules, which release more as they warm, giving an overall picture of temperatures in the troposphere. So far, and in stark contrast with the ground-based meteorological stations, the satellites have apparently picked up little evidence of warming.

Naturally, the sceptics have adopted Christy's data to suggest that global warming is a myth. In response, collectors of ground-based data have hit back. Jim Hansen, the NASA climate modeller who first put global warming onto the front pages back in 1988, claims that if the satellites can't see evidence of warming "there's something wrong with their data".

Both are wrong, says an exasperated Christy. First, his short time-series - just 18 years - is skewed by warming at the start, caused by a short-term natural warming in the Pacific, and by cooling towards the end, from the eruption of Mount Pinatubo in the Philippines. Filter out those effects and he reports "a very slight warming trend". But most importantly, says Christy, "the satellites don't measure surface temperatures, but average temperatures through the troposphere". Thus the surface and satellite data complement rather than contradict. **Put them together, he says, and they show that the surface of the planet is warming, but the bulk of the troposphere, the so-called free troposphere, is not.** [New Scientist July 19, 1997]

"THE THREAT of global warming has been blown out of all proportion by inaccurate computer simulation models, according to American research.

"If global warming is happening, it's very small. You can hardly notice it," says **John Christy**, the professor of atmospheric science who led the research. He and Justin Hnilo, a PhD student, examined the predictions of 14 computer simulations which, between 1979 and 1989, were forecasting potentially catastrophic rises in temperatures.

Data from systems set up by environmental agencies, universities, meteorological offices - including Britain's - and governments around the globe were compared with those from weather satellites to establish how accurate their predictions were compared to the facts.

Christy and Hnilo found that every system wildly exaggerated the problem. The most accurate predicted temperature rises four times higher than those experienced, while the worst exaggerated rises by a factor of 10.

During the 10-year study period the computer simulations, which were guiding government policy and public opinion around the globe, estimated that over the decade the atmosphere's temperature would rise by between 0.13C and 0.35C. The actual scientifically measured rise was only a "negligible" 0.03C.

"The models were generally far worse than we thought they would be," says Christy. He and Hnilo believe that there are several reasons for the exaggerated warnings.

Christy and Hnilo's examination of warming figures, gathered from satellites, shows that over the past 18 years there has been such a small rise in the temperature of the atmosphere, despite the doomsday warnings that any warming could be seen as natural. Meteorological data also suggest that there has been a rise in air temperature of only half a degree centigrade over 150 years. **Christy is left puzzled.**

"The negligible rise in temperature seems to be natural. It's strange because I can't really imagine how we cannot be adding to global warming with all the fossil fuels we're burning. I guess we're going to have to try to distinguish what part of the natural rise in temperature is down to us, and that's going to be difficult.

"What we can be sure about is that the dramatic predictions of the 1980s simply are not happening." [Sunday Times, February 16, 1997]

Some computer models have indicated that pollution will cause a dangerous temperature increase in future decades. But 16 years of satellite measurements studied by NASA and the University of Alabama at Huntsville show that recently, the lower atmosphere has warmed only about two-tenths of a degree per decade.

"That's only about one-third of what climate models predict," says **John**

Christy, professor of atmospheric science. [Austin American-Statesman, August 13, 1995]

That's the point stressed by the Reader's Digest article. **The data it presented come from satellite observations, analyzed by John Christy of the University of Alabama, Huntsville, and Roy Spencer of Marshall Space Flight Center, that provide the only truly global monitoring of temperature - and are a favorite of greenhouse contrarians.** They often cite the satellite record, which shows 15 years of ups and downs but little real warming, to support their contention that the climate models predicting global warming are off-base. [Science, February 3, 1995]

AN intensive search for evidence of man-made global warming, using the most advanced technology, has drawn a blank. **"We have found nothing but natural fluctuations," said Dr John Christy**, of America's space agency, Nasa. **"We've been surveying the entire Earth from a network of satellites since 1979, and if there is a warming trend it should have shown up."** This is the first time global temperatures have been monitored by satellite, rather than by ground-based thermometers. The latest data, collected by satellites operated by the United States National Oceanic and Atmospheric Administration, show that in June, as in the 19 previous months, average temperatures were cooler than those of 10 years ago. "We believe our method of collecting temperatures is more efficient than any other, since it monitors the entire planet evenly," said Dr Christy, who is based at Marshall Space Flight Centre at Huntsville, Alabama. "We think it is far superior to other methods that are now being used, such as collecting temperatures with thermometers that are mostly located in industrial areas such as airports and cities. "The only weakness in our method is that our satellites have been collecting data for only 14 years. "It is possible that the 1980s was a warmer decade than the 1970s, but the important point is that there is no sign of global temperatures rising during the 1980s," added Dr Christy. The satellites record the intensity of radiation from oxygen in the bottom four miles of the atmosphere. The higher the temperature, the more intense is this radiation.[The Daily Telegraph, July 30, 1993]

CNN
Science and Technology Week

January 23, 1993

HEADLINE: Global Warming May Only Be Conjecture

BYLINE: AL HINMAN

HIGHLIGHT:

Atmospheric scientists utilizing satellites to measure global temperatures claim global warming is a myth. Critics say measuring temperature from space is prone to inaccuracy and may not show true trends.

MILES O'BRIEN, Anchor: A new study of satellite weather information throws cold water on the already controversial theory of global warming. The study was presented this week at the American Meteorological Society meeting. CNN's Al Hinman looks at the escalating scientific battle over the Earth's temperatures.

AL HINMAN, Correspondent: It's too soon to blame global warming for Southern California's torrential, record-breaking January rains even though scientists say growing urban air pollution could lead to more intense and longer lasting storms, along with a rise in Earth's temperature.

THOMAS KARL, NOAA National Climatic Data Center: We're pretty convinced that there has been global warming in the last hundred years. The level at which is reported in that report is somewhere in the ballpark of three-tenths to six-tenths of a degree Celsius, somewhere between a half and one degree Fahrenheit.

HINMAN: The proof for global warming is based entirely on surface measurements from thermometers often located in or near big cities. Most of those urban areas have grown dramatically during the same period when Earth's temperature allegedly has gone up.

JOHN CHRISTY, University of Alabama-Huntsville: **What some people may see as a rise in temperature as global warming is really just a rise in the kind of urbanization around that temperature site.**

HINMAN: Christy says the better way to take Earth's temperature is from a satellite. In a joint project with NASA, scientists at the University of Alabama in Huntsville continue tracking and analyzing atmospheric temperature

measurements made by NOAA's Tyros satellites.

Mr. CHRISTY: We found over 14 years that the temperature has fluctuated but there is no trend. There is no upward or downward trend, it's zero.

HINMAN: That interpretation seems to knock down the widely held belief that growing levels of greenhouse gases are slowly warming up the planet.

Mr. CHRISTY: Do you have data that are truly global or do you have data that are misrepresentative of what is actually happening on the planet? Our data, we feel, has brought precision answers to the question.

HINMAN: Other atmospheric scientists are not so sure, saying satellite measurements are prone to error. Scientists say a lot more research, especially with satellites, is needed before global warming gets a formal scientific yes or nay.

O'BRIEN: The debate continues. In a few minutes, we'll give you a phone number where you can order transcripts of our program. And when we come back we'll meet an artist who can turn a skull into a face and find out how she's helping police solve crimes.

John R. Christy
Associate Professor of Atmospheric Science
University of Alabama in Huntsville
Huntsville, AL 35899
(1997)

**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
Assistant State Climatologist
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
IPCC (Invited Contributor) 1992 Scientific Assessment of Climate Change

PUBLICATIONS

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- Christy, J.R., R.W. Spencer, and D. Braswell, 1997: Satellite temperatures are accurate, *Nature*, (in press).
- Spencer, R.W., J.R. Christy, and N.C. Grody, 1996: Analysis of 'examination of "global atmospheric temperature monitoring with satellite microwave measurements"'. *Climatic Change*, **33**, 477-489.
- Christy, J.R., 1996: Arctic temperatures above the surface layer from the microwave sounding unit. *Arctic Monitoring and Assessment Program's Scientific Report*. (in press)
- Balling, R.C and J.R. Christy, 1996: Analysis of satellite-based estimates of tropospheric diurnal temperature range. *J. Geophys. Res.*, **101-D8**, 12,827-12,832.
- Parker, D.E., H. Wilson, P.D. Jones, J.R. Christy, C.K. Folland, 1996: The impact of Mount Pinatubo on world-wide temperatures. *International J. Climatology*, **16**, 487-497.
- Christy, J.R., 1995: Temperature above the surface layer. *Climatic Change*, **30**, 455-474.
- Christy, J.R. and R.W. Spencer, 1995: Assessment of precision in temperatures from the Microwave Sounding Units. *Climatic Change*, **30**, 97-102.
- Christy, J.R., R.W. Spencer and R.T. McNider, 1995: Reducing noise in the MSU daily lower tropospheric global temperature data set. *J. Climate*, **8**, 888-896.
- Christy, J.R. and J. Goodridge, 1995: Precision global temperatures from satellites and urban warming effects of non-satellite data. *Atmos. Env.* **29**, 1957-1961.
- Allen, M.R., G.M.C. Blumberg, J.R. Christy, R.T. McNider, D.T. Llewellyn-Jones and C.T. Mutlow, 1994: Global Change Detection. *Nature*, **370**, 24-25.
- Karl, T.R., R.W. Knight and J.R. Christy, 1994: Global and hemispheric temperature trends: Uncertainties related to inadequate spatial sampling. *J. Climate*, **7**, 1144-1163.
- Christy, J.R. and R. T. McNider, 1994: Satellite greenhouse signal. *Nature*, **367**, 325.
- Christy, J.R. and S.J. Drouilhet, 1994: Variability in daily, zonal mean lower-stratospheric temperatures. *J. Climate*, **7**, 106-120.
- Spencer, R.W. and J.R. Christy, 1993: Precision lower stratospheric temperature monitoring with the MSU: Validation and results 1979-91. *J. Climate*, **6**, 1194-1204.
- Dutton, E. G. and J.R. Christy, 1992: Solar radiative forcing at selected locations and evidence for global lower tropospheric cooling following the eruptions of El Chichon and Pinatubo. *Geophys. Res. Lett.* **19**, 2313-2316.
- Trenberth, K. E., J. R. Christy and J. W. Hurrell, 1992: Monitoring global monthly mean surface temperatures. *J. Climate*, **5**, 1405-1423.
- Spencer, R. W. and J. R. Christy, 1992: Precision and radiosonde validation of satellite gridpoint temperature anomalies, Part I: MSU channel 2. *J. Climate*, **5**, 847-857.

- Spencer, R. W. and J. R. Christy, 1992: Precision and radiosonde validation of satellite gridpoint temperature anomalies, Part II: A tropospheric retrieval and trends during 1979-90. *J. Climate*, **5**, 858-866.
- Christy, J. R., 1991: Diabatic heating rate estimates from European Centre for Medium-Range Weather Forecasts analyses. *J. Geophys. Res.*, **96**, 5123-5135.
- Spencer, R.W. and J.R. Christy, 1991: Response. *Science*, **251**, 317.
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- Spencer, R. W., J. R. Christy and N. C. Grody, 1990: Global atmospheric temperature monitoring with satellite microwave measurements: Method and results 1979-1985. *J. Climate*, **3**, 1111-1128.
- Christy, J. R., K. E. Trenberth and J. R. Anderson, 1989: Large-scale redistributions of atmospheric mass. *J. Climate*, **2**, 137-145.
- Trenberth, K. E., J. R. Christy and J. E. Olson, 1987: Global atmospheric mass, surface pressure and water vapor variations. *J. Geophys. Res.*, **92**, 14,815-14,826.
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- Trenberth, K. E. and J. R. Christy, 1985: Global fluctuations in the distribution of atmospheric mass. *J. Geophys. Res.*, **90**, 8042-8052.

Contributions to Books:

- Christy, J.R., "The MSU Data, 1979 to the Present." *Global Change*. A. Speranza, S. Tibaldi and R. Fantechi (Eds.) European Commission, Luxembourg, 1995, 431 pp.
- 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

- Christy, J.R. and R. W. Spencer, 1993: Monitoring global temperature from space. *Storm*, **1**, 18-24.
- Christy, J.R., 1993: Global Warming: Let's Cool the Rhetoric. *Huntsville Times, Atlanta Journal*. 22 April 1993.

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.
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- 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 Spunding Units. *Proceedings of the 5th Symposium on Climate Variations*, 14-18 October 1991. Denver CO.

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- 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.
- Christy, J.R., 1995: Merging strategies used in the MSU global temperature datasets. *EOS*, 76, S50, 1995 Spring Meeting American Geophys. Union, 30 May - 2 June 1995, Baltimore MD.
- 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. Mutlow, 1994: Potential impact of satellite-derived data sets on global change detection. *Proc. 19th Climate Diagnostics Workshop*, 15-19 November 1994, College Park, MD.
- Christy, J.R., 1994: Revising global tropospheric and stratospheric temperatures due to satellite orbit-time degradation. *Proc. 19th Climate Diagnostics Workshop*, 15-19 November 1994, College Park, MD.
- Christy, J.R. and C.-S. Yoon, 1994: Can we predict daily global temperatures? *Proc. 19th Climate Diagnostics Workshop*, 15-19 November 1994, College Park MD.
- 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.
- Christy, J.R. and C.-S. Yoon, 1993: Forecasting lower -tropospheric temperatures with 11-15 day lead time. *Proc. 18th Climate Diagnostics Workshop*, 1-5 November 1993, Boulder CO.
- Christy, J.R., and R.T. McNider, 1993: Detecting Global Warming using a Precise But Short (15-years) Satellite Data Set. *Proc. 18th Climate Diagnostics Workshop*. 1-5 November 1993 Boulder CO.

- 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.
- Christy, J.R., 1993: Precision global temperatures from satellites. *Proc. International Conf. on Sustainable Development*. 25-29 January, 1993. New Delhi, India.
- 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.
- Christy, J.R., and F.R. Robertson, 1990: The CCM1 at MSFC: Validation against satellite layer temperatures and ECMWF analyses. Workshop on the NCAR Community Climate Model. 16-20 July 1990, Boulder CO.
- Christy, J.R., and R.W. Spencer, 1990: Global tropospheric temperature variations since 1979 as measured from the Microwave Sounding Unit. *Proc. Climate Variations*, 4-7 February, 1990, Anaheim CA.
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- Spencer, R.W., and J.R. Christy, 1989: Global tropospheric temperature monitoring with passive microwave radiometers. *Proc. Fourteenth Ann. Climate Diagnostics Workshop*, 16-20 October, 1989, Scripps Institute of Oceanography, La Jolla CA.
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- Robertson, F.R., R.W. Spencer and J.R. Christy, 1989: Geophysical parameters from microwave retrievals. Workshop on the use of Satellite Data in the European Centre for Medium Range Weather Forecasts model. 8-12 May 1989, Reading UK.

- Christy, J.R., 1989: Global distribution of diabatic heating rate estimates. *Symposium on the Role of Clouds in Atmospheric Chemistry and Global Climate*. 29 January - 2 February, 1989, Anaheim CA.
- Christy, J.R., 1988: Global scale diabatic heating distributions and atmospheric mass anomalies. *Proc. Thirteenth Ann. Climate Diagnostics Workshop*, 31 October - 3 November 1988, Boston MA.
- Christy, J.R., 1988: Long term climate variability. *Proc. Alabama Irrigation Conf.*, 17 November 1988, Montgomery AL.
- Baker, E. S., J. R. Gyakum, and J. R. Christy, 1987: An examination of a strong gravity wave accompanying explosive cyclogenesis. *Third Conf. on Mesoscale Processes*, Vancouver B.C., Canada, 21-26 August, 1987.
- Christy, J. R., 1986: Very-large-scale atmospheric mass redistributions. *Proc. Eleventh Ann. Climate Diagnostics Workshop*, 14-17 October, 1986, Urbana IL. 318-322.
- Trenberth, K. E. and J. R. Christy, 1985: Global fluctuations in the distribution of atmospheric mass. *Third Conf. Climate Variations and Symposium on Contemporary Climate: 1850-2100*. 8-11 January 1985, Los Angeles CA, 48-49.
- 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.
- Trenberth, K. E. and J. R. Christy, 1985: The Southern Hemisphere circulation during FGGE and its representativeness. *Proc. First Nat. Workshop on the Global Weather Exp., 2*, National Academy of Sciences, Washington D.C., National Academy Press, 646-667.

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.
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Skeptics

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 $0.2^\circ\text{C}/\text{decade}$ 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 $\pm 0.03^\circ\text{C}/\text{decade}$, 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.

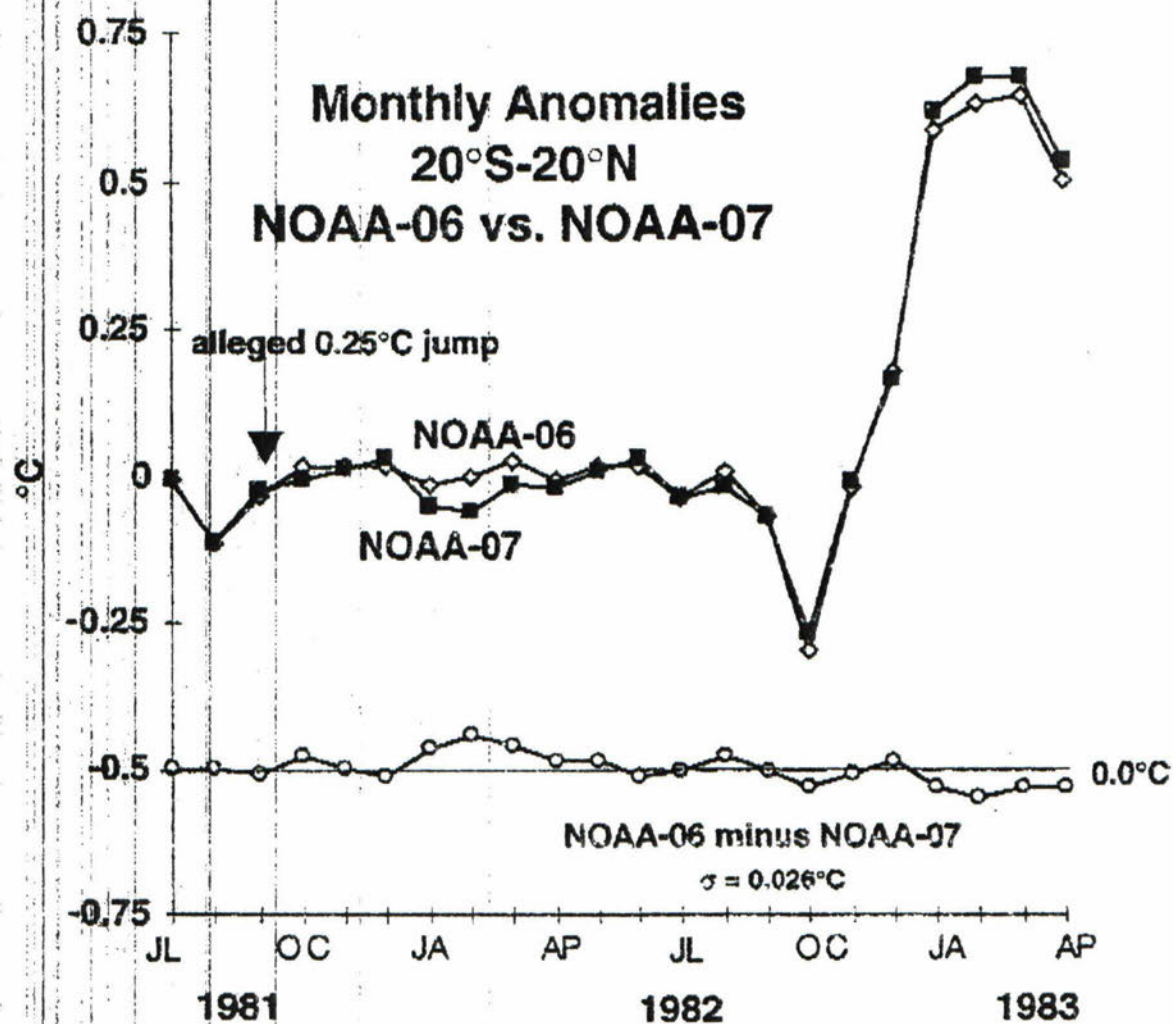
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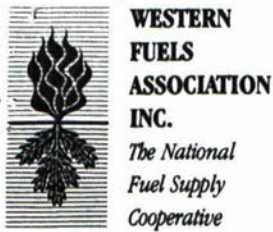
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Figure 1 Monthly temperature anomalies ($^{\circ}\text{C}$) for the tropics (20°S - 20°N) computed independently from two satellites, NOAA-06 and NOAA-07 for July 1981 to April 1983.





Skeptics

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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 *a/ways* 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

(more)

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.

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 apocalyst.)

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.

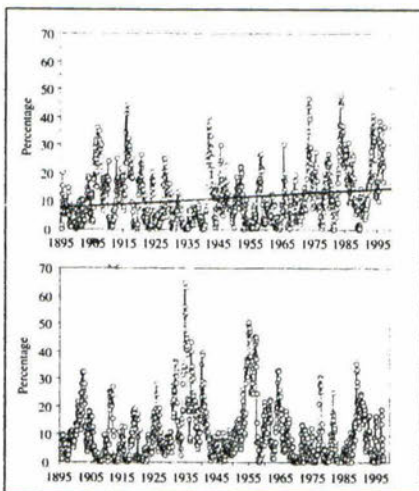


Figure 1. Percentage of the United States experiencing severe or extreme drought conditions (top) and severe or extreme wetness (bottom).

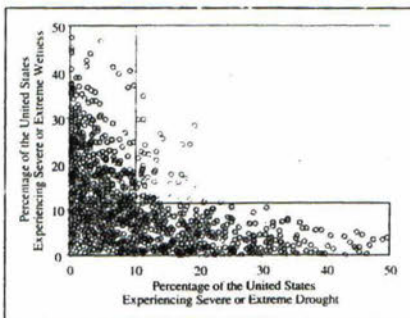


Figure 2. Relationship between areas of severe/extreme drought and areas of severe/extreme wetness. Points in the shaded area are below the mean in both categories.

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 $0.12^{\circ}\text{C}/\text{decade}$, 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?

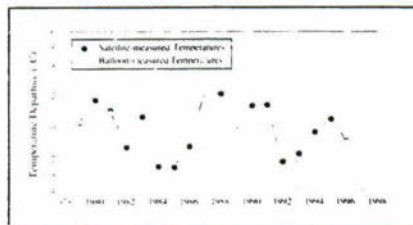
According to satellite guru Roy Spencer, what Hurrell and Trenberth did was to estimate the difference between surface temperatures and those measured by the satellite by using a general circulation climate model to calculate the bias by forcing the computer model with observed temperatures. That's right, 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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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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**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.

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.

skeptics

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American Meteorological Society

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

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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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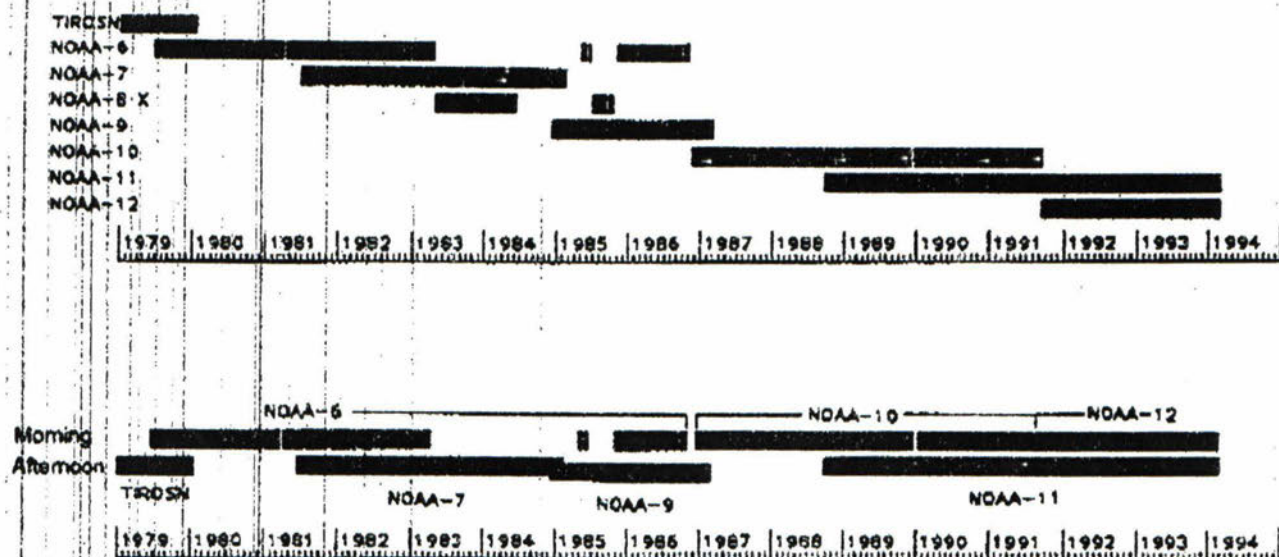


FIG. 1. (Top) Data availability from the operational NOAA polar orbiters, which carried Microwave Sounding Units. (Bottom) As above but categorized by crossing time: morning or afternoon.

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 K^2 , while the daily S is 0.032184 K^2 , 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 K^2 , 0.016512 K^2 , 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.

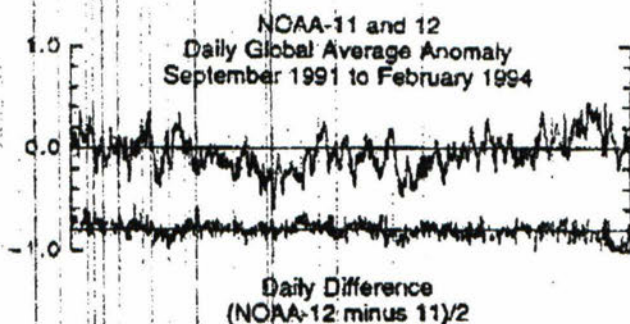


FIG. 2. (Top) The average of the daily global-mean anomalies for NOAA-11 and -12. (Bottom) The difference of the global-mean daily anomalies (offset by -0.8°C for clarity) divided by 2. This was the worst case of the six overlap comparisons.

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 $\sqrt{N} = (\sigma_{\Delta/2})$ 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

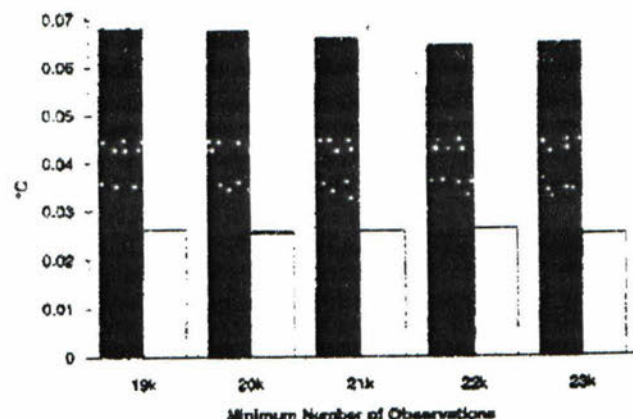


FIG. 3. Solid (open) columns represent $\sqrt{N}$ for daily (30-day mean) statistics. The left-to-right progression indicates results for minimum daily observation rates of 19 k, 20 k, 21 k, 22 k, and 23 k.

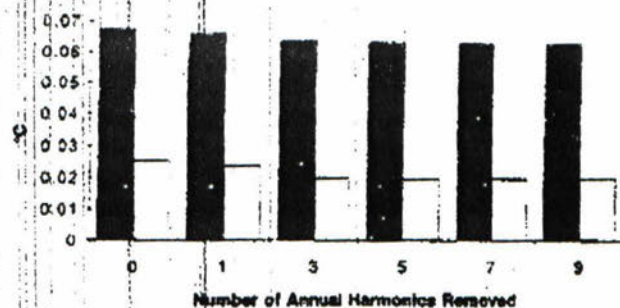


FIG. 4. Solid (open) columns represent $\bar{N}$ for daily (30-day mean) statistics. The left to right progression indicates results for removal of Fourier components of the annual period up to the wavenumber indicated below the columns.

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 $\bar{N}$ by over 20% in the case of waves 1-5. The daily $\bar{N}$ 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.

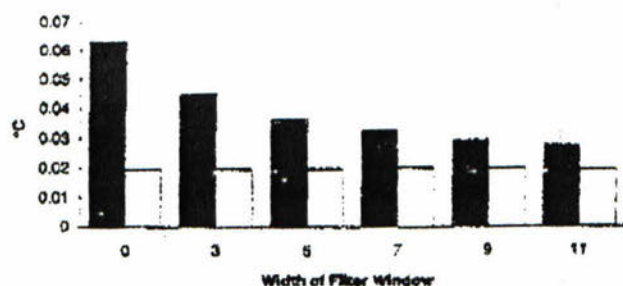


FIG. 5. Solid (open) columns represent $\bar{N}$ for daily (30-day mean) statistics due to median filtering with window width $2n+1$ indicated below.

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 $\bar{N}$ 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 $\bar{S}$ 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

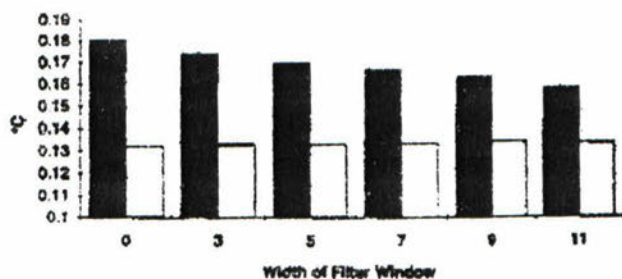


FIG. 6. As above for $\bar{S}$.

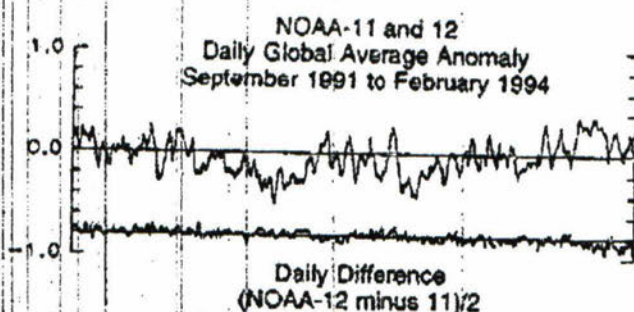


FIG. 7. As in Fig. 2 for the NOAA-11 and NOAA-12 overlap comparison after removal of five Fourier components of the annual period and inclusion of 5-point median filtering. Note the trend in the difference time series.

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 33%. 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

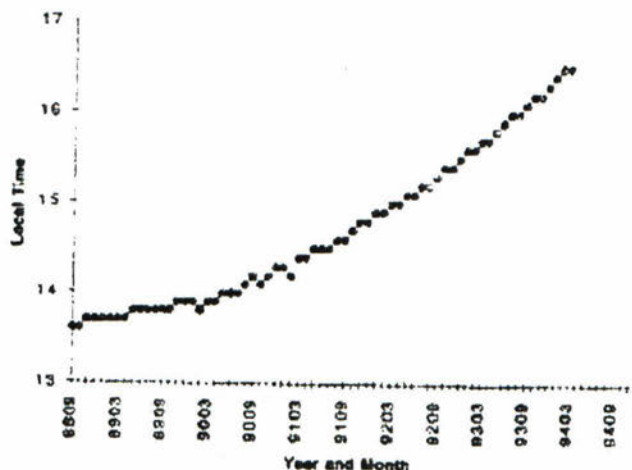


FIG. 8. Ascending pass crossing time at the equator for NOAA-11 from September 1988 to February 1994.

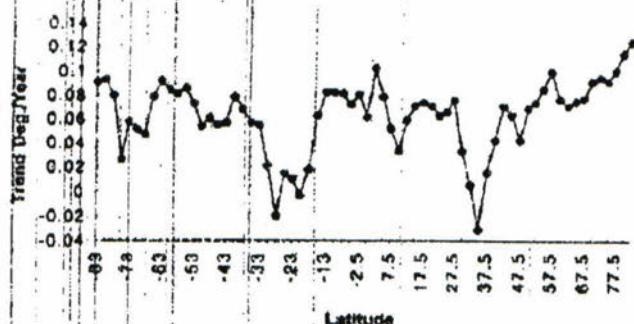


FIG. 9. Relative trend ($^{\circ}\text{C}$ per year) between NOAA-11 versus NOAA-10 and NOAA-12 determined from 1 January 1990 to 28 February 1994 as a function of latitude.

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-

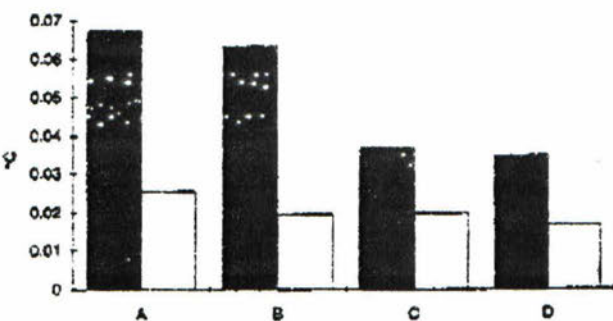


FIG. 10. Solid (open) columns represent $\sqrt{N}$ for daily (30-day) averages for A: unaltered data for 20 k observations; B: as in A with removal of five Fourier components; C: as in B with 5-point median filtering; and D: as in C after removal of NOAA-11 trend.

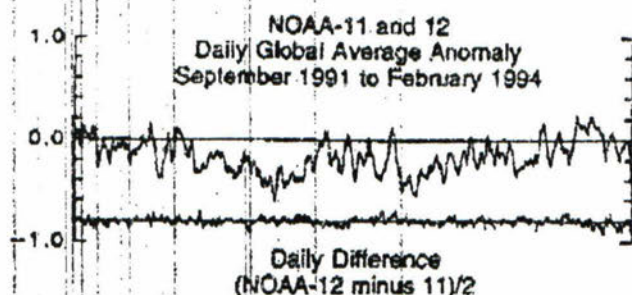


FIG. 11. As in Fig. 7 for the NOAA-11 and -12 overlap after latitudinal trends of NOAA-11 are removed.

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

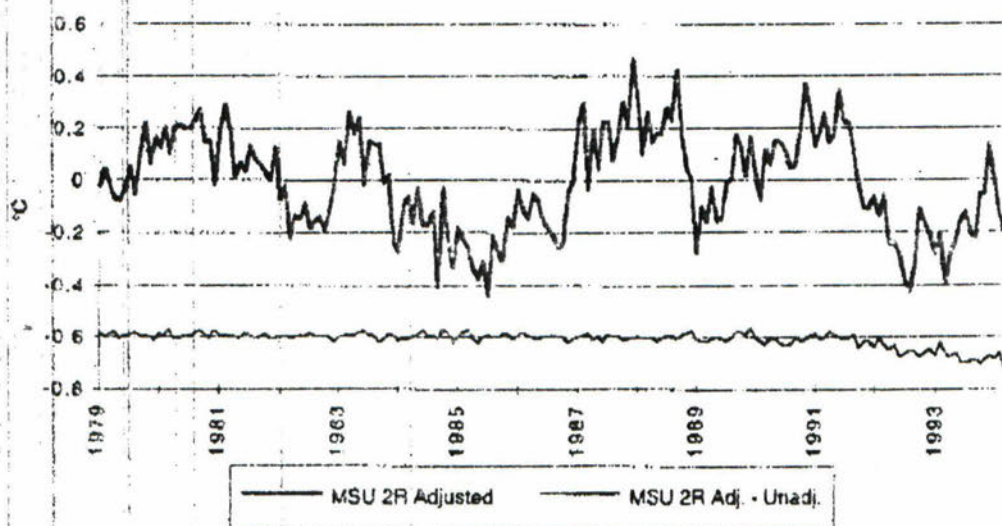


FIG. 12. Time series of monthly global anomalies (thick line) relative to 1982-91 annual cycle after removal of effects noted in this paper. Difference (thin line, offset by -0.6°C for clarity) relative to MSU 2R values reported prior to adjustments given in this paper. The time series here includes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

Acknowledgments. This research was supported by the NOAA Climate and Global Change Program and the NASA Mission to Planet Earth Program.

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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. Environmentalist 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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Skeptics

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.

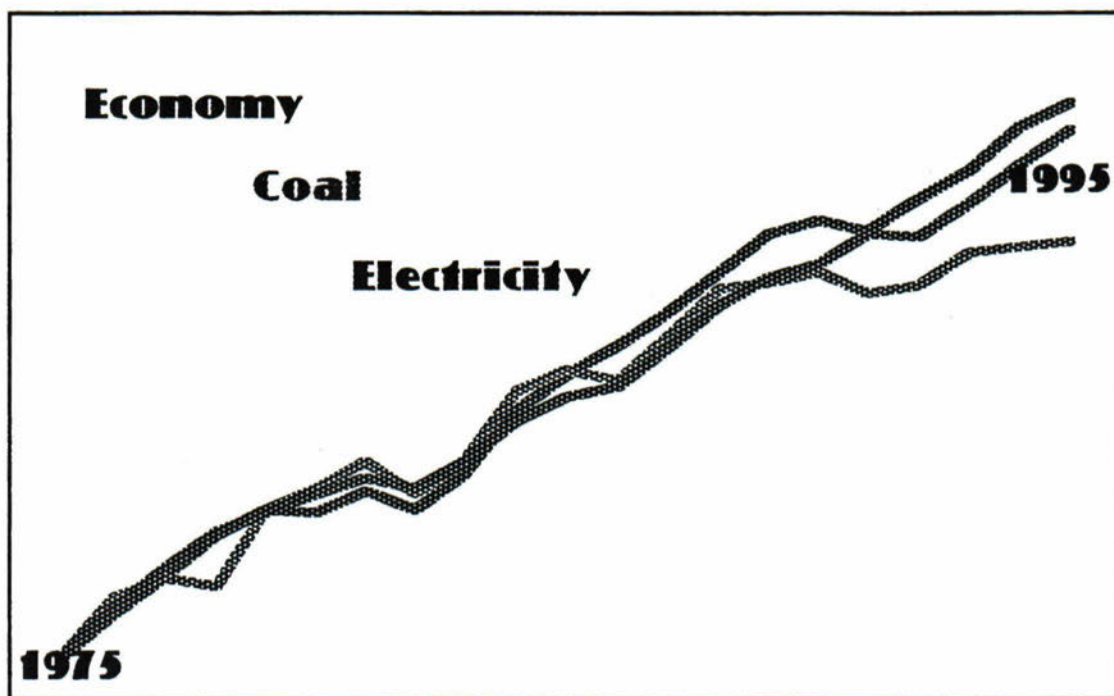
We reject this vision of apocalypse because, as you will hear from Dr. Robert C. Balling, Jr. and Dr. Patrick J. Michaels later in this seminar, scientific support for the vision of apocalypse does not exist. No science exists that justifies artificially limiting the United States' coal-fired electric 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

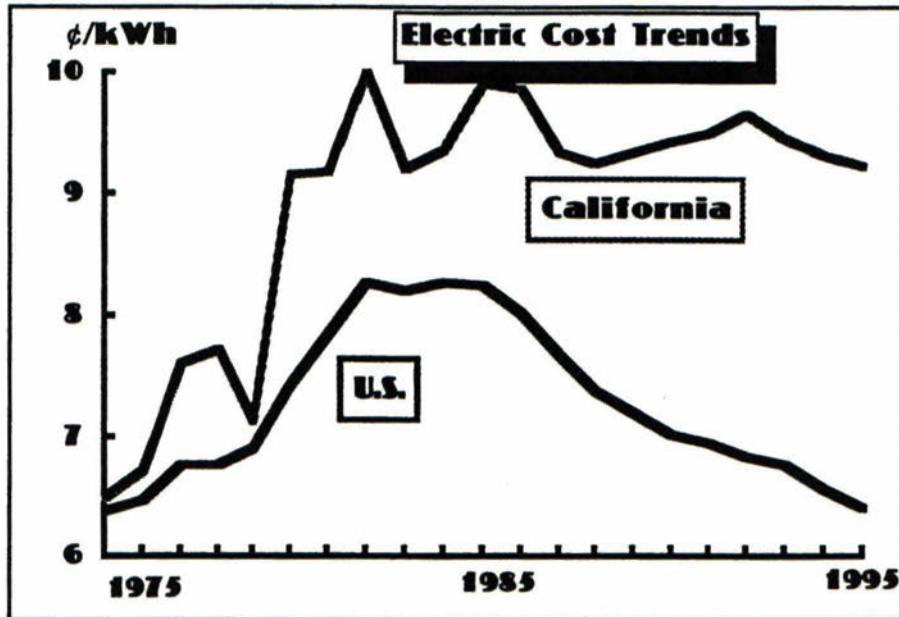
SUMMARIZED IN GRAPHICS



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

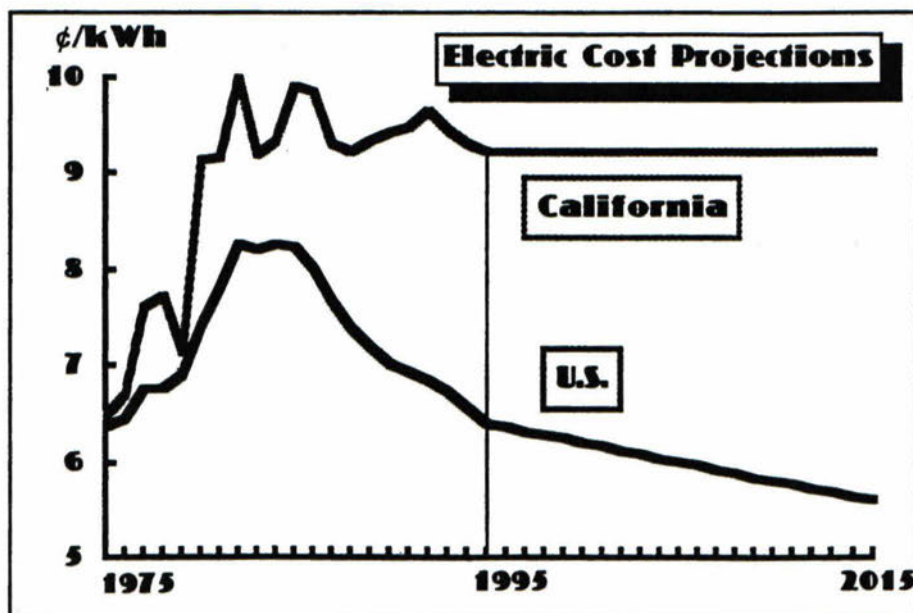
APRIL 1997

- 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.



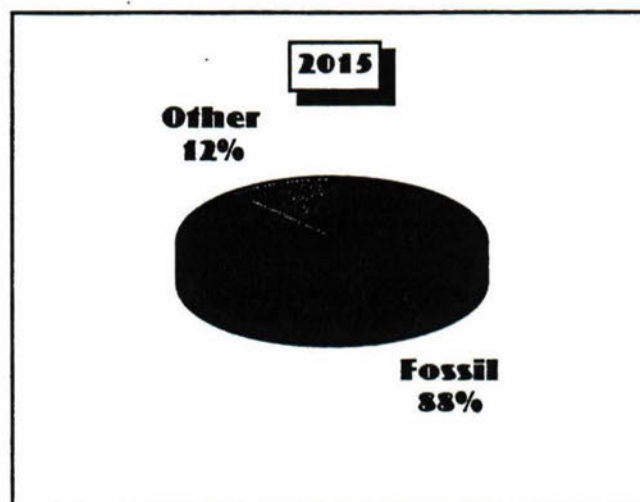
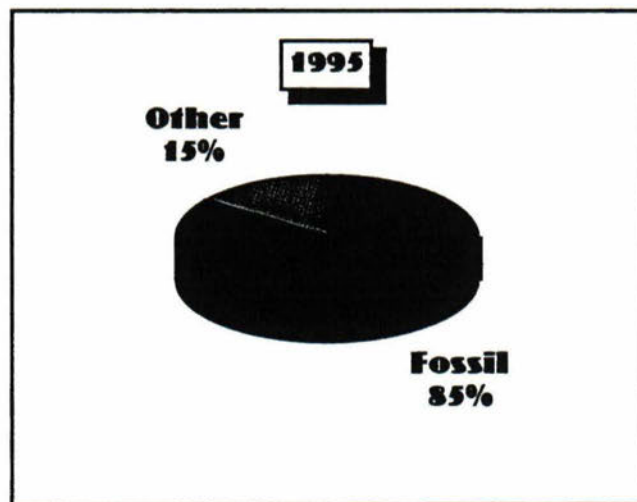
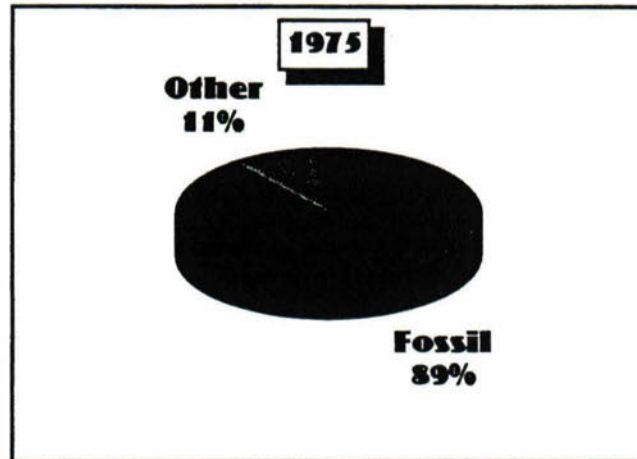
DATA FROM DOE/EIA, AND EEO
PRICES IN CONSTANT 1992\$

- 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?



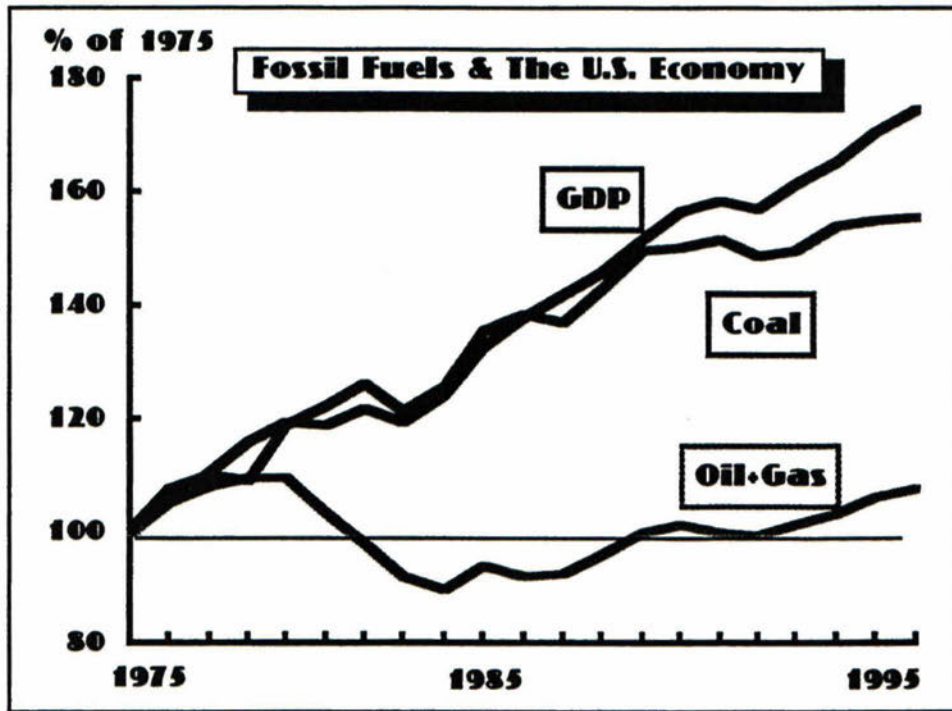
DATA FROM DOE/EIA, EEO: DOE 1997 ANNUAL ENERGY OUTLOOK.
PRICES IN CONSTANT 1992\$

- 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.



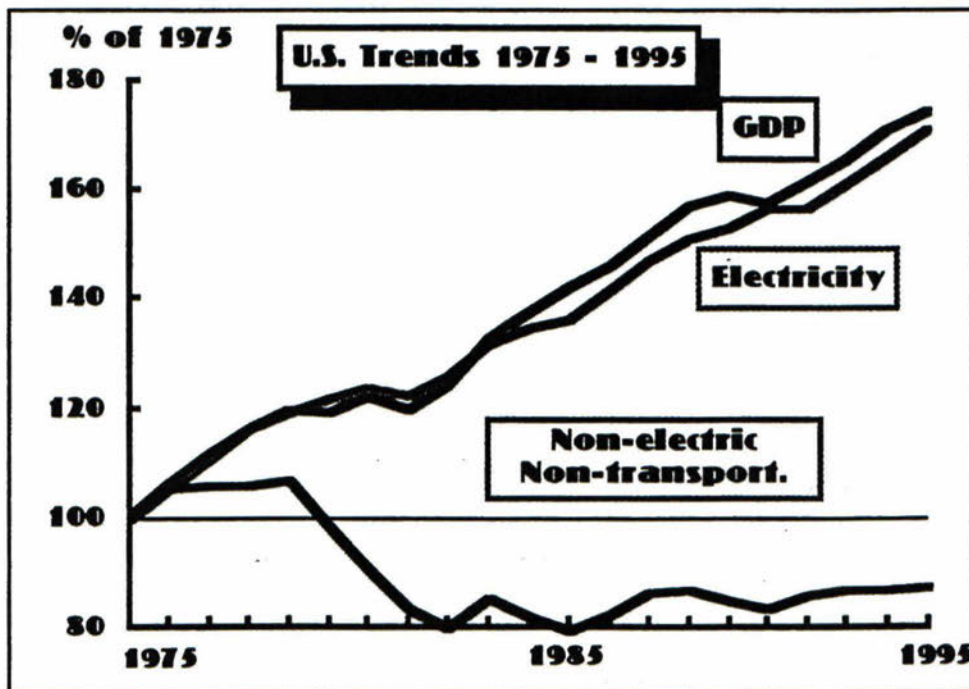
DATA FROM DOE/EIA, EEO: DOE 1997 ANNUAL ENERGY OUTLOOK.

- 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.



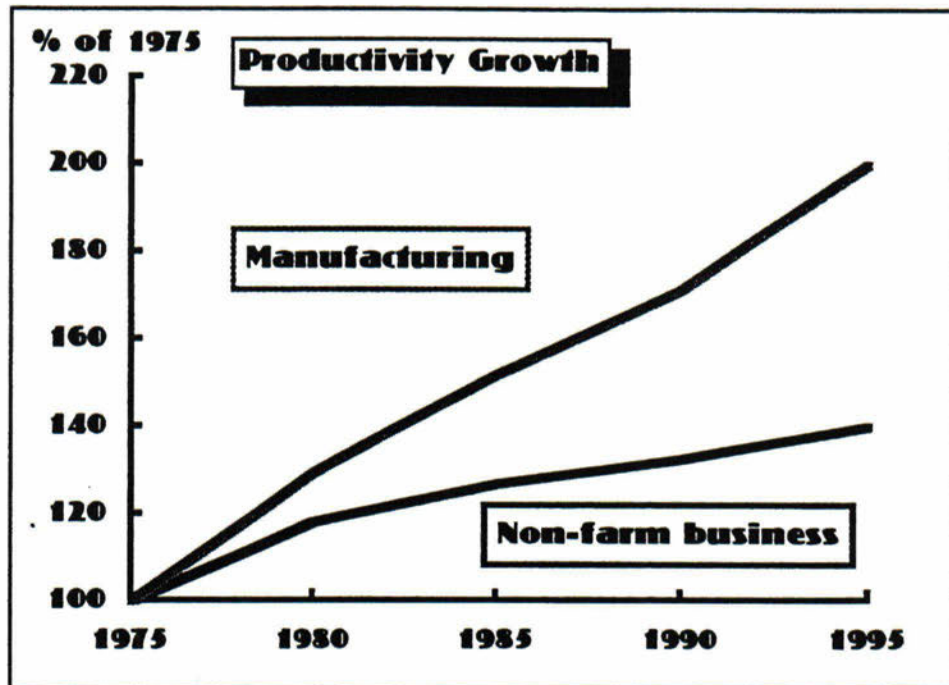
DATA FROM DOE/EIA

- 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.



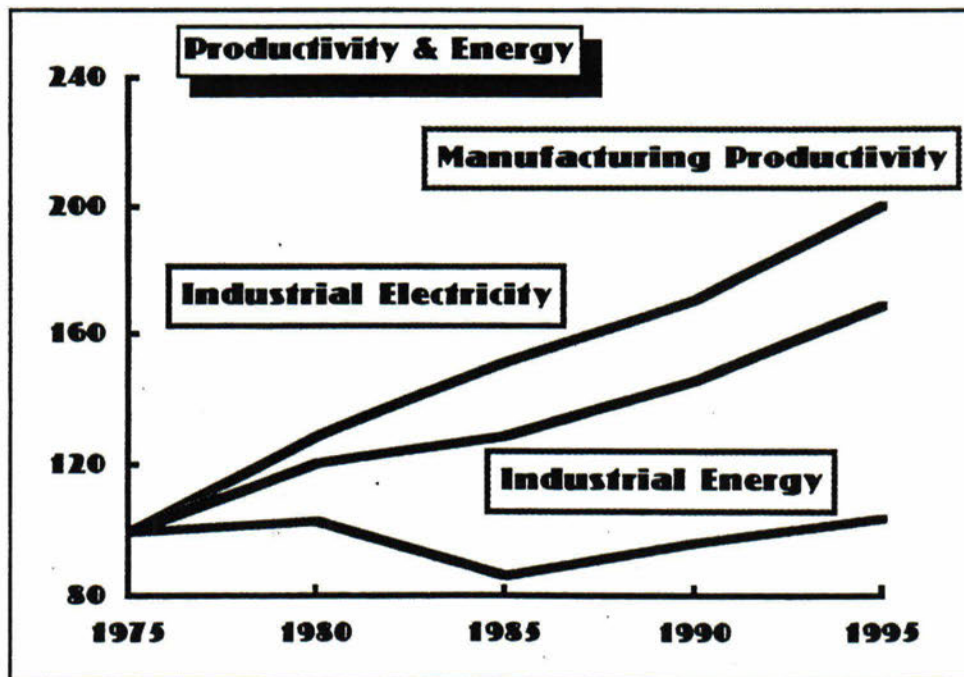
DATA FROM DOE/EIA

- 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.



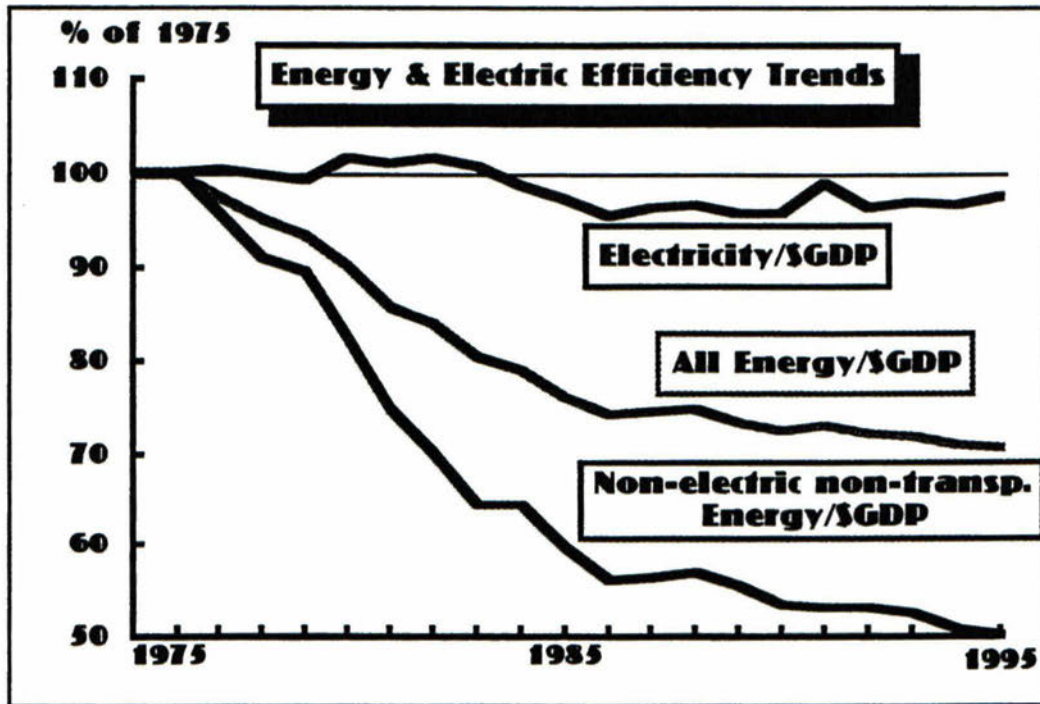
DATA FROM STATISTICAL ABSTRACT OF THE UNITED STATES

- 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.



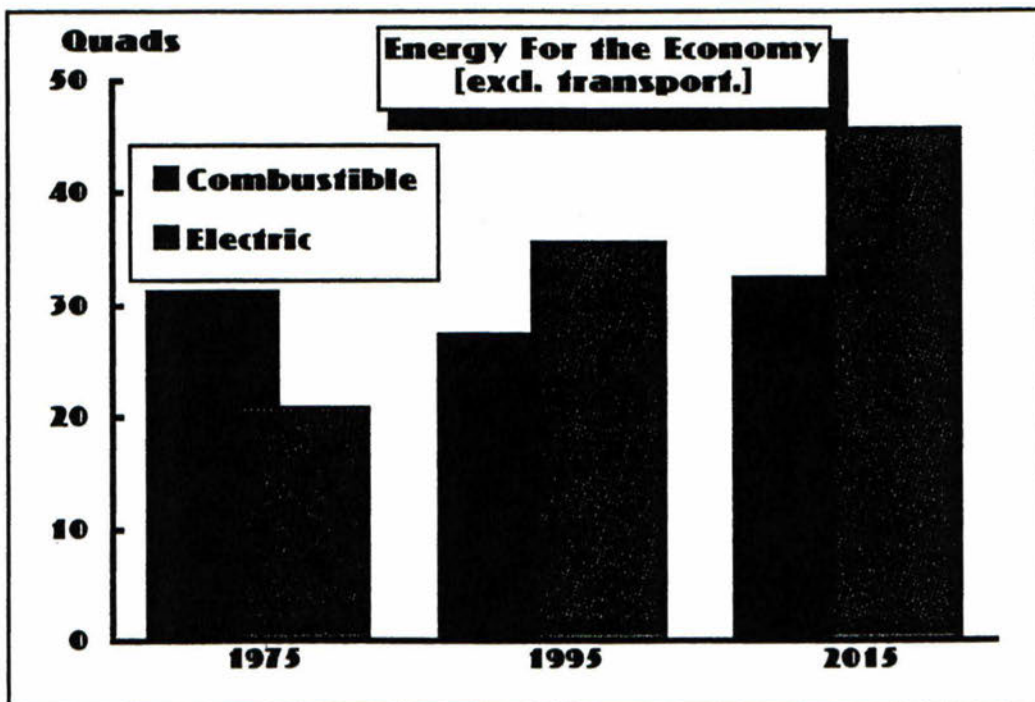
DATA FROM STATISTICAL ABSTRACT OF THE UNITED STATES & DOE/EIA

- 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.



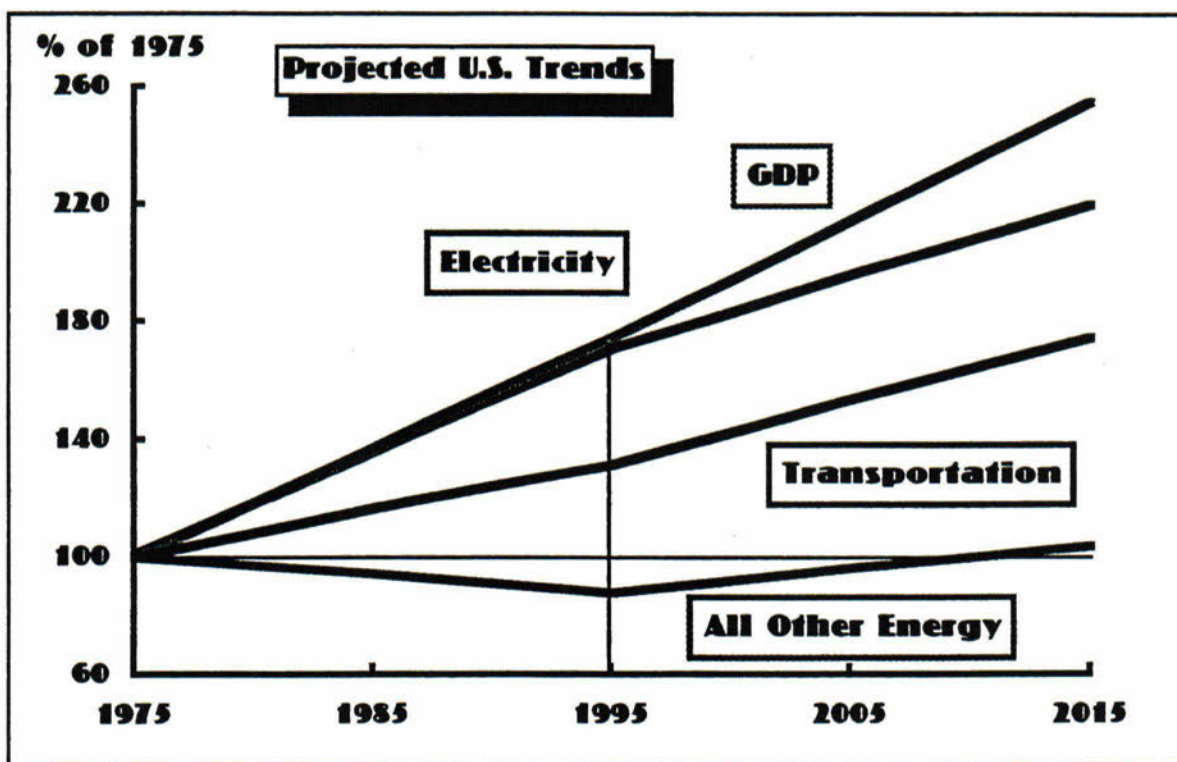
DATA FROM DOE/EIA
PRICES IN CONSTANT 1992\$

- 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.



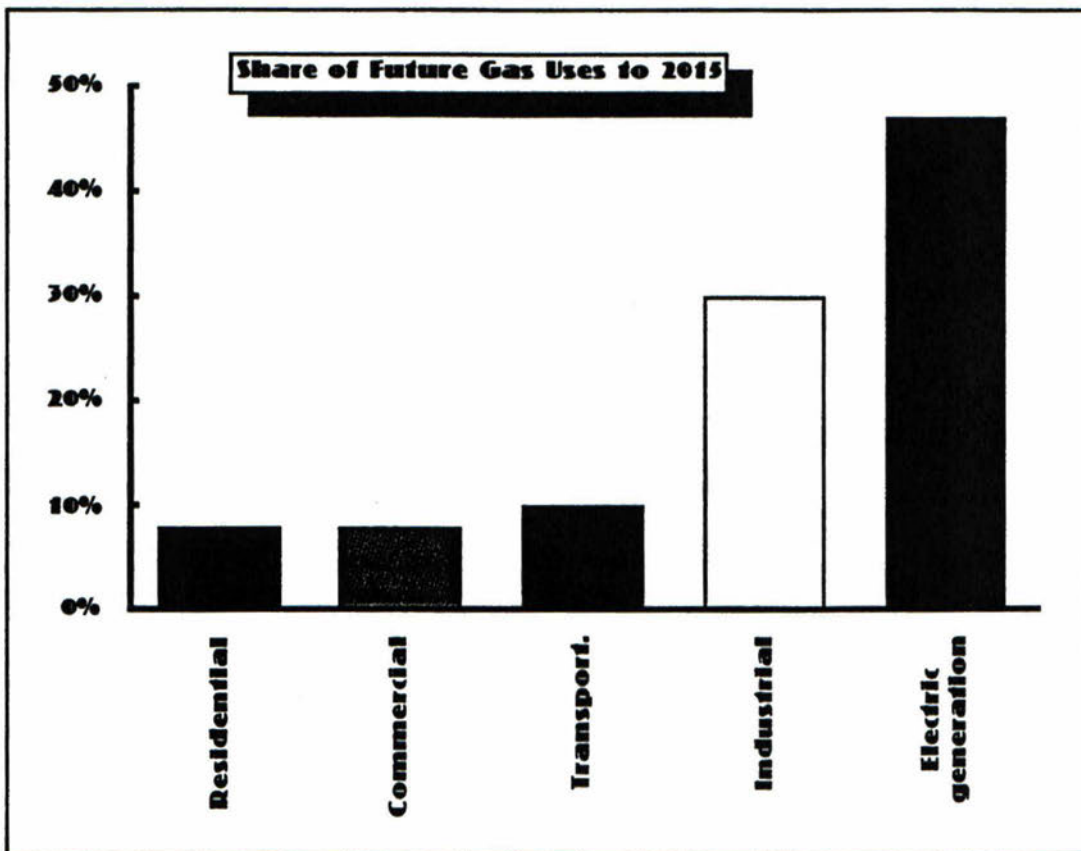
DATA FROM DOE/EIA
Page [6]

- 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.



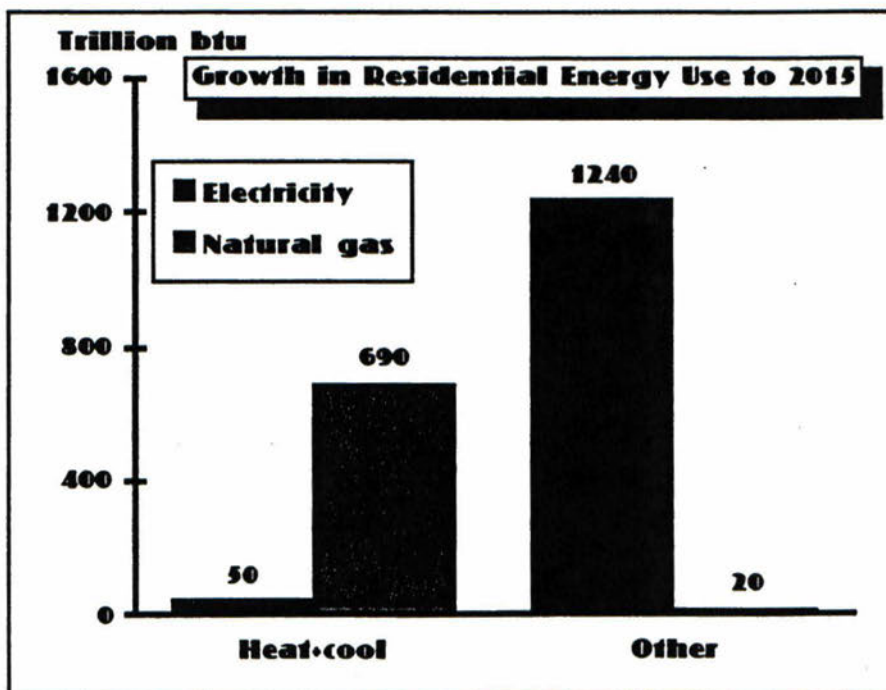
DATA FROM DOE/EIA 1997 ANNUAL ENERGY OUTLOOK TO 2015

- 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.



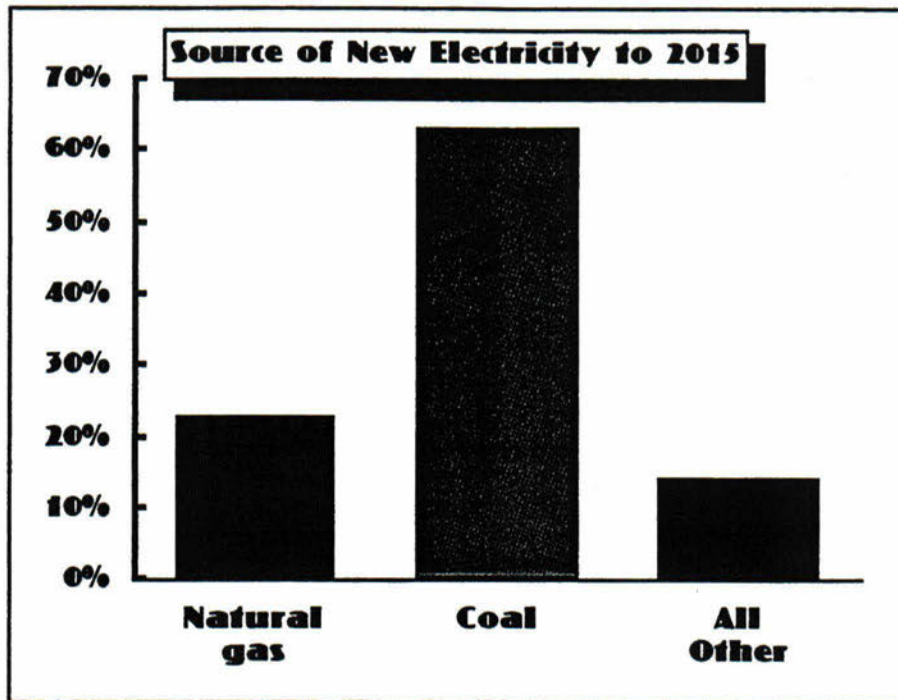
DATA FROM GRI BASELINE PROJECTIONS TO 2015

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



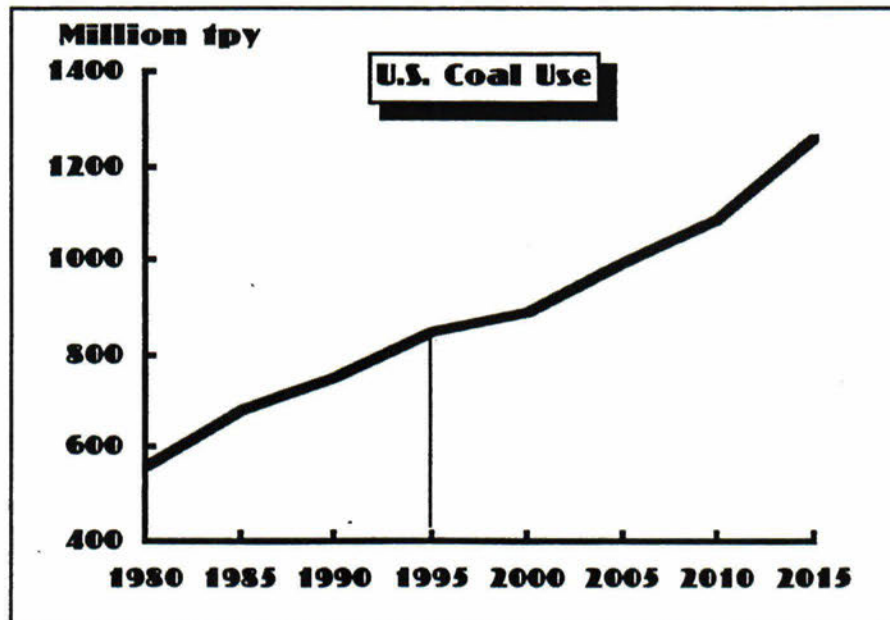
DATA FROM GRI BASELINE PROJECTIONS TO 2015

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



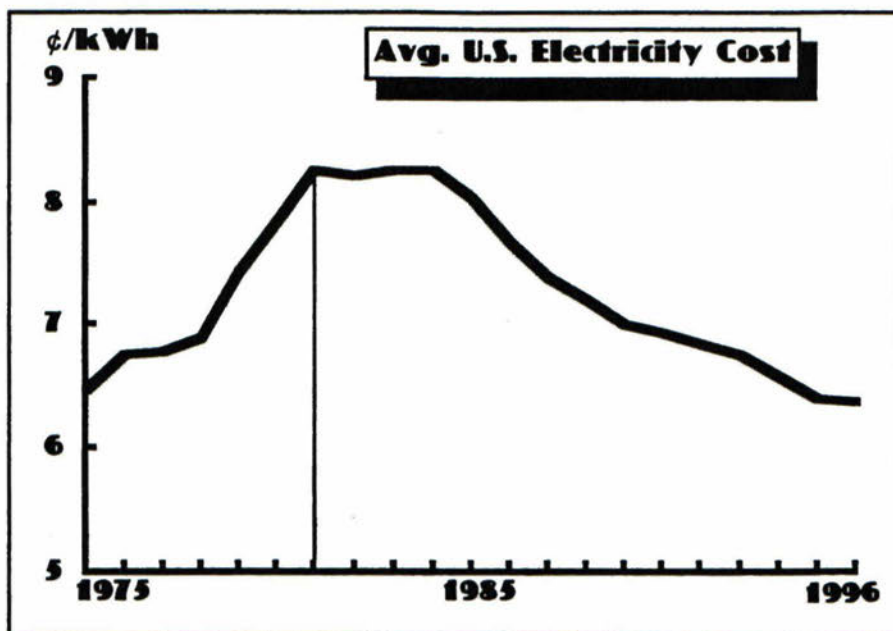
DATA FROM GRI BASELINE PROJECTIONS TO 2015

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



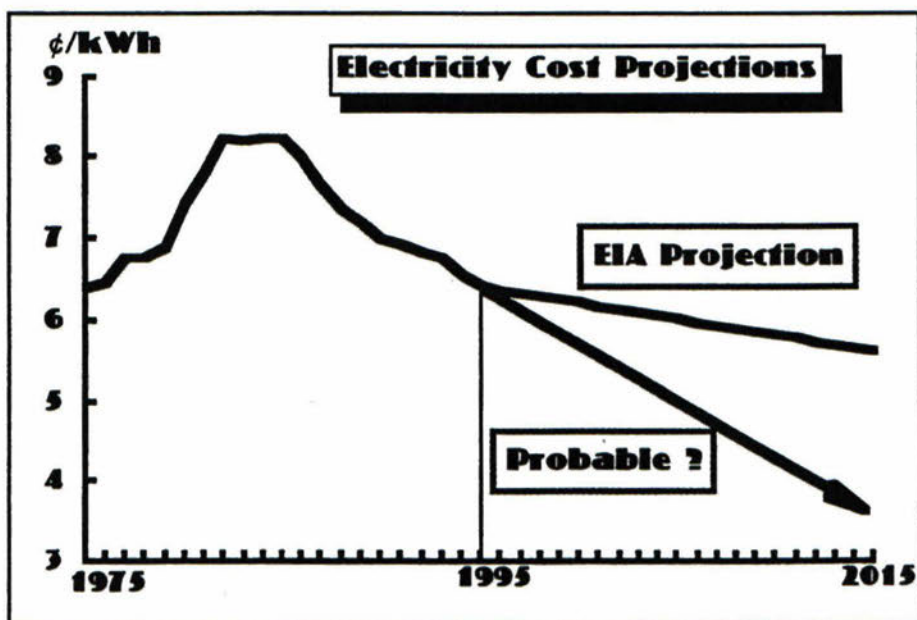
DATA FROM GRI BASELINE PROJECTIONS TO 2015 & U.S. DOE/EIA ANNUAL ENERGY OUTLOOK 1997

- 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.



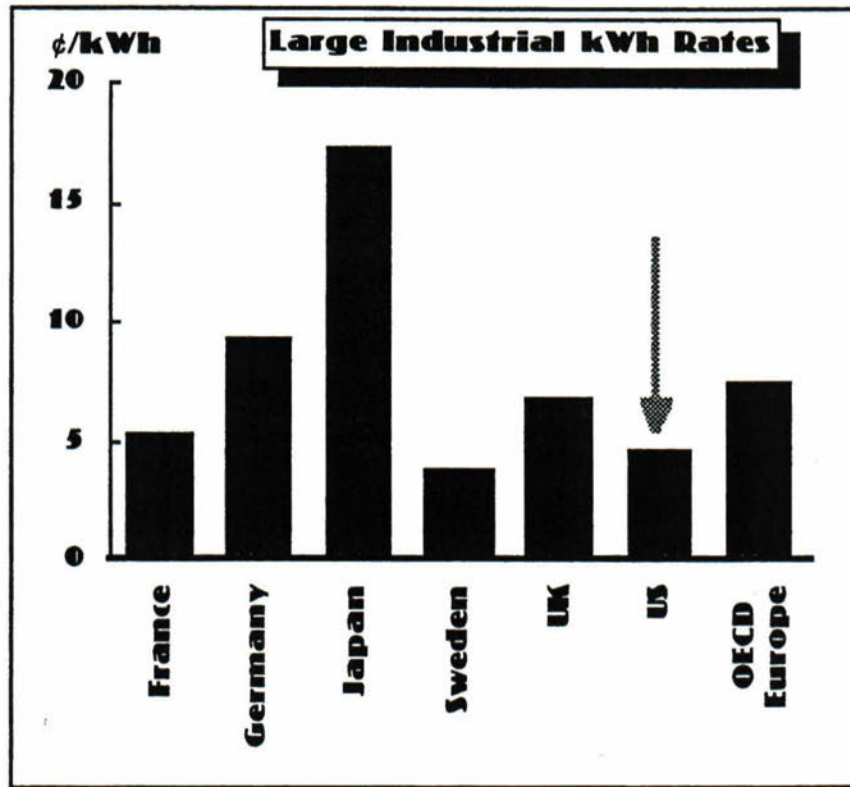
DATA FROM EEI STATISTICAL YEARBOOK
PRICES IN 1992\$

- 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.



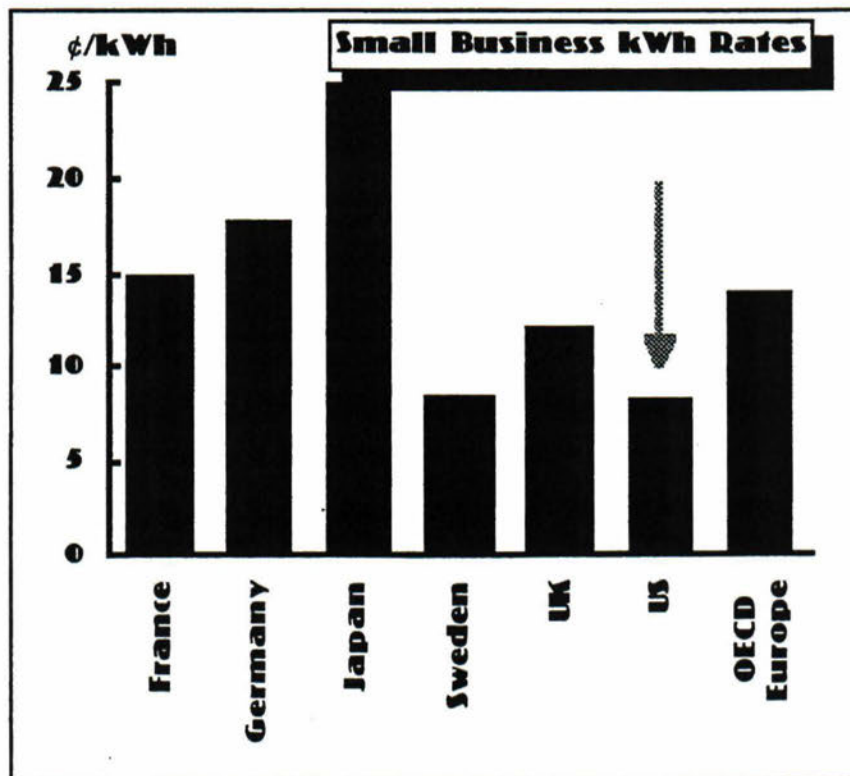
DATA FROM EEI STATISTICAL YEARBOOK & DOE/EIA ANNUAL ENERGY OUTLOOK 1997
COAL: CORNERSTONE OF AMERICA'S COMPETITIVE ADVANTAGE, MILLS•MC CARTHY & ASSOCIATES 1997
PRICES IN 1992\$

- 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.



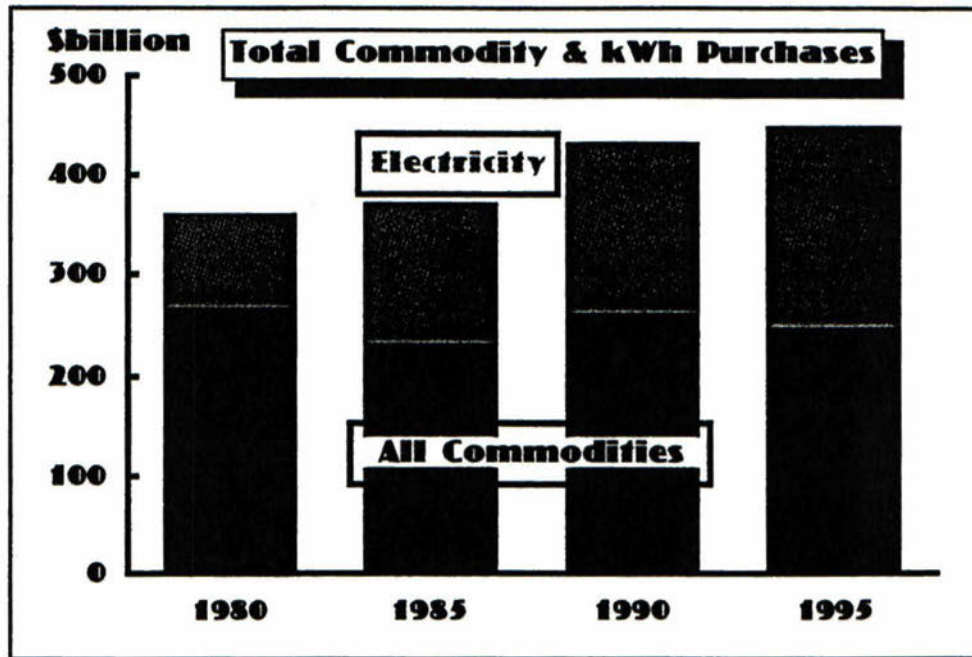
DATA FROM OECD IEA

- 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.



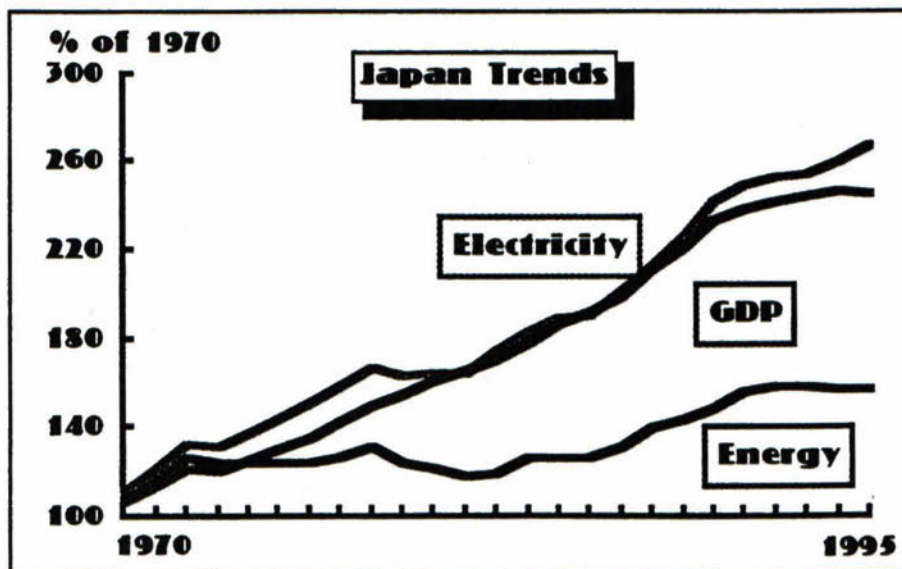
DATA FROM OECD IEA

- 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.)



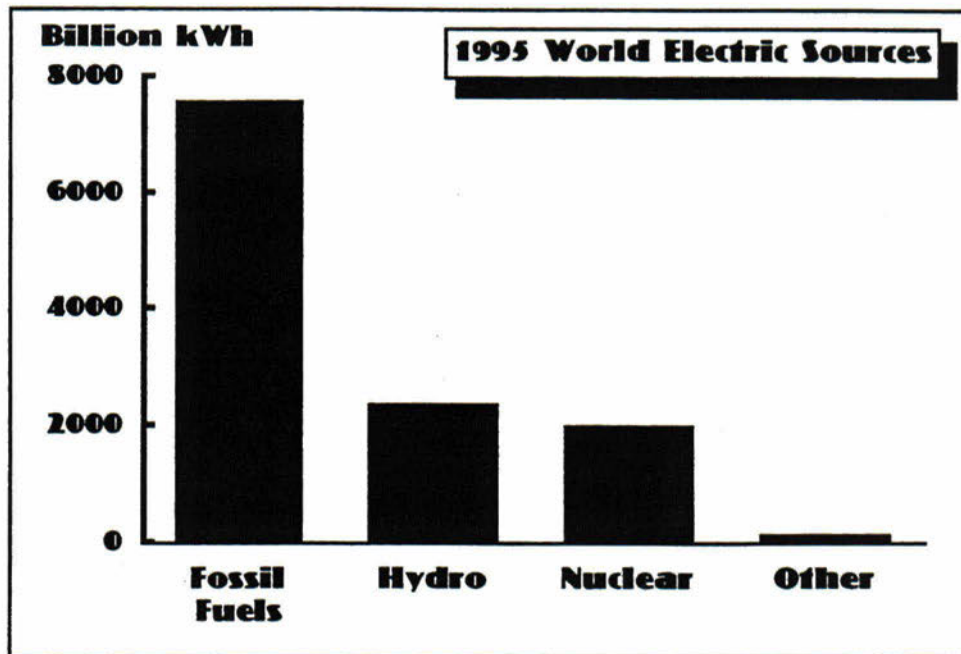
DATA FROM STATISTICAL ABSTRACT OF THE UNITED STATES

- 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.



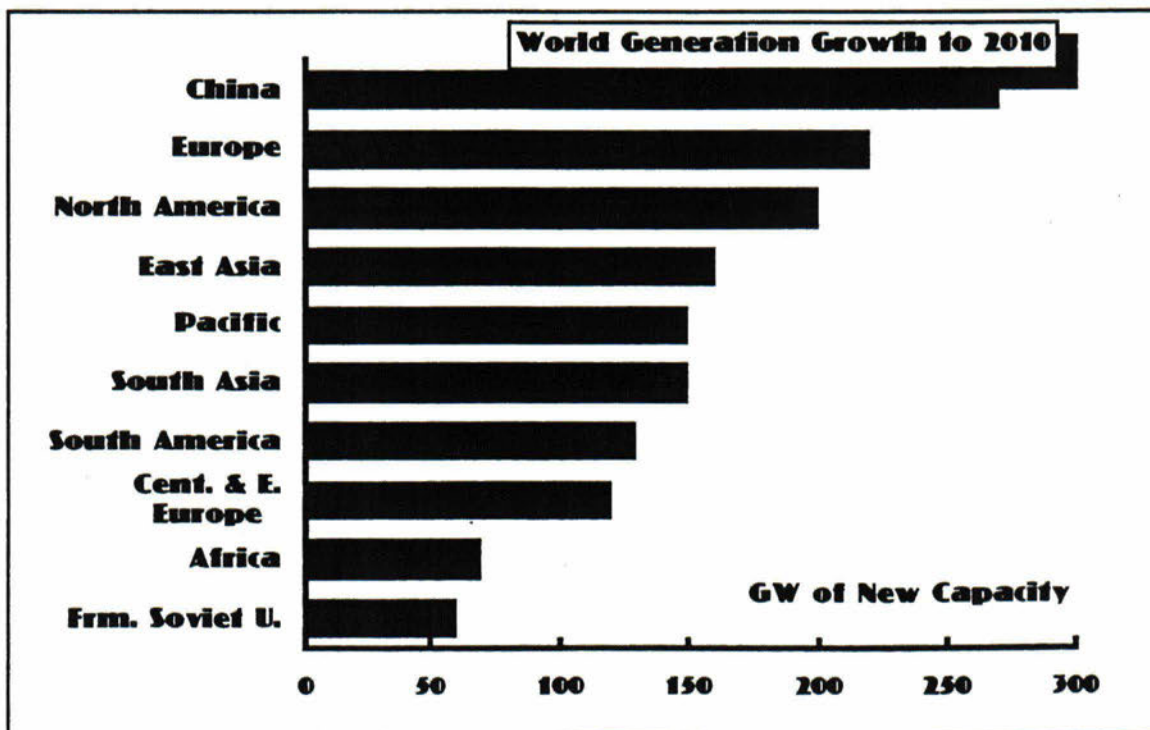
DATA FROM OECD/IEA

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



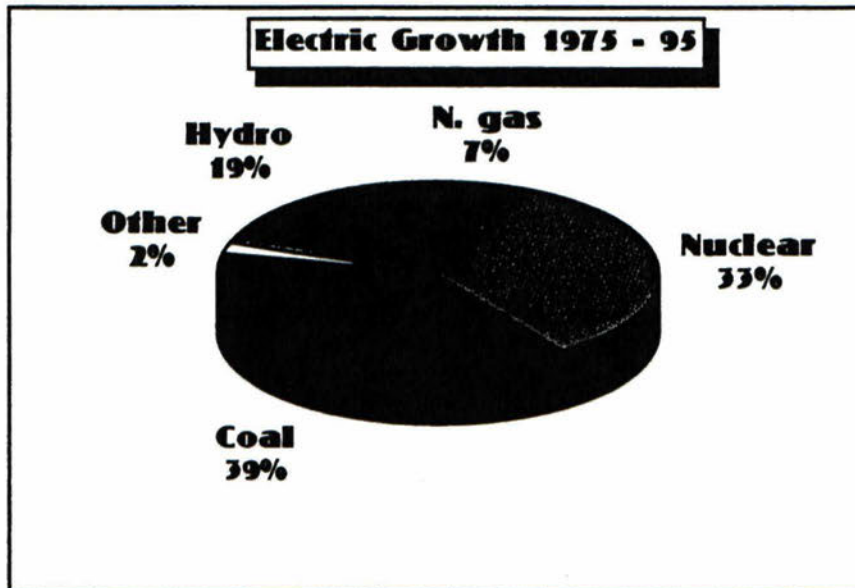
DATA FROM OECD/IEA, DOE ANNUAL ENERGY REVIEW

- 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.



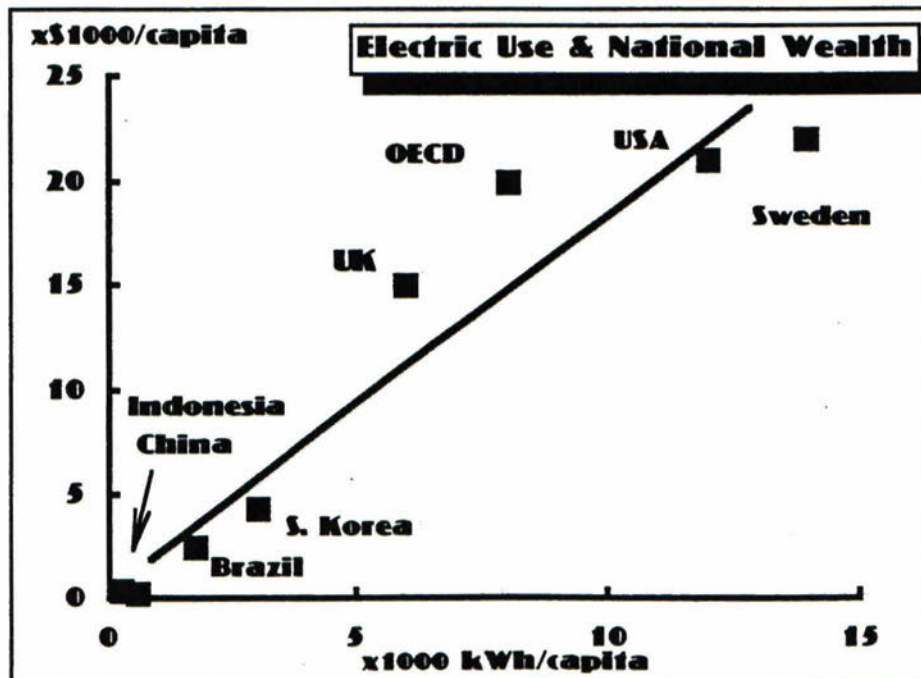
PROJECTION FROM SHELL OIL

- 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.



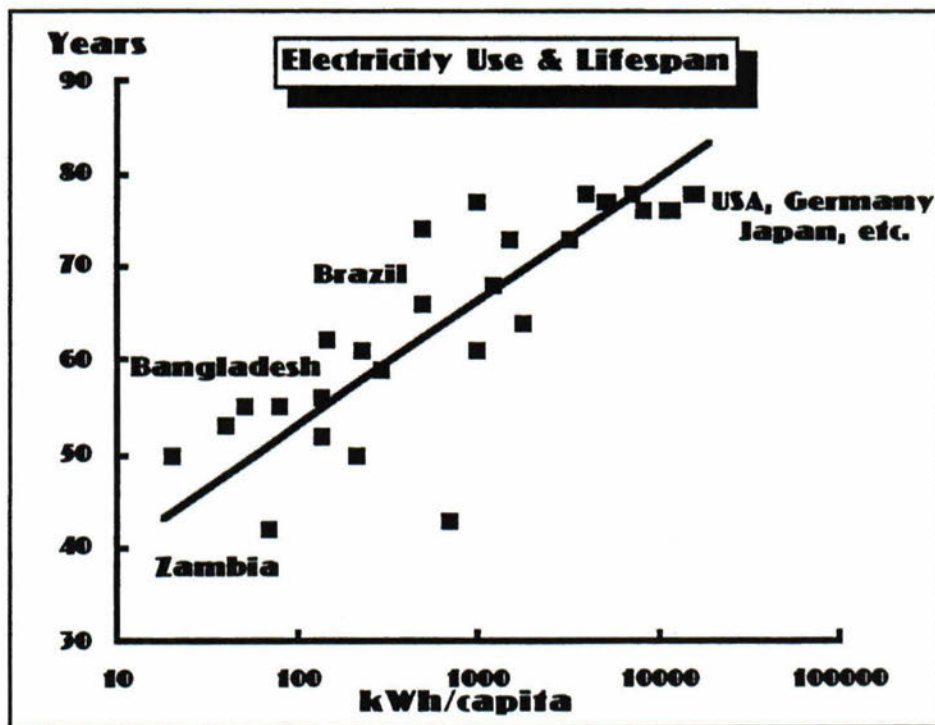
DATA FROM DOE ANNUAL ENERGY REVIEW, BP, OECD/EIA

- 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.



DATA FROM OECD/EIA, WORLD RESOURCES INSTITUTE

Climate

skeptics

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 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 salvos 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 slamdunk 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 hysteresis 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 Rosenzweig 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 hysteresis. 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.

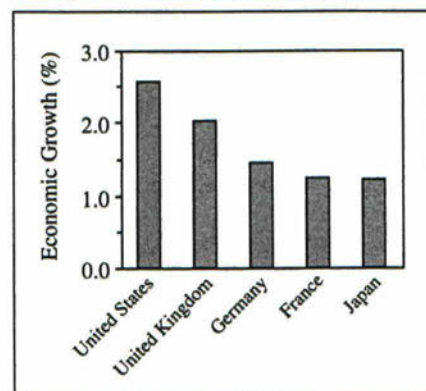
Spencer, R.W. and W.D. Braswell (1997). How Dry is the Tropical Free Tropical? Implications for Global Warming Theory. *Bulletin of the American Meteorological Society*, 78, 1097-1106.

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, nooooo....

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 a 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.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.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.

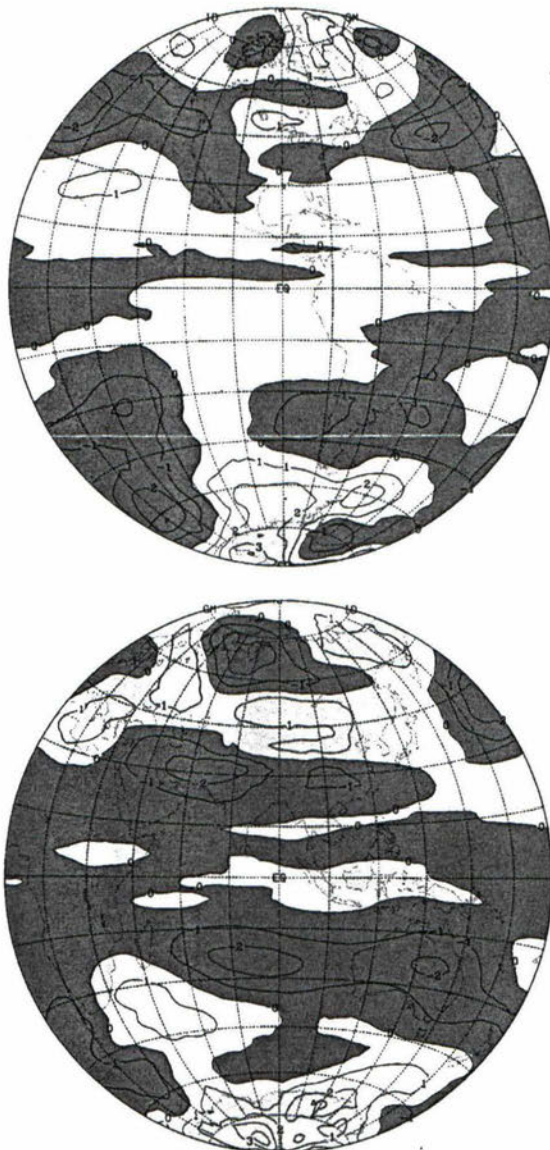
June 1997: A rather normal month. The global temperature departure of -0.07°C is just a few hundredths of

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.

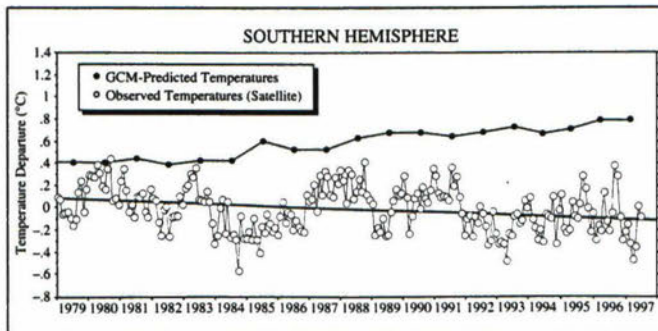
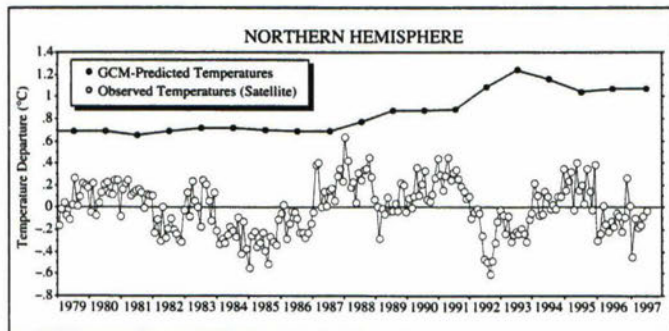
Not only were the hemisphere average temperatures very close to the long-term mean, but also the regional temperature anomalies typically did not stray too far to the extreme. In the Northern Hemisphere, the slightly warmer than normal central latitudes of Eurasia were sandwiched between regions of slightly 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 Climate Report

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 idea!

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.

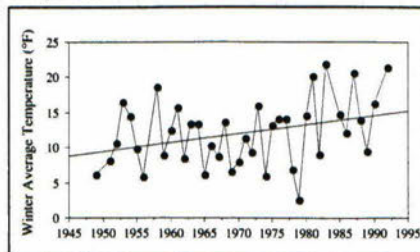


Figure 1. Winter average temperatures (°F) in Grand Forks, N.D., have been increasing since the late 1940s.

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.*

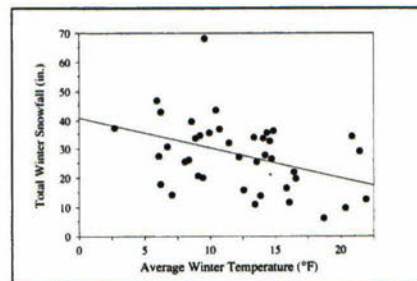


Figure 2. Relationship between snowfall and winter temperatures in Grand Forks, N.D.

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

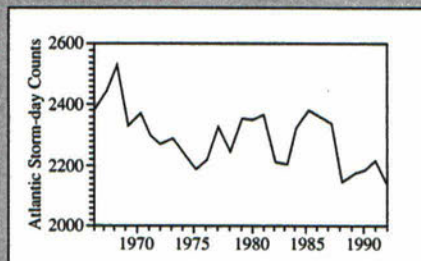
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Specifically, this allegation refers to a 1995 climate model published by J.M. Murphy and J.F.B. Mitchell, which says "The increased westerlies which coincide with an increase in the strength of the Atlantic storm track (emphasis added) are associated with an increase in the south-to-north temperature gradient [difference] between 30°N and 60°N."

Mark Serreze and three coauthors recently published an analysis of North Atlantic storms in the *Journal of Climate*. Our graph, adapted from their report, shows the significantly decreasing number of cyclones over the Atlantic between 30°N and 60°N.

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Serreze, M.C., et al., (1997) Icelandic Low Cyclone Activity: Climatological Features, Linkages with the NAO, and Relationships with Recent Changes in the Northern Hemisphere Circulation, *Journal of Climate*, 20, 453-464.



Despite models that indicate an "increase in the strength of the Atlantic storm track" from 30°N to 60°N, the frequency of storms there, is declining.

BIGGEST GREENHOUSE WHOPPER YET!

Now the same J.F.B. Mitchell and T.C. Johns have published a new paper that balances the greenhouse warming with cooling by sulfate aerosols and, as they say, a whole lot more!

The new *Journal of Climate* paper produces a global warming of 1.6°C by the year 2100. Looks bad. But wait! This is the

same model that produced only 2.5°C of warming for doubled carbon dioxide without the cooling from sulfates. When that was described in *Nature* two years ago, the authors wrote that their model predictions were "lower than most GCMs [climate models]." Even so, it predicted too much warming in the last three decades: "From 1970, the difference between [this model] and observations is significant in each decade" (Mitchell and Johns, 1995).

How on God's getting-greener (Myneni et al., 1997) Earth can dramatic warming be predicted by a model that doesn't warm up very much for doubling carbon dioxide? Simple. *Unrealistically jack up the carbon dioxide so the model warms!* So we find, in Table 1 of the new paper, that the effective concentration in the year 2050 is a whopping 859 parts per million (ppm).

This is so far outside the Consensus of Scientists it makes us look like U.N. High Commissioners. The most likely value, according to the new report of the Intergovernmental Panel on Climate Change (IPCC), is 534 ppm.

This makes the change from the technologically primitive "natural" background (275 ppm) effectively 259 ppm. Mitchell assumes the increase is 584 ppm. That's right. Mitchell more than tripled the natural CO₂ greenhouse effect by 2050. Fact is that we could switch all the electric production in the industrialized democracies to 100 percent coal and it wouldn't get that high!

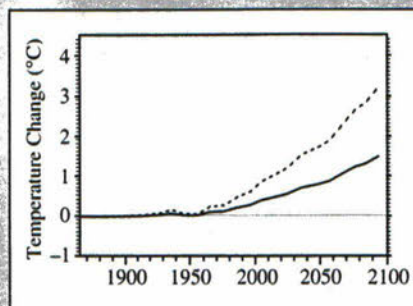
Climate models like this are surprisingly "linear" in their behavior, meaning that warming is proportional to the change in the greenhouse effect. Thus the real proportion is somewhere around 259 divided by 584, or 44 percent.

How much warming do you get if you make everything realistic instead of destroying reality to create a politically appropriate warming? Our graphic gives the answer: 0.7°C by the year 2050, and 1.6°C by 2100.

Except for one thing. Mitchell et al. (1995) claimed that their sulfate-greenhouse version correctly tracked the climate "after the 1930s and 40s." Let's be charitable and agree. It warmed 0.4°C in the ground-based record since then.* That leaves a grand total remaining of 1.2 degrees to

2100, and precious little to 2050.

When you tell the truth, the greenhouse party's over. Time to get a day job.



DOTTED LINE: Predicted global temperatures with the combined sulfate-greenhouse effect in the new Mitchell and Johns paper which uses a CO₂ concentration of 859 ppm 55 years from now. The concentration shoots up to 1414 ppm by the year 2100. Phew, that's hot!

SOLID LINE: Estimated global temperatures from the Mitchell and Johns model if we use the IPCC midrange effective CO₂ values of 534 ppm by the year 2050 and 842 ppm by 2100. Not much warming.

*Anyone want to wager that there is any climate model that said there would be no warming in the last decade in 1) the surface temperature record, 2) balloon-measured temperatures between 5,000 and 30,000 feet, and 3) the lower atmospheric layer as measured by satellite? Those are the facts.

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Mitchell J.F.B., et al., (1995) Climate Response to Increasing levels of greenhouse gases and sulphate aerosols. *Nature*, 376, 501-504.

Myneni, R.B., et al., (1997) Increased plant growth in the northern high latitudes from 1981 to 1991. *Nature*, 386, 698-702.

STATE OF THE CLIMATE REPORT

Our annual summary of events climatic is out and causing no end of trouble. The new report features an article by the esteemed Sylvan Wittwer, who, in more than 750 scientific publications, proved that carbon dioxide makes plants grow better. Also check out the essay by Roy Spencer, author of the most famous scientific paper on global temperature ever published. Call the number on our masthead for your copy.

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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.

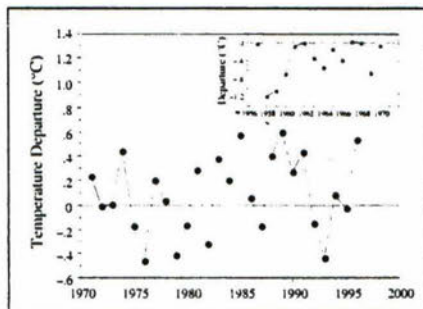


Figure 1. Antarctic temperature departures (°C) from the 1961 to 1990 mean, back to 1971 (from the IPCC record). Inset: Temperature departures from 1957 to 1970.

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

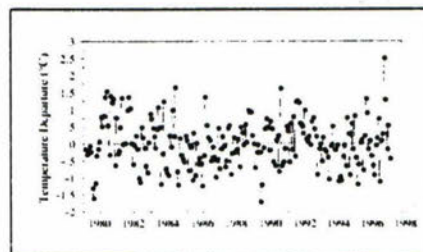


Figure 2. Satellite temperature departures (°C) also show no warming across Antarctica.

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

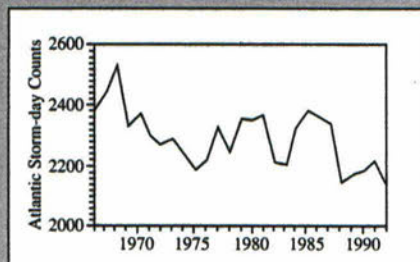
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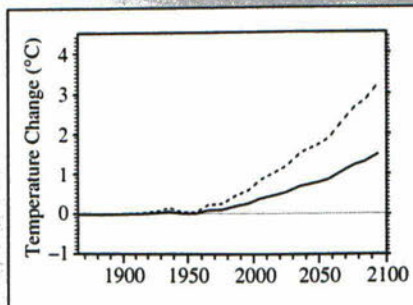
Climate models like this are surprisingly "linear" in their behavior, meaning that warming is proportional to the change in the greenhouse effect. Thus the real proportion is somewhere around 259 divided by 584, or 44 percent.

How much warming do you get if you make everything realistic instead of destroying reality to create a politically appropriate warming? Our graphic gives the answer: 0.7°C by the year 2050, and 1.6°C by 2100.

Except for one thing. Mitchell et al. (1995) claimed that their sulfate-greenhouse version correctly tracked the climate "after the 1930s and 40s." Let's be charitable and agree. It warmed 0.4°C in the ground-based record since then.* That leaves a grand total remaining of 1.2 degrees to

2100, and precious little to 2050.

When you tell the truth, the greenhouse party's over. Time to get a day job.



DOTTED LINE: Predicted global temperatures with the combined sulfate-greenhouse effect in the new Mitchell and Johns paper which uses a CO₂ concentration of 859 ppm 55 years from now. The concentration shoots up to 1414 ppm by the year 2100. Phew, that's hot!

SOLID LINE: Estimated global temperatures from the Mitchell and Johns model if we use the IPCC midrange effective CO₂ values of 534 ppm by the year 2050 and 842 ppm by 2100. Not much warming.

*Anyone want to wager that there is any climate model that said there would be no warming in the last decade in 1) the surface temperature record, 2) balloon-measured temperatures between 5,000 and 30,000 feet, and 3) the lower atmospheric layer as measured by satellite? Those are the facts.

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STATE OF THE CLIMATE REPORT

Our annual summary of events climatic is out and causing no end of trouble. The new report features an article by the esteemed Sylvan Wittwer, who, in more than 750 scientific publications, proved that carbon dioxide makes plants grow better. Also check out the essay by Roy Spencer, author of the most famous scientific paper on global temperature ever published. Call the number on our masthead for your copy.

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Skeptics



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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.

skeptics

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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.

X | 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.

X | 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. X

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. X

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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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.

It turns out these "skeptics" were right, and Mr. Gore can't ignore it.

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.

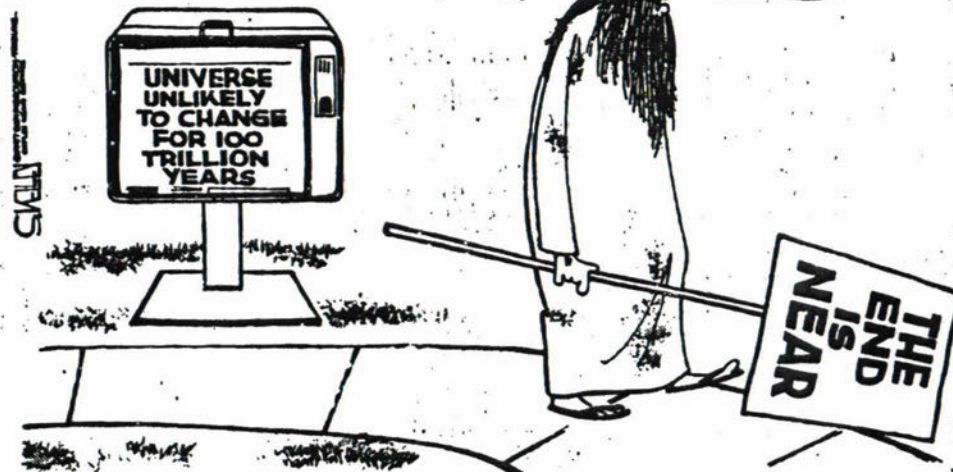
Need proof? The press was all over an article, in the very same

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 airmass 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 extremism: let's set the record straight. Studies 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.

Patrick J. Michaels is professor of environmental sciences at the University of Virginia and a member of the Science and Environmental Policy Project.

WORLD Climate Report

Volume 2, No. 9
January 20, 1997

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 as 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.

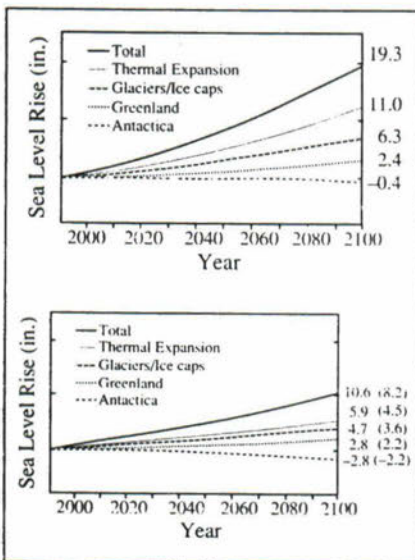


SEA CHANGE

Two months ago we noted a study by Marilyn Hughes and David Robinson that found increasing snowcover over the U.S. Great Plains, which is counter to the general perception that it has been declining because of global warming. Now comes a modeling study of the world's two great ice caps that says there will be a reduced rise in sea level because there isn't going to be much of a net melting of them after all.

This new study, by Atsumu Ohmura and two coauthors, projected that, under conditions of doubled atmospheric carbon dioxide that melting of Greenland would cause a sea level rise of 4.33 inches over a hundred years. But, at the same time, global warming makes the Antarctic Ice Cap grow, reducing sea level by 3.54 inches. The net difference, an increase of about 0.79 inches, is not likely to be noticed by even the most environmentally sensitive.

Sea level still does rise, though. About



Two scenarios used by the U.N. IPCC for sea level rise to the year 2100. The work of Ohmura et al. suggests that Greenland and Antarctica will cancel each other out, as in the bottom chart. In parentheses we have estimated these values with a net climate sensitivity of 1.7°C to CO₂ doubling (which includes sulfate aerosols).

half of the projected increases occurs simply because water expands as it warms. Glaciers and ice fields outside of Antarctica also melt; but the resulting amount of sea level rise from this effect is rather slippery. Ohmura et al. state that the total amount of water contained in these other ice sources is between 5.9 and 10.6 inches. But the 1995 report of the U.N. Intergovernmental Panel on Climate Change (IPCC) gives a sea level rise from melting this ice of 6.3 inches by 2100 (and continuing to rise rapidly). This is more than the lower estimate of the total amount of water that exists in these ice sources. Another IPCC scenario raises the sea level 4.7 inches from the melting of this ice.

Here we show two charts from the new IPCC report that illustrate these scenarios. The one with the larger sea level rise assumes more warming (a sensitivity to doubled carbon dioxide of 2.5°C) than the one with the lower rise (2.2°C). The lower rise also results by assuming, as Ohmura found, that Greenland's melting is compensated for by growth in Antarctica.

As noted in this *Report*, the climate model that best fits the observed climate, according to Mitchell et al., has an actual sensitivity of 1.7°C, due to the combined effects of sulfates and greenhouse gases. We have plugged into the lower IPCC scenario a linearized estimate of what sea level rise would become if this more plausible value is used. The net rise from now to the year 2100 becomes 8.2 inches. Let's hold a "town meeting" to stop this!

How much has all of this changed in six years? In the first (1990) report of the IPCC, which assumed modest emission reductions—essentially the same assumptions used in our graphs—the forecast was for 19 inches by 2100. Carbon tax does not compute: 8.2/19 = 43%.

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IMPERTINENT QUESTION DEPT.

If global warming will cause Antarctica to hold more ice, how come everyone got so upset when a big ("Rhode Island-Sized," said the press) piece broke off a few years ago?

SINGER'S UNFRIENDLY SKIES: BEYOND SULFATES

At the recent meeting of the American Geophysical Union in which sulfates bit the dust (see last issue), S. Fred Singer of George Mason University made a convincing argument that airplanes are changing the climate.

As *Report* acolytes know, temperatures measured by satellites are slightly cooling just about everywhere except in the mid latitude band of the Northern Hemisphere, roughly 35°N to 50°N, (*WCR*, Vol. 1, No. 12). That certainly begs for an explanation, and Singer thinks it's related to cirrus clouds (high-level cirrus, as opposed to low-level clouds, produce a slight net warming) caused by jet contrails, mainly from exponentially growing commercial traffic. Singer noted a positive relationship between rising temperatures in the mid latitude region and increasing nitrogen oxides in the mid- and high atmosphere, which is a good proximator of traffic density.

He closed with a "good news/bad news" story. The good news, he said, is that the U.N. was right! There is a "discernable human influence on the climate." The bad news (for the Vice-President, Singer joked) is that it's not from the greenhouse effect. Therefore the sensitivity of the surface temperature to carbon dioxide increases must be less than the Consensus of Scientists once thought it to be.

★ ★ ★ ★ ★

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S. FRED SINGERSUNDAY, MARCH 23, 1997 **The Washington Times**

Satellite weather data under siege

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.

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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.

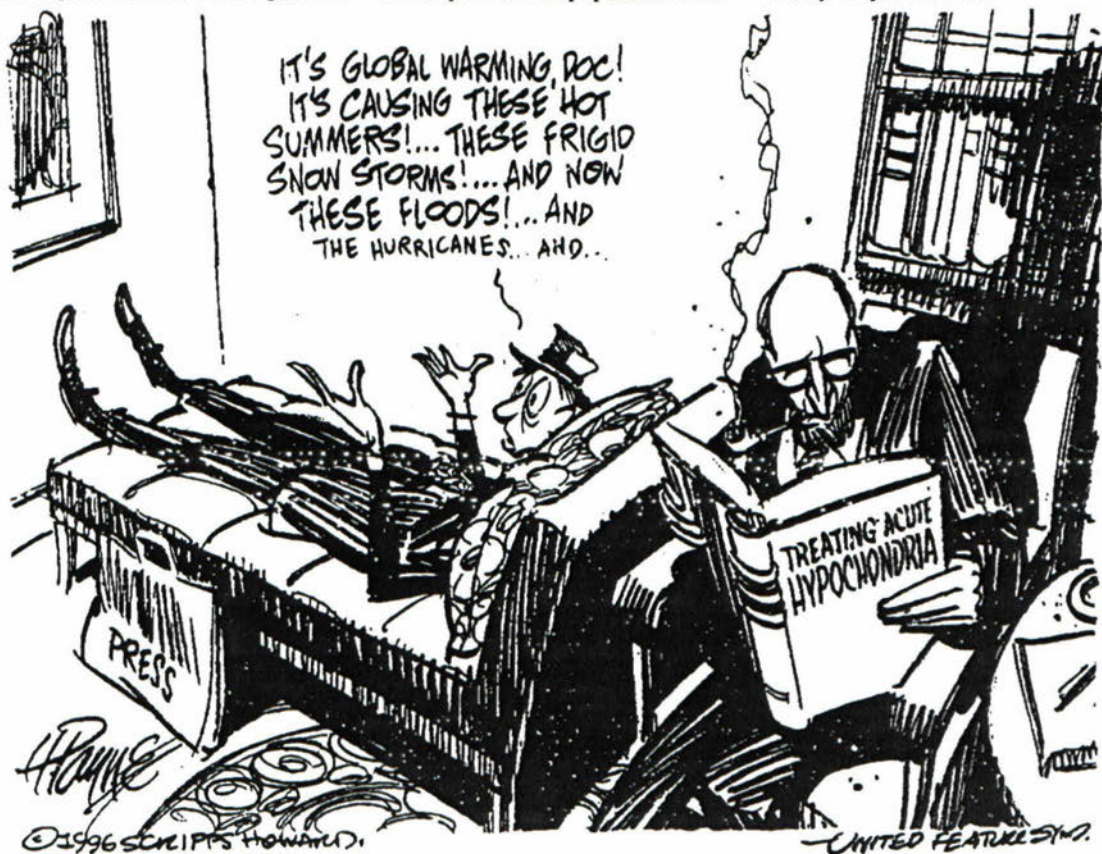
The most recent attack, published in the March 13 issue of the international journal *Nature*, accuses the satellite experimenters of technical errors in constructing the record that shows a cooling trend. The satellite experimenters will shortly reply with technical arguments that will be equally incomprehensible 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-



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.

Skeptics

THE GREENING OF PLANET EARTH

ITS PROGRESSION FROM HYPOTHESIS TO THEORY

A Report Prepared by

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for

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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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DRAFT

Notes and Comments from a Congressional Briefing Held on June 13th, 1997, Entitled "Truths, Myths and Impacts of Global Warming" by Tony Socci

On Friday, June 13th I attended a Hill briefing sponsored by the National Center for Policy Analysis, on "Truth, Myths and Impacts of Global Warming". Needless to say the speakers represented a collection of climate science skeptics and skeptics of the economics of climate mitigation.

My overall impression was that the assembled group of people never got around to identifying any so-called myths although they created a few of their own as they went along, in addition to having created a few straw dogs which they then proceeded to knock over. The economic tales of woe were also extremely one-dimensional in that all that was taken into consideration were some aspects of the cost of climate mitigation, mostly in the form of carbon taxes.

The moderator for the event was Sterling Burnett of the National Center for Policy Analysis

The opening statement was made by Dennis Fitzgibbons, Deputy Director, Minority Staff House Commerce Committee.

Two scientists/meteorologists spoke on "The Truths of the Science", Norman Macdonald, Consulting Meteorologist who spoke on "The Observational Evidence of Global Warming", and Robert Balling, Jr., AZ State University, who spoke on "Greenhouse Warming: The Other Consensus."

"The Impacts on the Economy" were addressed by Eugene Trisko, Attorney for the United Mine Workers of America (The Impact on Jobs), Fran Smith, President, National Consumer Coalition (The Consumer Losses), and Karen Kerrigan, President, Small Business Survival Committee (The Economic Hardship on Business).

And finally, "The Myths of the Global Warming Treaty" were addressed by Jonathan Adler, Competitive Enterprise Institute (Why the Treaty Isn't Green).

Comments:

Dennis Fitzgibbons stated that opinions of congressional members on the issue of global warming were largely unformed yet and that it was difficult to get a handle on the issue of global warming because there was nothing of substance to grab onto. He also conveyed that Congressional members did not want any impending climate treaty to adversely affect America's competitiveness, nor were they receptive to developing countries having no

binding obligations under a climate treaty.

Norm Macdonald, apparently a former local Washington, DC meteorologist for one of the major news networks, commented that there was no observational meteorological evidence for global warming, although he did not seem to dispute that the Earth's surface temperature had risen by about 1 degree C over the past century or so. He did however, offer that there were many possible reasons for this 1 degree C temperature rise, no one of which necessitated calling upon a greenhouse effect. He pointed out to the audience that the Earth has always undergone a series of natural climate changes, ranging from ice ages to times when the climate was much warmer, implying that we might, in fact, be witnessing nothing more than natural climate variability. He also felt that changes in sun spots and sunspot activity could account for the temperature change to date, and that the sun had surely influenced climate changes in the past. Norm's final point was that climate models were ill equipped to deal with climate change since they could not handle chaotic behavior.

[MY RESPONSE]

1) I seriously doubt whether Norm Macdonald has spent any time looking for any historic meteorological or climatological observational records or data for the U.S. or anywhere else. Nor am I convinced that Norm Macdonald is at all familiar with the climatological and/or meteorological research or the journals in which this research is housed. Had he done some homework he might have come upon a paper or two by Tom Karl (NOAA Climate Prediction Center). Tom's keystone paper on the observational record of climate change in the U.S., region by region, would have made it clear to Norm Macdonald that sweeping changes in temperature, precipitation, frequency and duration of precipitation events, and frequency of extreme precipitation events, in any number of regions of the U.S., had already occurred, regionally and nationally, within the last hundred years. Macdonald would have discovered that in general, parts of the western U.S. had warmed by 1-4 degrees C over the last 100 years, that precipitation within the southeastern U.S. had risen by 30%, that the Plains region had witnessed considerable drying, and that all of these observations and trends were consistent with the theory of greenhouse warming and with climate model projections of climate warming due to an enhanced greenhouse effect.

2. As Jerry Mahlman has often been quick to point out, if you agree that variations in solar output and sunspots can and do provoke significant climate changes, yet represent a climate forcing of roughly 0.3-0.5 watts/square meter, how could one then by contrast, trivialize climate changes due to the buildup of greenhouse gases, which presently represent a climate forcing of 2.5 watts per square meter? In light of this stark contrast in climate forcing, why would one then go out of one's way to ascribe the observed climate change (warming of roughly 1 degree C over the past century or more) to solar radiation, as opposed to a vastly more powerful climate driver, the present and escalating concentration of greenhouse gases? How can a small climate forcing such as solar variability be invoked for so large a climate change, while a vastly larger climate forcing, greenhouse gases, have such a negligible effect? It's like saying that one should be more concerned about getting into an automobile accident with a Volkswagen Beetle than with a Mack truck.

3. As to the matter of climate models not integrating chaotic behavior into their models, Macdonald is in error. Climate models (general circulation models) do include chaotic behavior.

Robert Balling basically assailed the credibility and reliability of climate models and climate model projections. Balling talked of the "conspiracy" to tell us that the world was warming, contesting the fact that the Earth's temperature had risen by 1 degree C over the past century or more, by calling attention to the Satellite temperature records which he claimed showed a cooling trend over the life of these records (Satellite records go back to 1979). He stated, for example, that Phoenix, AZ was not witnessing any warming, and that most of the warming that people were referring to was an urban heating effect, not global warming due to a greenhouse effect. He stated that thermometers over the last 10 years showed no warming. Balling also stated that there was a need to pursue other reasons or causes of climate warming other than greenhouse gases. He also made mention of the fact that in the 1970s many scientists were expressing concerns over global cooling, implying that scientists had historically flip-flopped all over this issue of global warming and why then, should they be taken seriously now.

Balling made no reference whatsoever to the surface temperature records of climate change. Balling argued that the models were unreliable largely because they could not deal with clouds, and if they could not get clouds right they could not get precipitation right (water balance) etc.... Ergo, if they could not get those these things right, they could not make any reliable projections. Models also did not do a good job on winds.

Balling also cited the recent evidence that the growing season is now lasting longer, stating that this was, in fact, good. On the issue of hurricanes and storms Balling criticized the "apocalyptic" predictions that hurricanes and storms would increase in number and intensity, stating that there was no evidence of an increase in extreme events such as hurricanes and that hurricanes had, in fact, become less intense. Balling also called upon the influence of dust in cooling climate and offsetting any anthropogenic warming influence.

[MY RESPONSE]

1. On the issue of the Satellite temperature versus the surface temperature records of climate change:

- i) The satellite temperature records of climate change and the surface temperature records are two very different measurements of two very different places.
- ii) The surface temperature records are the average of all surface-based temperature monitoring stations around the globe, including ocean buoys in some locations. The satellite temperature record is a measure of the temperature of the lower atmosphere taken between 5,000 and 30,000 feet in elevation. It is not a measure of the surface temperature.

iii) Within this layer of the atmosphere from 5,000 to 30,000 feet, the temperature varies considerably vertically, thus the satellite temperature record is a highly aggregated measure of the temperature within this 25,000 foot thickness of the atmosphere, averaged over time and geographic location to produce an annual average value constituting the globally-averaged satellite temperature.

iv) For all practical purposes humans live at the surface of the Earth not between 5,000 and 30,000 feet above the surface of the Earth.

v) The satellite temperature record extends back to 1979, a period of 17 years. Most climatologists maintain that despite all else, a record of 17 years in duration is too short a period of time over which to tease out a climate signature or signal. It's simply too short a timespan to make inferences as to any climate change or any sense of the direction of that change (positive or negative).

vi) Balling stated that the satellite records showed a cooling trend. According to John Christy, one of the co-authors of the original work on the satellite temperature records, after adjusting the satellite temperature records for influences due to ozone depletion and aerosols, one finds an overall slight net warming trend in the satellite records since 1979, contrary to Balling's assertion. John Christy's comments to this effect are also recorded in a recent transcript of a Congressional hearing which took place in 1996.

Furthermore, everyone agrees that in comparing balloon records of lower atmospheric temperature over the last 17 years with the satellite records of lower atmospheric temperatures for the same period of time, there is very good agreement between the two data sets (And well they should be highly correlated data sets since the balloons and satellites are essentially measuring the same temperature over the same thickness of the atmosphere.), thus all agree that balloon records are a good proxy record for the satellite-derived temperature records. If one then tacks on to this 17-year satellite temperature record going back to 1979, the balloon records going back to the 1950's, in order to produce a longer (40-50 year record) and therefore, more climatically sensitive and credible climate record, one then sees a decided warming trend in the satellite record, consistent with the observed surface temperature record over the same period, and consistent with climate model projections.

2. In stating that thermometers over the last 10 years show no warming, it is entirely unclear as to what Balling was referring to specifically. To my knowledge, 4 out of the last 6 years are the hottest years on record. Beyond that, I seem to recall that the last 10 years represent the hottest decade on record. However, from a climate perspective, no ten-year record provides enough of a climate trend to give it climatic significance. If a 17-year satellite record is too short a period to infer a climate trend or signal, why would a ten-year record be any better?

3. That Phoenix, AZ has witnessed no warming is hardly a negation of greenhouse induced warming globally, nor does it negate climate model projections or the theory of greenhouse warming. No scientists that I know ever stated that during global warming every place on Earth would

automatically become warmer. Some regions will not warm and some might even experience cooling, for any number of reasons. Nonetheless, all of this is entirely consistent with model projections and the theory of greenhouse warming.

4. Balling's attribution of an observed global warming signal to confusion with an urban heat island effect is entirely erroneous. In calculating the globally averaged temperature record for any number of years, Wigley, Jones and others have routinely stripped out any outside influences, such as an urban heat effect, from the surface temperature records.

5. As for climate models being seriously flawed, largely due to uncertainty surrounding clouds and precipitation, and therefore, not credible, Balling is distorting the case.

i) Clouds are a large source of uncertainty in model projections. However, Balling seemed to imply that if one cannot get the clouds right in models one cannot get the precipitation or water balance right. Here Balling is mis-stating the case by setting up a syllogism loaded with straw dogs, one of which is that clouds represent all or most of the water or water vapor in the atmosphere. Clouds, in general, contain very little of the water or water vapor housed in the atmosphere, and certainly account for a minuscule portion of the global water budget.

As it turns out, most general circulation models do a good job on getting the global water balance and circulation right.

ii) In terms of precipitation, how good or bad climate models (GCMs) do in the realm of precipitation is often a matter of scale, making Balling's comments on the inability of climate model's (GCMs) to correctly characterize precipitation, misleading. Global climate models make use of large-area grid scales (40 kilometer or more) in making their global-scale calculations. At this scale of resolution one cannot, in general, get a good feel for precipitation differences locally or regionally since precipitation is generally a more regional or localized phenomenon. The models are not designed to get at the smaller-scale aspects of precipitation. However, the general circulation models do a reasonably good job in characterizing precipitation trends for broader (area-wise) regions of the world on the scale of the interior of North America, for example.

iii) Nor is it the case that models do not deal with or account for uncertainty with respect to clouds. Uncertainty surrounding clouds, as well as other uncertainties, are embodied in virtually all global climate model projections of temperature change out to the year 2100, hence the reason for the wide range of model projected temperatures of 1.5-4.0 degrees C by the year 2100. Cloud uncertainty is already accounted for in models.

6. Balling was correct in stating that the IPCC concluded that it was uncertain as to whether hurricanes and tropical storms would increase or decrease in number in a greenhouse warmed world. However, contrary to Balling's assertions of a decrease in the intensity of hurricanes and other tropical storms in a warmer world, the IPCC concluded that in a warmer world the intensity of hurricanes and tropical storms was likely to increase, not decrease.

This expectation of an increase in hurricane and tropical storm intensity is consistent in that heat (warm ocean surface temperatures) is the overwhelming driving force behind the intensity of hurricanes and tropical storms. The hotter the world becomes one would logically expect more intense hurricanes and tropical storms. This expectation and model

projection are also consistent with Kerry Emanuel's (MIT) notion of "Supercanes" (extremely intense hurricanes) in the Earth's paleoclimate record when the Earth was warmer than it was today. The driving force behind these "Supercanes" was largely elevated temperatures. Unless of course Balling was referring to the intensity of hurricanes and tropical storms being less over the past few years, he almost certainly mis-stated the case for future decreases in hurricane and tropical storm intensity, as the climate warms.

7. As for Balling's comment that scientists in the 1970s were concerned about global cooling, and are now concerned about global warming, begging the credibility of scientists as well as their understanding (or lack thereof) of climate and the direction that climate will take, it amounts to a "red herring". Yes, some scientists were, and remain to be concerned about global cooling as well. However, the important point here is the fundamental difference in timescales involved.

Most scientists agree that natural cycles of ice ages and intervening warm ages are found throughout the paleoclimate record, largely at intervals or cycles of 21,000, 40,000, and 90,000 years. These natural cycles are driven by orbitally-driven changes in the distribution of solar radiation over the surface of the Earth, operating at the periodicities cited above. The peak of the last ice age occurred roughly 18,000 years ago. Consequently, there are a number of scientists who are rightly concerned about the next orbitally-driven natural cycle of cooling which is predicted to occur sometime within the next 3,000 years ($18,000 + 3,000 \text{ years} = 21,000 \text{ years}$), one of the key orbitally-driven cycles responsible for the onset and demise of ice ages.

Consequently, scientists should rightly be concerned about orbitally-driven, natural global cooling on the scale of thousands of years, while at the same time be concerned about rapidly escalating, anthropogenically-driven global warming on the scale of tens to hundreds of years. How this anthropogenically-driven rapid trend in the buildup of greenhouse gas emissions, in parallel with a sluggish, natural orbitally-driven trend toward a new ice age, will play out in the long run, is an important issue of concern. Being concerned about global cooling (on a scale of thousands of years) is not therefore, contradictory to being concerned about global warming (on a scale of tens to hundreds of years). This is hardly a measure of confusion or uncertainty among scientists, and should not be taken as such, contrary to what Balling and others would like to have the public believe.

8. As for the need to explore other possible reasons or causes of the observed climate change to date, I wonder to what extent Balling has embarked on a research program to do just that. Otherwise, I am somewhat at a loss to understand what Balling's contribution to climate science has been in terms of advancing our understanding of processes and feedbacks, or modeling. Searching for 'silver bullets' and trying to poke holes in climate models and the IPCC consensus understanding of the climate system is not what I would call being genuinely engaged in the business of scientific research. Perhaps Balling would entertain the idea of looking for other mechanisms and causes of climate change, and assess their importance and whether their effects can and are being observed.

9. Balling also made reference to the "apocalyptic" predictions of the impacts of global warming. I wonder who Balling was referring to specifically, in casting climate changes as apocalyptic? I know of no scientists that have described the impacts of climate change as an apocalypse or apocalyptic. Perhaps Balling could enlighten all of us as to who exactly is saying this. Otherwise, it's fair to conclude that this particular phraseology is part of a public relations media strategy.

10. Balling also commented on the fact that a longer growing season, as a consequence of spring arriving earlier (in the northern latitudes especially) was good, implying that even if climate is changing (warming) it's implicitly good. This notion of climate warming being inherently good and a longer growing season inherently better, is simplistic and misleading to the extreme, especially from an ecosystem perspective.

It turns out for example, that certain species of penguins in West Antarctica have been impacted indirectly by an observed 4-5 degree C warming and an earlier spring in this part of the Antarctic over the last half century. In this instance, a certain species of penguin had its breeding habitat altered or rendered unavailable at the crucial moment when recent offspring required habitat that was rendered unavailable by the change in climate and the change in the timing of the seasons. The consequence of this change amounts to no survival of offspring. The same is true for certain butterflies in the western U.S., where an observed 2-3 degree C warming has occurred over the past 100 years, altering the timing of food availability at a crucial moment in the growth of butterfly larvae such that food was no longer available for developing butterfly larvae at a crucial moment in their development. The net effect was that the butterfly larvae never reached maturity and the species is becoming extinct.

Each of these examples serve to underscore the complexity of ecosystem responses to climate warming. In addition, in each of these two examples there are a host of unknown ripple effects throughout the larger ecosystems of which these two organisms are a part. Climate warming or cooling is hardly simplistic in the way it plays out.

11. Balling's contention that dust will essentially cool off the planet in the face of any threat of global warming, is preposterous. While it is true that dust serves, in general, to cool the planet as a result of the particles reflecting sunlight back into space, dust in the atmosphere is not pervasive but localized. Thus, while one might anticipate some cooling due to dust, that cooling would largely be localized. In addition, some dust at certain levels of the atmosphere, tends to have an insulating or warming effect. Furthermore, if dust were to have acted to cool the planet down every time the planet tended to warm, there should never have been any records of past climate warming, yet the paleoclimate record is replete with episodes when the climate warmed considerably, and for long periods of time. In addition, there appears to have been more dust in the atmosphere during times in the Earth's past when the climate was much colder, during ice ages, for example. Consequently, the paleoclimate record flatly contradicts Balling's assertion.

Eugene Trisko, in discussing the impacts of binding international CO₂ emissions reductions, stated that mitigation policies could reduce the GDP by \$100-\$300 billion annually according to a recent report. This could spell a loss of \$500.00-\$1,500.00 dollars per capita if we chose emissions targets and timetables too prematurely. He stated that any binding mitigation efforts needed to be global, including responsibilities for developing countries. If developed countries alone agreed to an emissions ceiling of 450 ppm, for example, it would cost 1 million American jobs.

Frances Smith stated that the impact of climate change policies on consumers would be real, substantial and painful, and that consumers will be forced into a future of poverty that they will never be able to get over. She stated that most fuel costs would increase by 15%.

As for automobiles and auto efficiency, she stated that small cars are less safe and cannot accommodate families comfortably. Cars are now less safe due to a 500% reduction in weight to improve mileage and efficiency. According to a 1989 Harvard study she cited,

this reduction in automobile weight causes more deaths. According to her, there would be an additional 5.5% increase in mortality due to automobile accidents if we went to a 40 MPG fuel efficient vehicle.

She stated that climate change policies would have a serious impact on senior citizens with fixed incomes, and that such policies will worsen the disparity in the distribution of income in the U.S.

She stated that there were no clear federal policies on climate mitigation, no information, and no analyses to look at. She called for a clearer picture on risks. She claimed that there are lots of global warming scares that were not rooted in fact, and that conclusions regarding global warming were inconclusive. The risks of warming are speculations, and cited Fred Singer's Leipzig Declaration (a statement signed by 100 or so scientists who disagree with the conclusions of the IPCC). She quoted Congressman Dingell's comments calling the FCCC poorly conceived and badly executed.

Karen Kerrigan began by stating that new climate-related regulations on businesses would be a nightmare, and that through the FCCC the UN would be able to penalize U.S. businesses for not complying with CO₂ emissions reductions targets and timetables, while the developing world would be left untouched, giving the latter a serious economic advantage. She commented on the widespread disagreement on the issue of global warming itself and called for a go-slow attitude.

Jonathan Adler referred to the FCCC as "all pain and no gain", and that it could also cause environmental damage as well. He cited the Edmonds, Wigley, et al paper in saying that greenhouse gas reductions are not necessary until some 20 or so years down the road, and that we could afford to wait and see what happens. He stated that the cost of CO₂ reductions could reduce the GDP by 0.5 %. Slowing the rate of growth and the rate of technological development will have an acute negative effect on the economy and people in the U.S. "Wealthier is healthier." A slow down in economic growth will also result in premature mortality.

[MY RESPONSE]

The general conclusion reached by those who addressed the impacts of climate mitigation policies was economic destitution for U.S. citizens and the U.S. economy. It was clear from all of the presenters that this was a collection of exceedingly one-dimensional economic analyses (by non-economists for the most part), wherein the cost of climate mitigation was the only item in need of consideration.

i) What was left out of these presentations was balance and genuine expertise. For example, if the actual cost of climate mitigation might be on the order of 0.5% of the GDP (GDP is also projected to grow at a rate of roughly 2-3 % annually), how does that figure compare to the cost of the regional and global impacts of climate change? What would be the cost of doing nothing, or business-as-usual, compared to the cost of mitigation?

ii) There was also no allowance for fuel efficiency and the use of new and improved, cleaner energy technologies, and no recognition of the possibility that greater energy efficiency and the use of newer, cleaner energy technologies could, in fact, lead to a more robust economy that might also be more sustainable over the long haul, with side benefits such as cleaner air, lowered health care costs, and less or no acid rain damage to people, crops, forests, and ecosystems.

iii) Adler also mis-stated what Edmonds, Wigley, and others stated in their paper and elsewhere. Edmonds et al. make it very clear that in terms of climate mitigation options, one can essentially choose any one of an array of greenhouse concentration ceilings, and then embark on a pathway for reducing greenhouse gas emissions. However, in doing so Edmonds also made it clear that regardless of which greenhouse gas concentration target one selected as the ceiling, work on reducing emissions had to be initiated immediately. The sooner one got to work on reducing emissions the less extreme and less costly the reductions would be over the long haul. The longer one put off reducing emissions, the more difficult, drastic, and costly reducing emissions would be, and with less chance of success.

iv) Although Frances Smith was quick to ascribe more auto deaths to the loss of weight in cars over the years, one wonders what the impact of legal speed limits has had on deaths, as opposed to a loss in automobile body weight. There have also been advances in the use of lighter but stronger materials as well in automobiles. Consequently, this seemed to be a weak argument.

v) I found it exceedingly interesting to note that the industry lobbyists/representatives who railed against the economics of climate mitigation policies, elected to highlight their concern for how these policies would seriously adversely affect senior citizens and the economically disenfranchised (those at the low end of the widening economic gap of the haves and have-nots in the U.S.). I'm certain that the elderly and the economically disenfranchised would be surprised to hear how seemingly concerned these organizations are about their health and well being. I found this whole line of argument very hypocritical.

Final Comments

I was struck by the fact that virtually all of the scientific and economic presentations made were anecdotal in that they were presenting work done by others. One wonders why the original authors and experts were not called upon to convey their work directly, without second-and-third-hand interpretations by others.

At the end of nearly two hours of presentations before a good size audience made up mostly of Hill staff, the National Center for Policy Analysis elected to take a total of three questions from the audience, one of which was my own.



Truths, Myths and Impacts of Global Warming

Friday, June 13, 1997, 10:00 to 11:45 a.m.
1324 Longworth House Office Building, Washington, DC

Sponsored by the National Center for Policy Analysis

10:00 a.m.	MODERATOR	<i>Sterling Burnett</i> Environmental Policy Analyst National Center for Policy Analysis
10:05 a.m.	OPENING REMARKS	<i>Dennis Fitzgibbons</i> Deputy Director, Minority Staff House Commerce Committee
10:15 a.m.	Q & A	
The Truths of the Science		
10:20 a.m.	OBSERVATIONAL EVIDENCE OF GLOBAL WARMING	<i>Norman J. Macdonald</i> Certified Consulting Meteorologist
10:35 a.m.	GREENHOUSE WARMING: THE OTHER CONSENSUS	<i>Dr. Robert C. Balling, Jr.</i> Director, Office of Climatology Arizona State University
The Impacts on the Economy		
10:50 a.m.	THE IMPACT ON JOBS	<i>Eugene M. Trisko</i> Attorney United Mine Workers of America, AFL-CIO
11:05 a.m.	THE CONSUMER LOSES	<i>Fran Smith</i> President National Consumer Coalition
11:15 a.m.	THE ECONOMIC HARDSHIP ON BUSINESS	<i>Karen Kerrigan</i> President Small Business Survival Committee
The Myths of the Global Warming Treaty		
11:25 a.m.	WHY THE TREATY ISN'T GREEN	<i>Jonathan Adler</i> Associate Director, Environment Competitive Enterprise Institute
11:35 a.m.	QUESTIONS & ANSWERS	<i>The Panelists</i>

We hope you will be able to join us for this important and informative environmental policy briefing. Because seating is limited, please RSVP at 202-628-6671. If you have any questions, contact Erik Rudeen.

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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.**

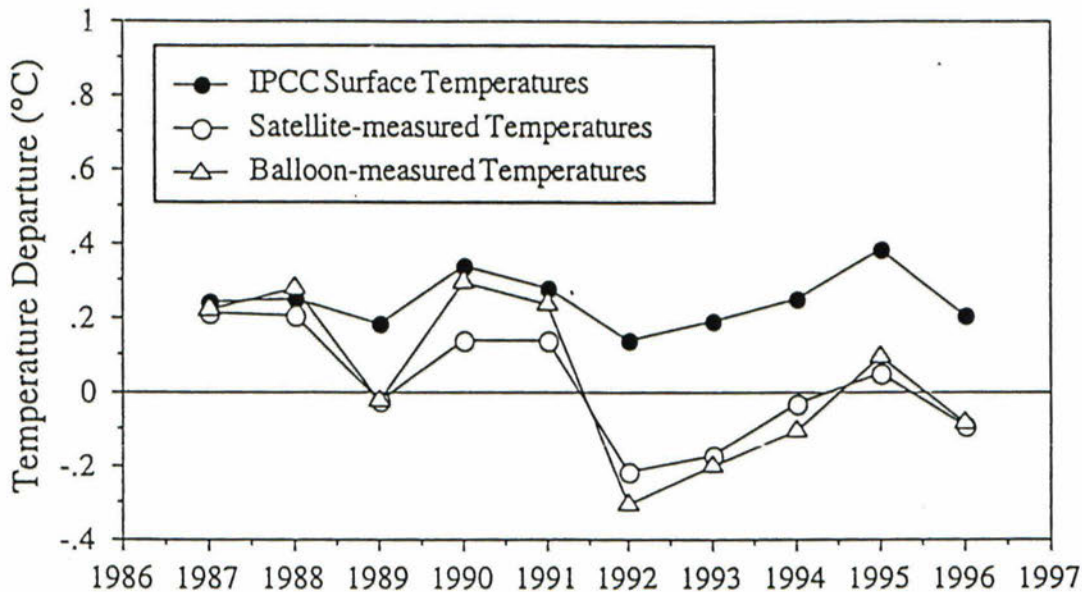
Hurrell and Trenberth's assertion requires scientists to ignore weather balloon temperatures recorded twice daily using highly-calibrated instruments sent skyward from locations blanketing the planet. On a year-to-year basis these data perfectly match the satellite temperature data taken in the atmospheric 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.

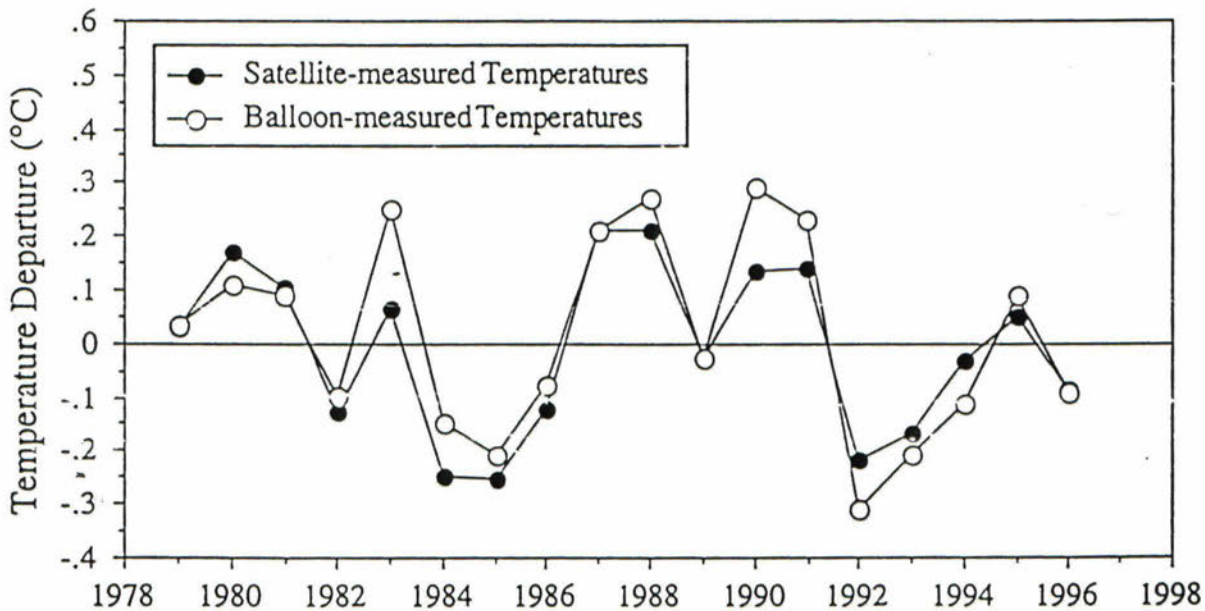
This statement is based upon information provided by New Hope Environmental Services, Inc.

#

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.

The Washington Times

PAGE A22 / FRIDAY, SEPTEMBER 12, 1997 ★

There's no credible evidence of human influence on global warming

Cord Meyer's Aug. 29 commentary on global warming, "Climate, technology and trepidation," is more misleading than enlightening. From start to finish, his piece is inaccurate.

He begins with the oft-repeated but false statement that 2,500 scientists make up the Intergovernmental Panel on Climate Change (IPCC). In fact, the IPCC includes government officials, social scientists, environmentalists, corporate employees and trade-association staff members, many of whom have no bona-fide credentials in the field of climate science.

Mr. Meyer goes on to suggest that extreme weather and higher insurance claims are related to fossil fuel use when, in fact, the IPCC made no such connection.

The IPCC did find that during the past century, average surface temperatures around the globe have increased about one-half degree Celsius, that the majority of the temperature increase occurred prior to the increase in emissions of greenhouse gases and that there is no credible evidence of increased frequency or severity of weather events related to increases in carbon dioxide or other greenhouse gases.

Mr. Meyer underscores the need for continued development and diffusion of energy-efficient technologies, but he fails to note that the product of current U.N. climate negotiations will be a treaty that, depending on what terms are selected, could require Americans to reduce energy use by 25 to 30 percent over very few years. There are

no new technologies that can replace so quickly that much energy produced from fossil fuels. The only way to achieve that goal would be a large energy tax or some form of energy rationing.

Readers also would not have known that in the United States, consumption of energy per unit of gross domestic product has improved by a third since 1974. This improvement is a significant step toward lowering greenhouse gas emissions. Also, American business is investing billions of dollars a year in search of even more efficient ways to operate.

WILLIAM F. O'KEEFE

Chairman
Global Climate Coalition
Washington

4888681

Are Human Activities Causing Global Warming?

**George C. Marshall Institute
Washington, D.C.**

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I. INTRODUCTION

Continuing controversy over the extent of human influence on climate change suggests that a review of the latest findings on global warming written for a general audience will contribute to a wider understanding of this critical issue. Previous analyses of the global warming problem by the Marshall Institute have concentrated on the validity of climate models, the climate record as revealed in temperature observations, and the lack of a greenhouse signal in the temperature record to date. This report summarizes some results discussed in earlier reports, but its focus is on new facts related to the global warming issue as it has been discussed over the last 12 months.

The study begins with a review of evidence relating to claims that 1995 was the warmest year on record, and that anthropogenic global warming has caused and will cause a greater frequency of severe storms and extreme weather events, including blizzards and hurricanes.

The remainder of the report concerns statements by the UN Intergovernmental Panel on Climate Change (IPCC) that for the first time it is now possible to discern in the temperature record a significant human influence on climate.

This most recent Marshall Institute review of scientific evidence on climate change confirms the earlier conclusion that predictions of an anthropogenic global warming have been greatly exaggerated, and that the human contribution to global warming over the course of the 21st century will be less than one degree Celsius and probably only a few tenths of a degree. Spread over a century, a temperature rise of this magnitude will be lost in the noise of natural climate fluctuations.

II. SIGNS OF GLOBAL WARMING CAUSED BY HUMAN ACTIVITIES

According to computer models of climate change, the average temperature of the earth's surface should have increased by approximately 1°C in the last 100 years, in response to the increased concentration of anthropogenic greenhouse gases in the atmosphere. A temperature rise of approximately one-half degree has been observed, but most of that rise occurred before 1940 while most of the greenhouse gases produced by human activities entered the atmosphere after 1940. (See Section V.) Thus, anthropogenic greenhouse gases can only account for a small part of the observed half-degree rise — at most a few tenths of a degree. This amount of global warming is considerably less than had been predicted to result from human activities. Recent work suggests that the cooling effect of atmospheric pollution can account for the apparent absence of global warming due to man-made greenhouse gases.¹ Section V discusses recent theoretical analyses leading to this conclusion.

An increase in the earth's average temperature would be the most direct manifestation of the climate impact of anthropogenic greenhouse gases. In view of the nonappearance of the predicted temperature increase, it has been suggested that signs of the climate impact of the anthropogenic greenhouse gases may be sought in other weather and climate phenomena, such as the occurrence of exceptionally hot years in the recent climate record, or an increase in the frequency of occurrence of hurricanes and other extreme weather events. Evidence bearing on these effects is discussed below.

1995: Warmest Year on Record?

On January 2, 1996, the British Meteorological Office (UKMO) and the University of East Anglia announced that 1995 had been the warmest year on record. The

1. Mitchell, J.F.B., T.C. Johns, J.M. Gregory and S.F.B. Tett, *Nature* 376, 501-504 (1995).

global warming implications in this finding led to a considerable amount of press comment, e.g.,

"95 Is Hottest Year on Record As the Global Trend Resumes"

— *New York Times*, 1/4/96

"Hottest year heralds global warming"

— *New Scientist*, 23/30 December 1995

According to the UKMO the global average surface temperature for 1995 was 0.04°C — $1/25$ of a degree — warmer than the average temperature for the previous record-breaking year, 1990. However, a NASA team's analysis of global temperature observations finds 1995 to be *cooler* than 1990 by about 0.01°C . Moreover, throughout the 1980-1995 period, the NASA analysis differs from the UKMO results by an average of 0.1°C — substantially greater than the difference that is supposed to make 1995 the warmest year. The year-to-year fluctuations in each temperature analysis also average 0.1°C . These facts suggest that the temperature difference that forms the basis for the UKMO announcement is not significant. That conclusion is supported by the satellite temperature measurements, released later in January, which indicate that 1995 was only the eighth warmest year in the last 17 years (the period for which satellite measurements have been available). The temperature for 1995 is precisely in the middle of the temperature range for the last 17 years. Far from being unusually warm, 1995 was an ordinary year in the satellite record.

The Warm 1980s and 1990s

The 1980s and 1990s to date have been a warm $1\frac{1}{2}$ decades with a temperature increase of approximately $0.2 - 0.3^{\circ}\text{C}$ from 1980 to the present. Over the last 17 years the temperature has been increasing at the rate of $0.17^{\circ}\text{C}/\text{decade}$ according to

surface measurements, and $0.09^{\circ}\text{C}/\text{decade}$ according to satellite data.² Is this very recent warming trend caused by anthropogenic greenhouse gases?

Trends of the order of $0.1 - 0.2^{\circ}\text{C}/\text{decade}$ are within the range of natural variability and occur frequently in the climate record. In themselves, they provide no indication of a human influence on climate. From 1890 to 1900, for example, the temperature rose at the rate of $0.2^{\circ}\text{C}/\text{decade}$ — somewhat greater than the rate of temperature increase measured between 1980 and 1994. From 1900 to 1910 the temperature fell at the rate of $0.2^{\circ}\text{C}/\text{decade}$. Between 1910 and 1940 the temperature rose approximately $0.15^{\circ}\text{C}/\text{decade}$ for a total increase of nearly 0.5°C .

All these warming and cooling trends in the half century prior to 1940 must have been mainly the product of natural factors in the climate system, since no significant anthropogenic influence on climate existed in that early period. In particular, as noted earlier, the half-degree warming between 1910 and 1940 occurred too early for carbon dioxide and other anthropogenic greenhouse gases to have played any significant role. The 1990 *IPCC Scientific Assessment* concurs:³ "The rather rapid changes in global temperature seen around 1920-1940 are very likely to have had a mainly natural origin." But if natural forces caused the half-degree temperature rise between 1910 and 1940, they could also have caused the temperature rise of 0.3°C observed in the 1980s and 1990s. Contrary to statements by some scientists that have been reported in the press, the recent temperature rise in the 1980s and 1990s provides no evidence of a global warming due to human activities.

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2. These values have been adjusted to include an estimate of the transient cooling caused by the eruption of the Mt. Pinatubo volcano in the Philippines. See Jones, P.D., *Geophys. Res. Ltrs.* 21, 1149-1152 (1994).
 3. *Climate Change: The IPCC Scientific Assessment*, Houghton, J.T., G.J. Jenkins and J.J. Ephraums, eds., p. 233, Cambridge University Press (1990).

III. EVIDENCE FROM THE RECORD OF ANCIENT CLIMATES

The geologic record reveals that major changes in the atmospheric concentration of carbon dioxide have occurred during the earth's history. A comparison with evidence for temperature changes occurring at the same time can yield information on the sensitivity of the earth's climate to CO₂ changes, and the planet's probable increase in carbon dioxide concentration expected in the next century. This empirically based determination of the temperature rise resulting from carbon dioxide increases could have greater validity than the theoretical estimates derived from computer models of the earth's climate, which are subject to major uncertainties because of difficulties in estimating cloud and water-vapor feedbacks.

Unfortunately for the usefulness of this approach to the global warming problem, the earth's climate record indicates that other significant factors in climate change frequently come into play simultaneously with the changes in CO₂ levels. These factors can add to the warming effect of an increase in CO₂, thus making the climate sensitivity to carbon dioxide changes seem greater than it really is; or they can subtract from the warming effect of the added CO₂, making the climate sensitivity to higher CO₂ levels seem smaller than it really is. Reliance on the paleoclimate record for clues to the magnitude of a future greenhouse effect may lead to seriously misleading results.

For example, in the Ordovician, 440 million years ago, the CO₂ concentration was as much as 10 times present levels. Using the IPCC's best estimate of a global warming of 2.5°C for the equilibrium response to a doubling of CO₂, the temperature in the Ordovician should have been approximately 8°C above today's levels. The lower limit of the range of IPCC estimates — a warming of 1.5°C for doubled CO₂ concentration — would have led to a warming of approximately 5°C in the Ordovician for this level of CO₂ concentration. However, the climate in the Ordo-

vician did not agree with either of these estimates. The geologic record reveals that during the Ordovician the earth was in the grip of a major ice age, with temperatures 5 - 10°C *below* today's levels.⁴

Crowley and Baum have shown the low temperatures in the Ordovician ice age may be explained as a result of the proximity of the South Pole to the continental mass which is now a part of Africa.⁵ Their analysis confirms that other factors — in this case, the altered geography in the Cretaceous — acting simultaneously with an increase in CO₂ can swamp the warming effect of the added CO₂. In general, these other factors are not fully understood; in some cases their existence may not be even be suspected. As a consequence, it may be impossible from the record alone to disentangle the temperature response to CO₂ changes.

In addition to episodes such as the Ordovician ice age — in which CO₂ increased but temperature did not — the climate record also reveals instances in which temperatures increased but CO₂ did not. An example is the warmest period of the current interglacial, in the mid-Holocene, ca. 4,000 BCE, when temperatures were 1 - 2° above today's levels,⁶ and about the same as the warming predicted by climate models for the end of the 21st century. However, the concentration of CO₂ at that time was approximately equal to that of the preindustrial era, i.e., 25% *below* today's levels.⁷

These examples indicate that large errors in forecasting climate can result from the assumption that changes in CO₂ concentration are one of the main driving forces in climate change. It is not possible to assume that temperature changes in

4. Crowley, T.J. and S.K. Baum, *J. Geophys. Res.* **96**, 22,597-22,610 (1991).

5. Crowley, T.J. and S.K. Baum, *J. Geophys. Res.* **100**, 1093-1101 (1995).

6. Lamb, H.H., *Climate, history and the modern world*, Methuen, London and New York (1982).

7. Ref 3, p. 202.

the paleoclimate record have been caused largely or entirely by one factor — a change in the concentration of CO₂.

IV. SEVERE STORMS AND GLOBAL WARMING

"Blizzards, Floods & Hurricanes: Blame Global Warming."
— *Newsweek*, 1/22/96

It has been suggested that greenhouse warming will increase the frequency and severity of violent storms and extreme weather conditions. Both the recent climate record and the history of past climate changes going back a thousand years indicate that this suggestion has no foundation in fact. The climate history of the past millennium demonstrates that cold — and not warmth — is associated with greater storminess.

The warmest conditions in the last thousand years on both sides of the Atlantic occurred in the 10th - 12th centuries, when the temperature was approximately 0.5°C warmer than today⁸ and comparable to the temperatures predicted by the climate models for the 2030 - 2050 period. Yet that was a period of benign climate in Europe and North America, when vineyards flourished in England and the southern regions of Greenland were free of ice and farmed by Norse settlers. Those relatively warm centuries are known as the Medieval Climatic Optimum.

In the 13th century the climate began to cool as the earth slid into a centuries-long cold period called the Little Ice Age. Temperatures in the depths of the Little Ice Age were 0.5 - 1°C cooler than today. The Little Ice Age lasted through the 17th and 18th centuries and into the 19th, when a recovery began and a climb to higher temperatures that appears to be still continuing. With the advent of colder weather

8. Lamb, H.H., *Climate: Present, Past, and Future*, Vol. 2, Methuen, London and New York (1972-1977).

in Europe starting in the 13th century, the severity and frequency of storms increased dramatically in the area around the North Sea. More than 100,000 people died in flooding of the North Sea by storms in 1421 and 1446; a storm in 1570 resulted in the deaths of over 400,000 people. The number of severe floods on the North Sea coast in the last 1000 years seems to have been greatest in the early 1400s and late 1600s; about three times as many disastrous floods occurred then as in the warmer 20th century.

Hurricanes and Tornadoes

A comparison of weather conditions in the Medieval Climatic Optimum and the Little Ice Age suggests that the general level of storminess will decrease, rather than increase, in a warmer climate. But can global warming cause an increase in the frequency and severity of the most violent storms — hurricanes and tornadoes? Meteorological records contain evidence bearing on this question. Figure 1 (p. 9) shows the dependence of the yearly number of hurricanes in the North Atlantic on the temperature of the Northern Hemisphere at the time each hurricane occurred.⁹ There is no indication of a trend toward an increase in the number of hurricanes with increasing temperature. Figure 2 (p. 9) shows the relation between the yearly number of tornadoes in the U.S. and the U.S. average temperature, again with no indication of a positive trend.¹⁰

9. *Hurricanes*: National Climatic Data Center, NOAA. *Temperature*: Jones, P.D., T.M.L. Wigley and K.R. Briffa, *Trends '93*, ORNL/CDIAC-65, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, TN, p. 603-608.

10. *Temperature*: Karl, T.R., D.R. Easterly, R.W. Knight and P.Y. Hughes, *Trends '93*, ORNL/CDIAC-65, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, Oak Ridge, TN, p. 689 and updates. *Tornadoes*: National Climatic Data Center, NOAA.

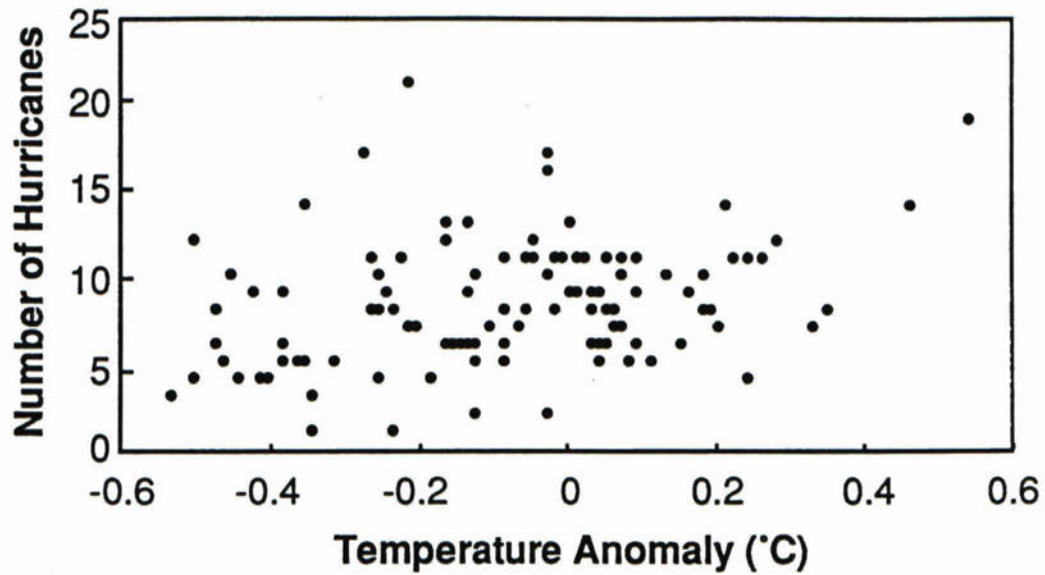


Fig. 1. Yearly number of North Atlantic hurricanes vs. Northern Hemisphere average temperature 1886 - 1995. (Source: ref. 9)

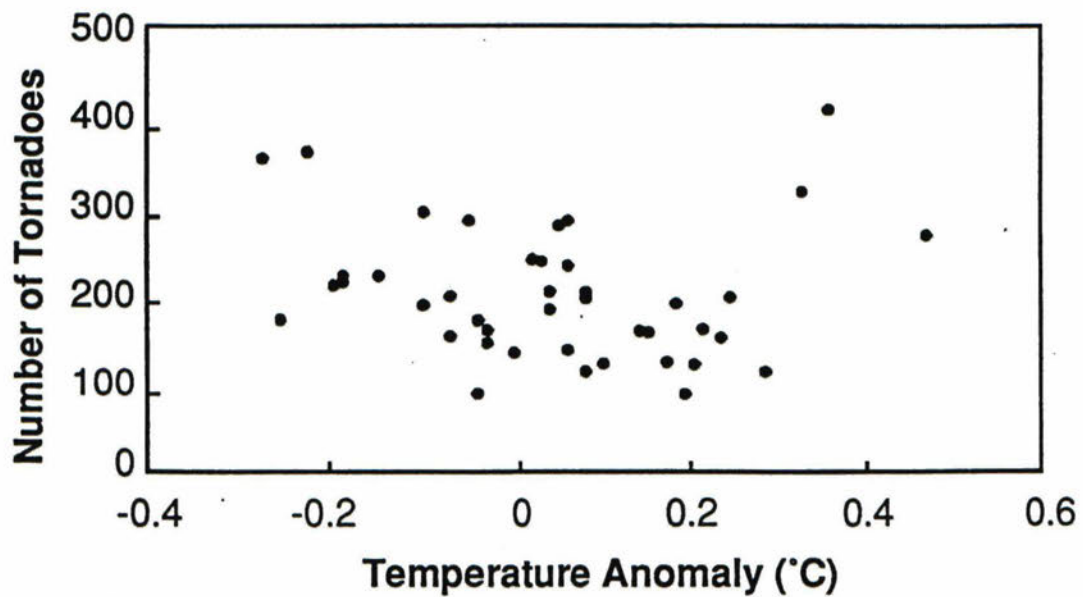


Fig. 2. Yearly number of tornadoes vs. U.S. average temperature 1953 - 1994. (Source: ref. 10)

Heavy Rains

The National Climatic Data Center has analyzed the number of heavy rains from 1910 to 1990. The records indicate that heavy rains, with accumulations greater than two inches over 24 hours, have increased in frequency over that period. The increase is modest: one additional heavy rain every two years.¹¹ Does this change constitute evidence for global warming due to human activity?

A change in the pattern of rainfall in the 1910-1990 period is not surprising, since there was a global warming of approximately one-half degree since 1910. A warmer earth means more evaporation and more condensation, and thus more and/or heavier rain. However, granting that global warming may change rainfall, the key question is: *Was the global warming caused by human activities?* Since, as noted earlier, most of the half-degree global warming occurred before 1940, while most of the CO₂ and other anthropogenic greenhouse gases entered the atmosphere after 1940, we can be certain that most of the half-degree warming was the product of natural factors and not the result of human activities. Therefore, these natural factors in climate change are the cause of heavier rainfall.

Severe Cold

It has been suggested that a global warming caused by human activities is responsible for the extremely cold weather that afflicted the eastern and southern U.S. in January 1996. However, the opposite is true; if the anthropogenic greenhouse effect has any appreciable impact on climate, it must be such as to make winters milder, not colder. The reason is that the warming effect of carbon dioxide and other greenhouse gases, as noted below in the discussion of Arctic temperature changes (Section VIII), is particularly effective at high latitudes; that is, the green-

11. Karl, T.R., R.W. Knight and N. Plummer, *Nature* 377, 217-220 (1995).

house effect warms the Arctic considerably more than the globe as a whole. When cold weather develops in the U.S., it is usually because cold polar air masses have moved southward. Because the warming due to the greenhouse effect is greatest at high latitudes, in and near the Arctic, these polar air masses are warmer than they would otherwise be, and the cold snap that develops over the U.S. is milder. If the warming caused by greenhouse gases has any significant impact on U.S. winters, the impact must be such as to make the winters milder.

Blizzards and Snowstorms

"Blame Global Warming for the Blizzard."

— *New York Times*, 1/14/96

The heavy snowfalls accompanying the cold weather of January 1996 have also been attributed to an anthropogenic global warming. This suggestion is based on the reasoning, again, that higher temperatures lead to more evaporation of water and a higher moisture content in the atmosphere, and thus to heavier snows when the warm, moist air encounters cold air masses moving southward from the polar regions.

However, observations indicate that the opposite is true, at least on the eastern seaboard, which was the site of much of the heavy snowfall in January 1996. Figure 3 (p. 12) shows, for the representative eastern seaboard state of Virginia, the number of inches of snow that fell in January and February for the years from 1927 to 1987, vs. the average temperature in January and February for the corresponding years.¹² The lines mark normal snowfall and temperature. Figure 3 demonstrates that, as intuition would suggest, heavy snowfalls occur when temperatures are low, and not when

12. *Virginia Climate Advisory*, Vol. 11, No. 4, p. 13.

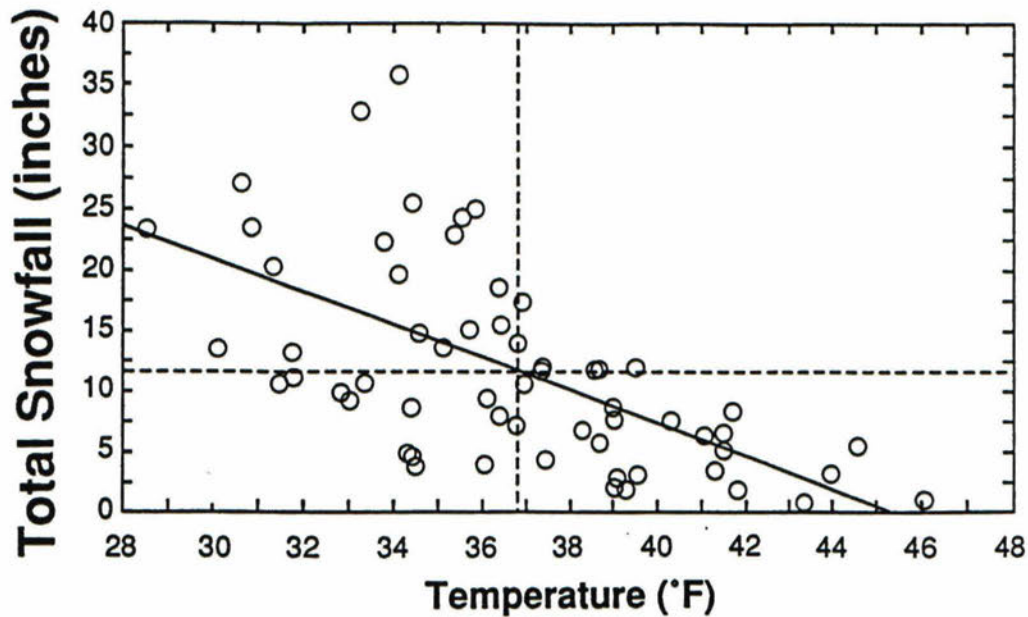


Fig. 3. Total snowfall in January and February vs. average January/February temperature for the period 1927 - 1987. The dotted lines indicate average snowfall and temperature in those months.

the weather is relatively warm. Note that the upper-right quadrant of the chart is empty: the heaviest snows *never* occur when the temperature is relatively high.

In sum: Both the recent climate record and the climate history of the last 1000 years demonstrate no connection between a warm global climate and an increased frequency and violence of storms. Storminess appears to be linked to cooler, rather than warmer temperatures. The most benign conditions have prevailed in times of elevated global temperatures.

V. CLIMATE IMPACT OF ATMOSPHERIC POLLUTION

As noted in Section II, it has been clear for some time that the earth is not warming as much as greenhouse theories had predicted. According to the climate model simulations of the greenhouse effect, carbon dioxide and other greenhouse gases added to the atmosphere in the last century should already have increased the

average temperature of the earth's surface by about one degree Celsius.¹³ The observations show an increase of approximately a half-degree over that period, suggesting, as noted earlier, that the calculations are exaggerating the greenhouse warming by a factor of two.

Exaggerated Estimates of Global Warming

The actual overestimate of man-made global warming must be considerably greater than a factor of two, because most of the half-degree rise occurred prior to 1940, whereas most of the CO₂ and other greenhouse gases entered the atmosphere after 1940.¹⁴ Anthropogenic greenhouse gases cannot be the cause of a warming which occurred before these gases entered the atmosphere. It follows that the greenhouse effect can only be responsible for at most a few tenths of a degree out of the observed half-degree rise. The computer simulations of climate, which estimate a warming of approximately one degree due to the greenhouse effect in the last 100 years, apparently have overestimated the greenhouse warming to date by a factor of three or more.

Why does it matter whether the warming caused by the greenhouse effect over the *last* 100 years has been one degree, or one-half degree, or one-quarter degree? Isn't the important question how big the greenhouse effect will be in the *next* 100 years?

13. Mitchell, J.F.B., R.A. Davis, W.J. Ingram and C.A. Senior, *J. Clim.* 8, 2364-2386 (1995).

14. The concentration of CO₂ in the atmosphere has increased by 20 - 25% in the last hundred years, and increases in other greenhouse gases, such as methane, have increased by the equivalent of another 20 - 25% rise in CO₂. Overall, there has been a greenhouse gas increase equivalent to approximately a 40 - 50% rise in the concentration of CO₂ in the atmosphere in the last hundred years. Most of that increase has occurred in the last fifty years.

The reason these global warming overestimates for the last 100 years are important is that the same climate models which have exaggerated the warming in this century are the source of the predictions of a harmful global warming in the next century. When the global warming forecasts are corrected for the three-fold exaggeration, the predicted warming in the next century drops to a few tenths of a degree. Spread over a century, a temperature increase as small as this will be lost in the noise of natural climate fluctuations.

An Explanation for the Absence of Anthropogenic Global Warming

Why has the predicted global warming due to increasing CO₂ concentrations failed to appear? A plausible explanation is that the warming effect of the greenhouse gases is as large as the climate models estimate, but has been masked by the cooling effect of atmospheric pollution. The burning of fossil fuels — oil, coal and natural gas — releases sulphur compounds into the atmosphere, where these compounds form small particles called sulphate aerosols. The sulphate aerosols create a haze that partly screens the earth from incident sunlight and tends to cool the planet. Recent calculations with the climate models confirm that when the cooling effect of the aerosols is combined with the warming effect of carbon dioxide and other greenhouse gases, the predicted temperature rise comes closer to temperature changes actually observed in recent decades. (The report by the IPCC Working Group I notes, "This agreement does not, however, constitute identification of an anthropogenic effect on climate and may be serendipitous.")

An example of the improvement gained by adding the effect of aerosols is shown in Figure 4 (p. 15), adapted from a report by the British Meteorological Office (UKMO),¹ which compares the observed global average temperatures (solid curve) with temperatures computed assuming greenhouse warming only (dash-dot curve)

or greenhouse warming plus aerosol cooling (dashed curve). The chart confirms that allowing for the cooling effect of aerosols improves the agreement between the observations and the computed global average temperatures for the last three decades.

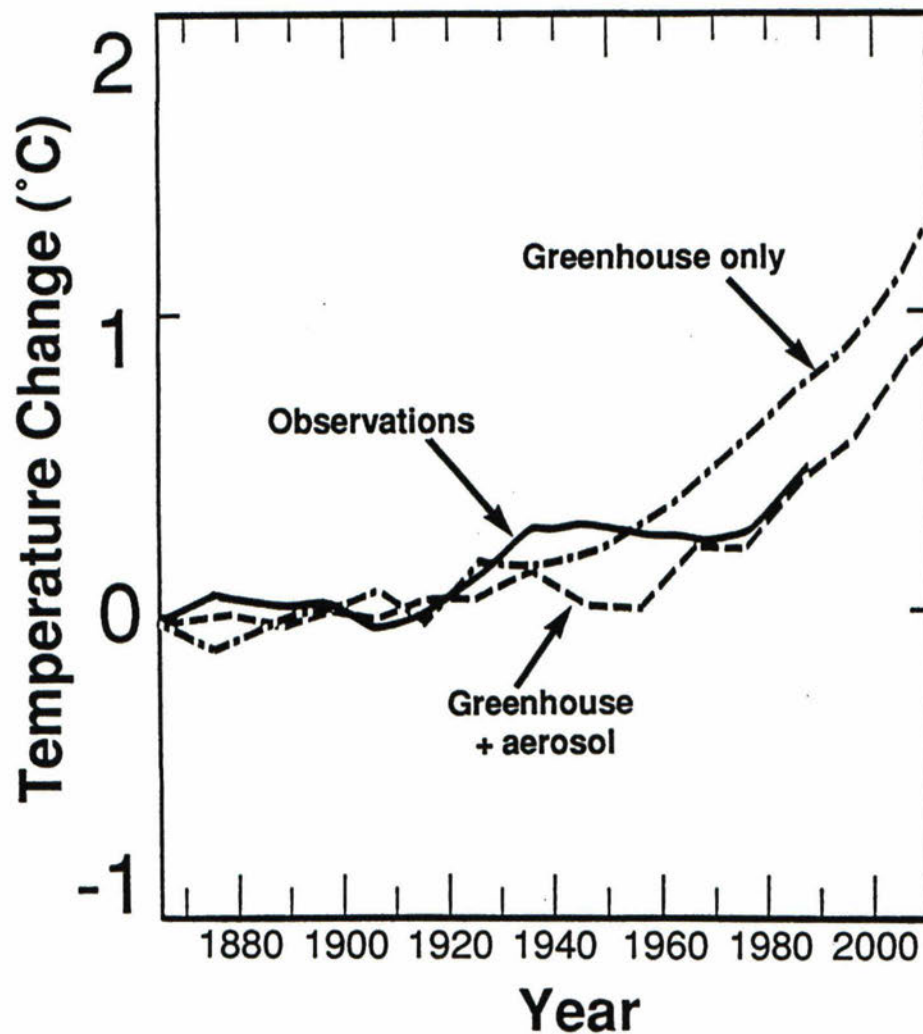


Fig. 4. Changes in global average temperature, computed from a climate model assuming greenhouse gases only (---) and greenhouse gases plus aerosols (— · —), compared with observed temperatures (—). Adapted from Mitchell et al., ref. 1.

Unresolved Discrepancies

However, while aerosols improve the agreement with observation in recent decades for the *globally* averaged temperature, in some regions of the globe the

inclusion of aerosols worsens the agreement. These regions include the heavily industrialized and densely populated areas of the U.S. and Europe, which are intense sources of aerosols and consequently are cooled by them to a greater degree than the globe as a whole. Figures 5 (a) and (b), also adapted from the UKMO report, show that in North America and Europe the agreement between the observed and calculated temperatures, which was fairly satisfactory without the aerosols, is poor when they are included in the climate computations because these regions are now too cool.

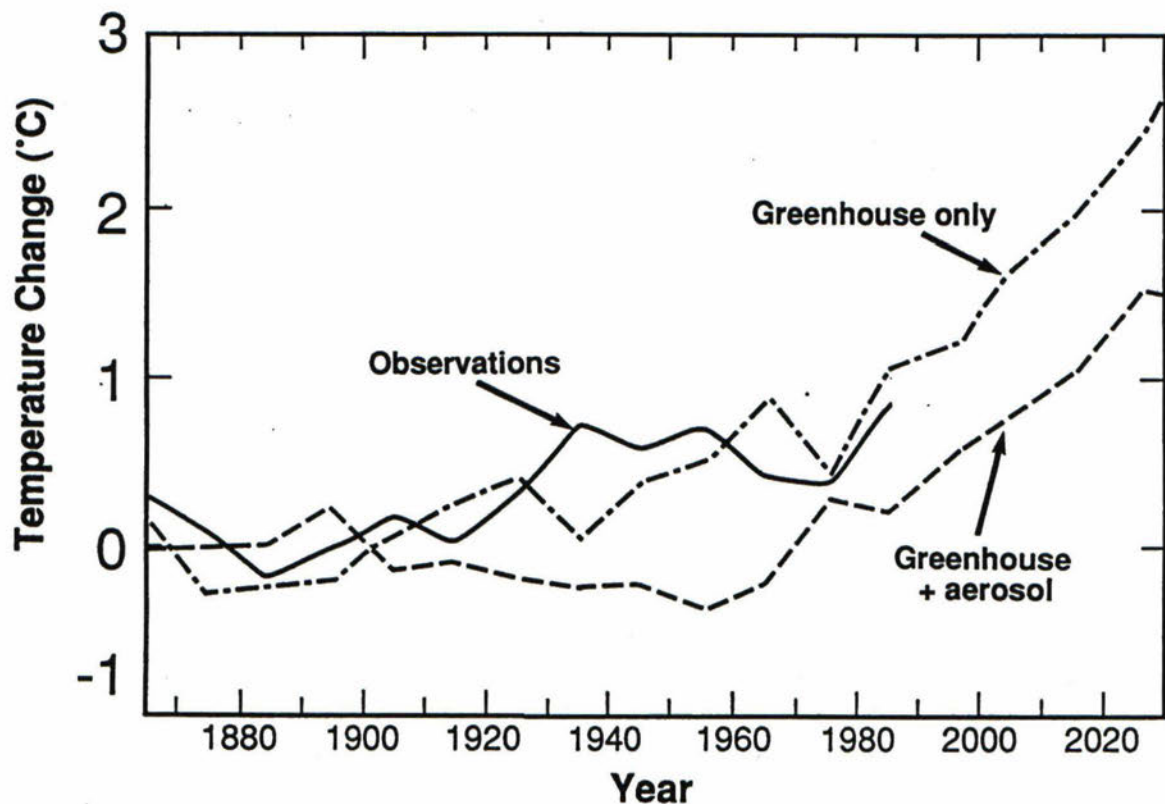


Fig. 5(a). Same as Fig. 4, for North America.

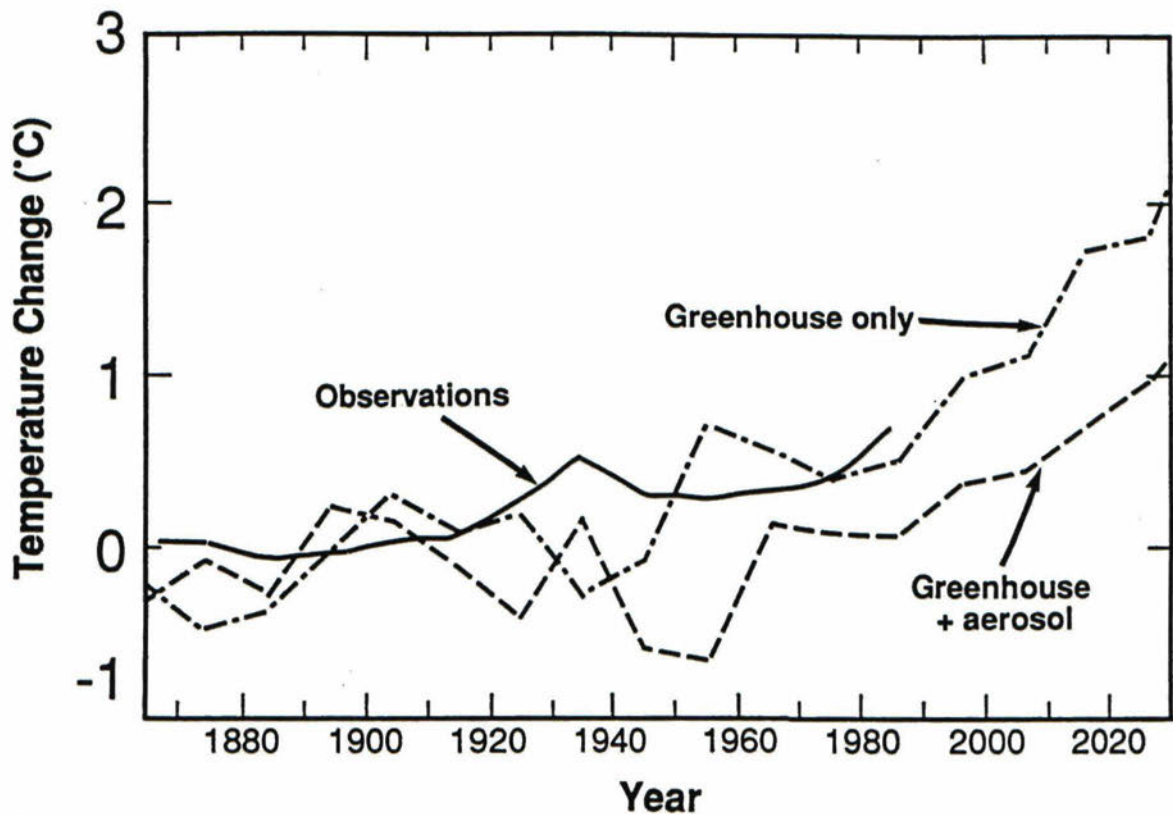


Fig. 5(b). Same as Fig. 1, for Europe.

VI. RECENT RESULTS ON REGIONAL PATTERNS OF TEMPERATURE CHANGE

Globally averaged temperatures are a relatively crude measure of climate change and do not reveal much information regarding the separate impact of the greenhouse gases and the aerosols. While it is useful to supplement the study of the global averages by looking at a few particular regions of interest, such as North America and Europe, a still more sensitive test of the climate impact of the greenhouse gases and aerosols results from a study of the comparison of the compiled and observed temperatures for every region on the entire globe. Since the greenhouse gases and the aerosols each place their own fingerprints on the climate in the form of a distinctive pattern of regional temperature changes, a comparison between the

observed and computed patterns of regional change may also enable us to estimate their separate contributions.

Analysis of Regional Temperature Patterns

Mitchell et al.¹ have undertaken an analysis of the regional patterns of temperature change produced by greenhouse gases and aerosols. The initial year chosen for the analysis is 1860. The surface of the earth is first divided into blocks of area 15 degrees on a side (approximately 1500 kilometers at the equator). The first in the series of numerical experiments is a control run in which the average temperature is computed in each block, assuming no change in greenhouse gases and no aerosol cooling.

In the next experiment, the calculations are carried out from 1860 to the present, assuming the appropriate changes in the concentration of greenhouse gases but still no aerosol cooling. They are repeated again with constant greenhouse gas concentrations, but with aerosol concentrations increasing with time according to observation.

Finally, the calculations are repeated assuming increasing concentrations of both greenhouse gases and aerosols. The gradually evolving patterns of regional temperature change relative to the control run are then compared with the observed patterns of temperature change for each of the three experiments — greenhouse only, aerosols only, and greenhouse + aerosols.

Figure 6 shows the results for the calculated regional patterns of temperature change for the case of aerosols and greenhouse gases combined, compared with temperature observations going back to 1860. The comparison is expressed in terms of the spatial correlation, R , which indicates the extent to which warm and cool regions in the observations are matched by similarly warm and cool regions in the

computations. R is defined to equal 1 if the correspondence between the observed and computed temperature patterns is perfect. A value of R close to zero signifies no similarity between the two patterns of regional temperature change.

From 1860 until approximately 1960, R fluctuates around zero — i.e., there is essentially no correlation between the observed and computed regional patterns of temperature change. Between the 1960s and 1980s, R increases to a peak value of 0.3.

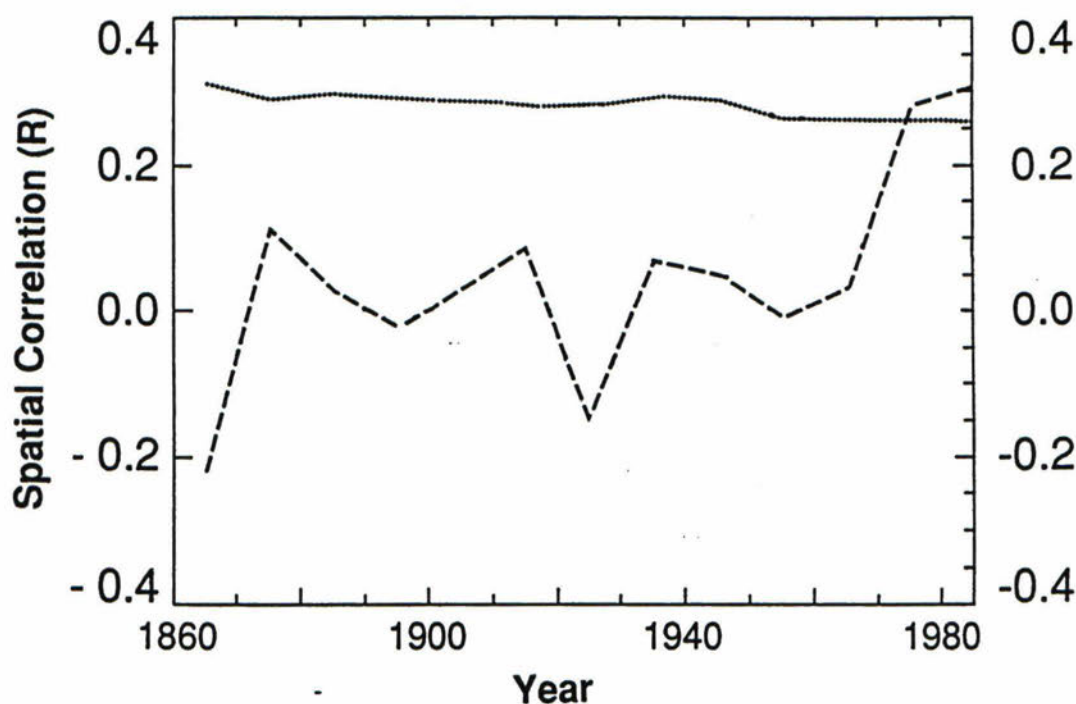


Fig. 6. Regional correlation between computed and observed decadal patterns of temperature change relative to the 1860-1990 mean, for the case of greenhouse gases + aerosols (adapted from ref. 1). The dotted line is the 10% (one-tailed) level of significance, based on climate model estimates of the natural variability of climate.

The increase in R since 1960 has been interpreted by Mitchell et al.¹ to be a combined greenhouse and aerosol signal gradually rising out of the background of natural climate variations in recent decades, as both the greenhouse gases and the aerosols increase in concentration and climate impact.

Similar results have been obtained by Santer et al.¹⁵ In their analysis, R begins to increase in the 1950s and rises to values in the neighborhood of 0.3 in the 1980s. Figure 7, adapted from reference 15, shows the correlation coefficients for the fall season, which display the increase in R clearly. The average value of R from Fig. 7 for the period 1953 - 1993 is 0.17. The upward trend in R is 0.006/yr for the interval 1942 - 1993. On the basis of climate model estimates of natural climate variability, Santer et al. estimate a probability of less than 5% that this upward trend is the result of natural climate fluctuations.

Santer et al. give no estimate of the statistical significance of the R values themselves in Figure 7. Assuming the values of R are significant, Figure 7 also suggests the gradual emergence of a combined greenhouse/aerosol signal in the temperature record.

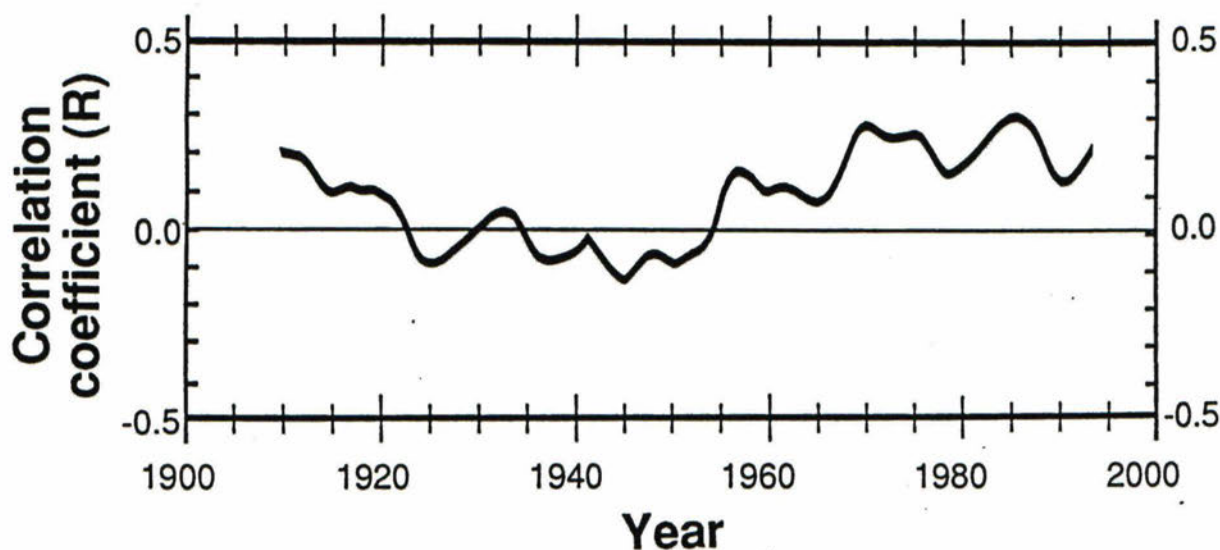


Fig. 7. Correlation coefficients between observed and computed regional patterns of temperature change, for greenhouse gases plus aerosols, and for the fall season (September/October/November) (adapted from reference 15).

15. Santer, B.D., K.E. Taylor, T.M.L. Wigley, J.E. Penner, P.D. Jones and U. Cubasch, *Clim. Dyn.* 12, 77-100 (1995).

Similar results are obtained for the summer season, although not for the winter and spring months.

The increasing correspondence in recent decades between the observed and computed patterns of regional temperature change is cited in IPCC reports as a significant part of the evidence for a detectable human influence on climate.¹⁶

VII. CLIMATE IMPACT OF GREENHOUSE GASES AND AEROSOLS

Which mechanism — greenhouse gases or aerosols — is primarily responsible for the improvement in the agreement between observed and computed regional temperature patterns?

Figure 8 shows the regional pattern correlation for the computation with aerosols alone and no greenhouse gas increase, again adapted from reference 15. As in the case of the aerosols and greenhouse gases combined, Fig. 8 also indicates an

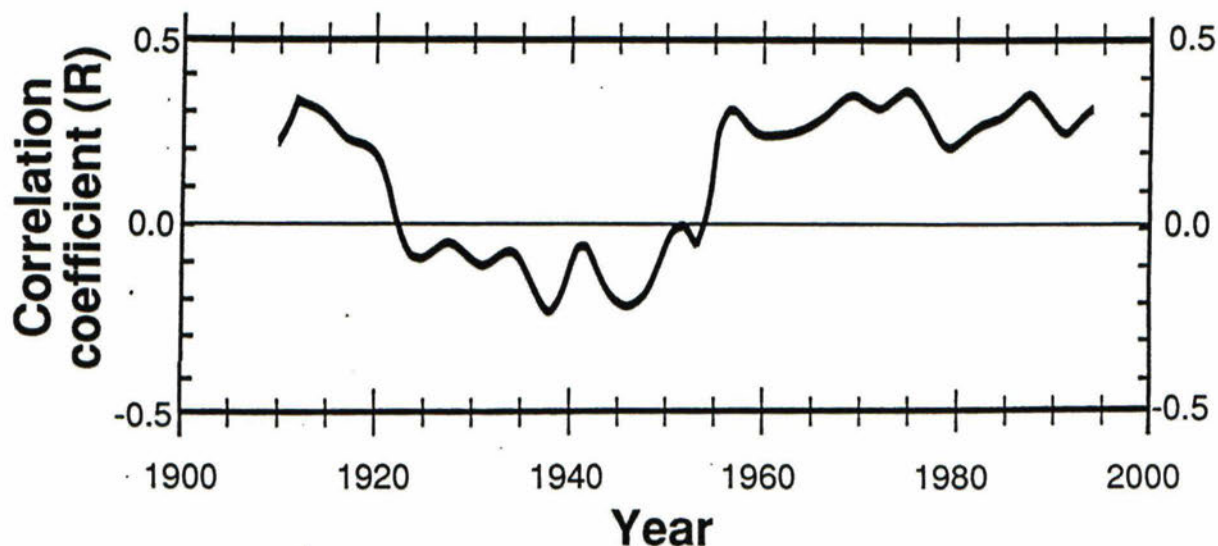


Fig. 8. As in Figure 7, for aerosols only.

16. Summary for Policymakers of the Contribution of Working Group I to the IPCC Second Assessment Report 1995.

increase in R, beginning in this case in the 1940s. For this case, the average value of R for the period 1953 - 1993 is 0.29. The upward trend in R for the 1942-1993 period is 0.009/yr.

Comparison between these results for the case of aerosols only, and the corresponding mean values of R and trend in R for the case of aerosols combined with greenhouse gases, leads to a significant result. Inclusion of the greenhouse effect in the temperature calculations makes the agreement with the observed regional temperature patterns somewhat poorer than in the case of the aerosols alone. Thus aerosols, and not the greenhouse effect, are the cause of the improved agreement between observed and computed regional temperature patterns in recent decades.

Again, assuming that the values of R and the changes in R are significant, the IPCC conclusion that "geographical patterns of temperature change provide important evidence for a discernible human influence on climate" is an accurate assessment of the evidence. However, the human influence in question is almost entirely that of the aerosols.*

The IPCC conclusion was widely misunderstood to imply observational confirmation of a global warming caused by human activity, e.g.,

"Experts Confirm Human Role in Global Warming"
New York Times, 9/10/95

"Global warming 'jury' delivers guilty verdict"
New Scientist, 12/9/95

* The climate models also predict a cooling of the stratosphere as a result of the increased concentration of atmospheric CO₂. This prediction is confirmed by radiosonde and satellite observations and has been cited as an additional item of evidence for the climate impact of anthropogenic CO₂. However, stratospheric cooling may be understood simply as a consequence of the fact that CO₂ is an efficient radiator in the infrared. It conveys no direct information regarding the amount of warming of the surface and lower atmosphere that would result from the addition of CO₂ to the atmosphere.

"Climate panel confirms human role in warming"
Nature, 12/7/95

However, examination of the regional pattern studies which were factored into the IPCC analysis leads to the contrary conclusion: the studies prove that the anthropogenic global warming produced by an increase in the concentration of greenhouse gases has been too small to have a detectable impact on temperatures.

The conclusions to be drawn from the studies of regional patterns of temperature change are the same as those derived earlier from the analysis of globally averaged temperature changes: (1) the greenhouse effect has had a negligible impact on global climate, and (2) the warming effect of the greenhouse gases is substantially smaller than the climate models have predicted.

VIII. ARCTIC TEMPERATURE CHANGES

The accuracy of the climate models can be further tested by examining their predictions at high latitudes in the Arctic zone. All climate models predict that the warming caused by the greenhouse effect will be particularly intense in the Arctic. This prediction of a large Arctic warming makes Arctic temperature measurements a particularly sensitive test of the accuracy of the greenhouse predictions.

Predictions of Arctic Warming Compared with Observations

The climate models predict that the Arctic should have become 1 - 2°C warmer in the last 50 years.¹⁷ However, surface temperature measurements in the Arctic for the last 40 years show that temperatures in the Arctic *decreased* by

17. Manabe, S., R.J. Stouffer, M.J. Spelman and K. Bryan, *J. Clim.* 4, 785-818 (1991).

approximately 1.5°C in that period.¹⁸ Satellite data for the last 17 years also show a cooling in the Arctic. (Figure 9)¹⁹

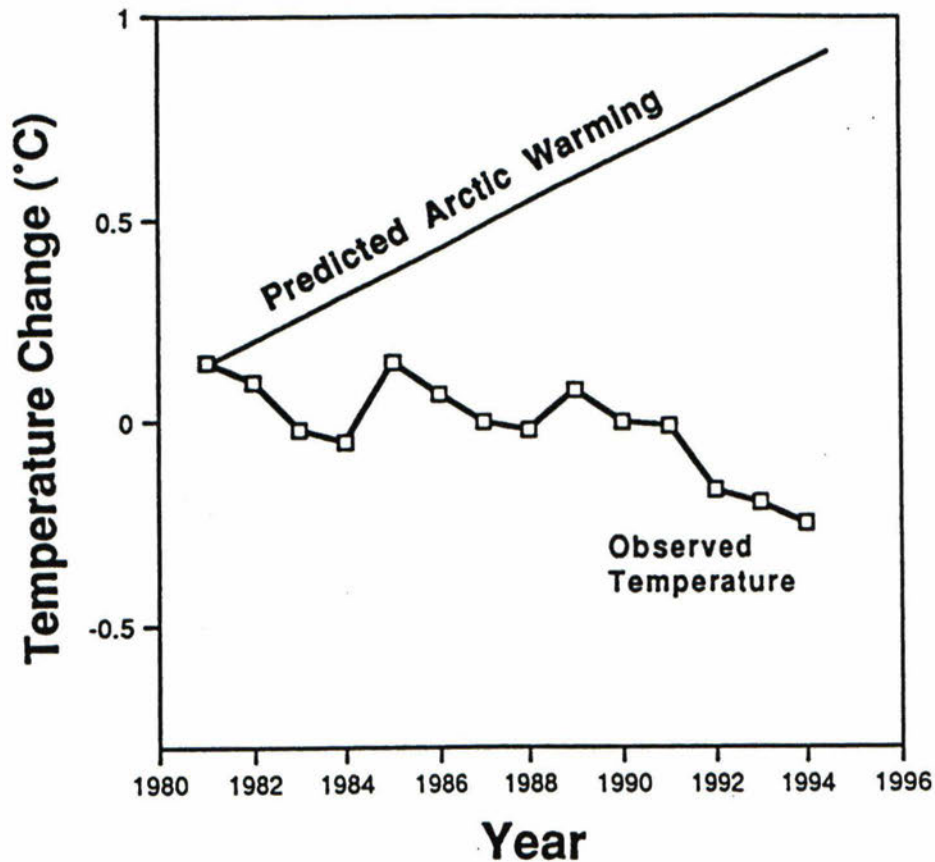


Fig. 9. Satellite measurements of annual average Arctic temperature for the latitude band 67.5N - 82.5N vs. greenhouse predictions. (Source: ref. 19)

Cooling by aerosols cannot explain this very large error in the predictions, since the concentration of aerosols in the Arctic is roughly 10 times smaller than at lower latitudes.¹

18. Kahl, J.D., D.J. Charlevoix, N.A. Zartseva, R.C. Schnell and M.C. Serreze, *Nature* 361, 335-337 (1993).

19. *Satellite observations:* Earth Science System Laboratory, University of Alabama at Huntsville; *predicted warming:* Stouffer, R.J., S. Manabe and K. Bryan, *Nature* 342, 660 (1989).

It was concluded above, on the basis of the comparison with globally averaged temperature data, that theoretical estimates of the greenhouse effect must be decreased by at least a factor of three to bring them into better agreement with global averages. A three-fold reduction in the computed Arctic warming would reduce the predicted Arctic temperature rise in the next century from 1 - 2°C to roughly 0.3 - 0.7°C. This range of Arctic temperature increases is still considerably greater than the measured values, which indicate that the Arctic has not warmed at all. It appears that a three-fold reduction in climate model predictions is not adequate to bring the computed Arctic values into line with observation, and a further reduction in the predicted warming is required.

This result implies that the temperature increase produced in the next century by anthropogenic greenhouse gases will be less than one degree, and probably no more than a few tenths of a degree.

IX. PENALTY FOR DELAY ON LIMITING CO₂ EMISSIONS

As the previous discussion indicates, significant new results on global warming are still accumulating. The general trend over the past five years has been toward a reduction in the magnitude of the global warming predictions. In view of the potential importance of the global warming phenomenon, it may be prudent to allow the process of collecting evidence on global warming to continue for some time before policy decisions are reached on CO₂ emission limits and possible mitigation measures.

A recent analysis by Wigley, Richels and Edmonds²⁰ estimates the additional global warming that would result from a delay of as much as 25 years before action is

20. Wigley, T.M.L., R. Richels and J.A. Edmonds, *Nature* 379, 240-243 (1996).

taken to limit worldwide CO₂ emissions. Wigley et al. take the goal of such action to be a stabilization of CO₂ concentration in the atmosphere at approximately twice the preindustrial CO₂ concentration, or 550 parts per million by volume (ppmv). They conclude that there is little difference between immediate (1995) emission cuts and initiation of cuts in 2020. Peak emissions are approximately 9 billion tons/year (GT/yr) for the case of immediate cuts, vs. 12 GT/yr for a business-as-usual policy — i.e., no cuts in CO₂ emissions — to 2020 and heavy cuts thereafter. Both scenarios lead to the same stabilized CO₂ concentration of approximately 550 ppmv. The penalty for a 25-year delay in action is an additional global temperature rise of 0.2°C in 2100. A 0.2°C rise distributed over a century would be insignificant.

It seems clear that even if fears of anthropogenic global warming were realized — a concern which finds no support in the scientific data — there is no significant penalty for waiting at least two decades before taking corrective action to reduce global CO₂ emissions.

APPENDIX. ACCURACY OF SATELLITE TEMPERATURE MEASUREMENTS

Because of their nearly complete coverage, the temperature data acquired by satellites add important information to the database of surface temperature measurements used in estimating the size of the greenhouse effect. The surface temperature measurements are sparse over the three-quarters of the earth's surface covered by oceans, and provide essentially no coverage of the polar regions. Coverage of the southern oceans is particularly poor. The satellite measurements provide coverage of all oceans as good as their coverage of land areas. They also survey the polar regions to within 4° of the Poles. The complete satellite global temperature survey includes 99% of the earth's surface and is repeated every four days.

The satellite data agree extremely well with ground-based temperature readings wherever the ground-based coverage is good. In Europe and North America, where surface temperature measurements are numerous and reliable, the correlation coefficient between satellite and surface measurements for the last 17 years is 0.95 — close to perfect agreement.²¹ Figure 10 (p. 28) shows the close agreement between the satellite and surface measurements with respect to year-to-year changes in globally averaged temperature.

The correlation coefficients noted above are not sensitive to long-term trends in the globally averaged data. However, fairly good agreement is also found between the satellite data and other sources of temperature measurement in respect to long-term trends. For the period 1979 - 1993, after adjustment for the transient cooling caused by the volcanic eruption of Mount Pinatubo in the Philippines, the satellite value for the global temperature trend is 0.09°C/decade, compared to

21. Christy, J.R., R.S. Spencer and R.T. McNider, *J. Clim.* 8, 888-896 (1995).

0.10°C/decade from the radiosonde balloon measurements and 0.17°C/decade from the surface temperatures.²

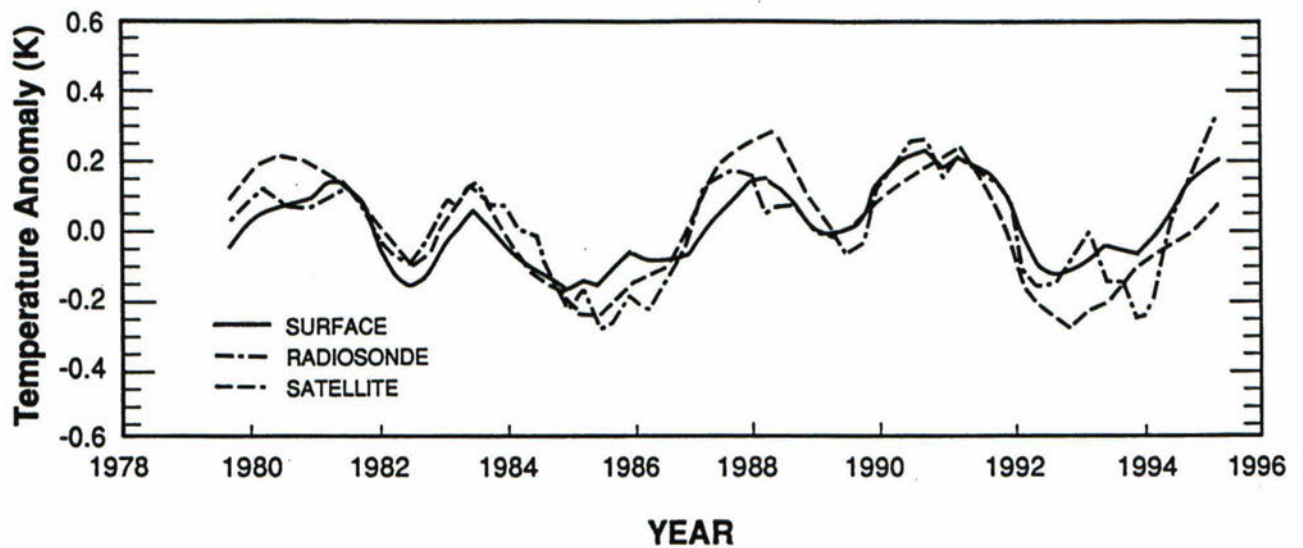


Fig. 10. Comparison of globally averaged temperatures from satellites (— · — · —), radiosonde balloons (— · — · —) and surface stations (—), courtesy A. Arking. Surface: Hansen, J. and S. Lebedeff, *Geophys. Res. Ltrs.* 15, 323-326 (1988). Radiosonde: Angell, J.K., *J. Clim.* 1, 1296-1313 (1988) plus updates. Satellite: J.F. Christy, Earth and Planetary Science Laboratory, University of Alabama at Huntsville.

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