

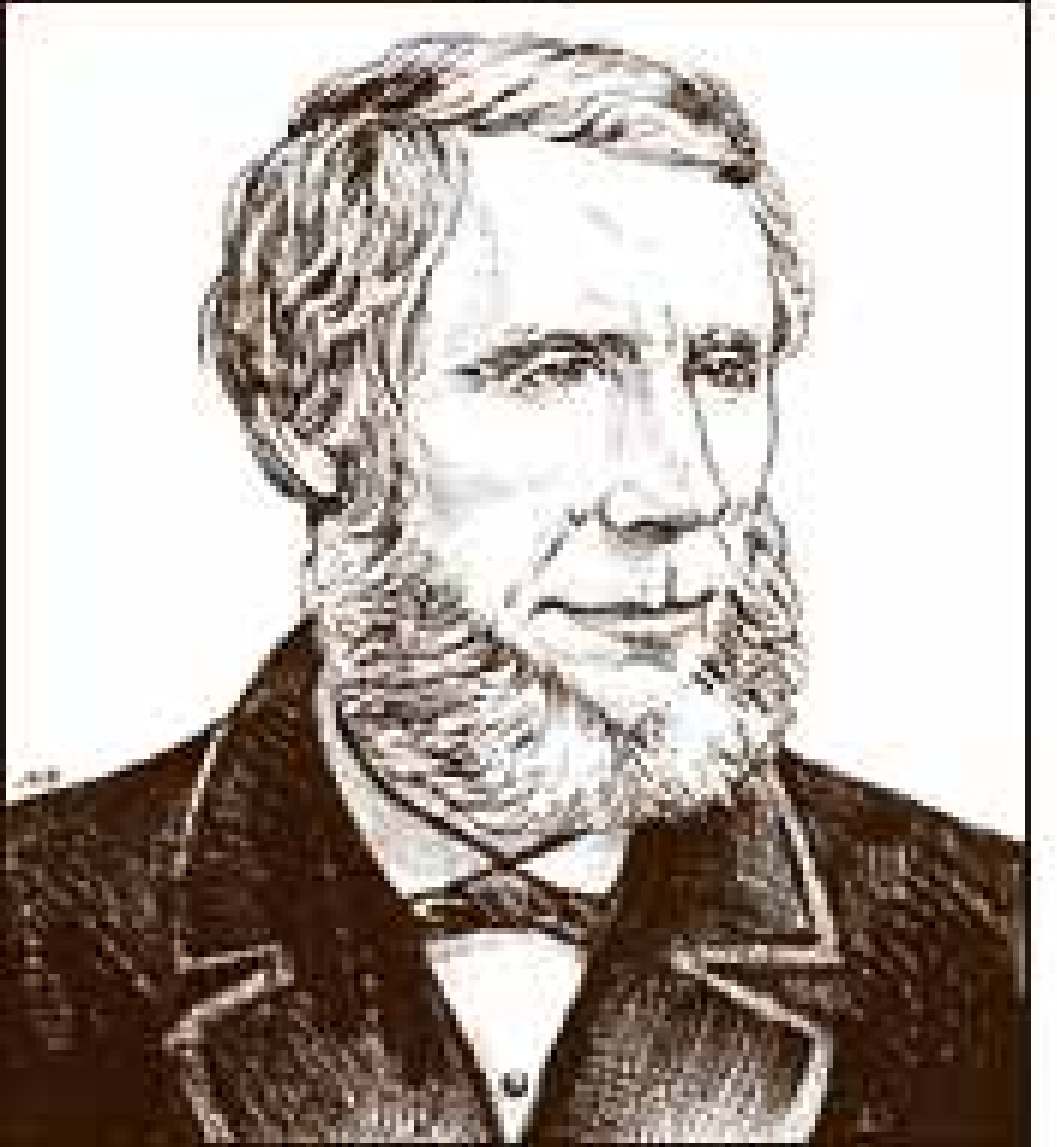
A New View of Science: Title Search Realism

Naomi Oreskes
Erik M. Conway

Consensus and Dissent

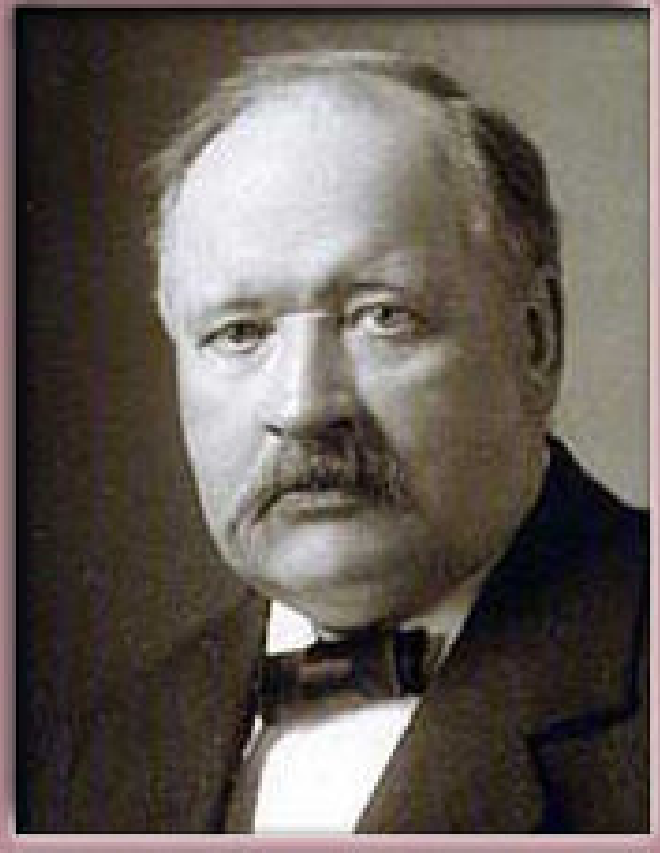
- Past several years: numerous talks on the scientific consensus on climate change
- Focused on the epistemic basis for that consensus: *evidence*.
- Crammed with “facts”...

Carbon Dioxide as Greenhouse Gas



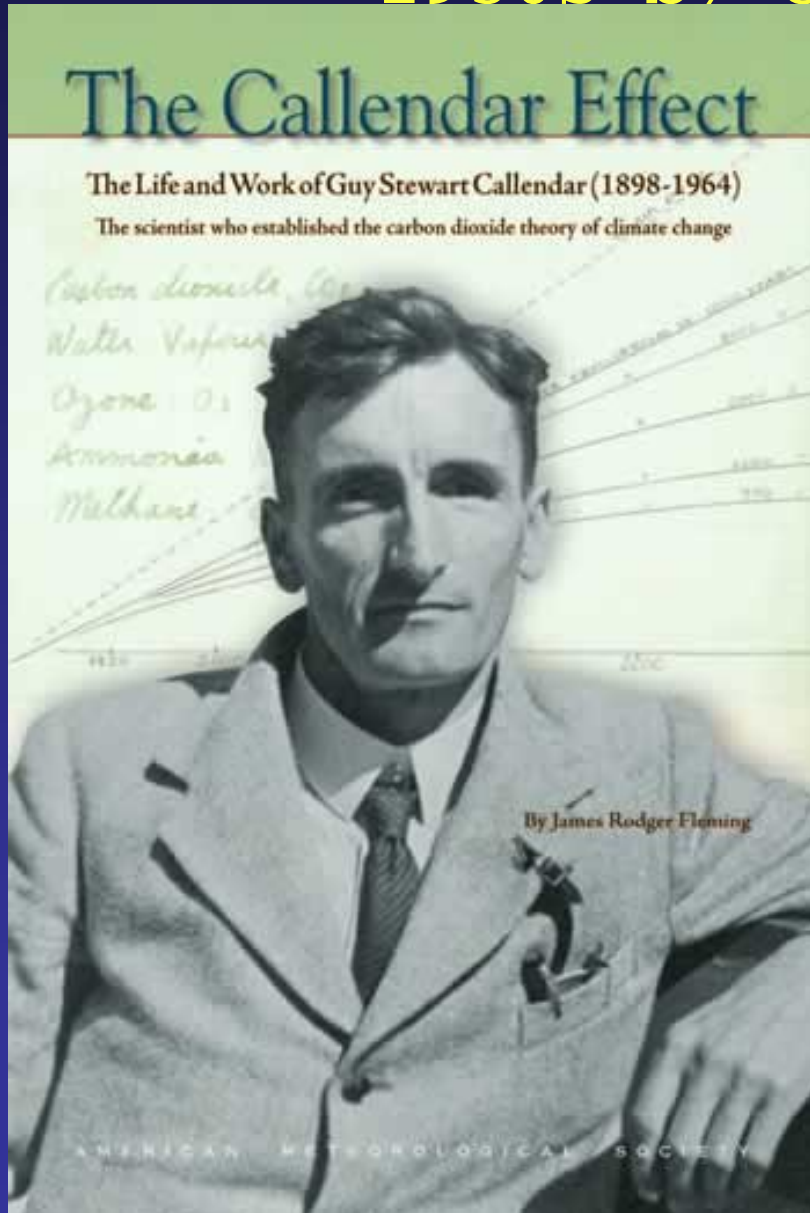
- John Tyndall
(1820–1893)
- Established
“greenhouse”
properties of
carbon dioxide,
water in 1850s

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.
- Wonderful new biography by T. D.

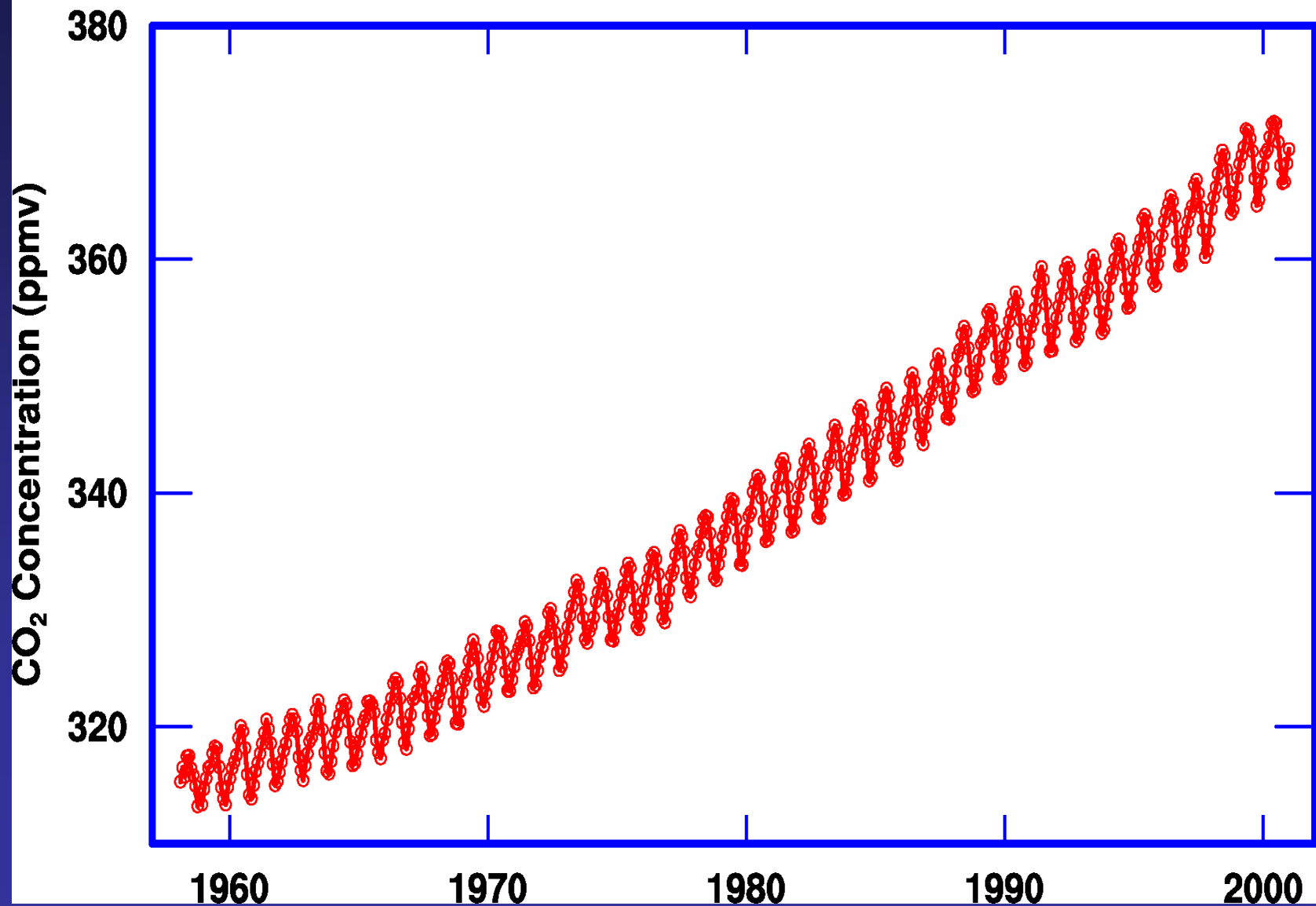
CO₂ inventory: Charles David Keeling

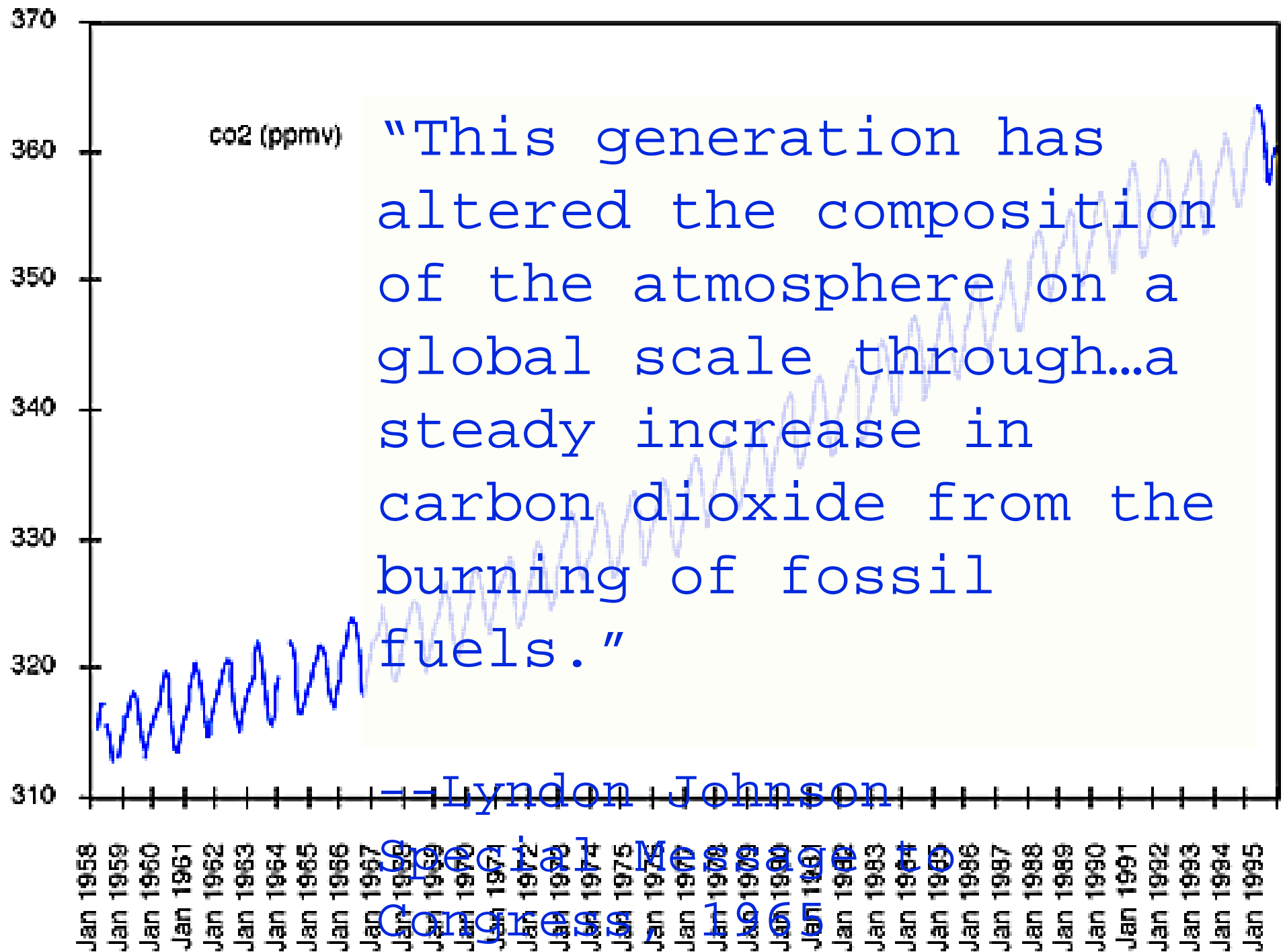
A black and white photograph of Charles David Keeling, an older man with white hair, wearing a striped shirt. He is pointing his right index finger towards a large graph on a wall. The graph shows a line that starts at a low point and rises steadily, representing the increase in atmospheric CO2 levels over time. The background is slightly out of focus, showing other parts of the room and possibly other graphs.

Keeling curve began in
1958 as part of the IGY

1960s: Clear trend of increasing atmospheric CO₂

CO₂ Concentration Data : Mauna Loa, Hawaii





By the 1970s, there was a consensus among scientific experts that, given the steady rise of CO₂ that Keeling had demonstrated, that sooner or later global warming would occur:

"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

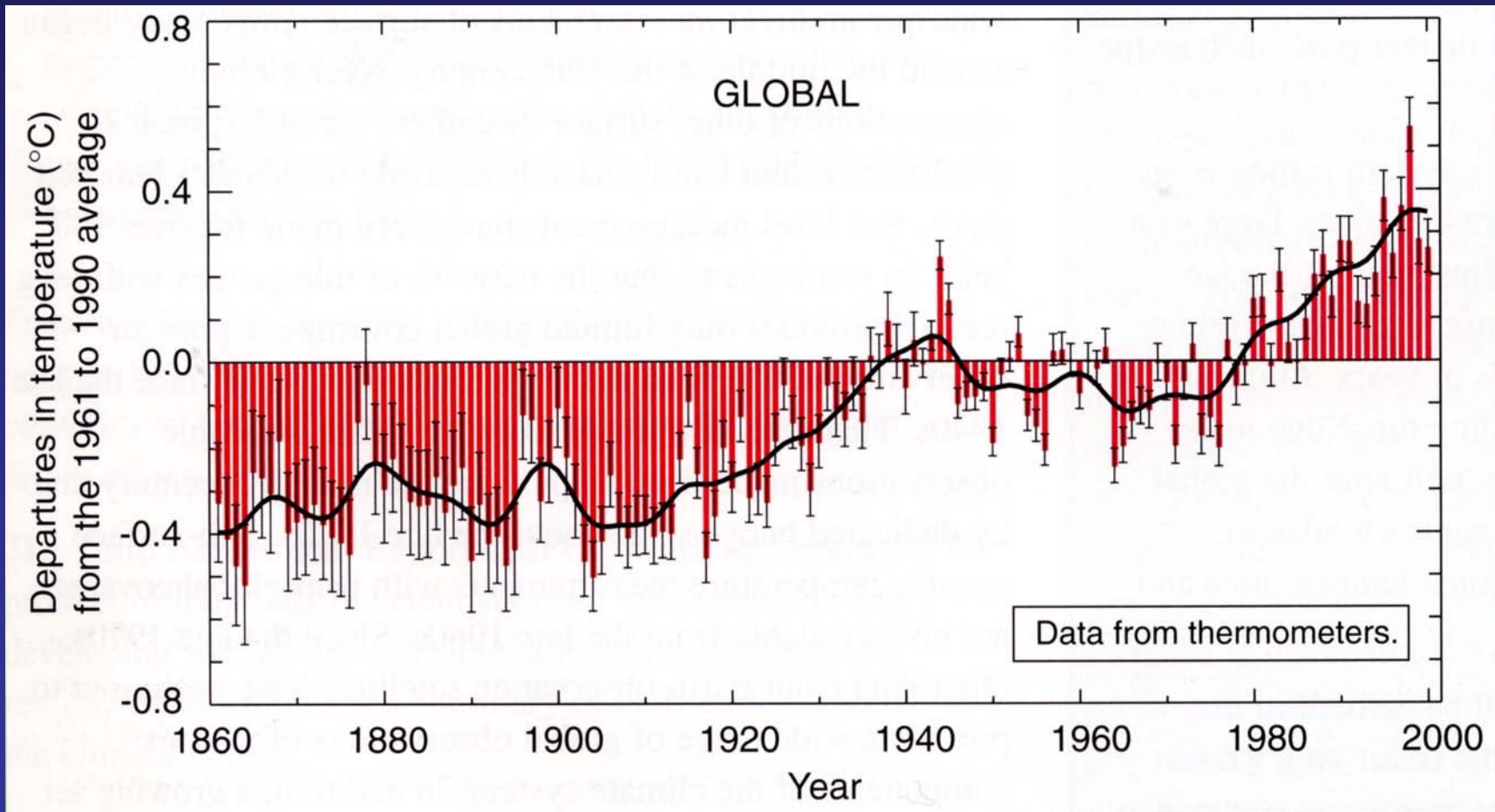
Big question was when?

Surprising answer: just a few
years later....

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



By early 1990s, most agree that a clear empirical signal clearly emerged...



1995: IPCC Second Assessment Report

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.

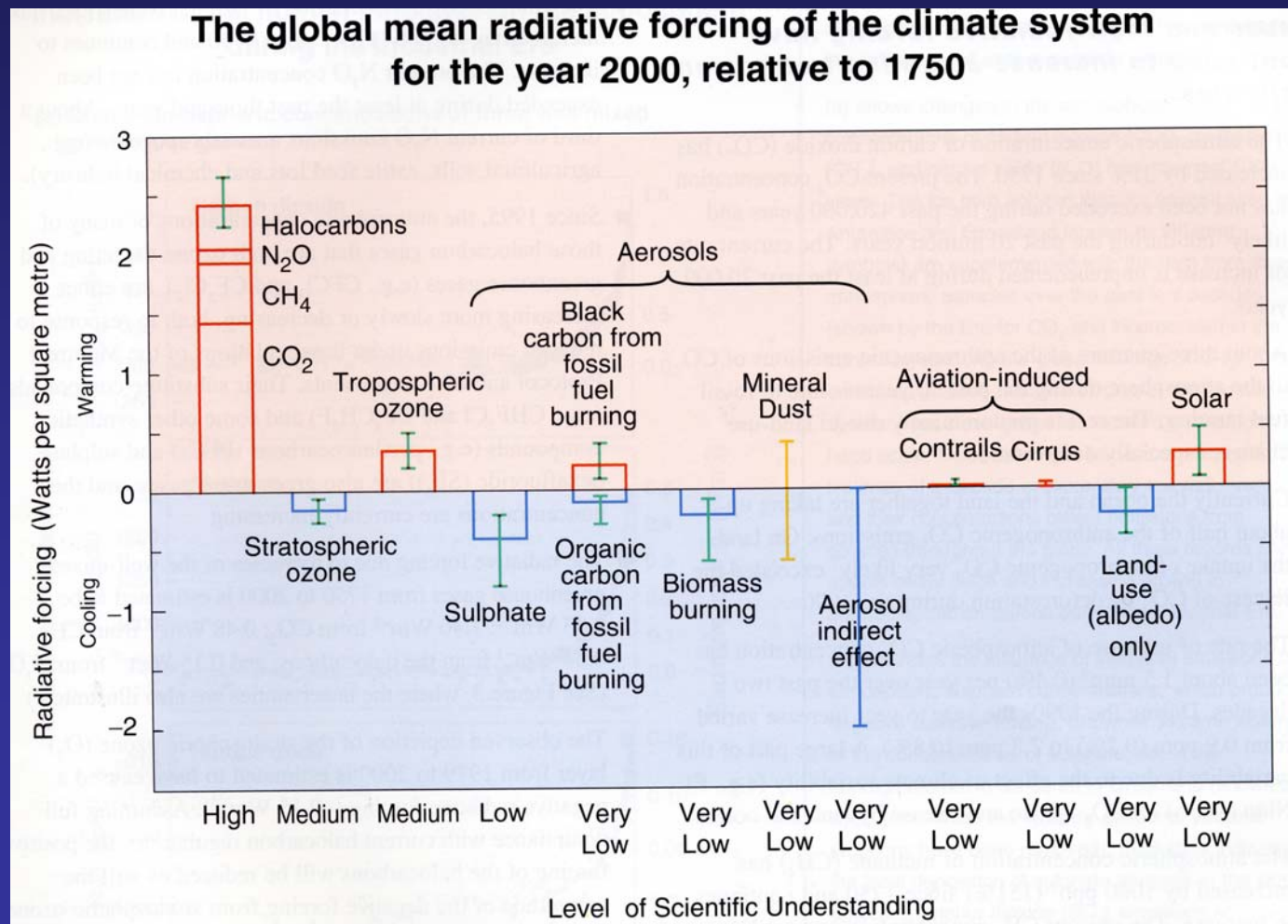
In the light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the last 50 years is likely⁷ to have been due to the increase in greenhouse gas concentrations.

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.

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

--Houghton et al., eds., *Climate Change 1995*, 5

Conclusion based on both observed empirical evidence of effects, and well-established theoretical framework linking the observed cause and effect



When I spoke about these things, invariably there would be skeptics in the audience...

How do we know it's not the sun?

Explain different predictions: GHGs v. solar irradiance

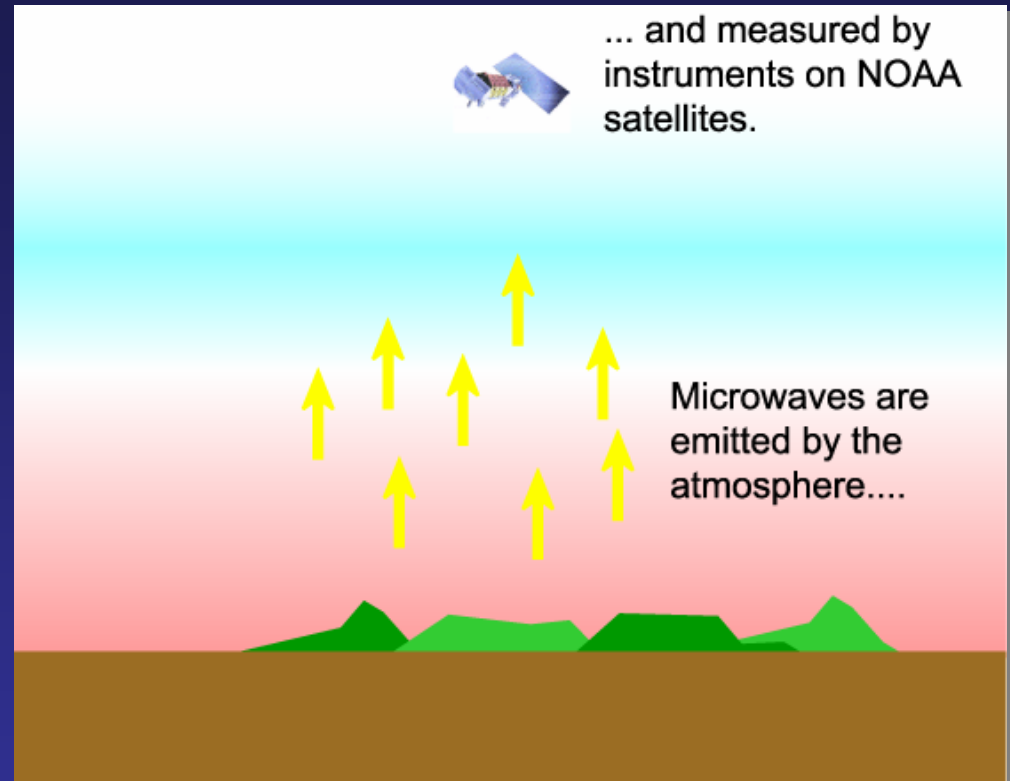
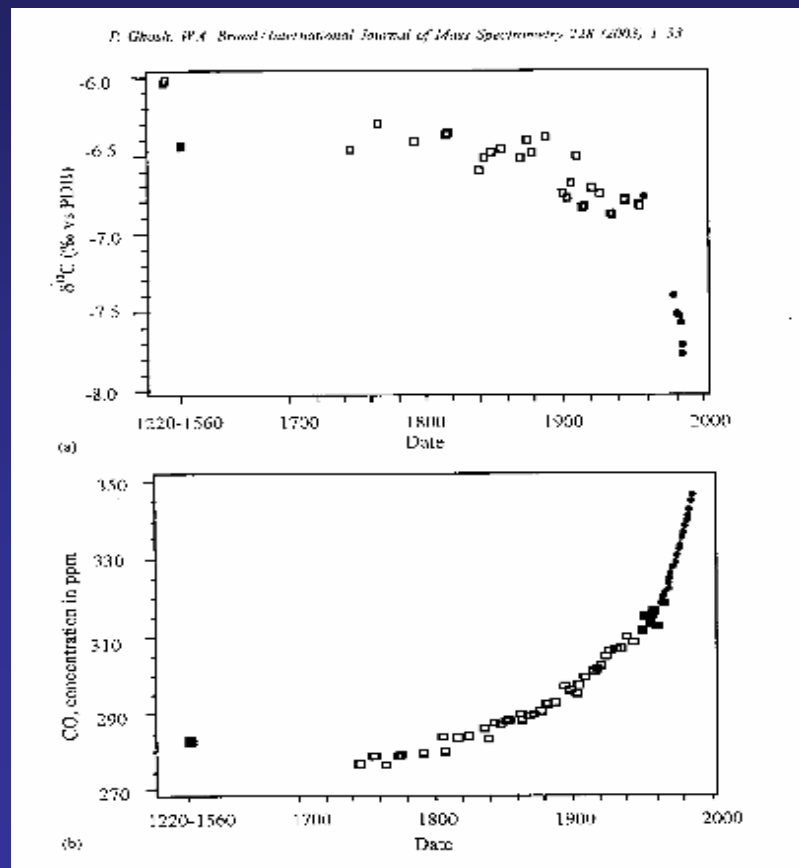


Figure and text courtesy of
Carl Mears, RSS, and Ben
Santer, LLML

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)

But interesting thing...how *similar*
these questions always were
(the sun did it, volcanoes did it)

Often these people sort of knew what they
were talking about...

Often the question began: Isn't it true that...?

Where were people getting all
this skeptical misinformation
from?

Yale Project on Climate Change/ Yale/ Gallup/ ClearVision Institute Poll, 2007

AMERICAN OPINIONS ON GLOBAL WARMING

A Yale University / Gallup / ClearVision Institute Poll

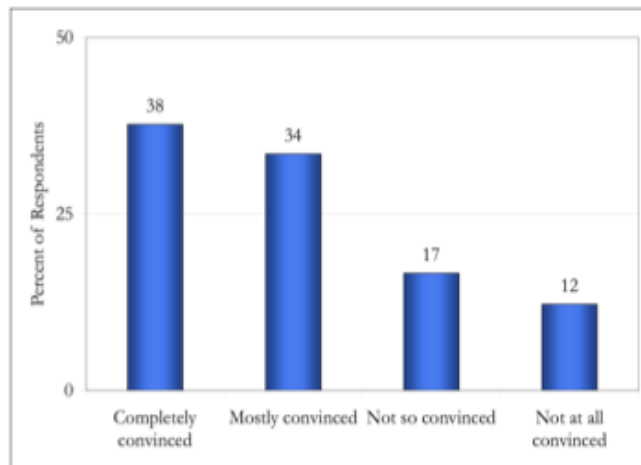
Principal Investigator:

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SURVEY RESULTS

Figure 1: Personally Convinced

"How convinced are you that global warming is happening -- would you say you are -- completely convinced, mostly convinced, not so convinced, or not at all convinced?"

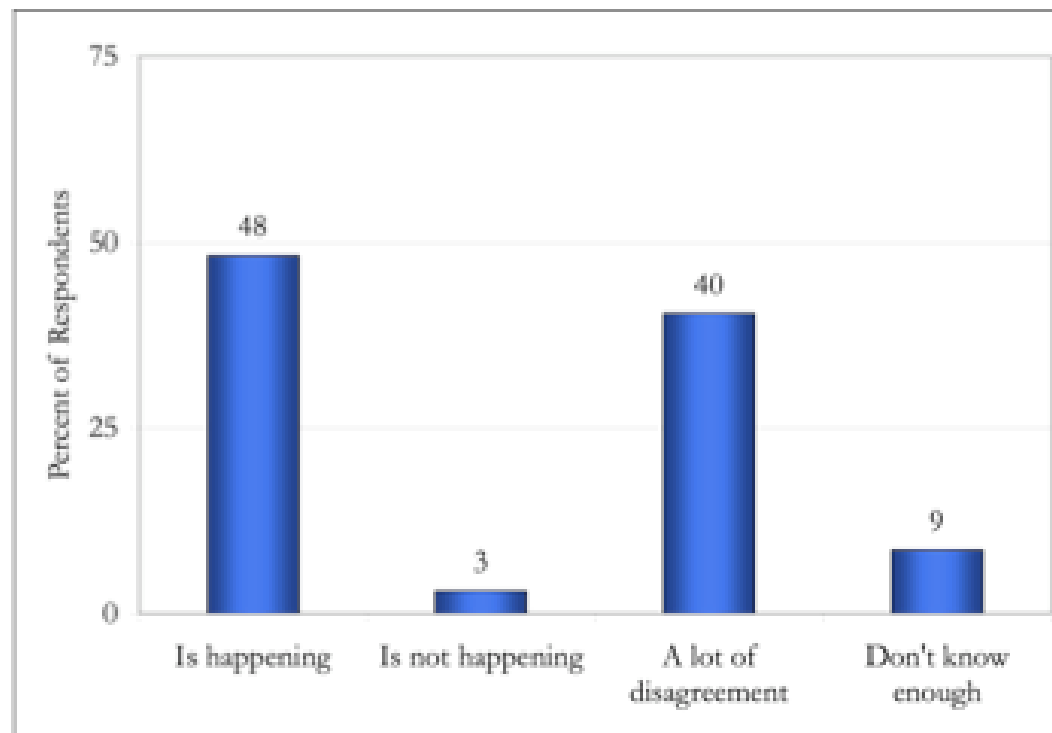


72 % of Americans
completely or mostly
convinced that global
warming is happening

40% thoughts *scientists* were still arguing

Figure 2: Scientific Consensus

“Which comes closer to your own view -- most scientists think global warming is happening, (or) most scientists think global warming is not happening, or there is a lot of disagreement among scientists about whether or not global warming is happening, or do you not know enough to say?”



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

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 Manestrel, 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 Sartori 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; to my research assistants S. Luit and G. Law; and to D. C. Agnew, K. Belitz, J. R. Fleming, M. T. Grens, H. Leffert, and R. C. J. Somerville for helpful discussions.

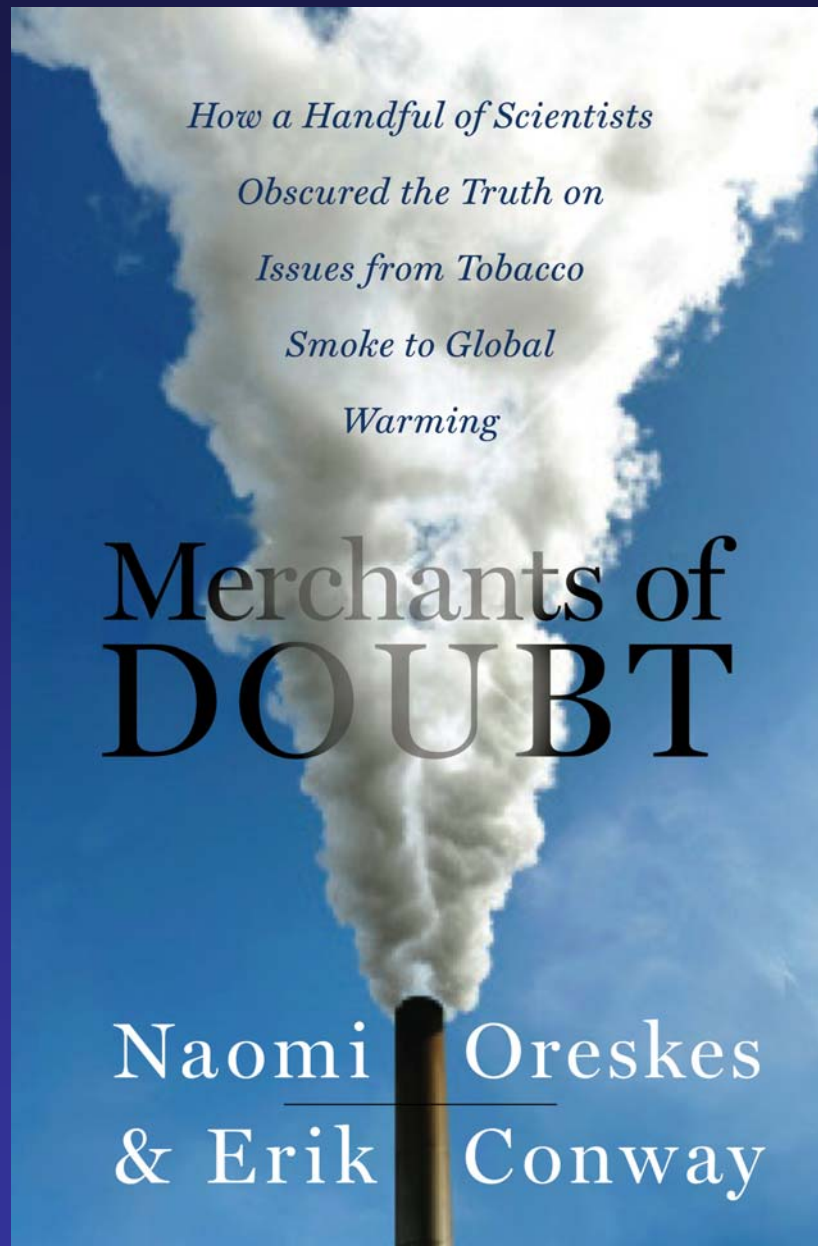
10.1126/science.1103618

- Scientists had a consensus that warming *would* happen since late 1970s
- Scientists had consensus it had become detectable since 1990s.
- Why *did* so many people have the impression of a raging debate?

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Short answer:

That is the impression that a small but powerful group of people, aided and abetted by well-funded think-tanks and a compliant mass media, wanted them to have.



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

Not for money, but in defense of an ideology of laissez-faire governance, opposition to government regulation

- Today: Extremely brief summary of the book
- Focus: how were we (the public, and the mass media) taken in by the claims of scientific uncertainty, in part because we have an incorrect view of science.
- Reading from the book's conclusion

We track the story of a small handful of Cold war physicists, promoted the idea of “doubt”—scientific uncertainty—to avoid action on a set of issues, ranging from tobacco to global warming

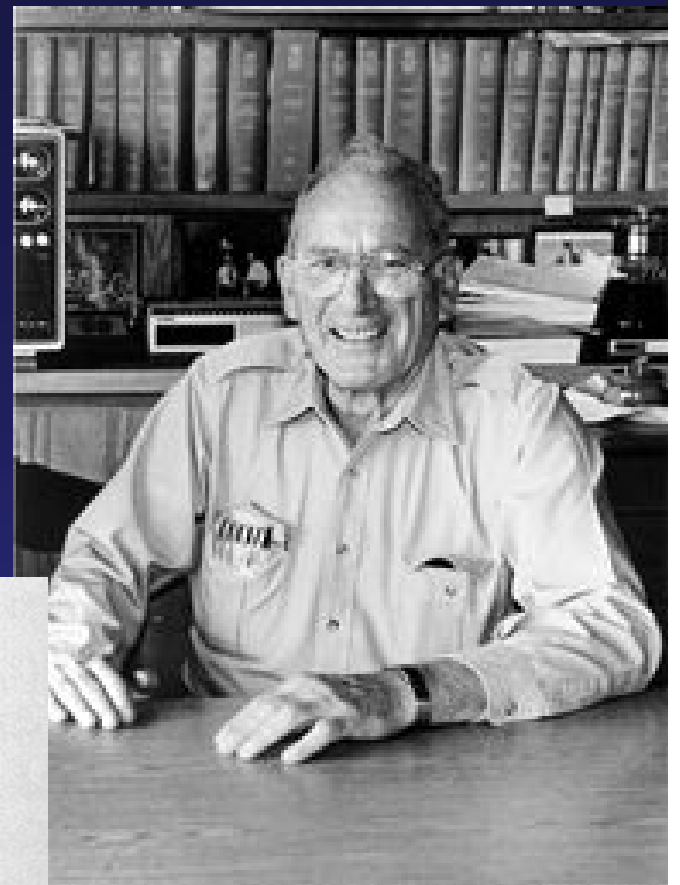
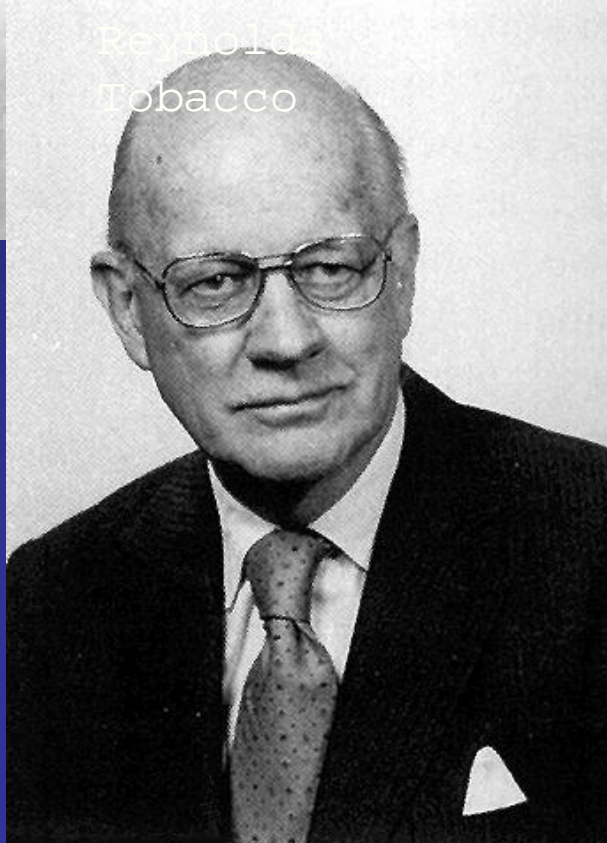
Three principal players...
and one think tank



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

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

The Think-Tank: The George C. Marshall Institute

- Founded to defend SDI against scientists' boycott of it.
- 1984-1989, Jastrow, Seitz and Nierenberg worked to defend SDI, and to promote an alarming view of Soviet strength and American weakness.

Major tactic: cast doubt on the doubters

Scientists said SDI wasn't feasible,
Jastrow, Seitz and Nierenberg
insisted that it was both feasible,
necessary, and urgent.

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. Reynold 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, Marshall Institute turned its attention to another matters
- Environmental “extremism”:
 - Exaggeration of threats
 - Insistence that government regulation was needed to control these threats
 - Acid rain, the ozone hole, second-hand smoke, global warming (and later, dangers of DDT)

The physicists denied the severity of all these problems

In every case, insisted that the science was too uncertain to justify government interference in market place.

- “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)

Dangers of DDT

Reality of acid rain

Severity of ozone hole

Human causes of global warming

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

Why we fell for it.

Because we have a wrong view of science...

We think that science provides absolute
answers...
positive proof.

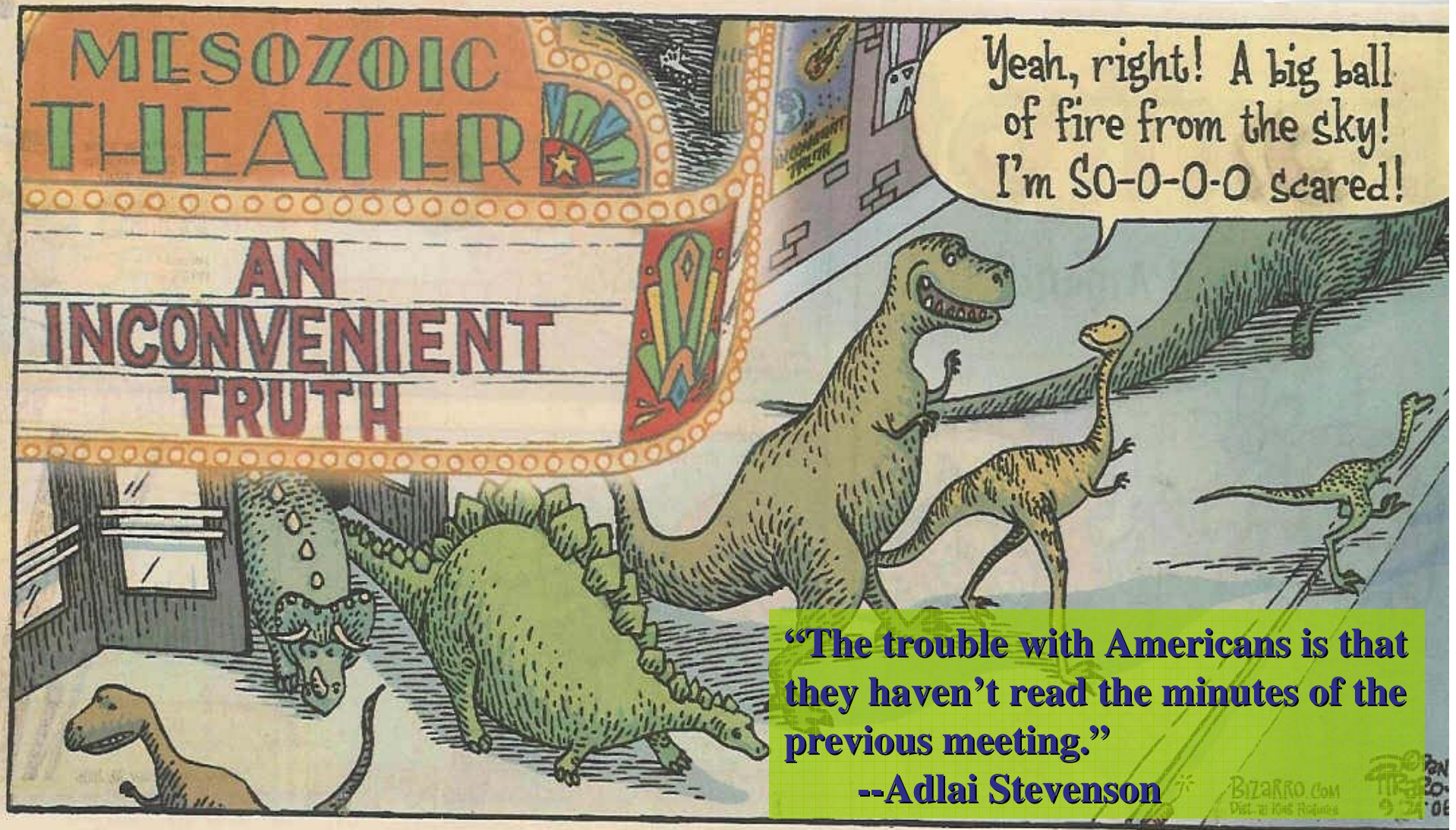
And when someone raises doubts, then we
think there is something wrong with the
science.

We need a more realistic view of
science

We call that view
“title search realism”



And we hope it's not too late...



Why they did it?
Free Market Fundamentalism
and the Slippery Slope to
Socialism

Capitalism and Freedom

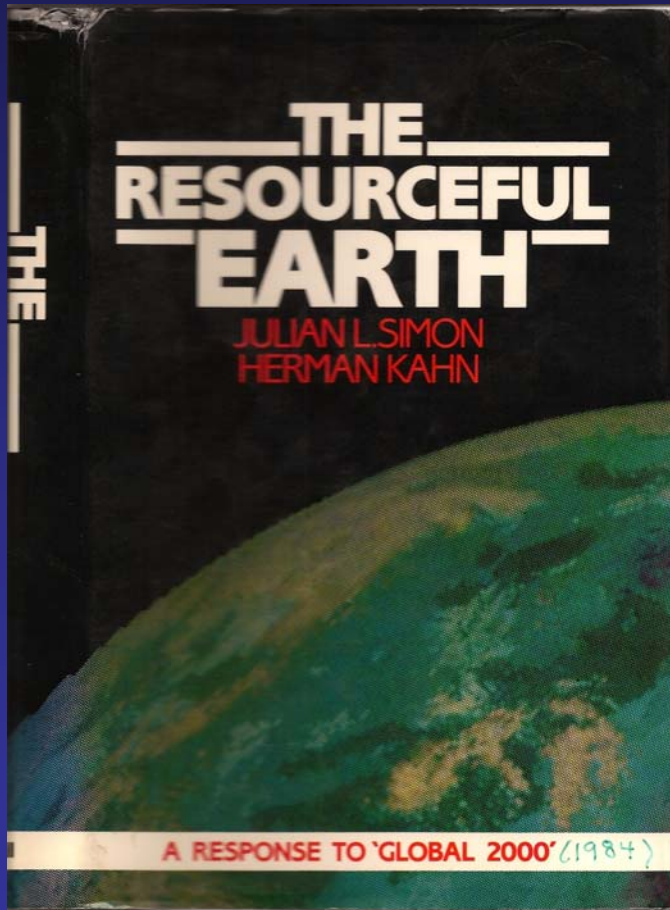
- Milton Friedman, *Capitalism and Freedom*, 1962
- Civic freedom and free markets are inextricably linked—without free markets, we're on the slippery slope to tyranny
- Environmentalism=creeping communism
- Environmentalists as watermelons..

Market Fundamentalism

- George Soros popularized this term for laissez faire economics in 1998
- The underlying axioms of laissez faire (or more properly, neoliberalism) have been shown to be false... (e.g. Great Depression, other market failures.
- Believing in things known to be false is an act of *faith, not science*

- Reagan administration argued “technology will ultimately be the answer to the problems of providing energy and protecting the environment”
- But recall Friedman, a hero of Ronald Reagan’s: “the great advances of civilization, in industry or agriculture, have never come from centralized government.” *Capitalism and Freedom*, 4.

Cornucopianism



- Friedman's not the only one
- This is also the view promoted by the followers of Julian Simon, the Cornucopians
- Only “free markets” produce innovation and technological change that societies need

- How many examples of “wrongness” can a historians fit on one slide?
 - US Army and interchangeable parts
 - Microwave technologies
 - Aviation and airlines
 - Feedback-control systems
 - Nuclear power!
 - Digital computing
 - Internet
 - Pollution control technologies...

We call this “technofideism”

Connection to anti-communism?

Environmentalists as
watermelons:
Green on outside, Red on
inside

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.

States to cap and reduce—unilaterally, if necessary—the emission of the major greenhouse gas, carbon dioxide resulting from fossil-fuel burning. The White House would be well advised to resist such pressure to place scientifically arbitrary and economically ruinous limits on energy generation.

The Hidden-Agenda Problem

It should come as no surprise to anyone that many people are hyping the greenhouse warming "threat" to push their own pet agendas. They seem undeterred by the growing scientific evidence that shows no climate effects from the increase in atmospheric greenhouse gases. For example, global temperatures did not increase during the past decade—contrary to cataclysmic predictions. Yet the *Today* show, PBS-TV specials like "Crisis in the Atmosphere," and most of the print media all still preach impending doom in the form of the collapse of global agriculture or a catastrophic rise in sea levels. An editor of *Time* magazine even assures journalists that it is all right to become environmental advocates, never mind scientific facts.³⁰

Why do so many different groups focus on greenhouse warming? Because this issue provides a wonderful excuse for doing things that they already want to do, under the guise of saving the planet. We find in one corner proponents of nuclear energy (which emits no CO₂), who see a chance to refurbish their public image. Next to them are natural gas producers, keen on beating out competition from cheaper, but more polluting coal. Even scientists are becoming cheerleaders: budgets for climate research just jumped to over one billion dollars.

In another corner we find proponents of energy conservation and renewable energy. These are quite commendable goals, really, except for those uneconomical measures that waste more energy than they save. The extremists in this crowd oppose all energy growth and economic growth.

More dangerous are those who have a hidden *political* agenda, most often oriented against business, the free market, and the capitalistic system. Of course, after the collapse of socialism in Eastern Europe it is no longer fashionable to argue for state ownership of industrial concerns. The alternative is to control private firms by regulating every step of every manufacturing process.

And then there are those who visualize global warming as a vehicle for international action, preferably with lots of treaties

The "hidden agenda" problem. .

More dangerous are those who have a hidden *political* agenda, most often oriented against business, the free market, and the capitalistic system. Of course, after the collapse of socialism it is no longer fashionable to argue for state ownership of industrial concerns.

The alternative is to *control* private firms by regulating every step of every manufacturing process.

--S. Fred Singer, 1991

...and when Singer defended
second-hand smoke...

"...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)

We didn't make the world safe
for green vegetables, or for polar
bears, or Pacific Islanders

The End.



"Sorry, Harold, but I'm reducing our carbon footprint."

