



How a Handful of Scientists

Obscured the Truth on

Issues from Tobacco

Smoke to Global

Warming

Merchants of DOUBT

Naomi Oreskes
& Erik Conway

How a small group of scientists exploited scientific uncertainty and promoted doubt about a set of environmental issues.

June 2, 2005, SAN FRANCISCO

"I say the debate is over.
We know the science.
We see the threat, and we know
the time for action is now."

--Arnold Schwarzenegger
San Francisco, June 2, 2005

My Austrian governor was correct, but he was also nearly alone among Republican political leaders in the United States

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EXCLUSIVE: Cheney on Global Warming

The President's Vice President on Global Warming



Vice President Dick Cheney talked about global warming in an exclusive interview today with ABC's Jonathan Karl. (J. Scott Applewhite/AP Photo)



Sydney, Australia, Feb. 23, 2007

— In an exclusive interview today, ABC's Jonathan Karl asked Vice President Dick Cheney about the topic of global warming, a subject Mr. Cheney has rarely addressed in the past. The vice president agreed that the earth is warming but, like President Bush, maintained there is debate over whether humans or natural cycles are the cause— a position that puts the administration at odds with the vast majority of climate scientists.

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The Intergovernmental Panel on Climate Change, made up of thousands of scientists from around the world, reported earlier this month they are more certain than ever that humans are heating earth's atmosphere through the burning of fossil fuels. In Australia, for example, the IPCC said that rising ocean temperatures brought about by global warming could make Australia's Great Barrier Reef "functionally extinct" by 2050.

Here is a portion of the transcript from the conversation with Mr. Cheney:

JONATHAN KARL: I want to ask you about another issue that's been a subject of controversy here in Australia,

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More typical were views of Vice President Dick Cheney in 2007, in interview after release of IPCC AR4

“I think there’s an emerging consensus that we do have global warming. ... Where there does not appear to be a consensus...is the extent to which that’s part of a normal cycle versus the extent to which it’s caused by man, greenhouse gases, etc.”

Emphasizing scientific uncertainty, alleging lack of scientific consensus, was official Republican party policy

THE ENVIRONMENT: A CLEANER, SAFER, HEALTHIER AMERICA

The core of the Democrat argument depends on the belief that "Washington regulations" represent the best way to preserve the environment. We don't agree.

- 1) First, assure your audience that you are committed to "preserving and protecting" the environment, but that "it can be done more wisely and effectively." (Absolutely do not raise economic arguments first.) Tell them a personal story from your life. Since many Americans believe Republicans do not care about the environment, you will never convince people to accept your ideas until you confront this suspicion and put it to rest.
- 2) Provide specific examples of federal bureaucrats failing to meet their responsibilities to protect the environment. Do not attack the principles behind existing legislation. Focus instead on the way it is enforced or carried out, and use rhetorical questions.
- 3) Your plan must be put in terms of the future, not the past or present. We are carrying forward a legacy, yes, but we are trying to make things even better for the future. The environment is an area in which people expect progress, and when they do not see progress being made, they get frustrated.
- 4) The three words Americans are looking for in an environmental policy, they are "safer," "cleaner," and "healthier." Two words that summarize what Americans are expecting from regulators and agencies are "accountability" and "responsibility."
- 5) Stay away from "risk assessment," "cost-benefit analysis," and the other traditional environmental terminology used by industry and corporations. Your constituents don't know what those terms mean, and they will then assume that you are pro-business.
- 6) If you must use the economic argument, stress that you are seeking "a fair balance" between the environment and the economy. Be prepared to specify and quantify the jobs lost because of needless, excessive or redundant regulations.
- 7) Describe the limited role for Washington. We must thoroughly review the environmental regulations already in place, decide which ones we still need, identify those which no longer make sense, and make sure we don't add any unnecessary rules. Washington should disclose the expected cost of current and all new environmental regulations. The public has a right to know.
- 8) Emphasize common sense. In making regulatory decisions, we should use best estimates and realistic assumptions, not the worst-case scenarios advanced by environmental extremists.

2003, Frank Luntz, Republican strategist, advised candidates to use phrase "climate change" rather than "global warming"

"Climate Change is a lot less frightening than global warming"

“Winning the global warming debate”

WINNING THE GLOBAL WARMING DEBATE – AN OVERVIEW

Please keep in mind the following communication recommendations as you address global warming in general, particularly as Democrats and opinion leaders attack President Bush over Kyoto.

1. *The scientific debate remains open.* Voters believe that there is *no consensus* about global warming within the scientific community. Should the public come to believe that the scientific issues are settled, their views about global warming will change accordingly. Therefore, *you need to continue to make the lack of scientific certainty a primary issue in the debate*, and defer to scientists and other experts in the field.
2. *Americans want a free and open discussion.* Even though Democrats savaged President Bush for formally withdrawing from the Kyoto accord, the truth is that none of them would have actually voted to ratify the treaty, and they were all glad to see it die. Emphasize the importance of “*acting only with all the facts in hand*” and “*making the right decision, not the quick decision.*”
3. *Technology and innovation are the key in arguments on both sides.* Global warming alarmists use American superiority in technology and innovation quite effectively in responding to accusations that international agreements such as the Kyoto accord could cost the United States billions. Rather than condemning corporate America the way most environmentalists have done in the past, they attack their us for lacking faith in our collective ability to meet any economic challenges presented by environmental changes we make. This should be our argument. *We need to emphasize how voluntary innovation and experimentation are preferable to bureaucratic or international intervention and regulation.*
4. *The “international fairness” issue is the emotional home run.* Given the chance, Americans will demand that all nations be part of any international global warming treaty. Nations such as China, Mexico and India would have to sign such an agreement for the majority of Americans to support it.
5. *The economic argument should be secondary.* Many of you will want to focus on the higher prices and lost jobs that would result from complying with Kyoto, but you can do better. Yes, when put in specific terms (food and fuel prices, for example) on an individual-by-individual basis, this argument does resonate. Yes, the fact that Kyoto would hurt the economic well being of seniors and the poor is of particular concern. However, the economic argument is less effective than each of the arguments listed above.

Emphasize scientific uncertainty
Insist there is no consensus

“The scientific debate remains open. Voters believe that there is **no consensus** about global warming within the scientific community. Should the public come to believe that the scientific issues are settled, their views about global warming will change accordingly. Therefore *you need to continue to make the lack of scientific certainty a primary issue in the debate...*

Was the scientific debate still open? No.

“Human activities...are modifying the concentration of atmospheric constituents...that absorb or scatter radiant energy. [M]ost of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations.”

--IPCC, Climate Change 2001,
Impacts, Adaptation and Vulnerability, p. 21.

In fact, the science had coalesced even earlier

There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities.

The SAR concluded: "The balance of evidence suggests a discernible human influence on global climate". That report also noted that the anthropogenic signal was still emerging from the background of natural climate variability. Since the SAR, progress has been made in reducing uncertainty, particularly with respect to distinguishing and quantifying the magnitude of responses to different external influences. Although many of the sources of uncertainty identified in the SAR still remain to some degree, new evidence and improved understanding support an updated conclusion.

- There is a longer and more closely scrutinised temperature record and new model estimates of variability. The warming over the past 100 years is very unlikely⁷ to be due to internal variability alone, as estimated by current models. Reconstructions of climate data for the past 1,000 years (Figure 1b) also indicate that this warming was unusual and is unlikely⁷ to be entirely natural in origin.
- There are new estimates of the climate response to natural and anthropogenic forcing, and new detection techniques have been applied. Detection and attribution studies consistently find evidence for an anthropogenic signal in the climate record of the last 35 to 50 years.
- Simulations of the response to natural forcings alone (i.e., the response to variability in solar irradiance and volcanic eruptions) do not explain the warming in the second half of the 20th century (see for example Figure 4a). However, they indicate that natural forcings may have contributed to the observed warming in the first half of the 20th century.
- The warming over the last 50 years due to anthropogenic greenhouse gases can be identified despite uncertainties in forcing due to anthropogenic sulphate aerosol and natural factors (volcanoes and solar irradiance). The anthropogenic sulphate aerosol forcing, while uncertain, is negative over this period and therefore cannot explain the warming. Changes in natural forcing during most of this period are also estimated to be negative and are unlikely⁷ to explain the warming.

- Detection and attribution studies comparing model simulated changes with the observed record can now take into account uncertainty in the magnitude of modelled response to external forcing, in particular that due to uncertainty in climate sensitivity.
- Most of these studies find that, over the last 50 years, the estimated rate and magnitude of warming due to increasing concentrations of greenhouse gases alone are comparable with, or larger than, the observed warming. Furthermore, most model estimates that take into account both greenhouse gases and sulphate aerosols are consistent with observations over this period.
- The best agreement between model simulations and observations over the last 140 years has been found when all the above anthropogenic and natural forcing factors are combined, as shown in Figure 4c. These results show that the forcings included are sufficient to explain the observed changes, but do not exclude the possibility that other forcings may also have contributed.

In the light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the last 50 years is likely⁷ to have been due to the increase in greenhouse gas concentrations.

Furthermore, it is very likely⁷ that the 20th century warming has contributed significantly to the observed sea level rise, through thermal expansion of sea water and widespread loss of land ice. Within present uncertainties, observations and models are both consistent with a lack of significant acceleration of sea level rise during the 20th century.

IPCC 1995: Second Assessment Report

“The balance of evidence suggests a discernible human impact on global climate.”

The Scientific Consensus on Climate Change

Naomi Oreskes

Policy-makers and the media, particularly in the United States, frequently assert that climate science is highly uncertain. Some have used this as an argument against adopting strong measures to reduce greenhouse gas emissions. For example, while discussing a major U.S. Environmental Protection Agency report on the risks of climate change, then-EPA administrator Christine Whitman argued, "As [the report] went through review, there was less consensus on the science and conclusions on climate change" (1). Some corporations whose revenues might be adversely affected by controls on carbon dioxide emissions have also alleged major uncertainties in the science (2). Such statements suggest that there might be substantive disagreement in the scientific community about the reality of anthropogenic climate change. This is not the case.

The scientific consensus is clearly expressed in the reports of the Intergovernmental Panel on Climate Change (IPCC). Created in 1988 by the World Meteorological Organization and the United Nations Environmental Programme, IPCC's purpose is to evaluate the state of climate science as a basis for informed policy action, primarily on the basis of peer-reviewed and published scientific literature (3). In its most recent assessment, IPCC states unequivocally that the consensus of scientific opinion is that Earth's climate is being affected by human activities: "Human activities ... are modifying the concentration of atmospheric constituents ... that absorb or scatter radiant energy. ... [M]ost of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations" [p. 21 in (4)].

IPCC is not alone in its conclusions. In recent years, all major scientific bodies in the United States whose members' expertise bears directly on the matter have issued similar statements. For example, the National

Academy of Sciences report, *Climate Change Science: An Analysis of Some Key Questions*, begins: "Greenhouse gases are accumulating in Earth's atmosphere as a result of human activities, causing surface air temperatures and subsurface ocean temperatures to rise" [p. 1 in (5)]. The report explicitly asks whether the IPCC assessment is a fair summary of professional scientific thinking, and answers yes: "The IPCC's conclusion that most of the observed warming of the last 50 years is likely to have been due to the increase in greenhouse gas concentrations accurately reflects the current thinking of the scientific community on this issue" [p. 3 in (5)].

Others agree. The American Meteorological Society (6), the American Geophysical Union (7), and the American Association for the Advancement of Science (AAAS) all have issued statements in recent years concluding that the evidence for human modification of climate is compelling (8).

The drafting of such reports and statements involves many opportunities for comment, criticism, and revision, and it is not likely that they would diverge greatly from the opinions of the societies' members. Nevertheless, they might downplay legitimate dissenting opinions. That hypothesis was tested by analyzing 928 abstracts, published in refereed scientific journals between 1993 and 2003, and listed in the ISI database with the keywords "climate change" (9).

The 928 papers were divided into six categories: explicit endorsement of the consensus position, evaluation of impacts, mitigation proposals, methods, paleoclimate analysis, and rejection of the consensus position. Of all the papers, 75% fell into the first three categories, either explicitly or implicitly accepting the consensus view; 25% dealt with methods or paleoclimate, taking no position on current anthropogenic climate change. Remarkably, none of the papers disagreed with the consensus position.

Admittedly, authors evaluating impacts, developing methods, or studying paleoclimatic change might believe that current

This year's essay series highlights the benefits that scientists, science, and technology have brought to society throughout history.

climate change is natural. However, none of these papers argued that point.

This analysis shows that scientists publishing in the peer-reviewed literature agree with IPCC, the National Academy of Sciences, and the public statements of their professional societies. Politicians, economists, journalists, and others may have the impression of confusion, disagreement, or discord among climate scientists, but that impression is incorrect.

The scientific consensus might, of course, be wrong. If the history of science teaches anything, it is humility, and no one can be faulted for failing to act on what is not known. But our grandchildren will surely blame us if they find that we understood the reality of anthropogenic climate change and failed to do anything about it.

Many details about climate interactions are not well understood, and there are ample grounds for continued research to provide a better basis for understanding climate dynamics. The question of what to do about climate change is also still open. But there is a scientific consensus on the reality of anthropogenic climate change. Climate scientists have repeatedly tried to make this clear. It is time for the rest of us to listen.

References and Notes

1. A. C. Revkin, K. Q. Seelye, *New York Times*, 19 June 2003, A1.
2. S. van den Hove, M. Le Manstrel, H.-C. de Bettignies, *Climate Policy* 2 [1], 3 (2003).
3. See www.ipcc.ch/about/about.htm.
4. J. J. McCarthy et al., Eds., *Climate Change 2001: Impacts, Adaptation, and Vulnerability* (Cambridge Univ. Press, Cambridge, 2001).
5. National Academy of Sciences Committee on the Science of Climate Change, *Climate Change Science: An Analysis of Some Key Questions* (National Academy Press, Washington, DC, 2001).
6. American Meteorological Society, *Bull. Am. Meteorol. Soc.* 84, 508 (2003).
7. American Geophysical Union, *Eos* 84 [51], 574 (2003).
8. See www.ourplanet.com/aaas/pages/atmos02.html.
9. The first year for which the database consistently published abstracts was 1993. Some abstracts were deleted from our analysis because, although the authors had put "climate change" in their key words, the paper was not about climate change.
10. This essay is excerpted from the 2004 George Sarton Memorial Lecture, "Consensus in science: How do we know we're not wrong," presented at the AAAS meeting on 13 February 2004. I am grateful to AAAS and the History of Science Society for their support of this lecture. I thank my research assistants S. Luit and G. Law; and to D. C. Agnew, K. Belitz, J. R. Fleming, M. T. Grana, H. Leffert, and R. C. J. Somerville for helpful discussions.

10.1126/science.1103618

- My historical analysis of published scientific literature: Scientists had a consensus on reality of human-caused climate change by early 1990s
- This result surprised many people, but it shouldn't have.

U.N. Framework Convention on Climate Change (1992)



Based on early warnings of IPCC and other scientific groups.

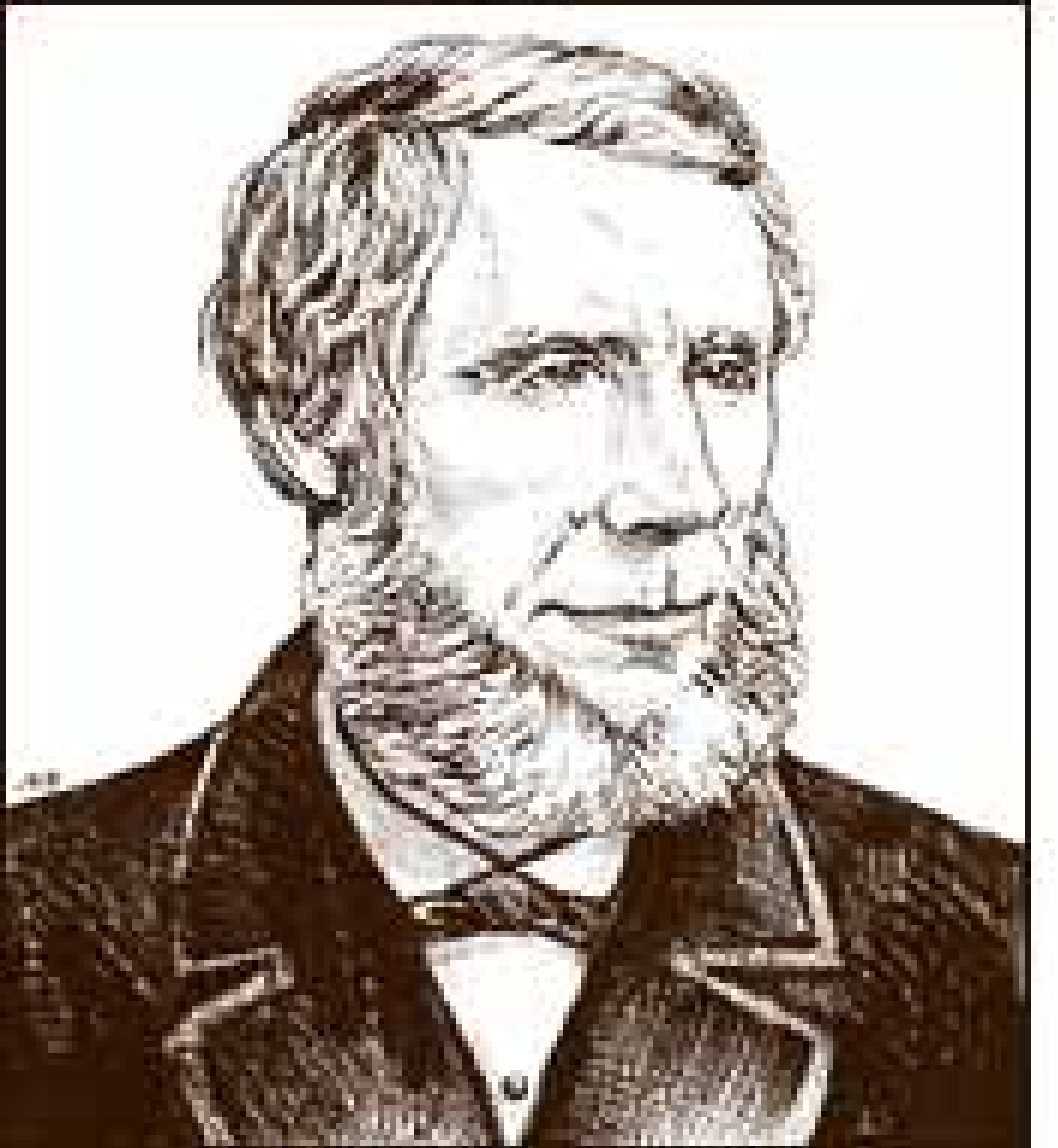
President George H.W. Bush called on world leaders to translate the written document into "concrete action to protect the planet."

What happened?
Why didn't we take those concrete
steps?

And why did Republican leadership
in US turn against climate science?

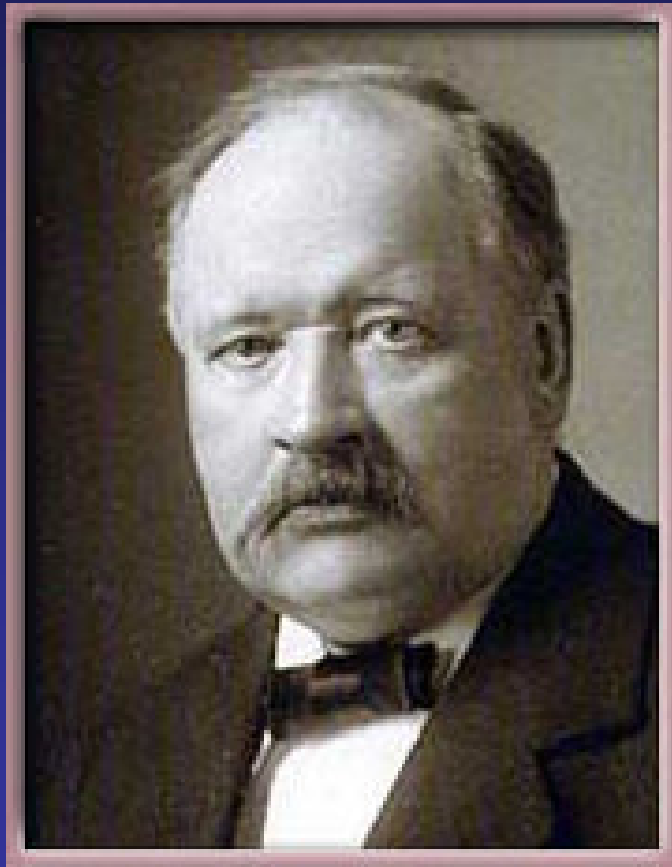
- Very brief history of evolution of climate science
- Recount the emergence of a political challenge to that science
- Ideologically motivated, rooted in free market fundamentalism
- Based on selling “scientific uncertainty” to argue that action at best premature, at worst entirely unnecessary

Carbon Dioxide as Greenhouse Gas



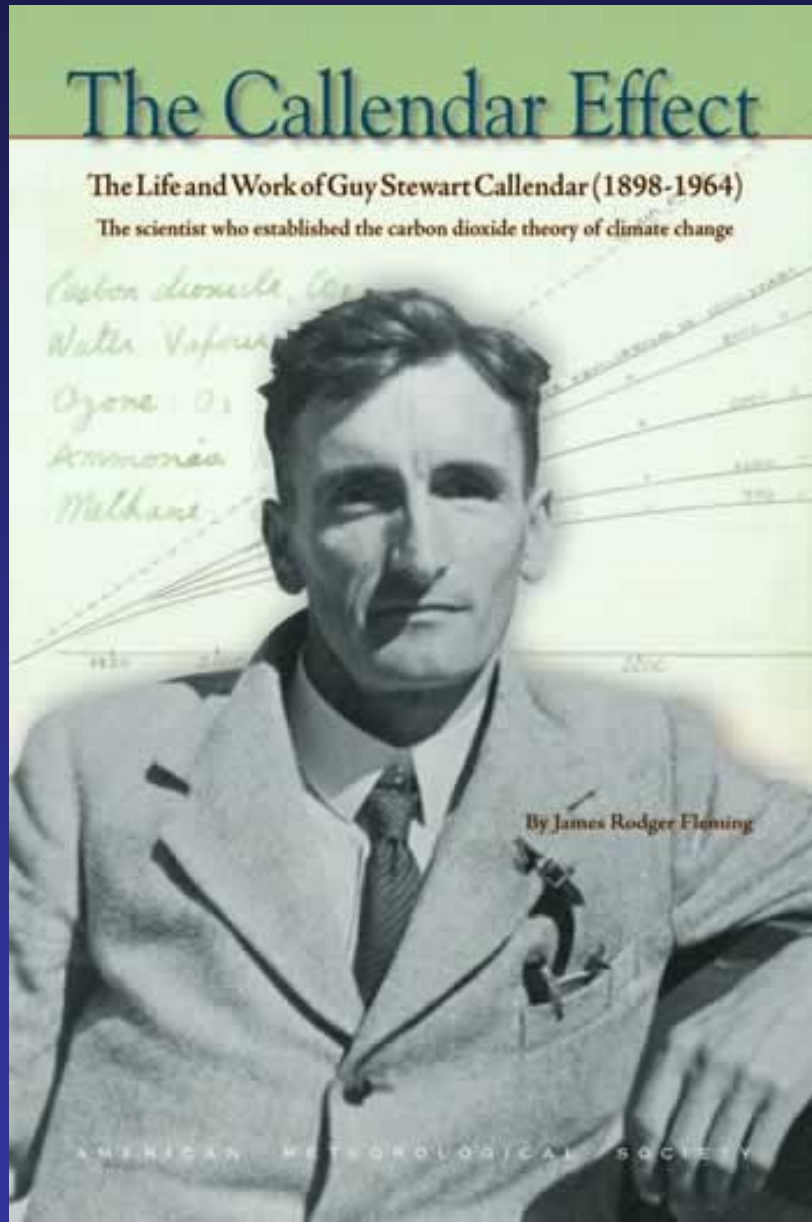
- John Tyndall (1820-1893)
- Established “greenhouse” properties of carbon dioxide, water in 1850s

1900s: Svante Arrhenius suggested that increased atmospheric CO₂ from burning fossil fuels *could* warm Earth



- Early calculations of effect of doubling CO₂:
 - 1.5 -4.5 ° C.
- Swede.. Thought global warming would be a good thing...

First empirical evidence of both increased CO₂ and warming detected in 1930s by G.S. Callendar



- Callendar argued that increase in CO₂ was *already* occurring (in the 1930s).
- *Quarterly J. Royal Meteorological Society* 64: 223 (1938) suggested that temperature might be increasing, too.
- Biography by J. R. Fleming

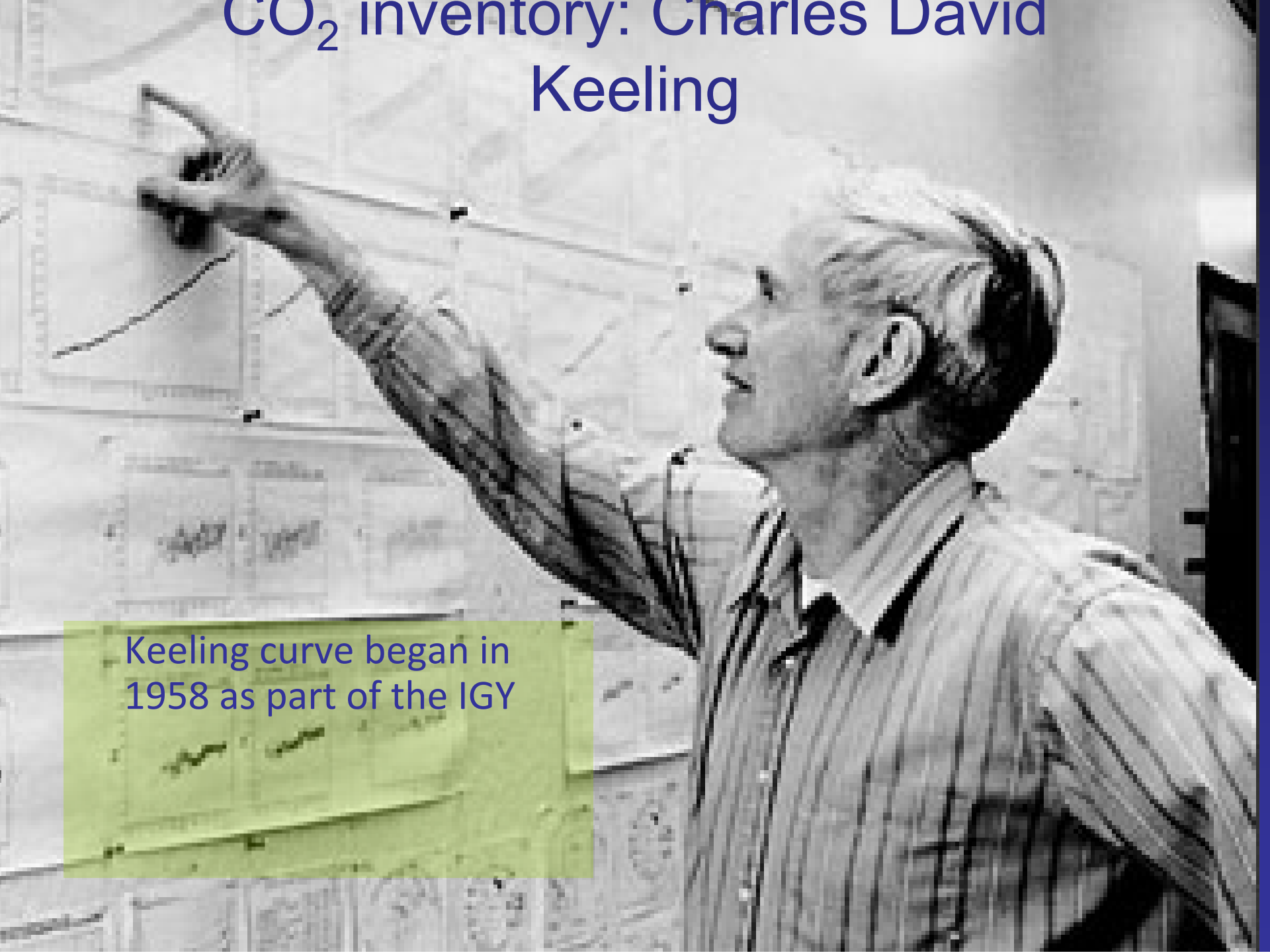
Suess and Revelle, *Tellus*, 1957



Mankind is performing “a great geophysical experiment...”

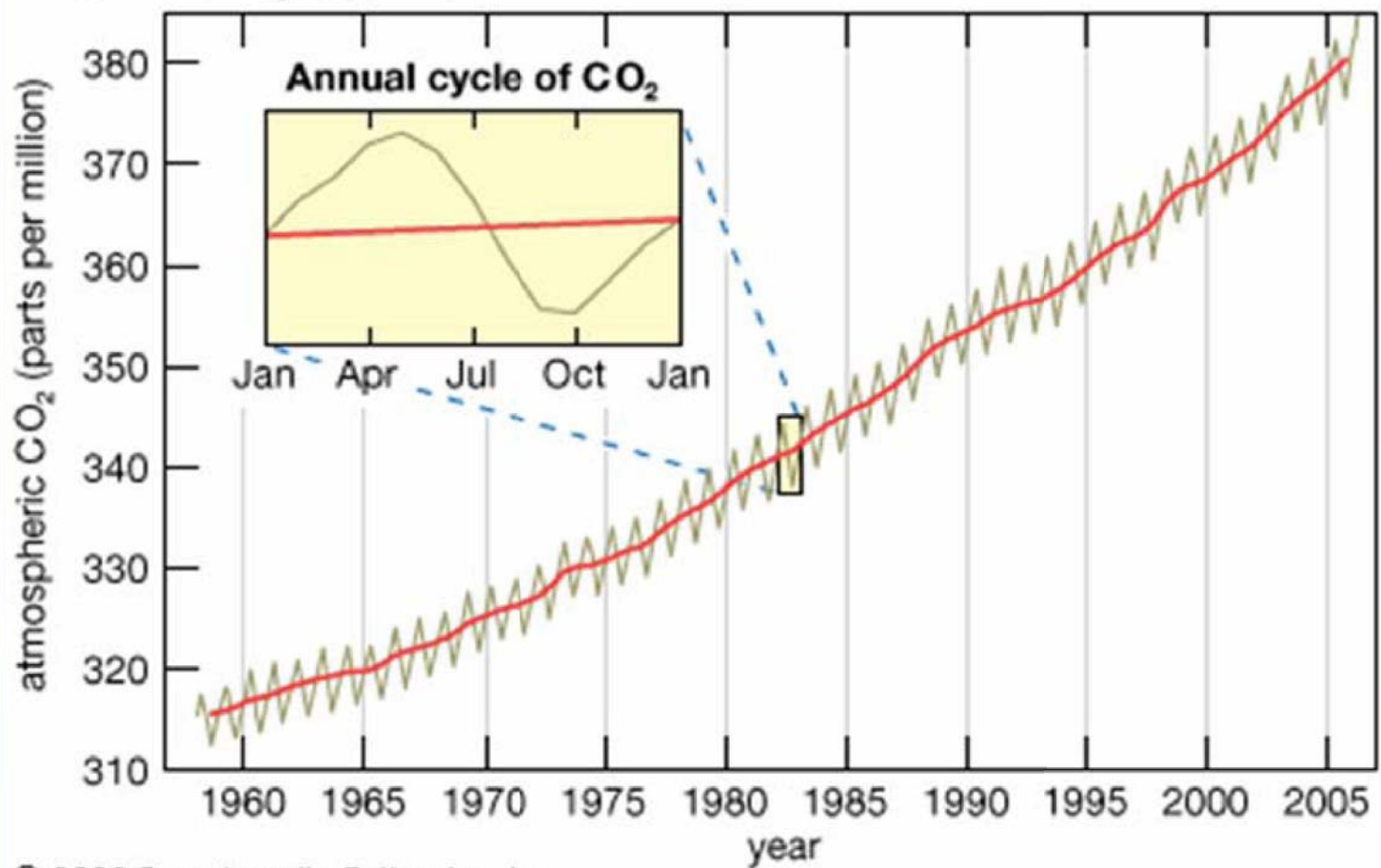
Similar argument made in Europe by Bert Bolin, later founder of IPCC

CO₂ inventory: Charles David Keeling

A black and white photograph of Charles David Keeling, a man with short, light-colored hair, wearing a striped shirt. He is standing in front of a wall covered with various graphs and papers. He is pointing his right index finger towards a graph on the wall. The graph he is pointing at shows a curve that starts at a low point and rises steadily. Other graphs are visible in the background, some showing more complex data patterns. A green rectangular box is overlaid on the bottom left of the image, containing text.

Keeling curve began in 1958 as part of the IGY

The Keeling Curve



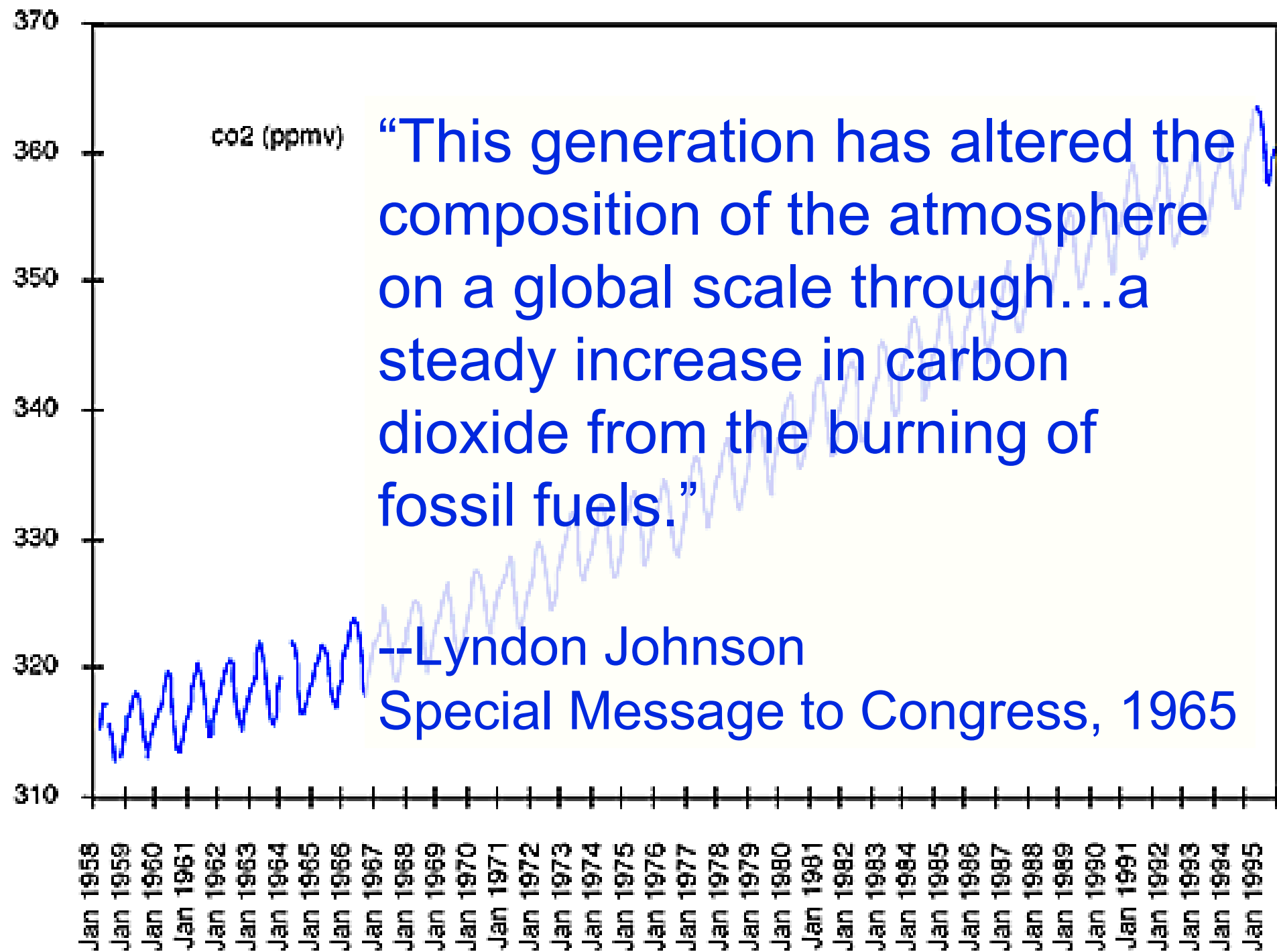
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1965: President's Science Advisory Committee, Board on Environmental Pollution

Committee led by Revelle and Keeling.

“....by the year 2000 there will be about 25% more CO₂ in our atmosphere than at present [and] this will modify the heat balance of the atmosphere to such an extent that marked changes in climate...could occur.”

- *Restoring the Quality of Our Environment*, Report of the Environmental Pollution Panel, Presidents Science Advisory Committee, The White House, December 1965, on p. 9



With the rise of computer modeling, there was soon a strong consensus among scientific experts that, given the steady rise of CO₂ that Keeling had demonstrated, sooner or later global warming would occur.

U.S. National Academy of Sciences,
1979:

“A plethora of studies from diverse sources indicates a consensus that climate changes will result from man’s combustion of fossil fuels and changes in land use.”

National Academy of Sciences Archives, An Evaluation of the Evidence for CO₂-Induced Climate Change, Assembly of Mathematical and Physical Sciences, Climate Research Board, Study Group on Carbon Dioxide, 1979, Film Label: CO₂ and Climate Change: Ad Hoc: General

Big question was when?

Most scientists thought “will result”
meant by the year 2000, or later...

A few mavericks suggested change
might already be underway...

1981, John Perry, National Academy of Sciences Climate Research Board

“Physically a doubling of CO₂ is no magic threshold. If we have good reason to believe that a 100 per cent increase in carbon dioxide will produce significant impacts on climate, then we must have equally good reason to suspect that even the small increase we have already produced may have subtly altered our climate...”

“Thus climate change is not a matter for the next century, we are most probably doing it right now.”

John Perry, “Energy and Climate: Today’s Problem, Not Tomorrow’s” *Climate Change* 3 (1981): 223-225, on 223-224

Was Perry right? Were changes already happening?

Roger Revelle (1982) *Scientific American*,
“Carbon Dioxide and World Climate.”

“Mathematical models of the world’s climate indicate that the answer is probably yes, but an unambiguous climate signal has not yet been detected.”

Six years later,
NASA Climate
modeler James
Hansen and his
team concluded
that the signal *had*
been detected.

Global Climate Changes as Forecast by Goddard Institute for Space Studies Three-Dimensional Model

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We use a three-dimensional climate model, the Goddard Institute for Space Studies (GISS) model II with 8° by 10° horizontal resolution, to simulate the global climate effects of time-dependent variations of atmospheric trace gases and aerosols. Horizontal heat transport by the ocean is fixed at values estimated for today's climate, and the uptake of heat perturbations by the ocean beneath the mixed layer is approximated as vertical diffusion. We make a 100-year control run and perform experiments for three scenarios of atmospheric composition. These experiments begin in 1958 and include measured or estimated changes in atmospheric CO_2 , CH_4 , N_2O , chlorofluorocarbons (CFCs) and stratospheric aerosols for the period from 1958 to the present. Scenario A assumes continued exponential trace gas growth, scenario B assumes a reduced linear growth of trace gases, and scenario C assumes a rapid curtailment of trace gas emissions such that the net climate forcing ceases to increase after the year 2000. Principal results from the experiments are as follows: (1) Global warming to the level attained at the peak of the current interglacial and the previous interglacial occurs in all three scenarios; however, there are dramatic differences in the levels of future warming, depending on trace gas growth. (2) The greenhouse warming should be clearly identifiable in the 1990s; the global warming within the next several years is predicted to reach and maintain a level at least three standard deviations above the climatology of the 1950s. (3) Regions where an unambiguous warming appears earliest are low-latitude oceans, China and interior areas in Asia, and ocean areas near Antarctica and the north pole; aspects of the spatial and temporal distribution of predicted warming are clearly model-dependent, implying the possibility of model discrimination by the 1990s and thus improved predictions, if appropriate observations are acquired. (4) The temperature changes are sufficiently large to have major impacts on people and other parts of the biosphere, as shown by computed changes in the frequency of extreme events and by comparison with previous climate trends. (5) The model results suggest some near-term regional climate variations, despite the fixed ocean heat transport which suppresses many possible regional climate fluctuations; for example, during the late 1980s and in the 1990s there is a tendency for greater than average warming in the southeastern and central United States and relatively cooler conditions or less than average warming in the western United States and much of Europe. Principal uncertainties in the predictions involve the equilibrium sensitivity of the model to climate forcing, the assumptions regarding heat uptake and transport by the ocean, and the omission of other less-certain climate forcings.

1. INTRODUCTION

Studies of the climate impact of increasing atmospheric CO_2 have been made by means of experiments with three-dimensional (3D) climate models in which the amount of CO_2 was instantaneously doubled or quadrupled, with the model then integrated forward in time to a new steady state [Manabe and Wetherald, 1975; Manabe and Stouffer, 1980; Hansen *et al.*, 1984; Washington and Meehl, 1984; Wilson and Mitchell, 1987]. These models all yield a large climate impact at equilibrium for doubled CO_2 , with global mean warming of surface air between about 2° and 5°C .

However, observations show that CO_2 is increasing gradually: its abundance was 315 parts per million by volume (ppmv) in 1958 when Keeling initiated accurate measurements and is now about 345 ppmv, with current mean annual increments of about 1.5 ppmv [Keeling *et al.*, 1982]. Also there are at least two other known global radiative forcings of comparable magnitude: growth of several other trace gases [Wang *et al.*, 1976; Lacis *et al.*, 1981; Ramanathan *et al.*, 1985] and variations in stratospheric aerosols due to

volcanic eruptions [Lamb, 1970; Mitchell, 1970; Schneider and Mass, 1975; Pollack *et al.*, 1976; Hansen *et al.*, 1978, 1980; Rebock, 1981]. Still other radiative forcings, such as changes of solar irradiance, tropospheric aerosols, and land surface properties, may also be significant, but quantitative information is insufficient to define the trends of these forcings over the past several decades.

In this paper we study the response of a 3D global climate model to realistic rates of change of radiative forcing mechanisms. The transient response of the climate system on decadal time scales depends crucially on the response of the ocean, for which adequate understanding and dynamical models are not available. Our procedure is to use simple assumptions about ocean heat transport. Specifically we assume that during the next few decades the rate and pattern of horizontal ocean heat transport will remain unchanged and the rate of heat uptake by the ocean beneath the mixed layer can be approximated by diffusive mixing of heat perturbations. This "surprise-free" representation of the ocean provides a first estimate of the global transient climate response which can be compared both to observations and to future simulations developed with a dynamically interactive ocean. We include in this paper a description of the experiments and an analysis of computed temperature changes; other computed quantities, such as

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Paper number 8DO569.
0148-0227/88/008D-9341\$05.00

1988 James Hansen declares 99% certain that climate change now detectable.



It was this emerging (and disturbing)
evidence that had led to the creation
of the IPCC in 1988...

U.S. National Energy Policy Act (1988)

“...to establish a national energy policy
[to] reduce the generation of carbon
dioxide and trace gases as quickly as
is feasible in order to slow the pace
and degree of atmospheric
warming....”

“The issue of an overheating world has suddenly moved to the forefront of public concern.”

The New York Times

August 23, 1988

Yet, at the same time as the scientific understanding was coalescing, so was a campaign to cast doubt upon it...

Campaign focused on claim that the science
was unsettled, and therefore it was
premature to act...

The origins of that claim can be traced back to
a small handful of people.

Today: Attacks on climate science from many quarters

- One of the most important for a long period of time, going back to the late 1980s, is the George C. Marshall Institute.
- A think tank in Washington, D.C.
- For many years, denied reality of global warming, or insisted that, if there were warming, it was not caused by human activities.


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Climate Change

Begun in 1989, the Institute's program involves a critical examination of the scientific basis for global climate change policy. The intent is to promote a clear understanding of the state of climate science and assess the implications for public policy. A major component of this effort is communicating the findings to policy makers, the media and the public policy community.

For about a decade, there has been an ongoing debate about the contribution of human activities to the global warming of the past century and how they may contribute to warming that may occur during the 21st century. Too often this debate has been contentious. International efforts to reach agreement on inferences about human influence on the climate system that can be drawn from science and policy prescriptions for addressing the climate change risk have been controversial as well.

Wise, effective climate policy flows from a sound scientific foundation and a clear understanding of what science does and does not tell us about human influence and about courses of action to manage risk. Many of the temperature data and computer models used to predict climate change are themselves uncertain. Reducing these many uncertainties requires a significant shift in the way climate change research is carried out in the U.S. and elsewhere.

Are calls about the uncertainty in the state of scientific knowledge a call for no action? Nothing could be further from the truth. The message to policy makers is not to delay actions until uncertainties are reduced. Rather, actions should flow from the state of knowledge, should be related to a long-term strategy and objectives and should be capable of being adjusted – one way or the other – as the understanding of human influence improves. There is a sufficient basis for action because the climate change risk is real. Yet it is equally true that actions must not be predicated on speculative images of an apocalyptic vision of life in the near future.

Shattered Consensus: The True State of Global Warming Four Authors Discuss Their

News

[Global-Warming Skeptics Cite Being 'Treated like a Pariah'](#)

Scientists skeptical of climate-change theories say they are increasingly coming under attack -- treatment that may make other analysts less likely to present contrarian views about global warming.

[The Politics of Global Warming](#)

Timothy Ball, a Canadian climatologist, argues that the widely propagated "fact" that humans are contributing to global warming is the "greatest deception in the history of science."

[Rapid Changes in Ice Discharge from Greenland Outlet Glaciers](#)

Scientists report that two of the largest glaciers have suddenly slowed, bringing the rate of melting last year down to near the previous rate.

[The Original Denier: Into The Cold](#)

Most scientists who are labelled as "deniers" for their views on global warming don't embrace this role. Dr. Richard Lindzen is an exception.

[Satellite Data Vital To UN](#)

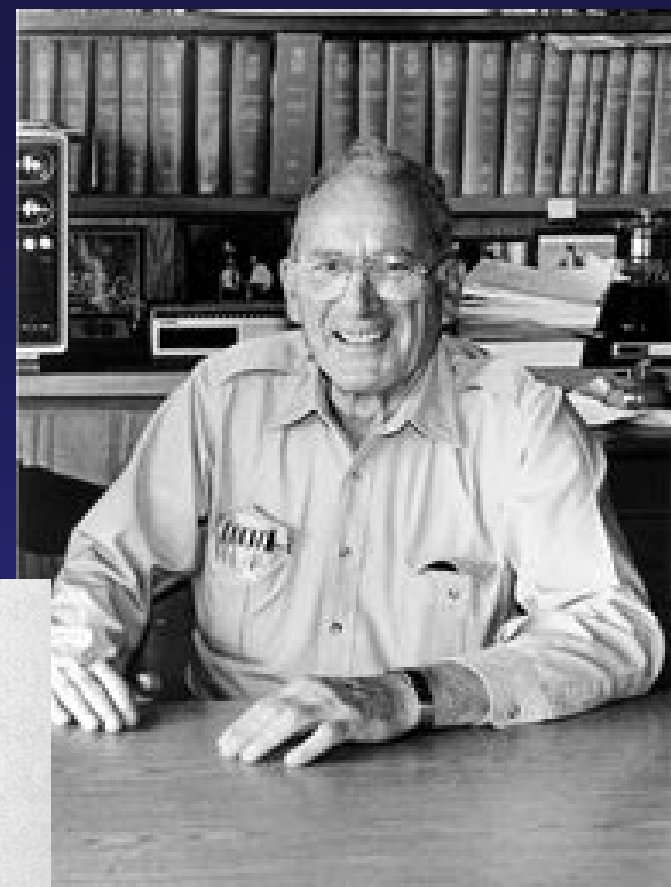
As recently as 2007, Institute quoted Timothy Ball, a Canadian climatologist, arguing that the widely propagated "fact" that humans are contributing to global warming is the "greatest deception in the history of science."

Where did the Marshall
Institute come from?

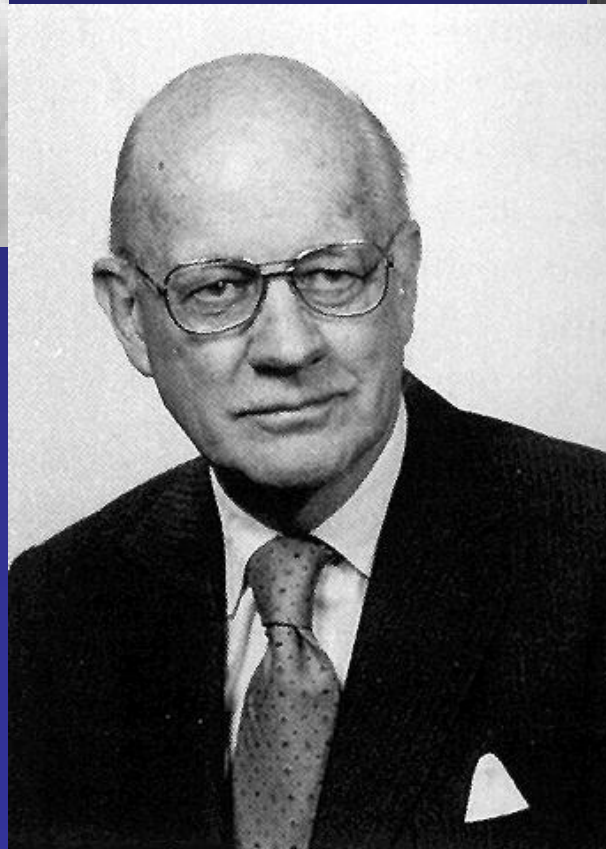
Why have they promoted doubt
about climate science?



Frederick Seitz,
President of NAS,
Rockefeller
University, and
Consultant to R J
Reynolds Tobacco



William Nierenberg,
Nuclear physicist and
long-time Director of
Scripps Institution of
Oceanography



Robert Jastrow,
Astrophysicist, Head of
Goddard Institute for
Space Studies.

Early 1980s, working together on an advisory panel to the Reagan Administration on SDI (Strategic Defense Initiative, or “Star Wars”)

1984: Founded the George C. Marshall Institute to defend SDI against scientists’ boycott

Most scientists said it
wasn't feasible, and if it were it would be
destabilizing.

Departure from long-established doctrine of
Mutual Assured Destruction.

With a missile shield, one side might be tempted
to launch a first strike.

6500 scientists and engineers signed petition,
declared boycott of program funds
(historically unprecedented)

Contra vast majority of their technical
colleagues, Jastrow, Seitz and Nierenberg
insisted that SDI was feasible, necessary, and
urgent.

1984-1989:

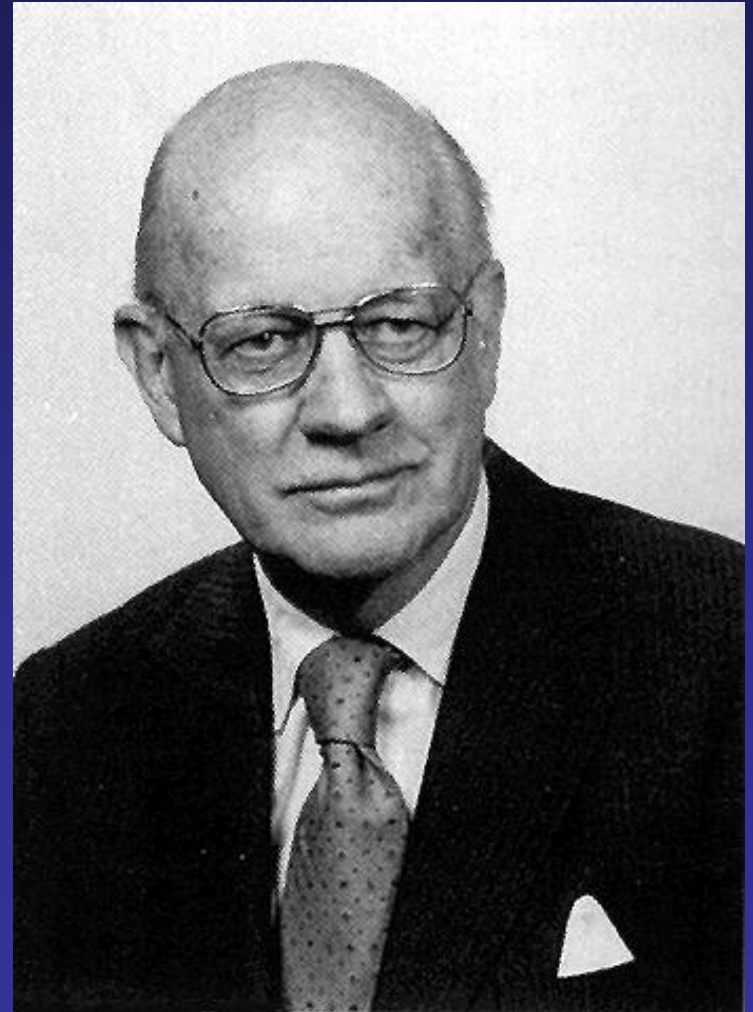
Jastrow, Seitz and Nierenberg
worked to defend SDI by promoting
an alarming view of Soviet strength
and a frightening picture of
American weakness.

1987, Jastrow published in *National Review*, insisting that if we did not act quickly to improve our nuclear capability, Soviets would overtake us, and be able dictate terms.



At time, Seitz was working as consultant to R.J. Reynolds Corporation

- Principle strategy of tobacco industry to defend its product was “doubt-mongering”
- To insist that the science was unsettled
- Premature to act to control tobacco use.



1989, these two strands merged

- Cold war ended, Soviet enemy was gone.
- Our Cold Warriors might have rested content.
- Found a new enemy: Environmental “extremism”
- They applied the “tobacco strategy”—to insist that the science was unsettled, premature for governments to act to control threat

- “Doubt is our product,” ran the infamous memo written by one tobacco industry executive in 1969, “‘since it is the best means of competing with the 'body of fact' that exists in the minds of the general public.”

- *Smoking and Health Proposal*, 1969, BN: 680561778, Legacy Tobacco Documents Library, <http://legacy.library.ucsf.edu/tid/nvs40f00>

These scientists supplied it

Harms of tobacco
(both direct and second-hand)

Reality of acid rain

Severity of ozone hole

Human causes of global warming

(DDT)

The scientists denied the severity
of all these problems

In every case, insisted that the science was
too uncertain to justify government action

How they did this, you'll have to
read the book

Why they did it.

Not for money...
rather, driven largely by ideology:

Free Market Fundamentalism

- Modern neo-liberalism: focused on de-regulation, “releasing” the “magic of the marketplace.”
- Came to prominence in early 1980s: Margaret Thatcher, Ronald Reagan.
- Continued through 1990s led by Bill Clinton and Tony Blair: “Washington Consensus” to foster growth through market deregulation.
- Intellectual roots in ideology of two key thinkers:
 - Milton Friedman, *Capitalism and Freedom* (1962)
 - Friedrich Hayek, *Road to Serfdom* (1944)

- Capitalism and Freedom (1962)

Milton Friedman:

- Civic freedom and free markets are inextricably linked: to control markets, states have to control people. Without free markets, we're on the slippery slope to tyranny...

- Road to Serfdom (1944)

Friedrich Hayek:

- Passionate opponent not only of Soviet-style communism, but of Western European social democracy, fearing that it would put us on the "road to serfdom."

Contrarians took this argument one step further:

Environmentalism →
slippery slope to socialism

Because environmentalists invariably argued for government regulation, and from regulation of acid rain or second-hand smoke, it was only a small step towards government control, generally.

Idea articulated in several of
their writings, but most clearly
by a fourth scientist...

S Fred Singer, also a Cold War physicist-in fact, a rocket scientist.

Also involved in campaigns to challenge evidence of acid rain, global warming, ozone hole, and harms of tobacco



1979-1985: Seitz had worked for R.J.
Reynolds Tobacco.

Early 1990s, Singer attacked the EPA
to defend second hand smoke

1993:

S. Fred Singer and Kent Jeffrey,
“EPA and the Science of Environmental
Tobacco Smoke”

Published by Alexis de Tocqueville Institute,
with funding from Tobacco Institute

Jeffreys: Lawyer affiliated with the Cato Institute and
the Competitive Enterprise Institute.

EPA had declared second-hand smoke a carcinogen.

Result affirmed by U.S. Surgeon General.

Independent expert panel:

Second-hand smoke responsible for 3000
additional adult cancer deaths per year

150,000-300,000 additional cases of bronchitis and
pneumonia in infants and young children.

Also implicated in increase in SIDS.

Evidence supported by diverse,
independent studies.

Why would a rocket scientist challenge it?

“...if we do not carefully delineate the government’s role in regulating...dangers there is essentially no limit to how much government can ultimately control our lives.”

S. Fred Singer, “EPA and the Science of Environmental Tobacco Smoke” , Alexis de Toqueville Institute, (p. 2)

Suspicion, even allegation, that environmentalists are socialists in disguise

- Environmentalists as 'watermelons'
- George Will: Green tree with red roots
- Senator James Inhofe: (threatened to indict climate scientists for conspiracy to lie to Congress) "liberal conspiracy to bring down global capitalism."

Throughout their writings, contrarians assert that environmentalists—and by implication scientists working on environmental issues—have a hidden agenda.

ably those with hidden agendas of their own—not just to “save the environment” but to change our economic system. The telltale signs are the attack on the corporation, the profit motive, and the new technologies.

Some of these “coercive utopians” are socialists, some are technology-hating Luddites; most have a great desire to regulate—on as large a scale as possible. That’s what makes the CFC/ozone issue so attractive to them. And it showed tellingly at the Hague conference this March—to which the U.S. was not invited. You can perhaps guess why. These geo-eco-politicians actually proposed a new UN agency, aptly named “Globe.” Globe was supposed to invoke and enforce sanctions on nations that did not knuckle under to the environmental dictates of those who knew better. Wow!

Globe didn’t fly—this time round. Here is David Doniger, senior attorney for the activist Natural Resources Defense Council, writing in the National Academy’s *Issues in Science and Technology* in 1988: “[The CFC protocol] serves as a precedent for . . . [protocols on] carbon dioxide and a dozen other trace gases.” So that’s what they are headed for. Doniger fairly chortles when he recounts

*When people ask me whether
the climate is getting warmer
or colder, I generally just answer
'yes.' It all depends on
over what time scale
we average.*

how “hard-liners” and “anti-regulatory elements” in the White House fought a losing battle against tough control on CFCs because they “seemed either to disbelieve the scientific evidence of ozone depletion or to belittle its consequences.”

As one of those hard-liners, I need to explain where I stand and why I am unrepentant in considering any extreme controls on CFCs to be premature. I tried to explain all this in a letter to the editor of *Issues*, but he turned it down. Twice, in fact. So much for open discussion of important scientific and public-policy issues.

I am not against CFC control at all; but look at the poor state of the scientific evidence. The case against CFCs is based on a theory of ozone depletion, plausible but quite incomplete—and certainly not reliable in its quantitative predictions. Doniger himself does a good job of undermining the credibility of the theory—his only “witness for the prosecution.” In his own words:

—“Current models for predicting ozone depletion are inadequate.”

—“A National Academy of Sciences [NAS] report . . . quickly became outdated because of new scientific information.”

He neglects to inform us that during the past decade the NAS results have varied all over the place. To make matters worse for Doniger’s case, evidence is firming up that

volcanoes, and perhaps salt spray and bio-chemical emissions from the oceans, contribute substantially to stratospheric chlorine, and thus dilute the effects of CFCs. And new scientific results, from the laboratory and the stratosphere, are pouring in constantly; the theory has been in a state of flux and is bound to change.

Having impugned the CFC/ozone theory—the only basis for making predictions—Doniger nevertheless insists on immediate draconian measures to control CFC production. Not content with a temporary freeze or a rollback, he argues for a complete phase-out of CFCs—without waiting for better scientific data.

THE STANDARD CFC/ozone theory did not predict the ozone hole, nor can it account for its future course.

According to recent reports, an ozone hole is just about to open in the Arctic—and, by implication, all over the globe. That’s a scary thought—and it has made a great impact on the public as well as on governments. It probably was the main impetus for the Montreal Protocol.

This sudden growth of the AOH may, however, as I mentioned before, simply signal the presence of a triggering mechanism that has nothing to do with the steady increase in CFC concentration. Under this hypothesis, the AOH would not continue to grow as CFCs build up, and could even be ephemeral.

In reaction to my suggestion published in *Eos*, Professor Marcel Nicolet, a distinguished Belgian atmospheric physicist, has reminded us in a note to the same journal of a long-forgotten publication by G. M. B. Dobson, the Oxford professor who started modern ozone observations. Dobson recounts that when the Halley Bay Antarctic station was first set up in 1956, the monthly telegrams showed that “the values in September and October 1956 were about 150 [Dobson] units [50 per cent] lower than expected. . . . In November the ozone values suddenly jumped up to those expected. . . . It was not until a year later, when the same type of annual variation was repeated, that we realized that the early results were indeed correct and that Halley Bay showed a most interesting difference from other parts of the world.”

AS NOTED EARLIER, the Ozone Trends Panel of NASA has not yet released its full report for general review. Yet much political action has already been initiated on the basis just of the announcement. For example, Western nations, principally the UK, are pushing to tighten the Montreal Protocol by completely phasing out most CFCs, instead of just freezing and gradually rolling back CFC production to 50 per cent as agreed to in the protocol.

While the OTP report itself is not available, a parallel report from the Center for Applied Mathematics of Allied-Signal, Inc., was distributed at a UN Ozone Science Meeting at the Hague in October 1988. The Allied study deals with many of the corrections necessary to establish a believable trend. The estimated change in total ozone over the 17 years 1970–86 is somewhat less than the OTP result. But the change shows a surprisingly strong dependence on the choice of time period. A simple explanation may be that the 1970–86 period covers only one and a half so-

“And then there are probably those with hidden agendas of their own—not just to ‘save the environment’ but to change our economic system. Some of these ‘coercive utopians’ are socialists, some are technology-hating Luddites; most have a great desire to regulate—on as large a scale as possible.”

S. Fred Singer (1989) “My Adventures in the Ozone Layer”, 36-37.

U.S. environmental movement has a long history

Origins not in left-wing politics, but in 1920s in
Progressive Republicanism:

Teddy Roosevelt, Gifford Pinchot,
John D. Rockefeller.

1950s -60s: Bipartisan Consensus

When the Wilderness Act of 1964 designated over nine million acres of American lands as “areas where man himself is a visitor and does not remain,”

It passed the U.S. Senate by a vote of 73–12 and the House of Representatives 373–1.

1970s: Environmental Protection Agency created Republican President Richard Nixon

Signed into law key pieces of environmental legislation

- The Clean Air Act Extension
- The Clean Water Act
- Endangered Species Act
- Marine Mammal Protection Act
- The National Environmental Policy Act.

Things began to change in the 1980s...

- When scientific evidence began to reveal serious environmental problems *not* amenable to local solutions
- Acid rain, ozone hole, and global warming :
 - Appeared to demand national and even international cooperation
- Issues emerged just as Reagan administration was arguing for less government, less regulation (and also less internationalism)
- Put Reagan administration (and later the Republican party generally) on collision course with science...

Ronald Reagan may have had a point
about the expansion of the federal
government since the New Deal...

...and some environmentalists may be
socialists....

...but it doesn't mean the *science*
is wrong

It doesn't mean that DDT, acid rain, the ozone hole, and second-hand smoke weren't real problems needing solutions.

In the 1990s, when the U.S. instituted a cap-and-trade system to control acid rain...

...acid emissions fell, electricity prices fell, and people in the mid-west did not find themselves with noticeably less liberty than other U.S. citizens.

(One might note the same about British Columbian carbon tax)

We've learned a few things since 1962

Hayek was *wrong* about the road to serfdom

- Predicted that if Labour came to power in U.K. and instituted social democracy, it would lead to fascism.
- On the contrary, virtually every major western European country after World War II instituted some form of social democracy, and none of them became fascistic.
- Rather, these countries all became more egalitarian, more democratic

Milton Friedman was wrong about an inextricable link between economic and political freedom

- Consider recent histories of Chile and China.
 - In Chile in 1970s, Augusto Pinochet overthrew democratically elected socialist government, and instituted a capitalist dictatorship
 - In China today, we have a previously unimagined form of communistic capitalism (“market authoritarianism”)
- England where capitalism was invented, in the 19th century, prohibited the emigration of skilled workers
- Think about the long history of slavery in the United States

We also know from history (as well as from recent events from Wall Street to the Gulf of Mexico) that free markets *require* sensible regulation and enforcement, both to function as free markets, and to avoid unacceptable costs to bystanders.

“Negative externalities”—costs that accrue to people who did not reap the benefits of those activities

Irony:

- While we have delayed acting on global warming, the problem has gotten worse.
- Many scientists now think we are reaching, or have even passed, key “tipping points” that could lead to true catastrophe, massive human dislocation and suffering...
- Longer we wait, the more we increase the likelihood that we will need intrusive government action to prevent catastrophe.
- By fostering delay, the *Merchants of Doubt* have made it more likely that the very thing they most dreaded will actually occur.

Conclusion


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The New York Times Tuesday, April 13, 2008

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The Editorial Notebook; Mr. Darman and Green Vegetables

By NICHOLAS WADE
Published: May 14, 1996

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SAVE

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LEAD: Richard Darman, director of the Office of Management and Budget, is a delightful scold. Sometimes he needles business leaders, sometimes Congress or environmentalists or opinion makers, but the stiletto is always wrapped in a colorful phrase. In a metaphor-strewn speech at Harvard recently, he accused the usual suspects of having lost confidence in

Richard Darman, director of the Office of Management and Budget, is a delightful scold. Sometimes he needles business leaders, sometimes Congress or environmentalists or opinion makers, but the stiletto is always wrapped in a colorful phrase. In a metaphor-strewn speech at Harvard recently, he accused the usual suspects of having lost confidence in America.

Mr. Darman's bete noire is green. In his view, there are good environmentalists, like his wife and children and the President; and bad environmentalists - they know who they are - who want to manage the global economy, who oppose growth, who fear all risks, and who, under their green masks, are closet socialists. "Americans did not fight and win the wars of the 20th century to make the world safe for green vegetables," Mr. Darman declaimed.

Joining the bad environmentalists in Mr. Darman's doghouse are the America-in-decline theorists who believe America's prime has past and Japan is the new hegemon. What these two groups share, he explains, is an aversion to risk and the values of American Romance. Risk-taking made America great, and in Mr. Darman's view we must commit ourselves to more risk, like "manned missions to Mars and beyond," missions that "symbolize directly what is at the heart of the American Romance."

That's stirring rhetoric but Mr. Darman has surely missed the point about risk. Not all risks are equally worth running: it depends on the reward. Now it's true that a few environmentalists speak as if every hazard were an imminent menace to life, a position that leads quickly to pastoral nomadism. But most seek precautions against real risks: for what happens when such risks are ignored, take a look at the polluted wreckage of Eastern Europe.

Businessmen dislike risk as much as environmentalists. Japanese companies are more adventurous not because they are Romantics like Mr. Darman, but because they face less risk than their American competitors. Their Government, unlike Mr. Darman's, has run its economy so as to provide plentiful capital at low interest rates. Investments look less risky at 3 percent interest than at 9 percent. Japanese companies also reduce risk by


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The New York Times

TECH

nytimes.com/tech



1990: Richard Darman, Director of OMB under President George H.W. Bush:

“Americans did not fight and win the wars of the 20th century to make the world safe for green vegetables.”



But while scientists have been warning us for decades about the real and serious risks, we ignored those warnings.

And we didn't make the world safe, not for polar bears, not for Pacific Islanders...

..and ultimately, not for any of
us, either.

The End.



How do we know it's not the sun?

GHGs v. solar irradiance: different predictions

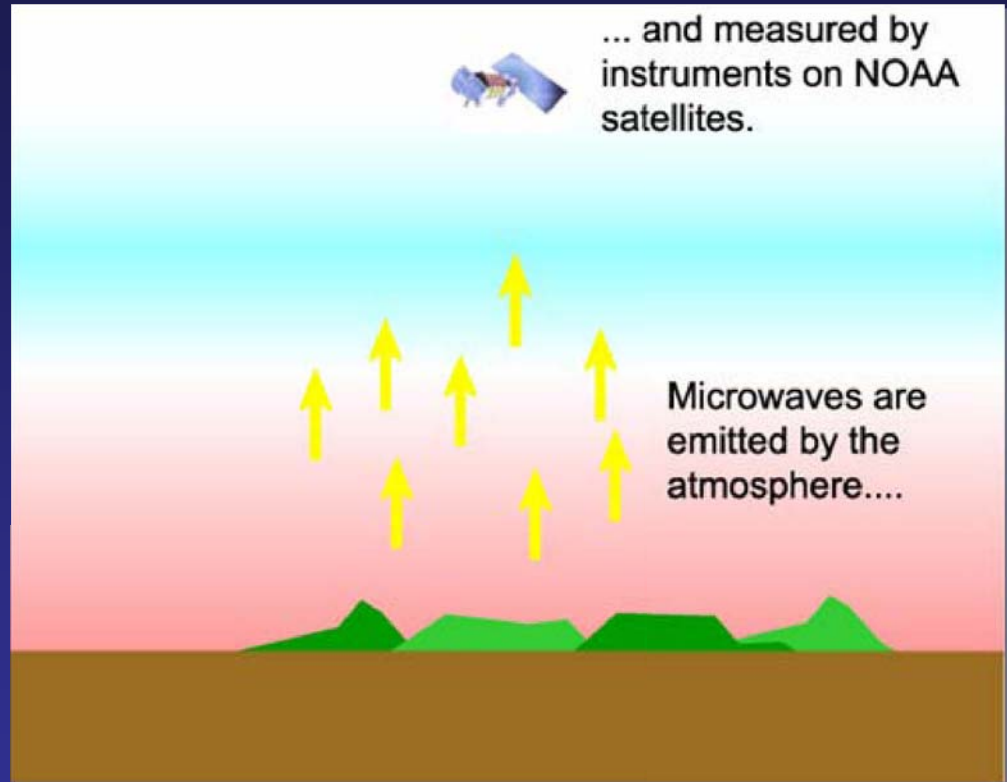
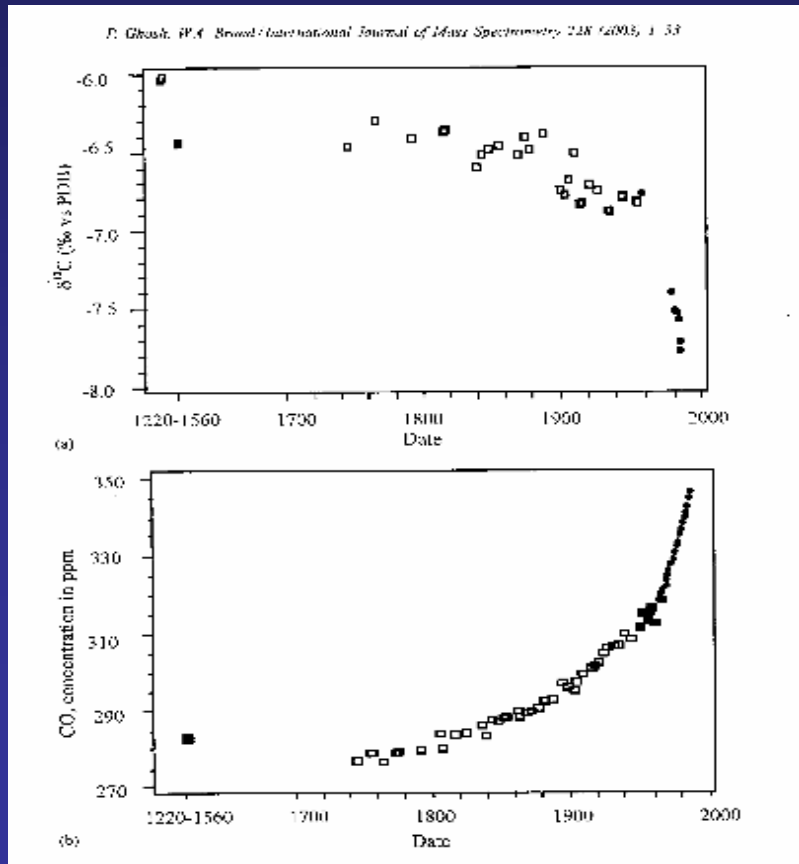


Figure and text courtesy of Carl Mears, RSS, and Ben Santer, LLML

Used satellites to measure atmospheric temperature.
Demonstrated tropospheric warming, stratospheric
cooling. Consistent with GHG, not sun

How do we know the CO₂ isn't from volcanoes?

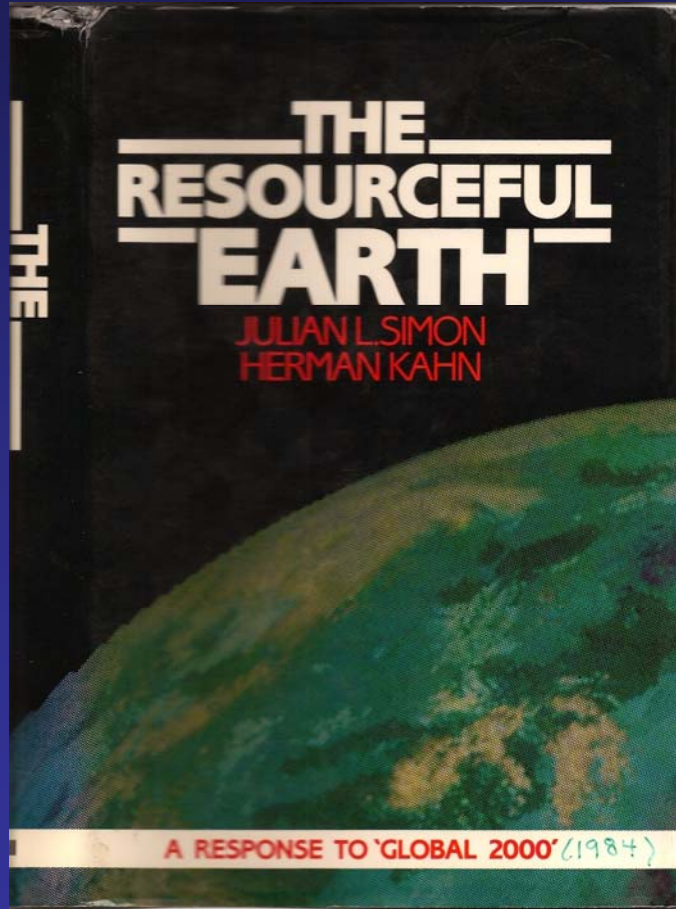
Stable isotope evidence that this CO₂ produced by burning fossil fuels



Clear correlation of falling $\delta^{13}\text{C}$ values with rising CO₂ (Ghosh and Brand, 2003)

(P.S. Absolute values also preclude volcanoes)

Cornucopianism

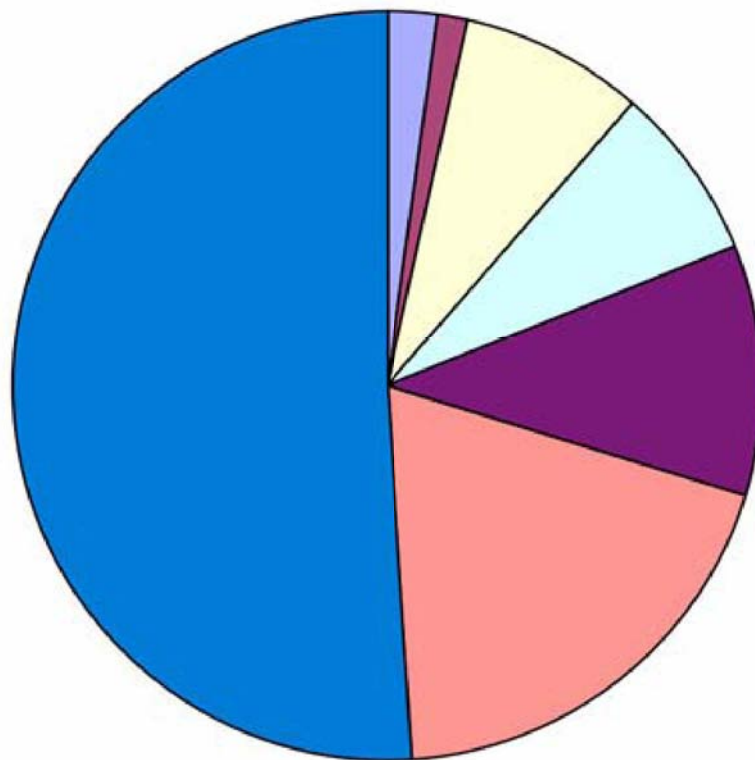


Free market fundamentalism is also promoted by the followers of Julian Simon, the Cornucopians, who include Bjørn Lomborg

- Only “free markets” produce innovation and technological change that societies need
- Note Herman Kahn connection...

Climate Research vs All Federally Funded Science

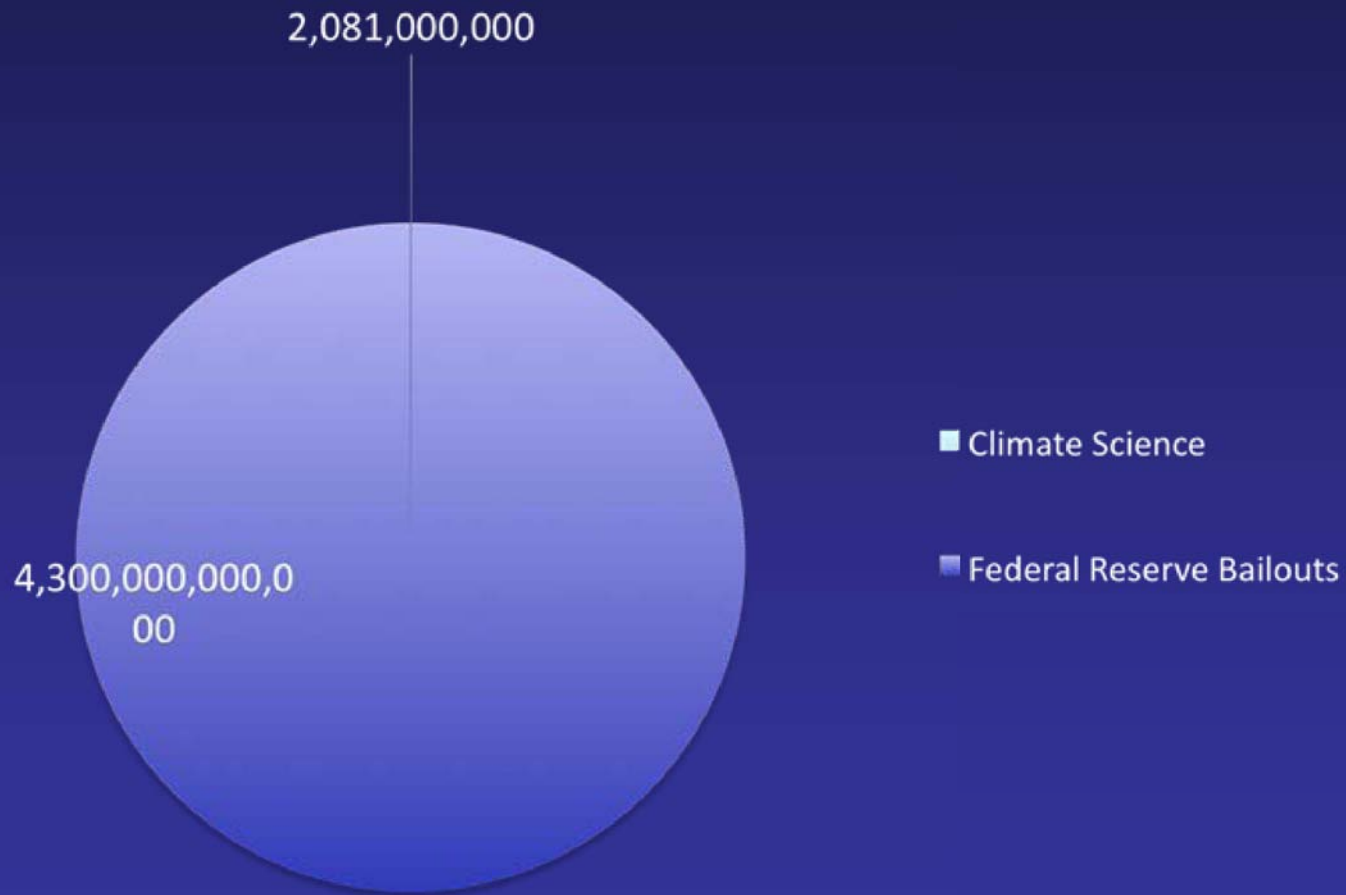
2009 US Science Budgets, in Billions \$



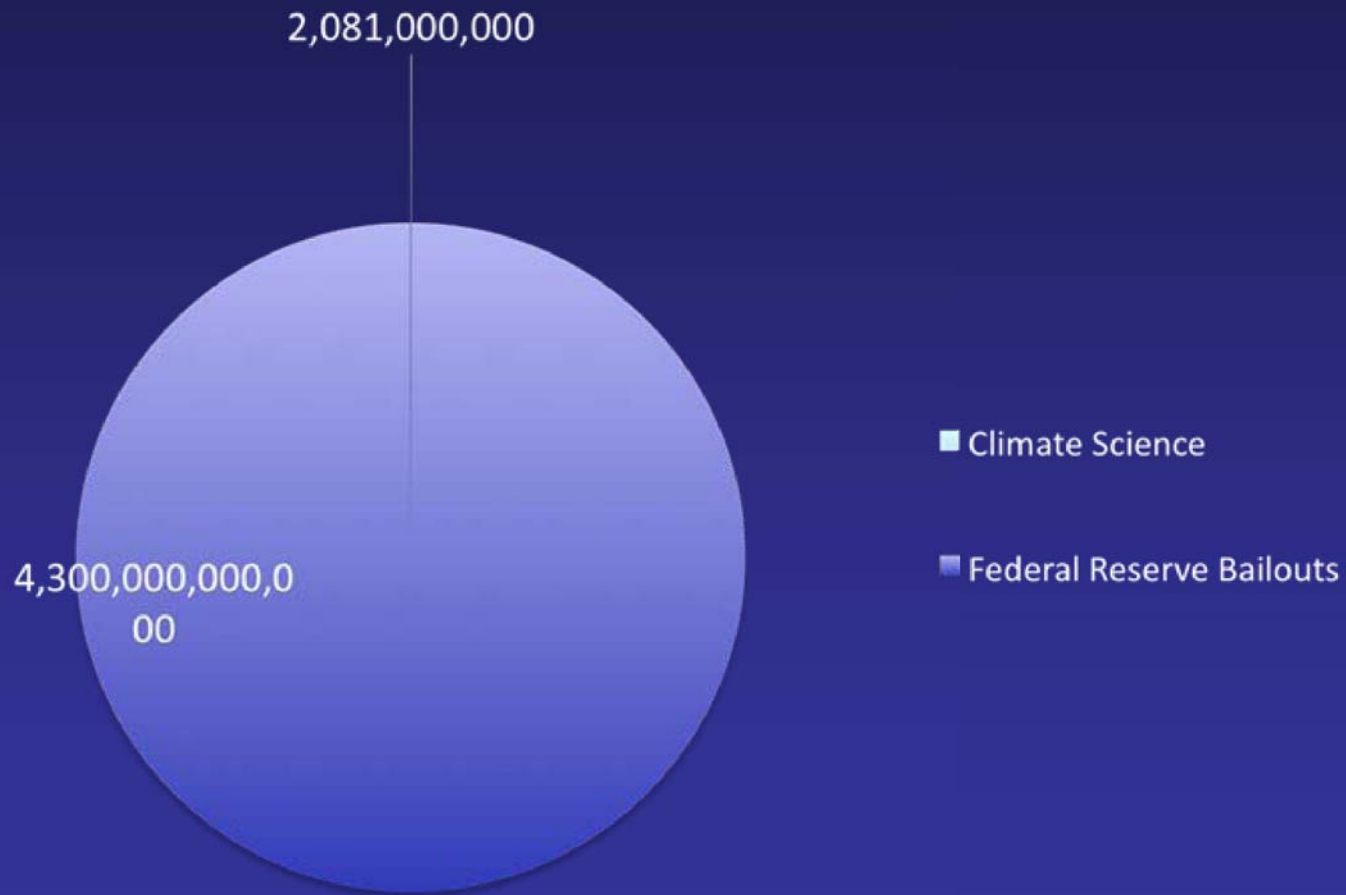
- Climate science without satellites
- Climate satellites
- Department of Energy science
- NASA science
- National Science Foundation
- Defense Department Science
- National Institutes of Health

Total US Science: \$59.83 billion

More Context: Climate Science v. Bank Bailout



More Context: Climate Science v. Bank Bailout



Denial at the highest level

2007, interview after release of IPCC AR4...

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EXCLUSIVE: Cheney on Global Warming

The President's New Air Task Force: Warning of Climate Change



Vice President Dick Cheney talked about global warming in an exclusive interview today with ABC's Jonathan Karl. (J. Scott Applewhite/AP Photo)

abc NEWS

Sydney, Australia, Feb. 23, 2007

— In an exclusive interview today, ABC's Jonathan Karl asked Vice President Dick Cheney about the topic of global warming, a subject Mr. Cheney has rarely addressed in the past. The vice president agreed that the earth is warming but, like President Bush, maintained there is debate over whether humans or natural cycles are the cause— a position that puts the administration at odds with the vast majority of climate scientists.

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The Intergovernmental Panel on Climate Change — made up of thousands of scientists from around the world — reported earlier this month they are more certain than ever that humans are heating earth's atmosphere through the burning of fossil fuels. In Australia, for example, the IPCC said that rising ocean temperatures brought on by global warming could make Australia's Great Barrier Reef "functionally extinct" by 2050.

Here is a portion of the transcript from Jonathan Karl's conversation with Mr. Cheney:

JONATHAN KARL: I want to ask you about another issue that's been a subject of controversy here in Australia,

- “I think there's an emerging consensus that we do have global warming. ...Where there does not appear to be a consensus...is the extent to which that's part of a normal cycle versus the extent to which it's caused by man, greenhouse gases, etc.”

II. The consensus included the cause

“...most of the observed warming over the last 50 years is very likely to have been due to the increase in greenhouse gas concentrations.”

IPCC 4th Assessment (2007)

IPCC also explicitly rejects the claim that it observed changes are natural variation

“The observed widespread warming of the atmosphere and ocean, together with ice mass loss, support the conclusion that it is *extremely unlikely* that global climate change of the past fifty years can be explained without external forcing....”

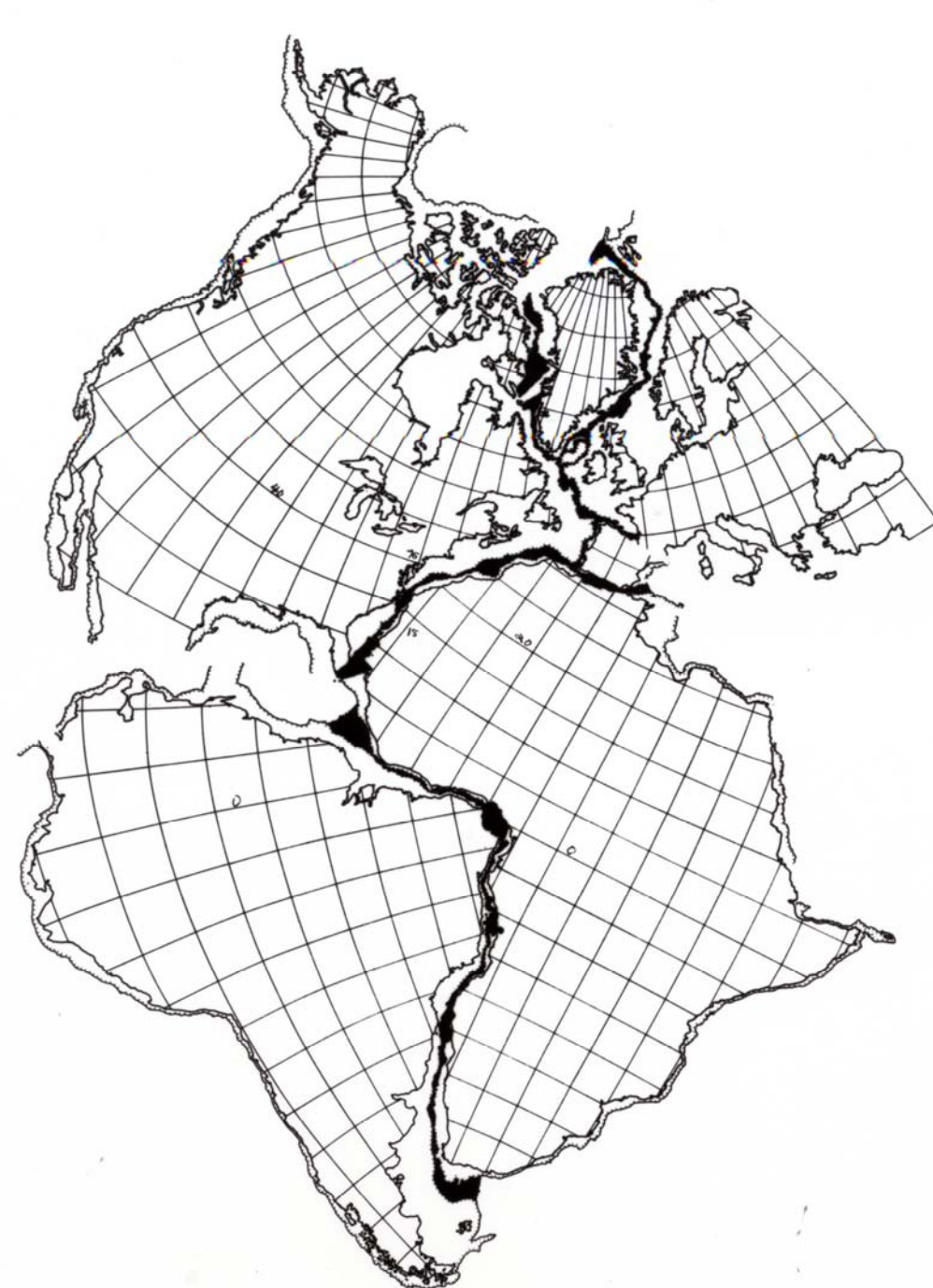
Fallibility question

Science is fallible.



Numerous examples from history of science of consensus, overturned

- Geocentric Universe
- Absolute nature of time and space
- Fixity of species
- Physical explanation is causal and deterministic
- Luminiferous ether
- Fixity of continents



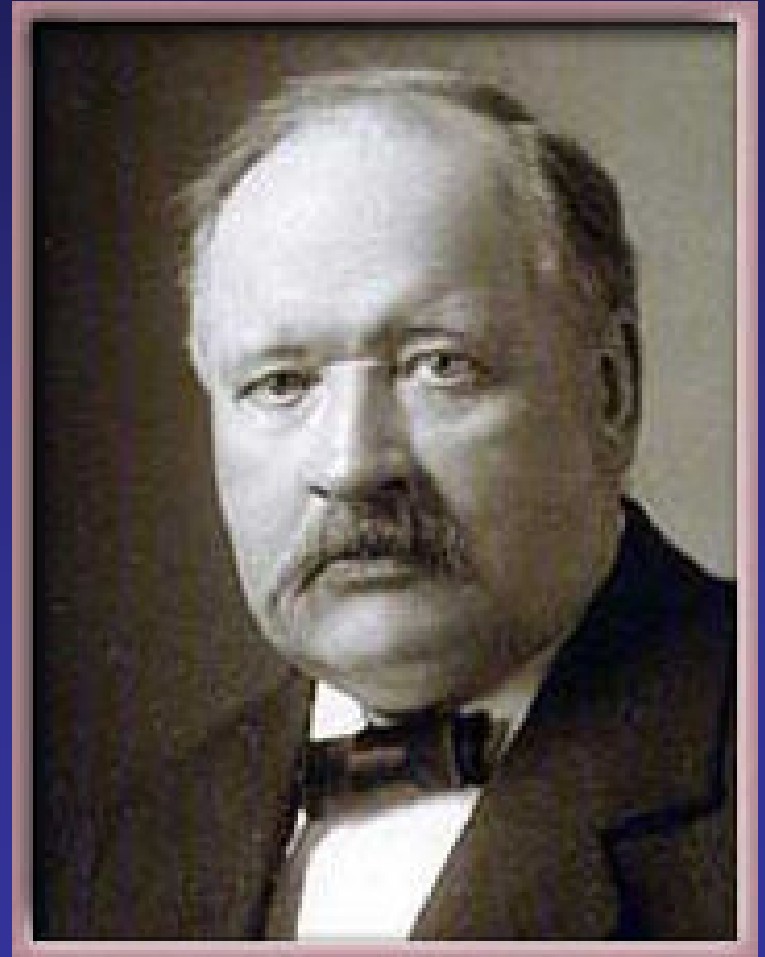
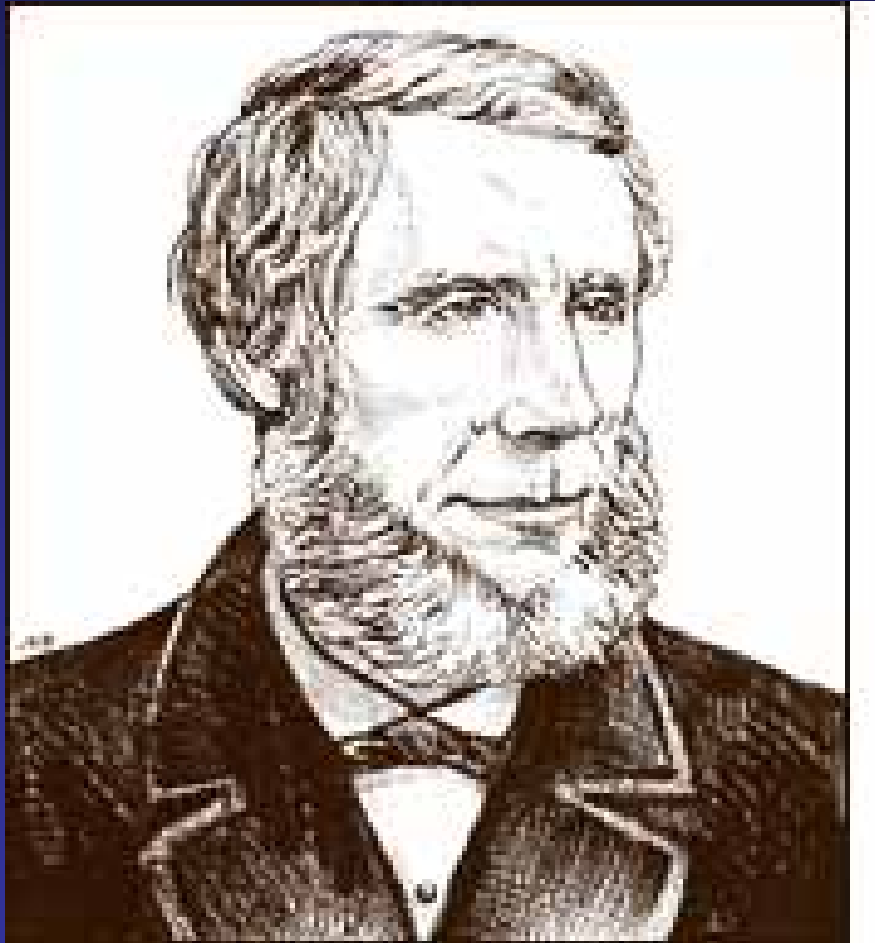
The Rejection *of* Continental Drift

□ No one had to make a huge policy decision in the 1920s that hinged on whether or not continental drift was true

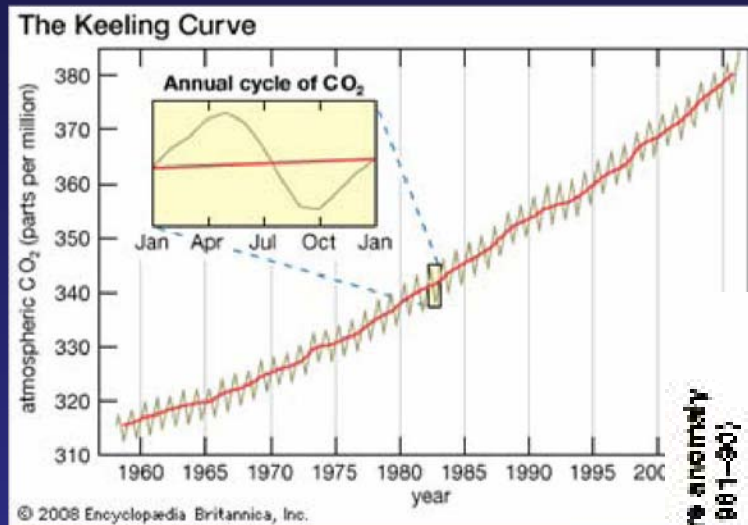
We do have to make decisions about global warming

The most reasonable position is to
decide on the basis of what we
know to be true

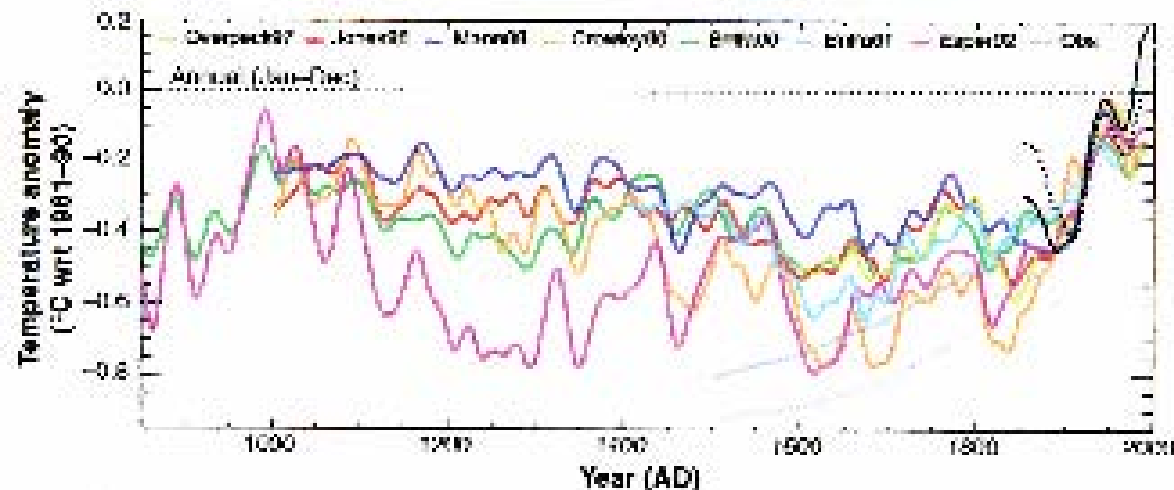
We've known for more than a century that if carbon dioxide increases, temperature should increase, too.



Carbon dioxide *has* increased...



...temperature has increased, (and many different, independent studies show this)...

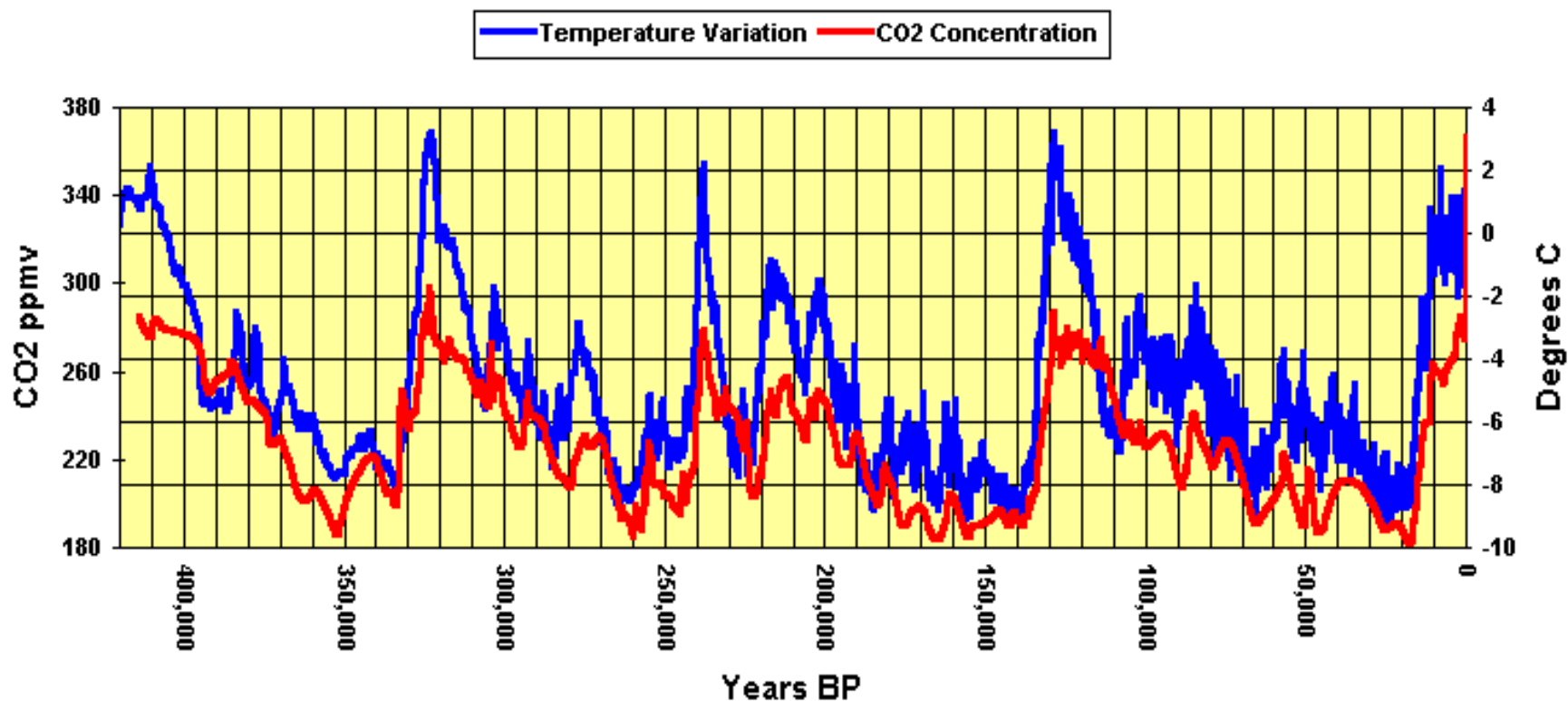


...and scientists *have* ruled out other causes.

Records of past climate. Solid colored lines indicate seven reconstructions of Northern Hemisphere climate: yellow, (4); red, (5); purple, (3); orange, (6); green, (7); blue, (9); and pink (7). All records were re-calibrated with linear regression against 1801–1960 mean annual temperature observations averaged over land areas north of 20°N, and the results smoothed with a 50-year filter. The black dotted line shows the estimate that would be made if the predictor was observed warm-season temperatures from the same region, highlighting the difference between warm season and annual temperature changes during the observed record. Black solid line: smoothed observations, truncated in 1993 when the record of Esper et al ends. Gray lines: annual temperature changes estimated from Northern Hemisphere borehole temperature profiles [dotted line, unweighted average of many sites (9); solid line, records gridded before averaging].

Vostok Ice Core Data

Antarctic Ice Core Data 1



Hurricane Question



Numerous predictions of climate science have come true

- Melting of polar ice sheets & continental glaciers
- Polar amplification
- Rising sea level
- Earlier spring onset
- More warming at night than in day
- More precipitation in some regions
- Intensification of extreme weather events (Katrina, record-breaking season of 2005)

2005: Most intense Atlantic hurricane season in recorded history

- Most tropical and subtropical storms (28)
- Record number (15) became hurricanes
- Record number (4) became category 5
 - Most “retired” names
- Katrina: Costliest (\$100 billion damages)
- Wilma: Most intense
 - Lowest pressure ever recorded in eye of hurricane
- Hurricane season continued long past “official end”
 - Official end is Nov. 30, storms continued into January

Climate models predicted intensification of hurricanes, caused in increase in sea surface temperature, well before 2005

Two papers in summer 2005 (before Katrina) documented increasing hurricane intensity

REPORTS

16. E. Kalnay et al., *Bull. Am. Meteorol. Soc.* **77**, 437 (1996).
17. J. E. Niiler, Y. Gao, H. Drange, T. Furukawa, M. Bertens, *Geophys. Res. Lett.* **30**, 10.1029/2002GL015697 (2003).
18. H. Vellinga, A. Seneo, H. Drange, M. Bertens, in *The Nordic Seas: An Integrated Perspective*, AGU Monograph 158, H. Drange, T. Furukawa, T. Furukawa, S. Gertzel, W. Berger, Eds. (American Geophysical Union, Washington, DC, 2003), pp. 219–230.
19. M. Bertens, *J. Geophys. Res.* **107**, 10.1029/2001JC000921 (2002).
20. N. P. Haldimann, *J. Geophys. Res.* **108**, 10.1029/2002JC001944 (2003).
21. T. P. Berger, S. Levitus, J. J. Antonov, R. A. Locantore, H. E. Garcia, *Geophys. Res. Lett.* **32**, 10.1029/2004GL021191 (2005).
22. T. M. Joyce, P. Iselin, *J. Clim.* **9**, 3121 (1996).
23. S. Haldimann, P. B. Rhines, *Science* **304**, 553 (2004).
24. N. P. Haldimann, R. T. Pollard, J. E. Read, H. Leach, *Deep-Sea Res.* **47**, 1303 (2000).
25. D. J. Elliott, J. H. A. Morfitt, *Deep-Sea Res.* **20**, 585 (1973).
26. D. J. Elliott, S. J. Jones, "Surface temperature and salinity time-series from the Rockall Channel, 1948–1992" (fisheries research data report number 36, Ministry of Agriculture, Fisheries, and Food, Directorate of Fisheries Research, Lowestoft, 1994; www.defra.gov.uk/publications/default.asp?id=36).
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Changes in Tropical Cyclone Number, Duration, and Intensity in a Warming Environment

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We examined the number of tropical cyclones and cyclone days as well as tropical cyclone intensity over the past 35 years, in an environment of increasing sea surface temperature. A large increase was seen in the number and proportion of hurricanes reaching categories 4 and 5. The largest increase occurred in the North Pacific, Indian, and Southwest Pacific Oceans, and the smallest percentage increase occurred in the North Atlantic Ocean. These increases have taken place while the number of cyclones and cyclone days has decreased in all basins except the North Atlantic during the past decade.

During the hurricane season of 2004, there were 14 named storms in the North Atlantic, of which 9 achieved hurricane intensity. Four of these hurricanes struck the southeast United States in rapid succession, causing considerable damage and disruption. Analysis of hurricane characteristics in the North Atlantic (1, 2) has shown an increase in hurricane frequency and intensity since 1995. Recently, a causal relationship between increasing hurricane frequency and intensity and increasing sea surface temperature (SST) has been posited (3), assuming an acceleration of the hydrological cycle arising from the nonlinear relation between saturation vapor pressure and temperature (4). The issue of attribution of increased hurricane frequency to increasing SST has resulted in a vigorous debate in the press and in academic circles (5).

Numerous studies have addressed the issue of changes in the global frequency and intensity of hurricanes in the warming world. Our basic conceptual understanding of hurricanes suggests that there could be a relationship between hurricane activity and SST. It is well established that SST > 26°C is a requirement for tropical cyclone formation in the current climate (6, 7). There is also a hypothesized relationship between SST and the

maximum potential hurricane intensity (8, 9). However, strong interannual variability in hurricane statistics (10–14) and the possible influence of interannual variability associated with El Niño and the North Atlantic Oscillation (11, 12) make it difficult to discern any trend relative to background SST increases with statistical validity (9). Factors other than SST have been cited for their role in regulating

hurricane characteristics, including vertical shear and mid-tropospheric moisture (15). Global modeling results for doubled CO₂ scenarios are contradictory (15–20), with simulations showing a lack of consistency in projecting an increase or decrease in the total number of hurricanes, although most simulations project an increase in hurricane intensity.

Tropical ocean SSTs increased by approximately 0.5°C between 1970 and 2004 (21). Figure 1 shows the SST trends for the tropical cyclone season in each ocean basin. If the Kendall trend analysis is used, trends in each of the ocean basins are significantly different from zero at the 95% confidence level or higher, except for the southwest Pacific Ocean. Here we examine the variations in hurricane characteristics for each ocean basin in the context of the basin SST variations. To this end, we conducted a comprehensive analysis of global tropical cyclone statistics for the satellite era (1970–2004). In each tropical ocean basin, we examined the numbers of tropical storms and hurricanes, the number of storm days, and the hurricane intensity distribution. The tropical cyclone data are derived from the best track archives

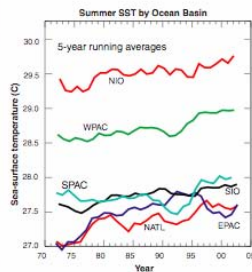


Fig. 1. Running 5-year mean of SST during the respective hurricane seasons for the principal ocean basins in which hurricanes occur: the North Atlantic Ocean (NATL; 90° to 20°E, 5° to 25°N, June–October), the Western Pacific Ocean (WPAC; 120° to 180°E, 5° to 20°N, May–October), the Eastern Pacific Ocean (EPAC; 90° to 120°W, 5° to 20°N, June–October), the Southern Indian Ocean (SI; 50° to 110°E, 5° to 20°N, April–May and September–November), and the North Indian Ocean (NI; 50° to 110°E, 5° to 20°N, November–April).

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Increasing destructiveness of tropical cyclones over the past 30 years

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Theory¹ and modelling² predict that hurricane intensity should increase with increasing global mean temperatures, but work on the detection of trends in hurricane activity has focused mostly on their frequency^{3,4} and shows no trend. Here I define an index of the potential destructiveness of hurricanes based on the total dissipation of power, integrated over the lifetime of the cyclone, and show that this index has increased markedly since the mid-1970s. This trend is due to both longer storm lifetimes and greater storm intensities. I find that the record of net hurricane power dissipation is highly correlated with tropical sea surface temperature, reflecting well-documented climate signals, including multidecadal oscillations in the North Atlantic and North Pacific, and global warming. My results suggest that future warming may lead to an upward trend in tropical cyclone destructive potential, and—taking into account an increasing coastal population—a substantial increase in hurricane-related losses in the twenty-first century.

Fluctuations in tropical cyclone activity are of obvious importance to society, especially as populations of afflicted areas increase⁵. Tropical cyclones account for a significant fraction of damage, injury and loss of life from natural hazards and are the confined natural catastrophes in the US⁶. In addition, recent work suggests that global tropical cyclone activity may play an important role in driving the ocean's thermohaline circulation, which has an important influence on regional and global climate⁷. Studies of tropical cyclone variability in the North Atlantic reveal large interannual and interdecadal swings in storm frequency that have been linked to such regional climate phenomena as the El Niño/Southern Oscillation⁸, the stratospheric quasi-biennial oscillation⁹, and multi-decadal oscillations in the North Atlantic region¹⁰. Variability in other ocean basins is less well documented, perhaps because the historical record is less complete.

Concerns about the possible effects of global warming on tropical cyclone activity have motivated a number of theoretical, modelling and empirical studies. Basic theory¹¹ establishes a quantitative upper bound on hurricane intensity, as measured by maximum surface wind speed, and empirical studies show that when accumulated over large enough samples, the statistics of hurricane intensity are strongly controlled by this theoretical potential intensity¹². Global climate models show a substantial increase in potential intensity with anthropogenic global warming, leading to the prediction that actual storm intensity should increase with time¹³. This prediction has been echoed in climate change assessments¹⁴. A recent comprehensive study using a detailed numerical hurricane model run using climate predictions from a variety of different global climate models supports the theoretical predictions regarding changes in storm intensity. With the observed warming of the tropics of around 0.5°C, however, the predicted changes are too small to have been observed, given limitations on tropical cyclone intensity estimation.

The issue of climatic control of tropical storm frequency is far

more controversial, with little guidance from existing theory. Global climate model predictions of the influence of global warming on storm frequency are highly inconsistent, and there is no detectable trend in the global annual frequency of tropical cyclones in historical tropical cyclone data.

Although the frequency of tropical cyclones is an important scientific issue, it is not by itself an optimal measure of tropical cyclone threat. The actual monetary loss in wind storms rises roughly as the cube of the wind speed¹⁵ as does the total power dissipation (PD; ref. 15), which, integrated over the surface area affected by a storm and over its lifetime is given by:

$$PD = 2\pi \int_{r_0}^{\infty} \int_{t_0}^{\infty} C_D |\mathbf{V}|^3 r dr dt \quad (1)$$

where C_D is the surface drag coefficient, p is the surface air density, $|\mathbf{V}|$ is the magnitude of the surface wind, and the integral is over radius to an outer storm limit given by r_0 and over t , the lifetime of the storm. The quantity PD has the units of energy and reflects the total power dissipated by a storm over its life. Unfortunately, the area integral in equation (1) is difficult to evaluate using historical data sets, which seldom report storm dimensions. On the other hand, detailed studies show that radial profiles of wind speed are generally geometrically similar¹⁶ whereas the peak wind speeds exhibit little if any correlation with measures of storm dimensions¹⁷. Thus variations in storm size would appear to introduce random errors in an evaluation of equation (1) that assumes fixed storm dimensions. In the integrand of equation (1), the surface air density varies over roughly 15%, while the drag coefficient is thought to increase over roughly a factor of two with wind speed, but leveling off at wind speeds in excess of about 30 m s⁻¹ (ref. 18). As the integral in equation (1) will, in practice, be dominated by high wind speeds, we approximate the product $C_D \rho$ as a constant and define a simplified power dissipation index as:

$$PDI = \int_{r_0}^{\infty} \int_{t_0}^{\infty} |\mathbf{V}|^3 r dr dt \quad (2)$$

where V_{max} is the maximum sustained wind speed at the conventional measurement altitude of 10 m. Although not a perfect measure of net power dissipation, this index is a better indicator of tropical cyclone threat than storm frequency or intensity alone. Also, the total power dissipation is of direct interest from the point of view of tropical cyclone contributions to upper ocean mixing and the thermohaline circulation¹⁹. This index is similar to the 'accumulated cyclone energy' (ACE) index²⁰, defined as the sum of the squares of the maximum wind speed over the period containing hurricane-force winds.

The analysis technique, data sources, and corrections to the raw data are described in the Methods section and in Supplementary Methods. To emphasize long-term trends and interdecadal variability, the PDI is accumulated over an entire year and, individually, over

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Cause is not disputed:
Elevated sea surface
temperatures

Only question is whether global
warming caused those elevated
temperatures. But there is no other
known cause...

Isaac Newton, *Principia Mathematica* (1687)

“In experimental philosophy we are to look upon propositions inferred by ...induction from phenomena as accurate or very nearly true notwithstanding any contrary hypothesis that may be imagined....This rule we must follow, [and] may not be evaded by [speculative] hypotheses.”

You can *imagine* other possible causes, but scientific explanation relies on the causes inferred from evidence.



And if we don't act soon to stop or at least slow the rise in global temperature, our polar bears may soon have no where left to go.