



Fig. 29.1. Hansen and Jerry Mahlman at 8 May 1989 Senate Hearing.

Chapter 28. Dry Gets Drier, Wet Gets Wetter, Storms Get Stronger

The invitation was in a letter from Ernest Hollings, Chairman of the Senate Committee on Commerce, Science and Transportation, a request to testify on my “research on global climate models.” Specifically, “to discuss what processes are included in the models and what are not, and to summarize the conclusions that can be drawn from the models.” Senator Al Gore would chair the hearing, initially planned for April 1989. The hearing was postponed when Gore’s six-year-old son, Al Gore III, was hit by a car as he ran onto a busy street outside Memorial Stadium after a Baltimore Orioles baseball game. After his recovery progressed, the hearing was rescheduled for Monday 8 May.

Most of the world is sometimes dry and sometimes wet, so increases of dry and wet extremes can be hidden on average. Also, models do not depict well the location and timing of extremes. Thus, we sorted our model diagnostics according to how wet a location was in the normal (control run) climate. With warming climate, dry places tended to get drier and wet places wetter, and statistics showed an increase of both dry and wet extremes at most places. Seasonal averages over large regions also revealed increasing extremes. For example, summers in the Southwest U.S. and the Mediterranean and Middle East – in the dry subtropics – become even hotter and drier, while climatologically wet regions become wetter with global warming. We showed that results of Manabe and Wetherald¹ were consistent with our results. A clear picture emerged: intensification of dry and wet conditions as temperature increases, as a result of increased surface heating, more rapid evaporation, and more water vapor in the air in a warmer world.

Storms were not resolved by climate models in 1989, yet we could infer how storm intensity changes with warming. We calculated the “fuel” for storms, called “moist static energy,” which is the sum of sensible heat, latent heat, and geopotential energy. Our model yielded a rational result: increased evaporation with global warming leads to a large increase of moist static energy near the surface, implying that a warmer climate is prone to more powerful vertical convection that reaches greater altitude. We showed that a similar conclusion follows for the very different moist convection treatment of Manabe and Wetherald. We also showed that in regions of greater sea surface temperature observed moist convection penetrates higher in the atmosphere. Doubled CO₂ increased the height of the convective storm cells several hundred meters in our model and

produced heavier rainfall. The greater absolute humidity, greater latent heat, and resulting higher penetration of moist convection cause a larger portion of rainfall to be in intense thunderstorms, as opposed to the gentler rainfall from large-scale stratiform clouds.^I

Increased storm strength is not limited to thunderstorms. Kerry Emanuel of MIT, a world expert on tropical storms, used sea surface temperature changes from our 2×CO₂ experiment to estimate the effect of greenhouse warming on the maximum intensity of tropical cyclones. The minimum sustained surface pressure decreased from 880 to 800 millibars and maximum wind speed increased from 175 to 220 miles per hour. Tropical storm strength depends on many factors and seldom approaches its maximum potential intensity. However, storm damage increases rapidly with wind speed, so the infrequent most intense storms cause the lion's share of storm damage.

We completed a paper² prior to my testimony, which I included as part of my written testimony. The paper concluded that global warming pumps up both ends of the hydrologic cycle – dry-gets-drier, wet-gets-wetter, and storms get stronger. The paper also addressed several issues that had been raised about my 1988 testimony.

Friday 5 May, I received a call from NASA Headquarters. The White House OMB (Office of Management and Budget) wanted changes in my testimony, which I had submitted to NASA a few days earlier. The changes were being sent to me by fax. Embers of anger began to smolder as I waited delivery of the fax. I did not see why OMB even had a right to review my testimony. When I received OMB's instructions, the embers burst into flame.^{II}

OMB's first change was an added paragraph: "Again, I must stress that the rate and magnitude of drought, storm and temperature change are very sensitive to many physical processes mentioned above, some of which are poorly represented in the GCMs. Thus, these changes should be viewed as estimates from evolving computer models and not as reliable predictions." Our paper was careful to focus on basic physics of climate processes, not on detailed model results, so I could write "...certain fundamental conclusions emerge which we believe are very unlikely to change as knowledge of the climate system becomes more precise." We included appropriate caveats, and as the first paragraph of my testimony, I wrote "This statement is based on studies carried out with my colleagues David Rind, Andy Lacis, Tony Del Genio, Reto Ruedy, Sergej Lebedeff, Michael Prather and Peter Stone at the NASA Goddard Institute for Space Studies. The opinions expressed represent our scientific conclusions, but they do not necessarily represent NASA policy or a consensus of the scientific community." The added OMB paragraph was not needed. Its intent, it seemed to me, was to make the testimony appear meaningless.

OMB's second change was to add the sentence: "One point that remains scientifically unknown is the relative contribution of natural processes and human activities to these forcings." The third and final OMB change was to replace my statement: "Although it will be more difficult to constrain CO₂ emissions than was the case for CFCs, there are many policy options which would

^I We did not discuss hail, the ice-balls sometimes produced by powerful thunderstorms in regions such as the Midwest United States, but the effect of global warming on hail follows from the change of deep moist convection. With a greater portion of rainfall in more powerful thunderstorms reaching greater heights with stronger updrafts, hailstone size from strong thunderstorms will increase while the number of storms with small hailstone size will decline, consistent with recent research (Brimelow JC, Burrows WR, Hanesiak JM. The changing hail threat over North America in response to anthropogenic climate change. *Nature Clim Chan* 7, 516-22, 2017)

^{II} I have a mild, quiet, personality, but occasional bursts of anger. Anniek says this is a common trait of Asperger syndrome, surfacing when the person is unable to otherwise express himself.

reduce atmospheric CO₂ growth rates and make good economic and environmental sense, independent of concerns about an increasing greenhouse effect.” The OMB replacement read: “Although it will be more difficult to constrain CO₂ emissions than was the case for CFCs, any policy options which should reduce atmospheric CO₂ growth rates should make good economic and environmental sense, independent of concerns about an increasing greenhouse effect.”

Only this third change was directly relevant to the nation’s budget. However, they were saying that the nation should not even consider actions to address the greenhouse effect, per se, only actions that made sense independent of the greenhouse effect. They wanted me to make that policy statement, as if I agreed with it and as if it were my own statement. I explained to the intermediary (at NASA’s Office of Congressional Affairs) why I could not make the requested changes and then awaited OMB’s further response.

Late Friday OMB’s decision arrived: their only concession was to replace “these climate forcings” in their second insertion with “non-CFC climate forcings.” My feelings hardened. The only solution, despite the risks, was to expose OMB’s activity: testimony of government scientists was not their free scientific opinion – it was distorted to fit the preference of the White House. I asked my secretary to make the one change that OMB approved and to let Senator Gore’s office know that I was sending them a fax.³ The fax outlined the points I wanted to make in my testimony, and I suggested that Senator Gore query me during the hearing about the first OMB insertion. I would make clear that the statement was OMB’s opinion, not mine.

It was after 7 PM when I got home. Anniek greeted me, saying that Senator Gore had called.

“What did he say?”

“He wants you to call him. I only asked him about his son.”^{III}

When I called, Gore expressed indignation about OMB’s edits of my testimony. He wanted to make an issue of it, if I had no objection. Of course, I agreed – my aim was to draw attention to the practice of White House censorship, as well as to our views on the science. Senator Gore asked if I was willing to do an interview with the New York Times over the weekend, warning me that I might get in trouble.

“It’s o.k. I think I’m in trouble anyhow.”

Gore responded “there’s an old Chinese proverb that covers cases like this.”

Unwittingly, I played the straight man: “Oh? What’s that?”

“If they can’t take a joke, fuck ‘em.”

I chuckled. He asked me to stop by his office Monday morning before the hearing.

After I hung up, Anniek asked why I had laughed. I told her what he said. She frowned. I guess she does not appreciate Chinese proverbs.

Senator Gore saw an opportunity for a brouhaha that could affect an ongoing battle. Was there a need for an international global climate agreement? It was up to President Bush. Without the United States, it would be almost meaningless. Bush had claimed to be an activist during the hot

^{III} His son was home in a full body cast, after suffering multiple broken bones and a concussion. More than half of his spleen had been removed, but he was expected to recover.

1988 summer. “Those who think we are powerless to do anything about the greenhouse effect forget about the ‘White House effect’; as President, I intend to do something about it,” he said in Michigan in August. He promised to convene an international environmental conference. “We will talk about global warming, and we will act.”

Not so fast. Bush was no scientist. Once elected, he needed technical advice. He found it at his right hand as soon as he chose John Sununu, ex-governor of New Hampshire, to be his chief-of-staff. Sununu had once been a scientist. He had a Ph.D. in mechanical engineering from MIT. Sununu was also a politician, a successful three-term Governor of New Hampshire. He was a pragmatic conservative, who turned a budget deficit into a surplus without raising taxes. His environmental record was strong. He increased spending on public-land preservation. He signed the nation’s first acid-rain legislation, and he lobbied President Reagan for a national 50 percent reduction of sulfur emissions, consistent with the target advocated by the Audubon Society.

Sununu had both political and scientific perspectives on climate change. First, let’s consider his political perspective. Core conservative values include minimal government size and minimal regulations. Conservatives believe that economic growth will help solve global environmental problems, including over-population. Their rationale is that family size will decline as living standards rise, even to the point that fertility rates fall to or below replenishment levels. Most people agree that other things are required to make this approach work globally, including universal women’s rights. Let’s call this the “growth” perspective.

The “antigrowth” perspective is exemplified by *Limits to Growth*,⁴ a study focused on consequences of finite world resources. *Limits to Growth* was widely panned because it gives short shrift to the potential for technology to solve problems of resource depletion, pollution, and food production. Nevertheless, it can be argued, much real-world data remain consistent with the business-as-usual scenarios in *Limits to Growth* that lead to economic and societal collapse in the latter part of the 21st century. So, the growth/antigrowth perspectives are still debated.

Sununu’s political perspective was simple. He saw an international global climate agreement as a threat. Such an agreement would be used by the antigrowth crowd to promote the command and control, antigrowth, policies that he feared. The United States, with its high per capita level of resource consumption, was certain to be a target.

Skepticism, was Sununu’s scientific perspective, to put the best face on it. D. Allen Bromley, President Bush’s science adviser and once a nuclear physicist, was also a global warming skeptic. Skepticism is the soul of good science, when it induces rigorous study of critical issues, but scientific skepticism must be unbiased. If preference or ideology affects a person’s analysis, that person is likely to be exposed as a second-rate scientist or even a quack. Cherry-picking is the dominant characteristic of the biased scientist, who chooses data that support, or seem to support, a preferred conclusion, while ignoring contrary data.

Sununu thought the ocean’s huge heat capacity would make human-made warming negligible. Warren Washington, leader of the National Center for Atmospheric Research (NCAR) modeling group, explained to Sununu that only the ocean upper layers come into play on short time scales, but Sununu wanted a climate model to play with on his Compaq 386 desktop computer⁵ and he badgered Bromley to extract a model from NCAR. Eventually NCAR provided Sununu a simple one-dimensional model, which allowed him to mix heat into the ocean as he chose.

Ocean mixing was a crucial issue, but that was no surprise to the climate research community. Ocean models were being developed to explore the mysteries of sudden climate changes during Earth's paleoclimate history and to anticipate effects on global climate caused by increasing meltwater from Greenland and Antarctica. However, Sununu had no such model. He did not need it. His main interest was not science. He had become a politician. He aimed to thwart antigrowth environmentalists. There is no evidence that he used his little model for any meaningful study, but he did use his knowledge of scientific terminology to cast doubt on credible science and on the climate change issue.

Bromley aided and abetted Sununu. To give Bromley his due, he was an effective Science Adviser. He pushed for increases in research funding intended to keep American manufacturing competitive and he supported expansion of the high-speed network that became the internet. Bromley dutifully went along with Sununu's belief that global warming concerns were largely "poppycock." Bromley's responses to questions during congressional hearings illustrate his position. At one hearing Senator Gore asked, "Do you believe that the doubling of carbon dioxide in the atmosphere, which will occur in the next 40 years or so, is likely to result in global warming?" Bromley replied, "It's certainly possible, and probable to some degree, but that's as far as I can say on the basis of the evidence." Citing recent results⁶ of British climate modeler John Mitchell, Bromley concluded "my answer is that I simply don't know."⁷

Mitchell showed that doubled CO₂ climate sensitivity of his model fell from 5.2°C to 1.9°C, if he altered his cloud calculations. Scientists like to publish results that stir things up; such papers are useful if they identify informative observations. However, media often aggrandize such papers for the sake of "news," thus causing public confusion. Bromley's job, as lead scientist for the nation, was to clarify the science. He should have explained that models, by themselves, do not practically constrain climate sensitivity, but real-world climate sensitivity is known to be high, based on paleoclimate data. Bromley should have tossed water on the little fire started by Mitchell and the media. Instead, he threw gasoline on it. Bromley served Sununu well.

Sununu understood the big picture. The issue was whether the United States would support an international framework convention on climate change and agreement that the world must avoid dangerous human-made climate change. A framework convention would be the crucial first step – a big step – toward effective climate policies. Treaties would be expected to follow.

Sununu was dead set against a framework convention. His main opponent in the Administration was EPA Administrator Bill Reilly. Secretary of State James Baker III also favored a framework convention. Sununu had the upper hand, as the trusted chief of staff for President Bush. Cartoons depicted Sununu as so huge as to blot out the Sun. Sununu controlled the U.S. position at the international meetings. He gave the orders. He discouraged the idea of following through on the Bush campaign promise to host an international environmental conference. Reilly lobbied for the United States to get involved in climate treaty making, but Sununu was in charge. Sununu ordered American delegates planning to attend a climate meeting in Geneva in late May 1989 to make no commitment. That was the setting for Albert Gore's Senate hearing.

I had to get up early in Ridgewood, New Jersey to catch the 6 AM Shuttle from LaGuardia Monday morning. As I boarded the plane, I failed to grab a free copy of the New York Times,

because I was tired and still had to read and edit my oral testimony. So, I was blissfully unaware of a headline on the front page: “Scientist Says Budget Office Altered His Testimony.”⁸

Senator Gore showed me the paper when I entered his office. I had expected Shabecoff’s article to appear the next day, after my testimony. The article laid out some of the climate science, my assertions of censorship, and the internal battle between Sununu, Bromley, and Richard Darman (the head of OMB), on one hand, and Reilly and Baker, on the other. Gore wanted to start the hearing with the censorship issue. I preferred to do the hearing as scheduled, because I wanted to describe the science as I had prepared it. I did not trust my ability to extemporize. Senator Gore was considerate; he consented and asked if I was all right. “You like this stuff, right?”

“No, but it’s not a problem.”

As we left his office, he said “Let’s take separate stairs. If we go together, they can get us both with one hand-grenade.” I assumed that he did not want the media to think we were conspiring.

Senator Gore was right. My request to begin the hearing with science, not the censorship matter, may have worked, if I had a good presentation, appropriate to the audience. I began with the increase of greenhouse gas climate forcing since Keeling initiated precise monitoring of CO₂ in 1958. We calculated the added forcing as 1.1 W/m² with an uncertainty of order 10 percent. That forcing, by itself, is a huge drive for climate change. It’s four times larger than the change of solar forcing between solar minimum and solar maximum. It’s comparable to forcings that drove glacial-to-interglacial climate change. My point was that the forcing was large; thus – given our knowledge of climate sensitivity, the long lifetime of the greenhouse gases, the thermal inertia of the global ocean, and the resulting delayed climate response – we were in the process of locking in large consequences for young people and later generations.

Such a presentation may work for informed physicists who see connections immediately. Richard Feynman described an example.⁹ However, a simple, clear, presentation is needed for the lay public. Instead, I started by holding up a tiny Christmas tree light, which had a power output of about 1 watt. Increased greenhouse gases were heating Earth with an energy of one of these bulbs absorbed by every square meter of Earth’s surface. Some newspapers had a photo of me holding up the tiny bulb, with Senator Gore squinting down as if to say “what the devil are you trying to show?” I was told that the effect was probably the opposite of my intention. The lay person thinks “the human effect amounts to a tiny lightbulb? All the fuss is about that?”

In retrospect, I should have prepared a succinct description of dry-gets-drier, wet-gets-wetter, and storms-get-stronger. My message on those topics was buried in too much other stuff. There was no chance that the media would pick up on my discussion of the science when there was a much more compelling story in the censorship by the White House. I had a second chance when a reporter crawled along the floor and handed me a note, while Jerry Mahlman, Director of the Geophysical Fluid Dynamics Laboratory at Princeton, gave his testimony. The note said that there would be a press conference with Senator Gore after the hearing – could I come?

“No, I must catch a plane,” I wrote on the note. Erik, a sophomore at Ridgewood High School, would be the starting pitcher in a JV game that afternoon. I had just enough time to get there. If I had had my wits about me, I would have prepared a few lines while Jerry was talking. There was still an opportunity, with all the cameras rolling, to draw attention to how we, humanity, were



Fig. 29.2. Impromptu news conference outside Senate hearing room.

pumping up both ends of the hydrologic cycle. I would kick myself later – a missed opportunity to focus on the science – but I preferred to escape the hearing.

However, there was no immediate escape. The reporters sat up microphones just outside the hearing room door. I could not avoid Senator Gore’s press conference. The censorship matter was the lead story on the evening news. I appeared in cameo as Gore castigated Bush. An Administration spokesman said that I was entitled to my opinion, and there would be no retaliation against me. Really? More on that topic later. The important point was that the climate policy issue got elevated above Sununu. President Bush could not avoid the issue. Senator Gore made certain of that by ridiculing President Bush’s prior claim to be the environmental President. The ball was now in Bush’s court.

¹ Manabe S, Wetherald RT. [Large-scale changes of soil wetness induced by an increase in atmospheric carbon dioxide](#). *J Atmos Sci* **44**, 1211-35, 1987

² Hansen J, Rind D, Del Genio A et al. [Regional greenhouse climate effects](#), in *Preparing for Climate Change*, Climate Institute, Washington, D.C., 1989. Available, including color figures, in *Documents as Hansen et al.* (1989).

³ Hansen J, Memo to Senator Al Gore, 05 May 1989, 3 pages, available in *Documents as Gore memo* (1989).

⁴ Meadows DH, Meadows DL, Randers J et al. *The Limits to Growth*, Potomac Associates, 205 pp, 1972.

⁵ Warren Washington, private (e-mail) communication to the author, 2019.

⁶ Mitchell, J.F.B., C.A. Senior and W.J. Ingram, [CO₂ and climate: a missing feedback?](#) *Nature* 341, 132-134, 1989.

⁷ Sun, M., [Global warming becomes hot issue for Bromley](#), *Science*, 246, 569, 1989.

⁸ Four articles and a lead editorial from that week are in *Documents as New York Times* (1989).

⁹ As described on pp. 54-55 of *Storms of My Grandchildren*, Oppenheimer, Tolman, Compton, Rabi and others in the Manhattan project listened to alternative ideas on how to separate pure uranium. After hearing those and without repeating the arguments, Tolman (chairman for this task) said, in effect, “It’s clear that Compton’s argument is best; let’s go ahead.” They had looked at the problem from all angles, and could recognize the best approach.