Hansen *vs.* the World on the Greenhouse Threat

Scientists like the attention the greenhouse effect is getting on Capitol Hill, but they shun the reputedly unscientific way their colleague James Hansen went about getting that attention

Amherst, Massachusetts

SCIENTISTS GATHERING at the Workshop on Greenhouse–Gas-Induced Climatic Change here in early May were waiting in vain for their unofficial guest of honor to appear. James Hansen, climate modeler and leading scientific spokesman for the greenhouse effect, was in Washington testifying to Congress, again.

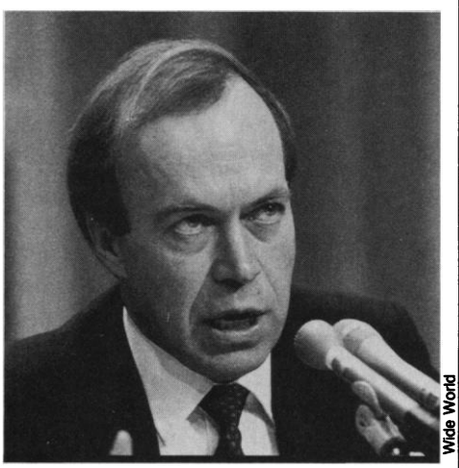
Last summer, Hansen made the headlines of virtually every major newspaper, carried his message onto the network news shows . . . and irked practically everyone in the field when, in the midst of a drought, he told Congress that the greenhouse warming is here. It was this sort of unconditional claim from Hansen and his group that had prompted this meeting. The greenhouse community was determined to set the record straight with hard facts, but now, even as they got their meeting under way, Hansen was at it once more on Capitol Hill.

This time Hansen was in Washington to stress that climate models had become reliable enough to conclude that rapid strengthening of the greenhouse effect would lead to "drought intensification at most middle- and low-latitude land areas." But the Office of Management and Budget (OMB), in its role as monitor of federal policy statements, was not buying Hansen's views outright. Over his objections, it attached a caveat to Hansen's written testimony—". . . these changes should be viewed as estimates from evolving computer models and not as reliable predictions."

When Hansen complained, he touched off a furor in Washington among the politicians but not among the greenhouse scientists in Amherst. "I can't say I agree with censorship," observed Rick Katz, who studies climate change impacts at the National Center for Atmospheric Research in Boulder, "but it seems OMB has better people than I thought. I'd have to agree with their angle."

So Hansen, who is director of NASA's Goddard Institute of Space Studies in New York City, was once again at loggerheads with his colleagues in the climate community over how to speak to outsiders. That Hansen's colleagues are taking pleasure in the federal bureaucracy's meddling in scientific testimony illustrates the resentment these climatologists feel toward their now famous colleague.

But there's an irony: had it not been for Hansen and his fame, few in public office, and certainly not the public itself, would have paid much attention to a problem that everyone at Amherst agrees threatens social and economic disruption around the globe. After all, experts had been hemming and hawing for a decade on the likely magnitude of the problem, and hardly anyone had listened. Then came Hansen. Now greenhouse scientists have the attention they have wanted but for reasons they think unsound.



Wide World

"It's just a logical conclusion that the greenhouse is here."

—James Hansen

By day two of the workshop, Hansen had appeared and, in an interview with *Science*, recalled his testimony on that sweltering day in Washington in the midst of last summer's drought. "I said three things. The first was that I believed the earth was getting warmer and I could say that with 99% confidence. The second was that with a high degree of confidence we could associate the warming and the greenhouse effect. The third was that in our climate model, by the late 1980s and early 1990s, there's already a noticeable increase in the frequency of drought. Despite all the criticism, I wouldn't change any of these."

His colleagues certainly wish he would. What really bothers them is not that they believe Hansen is demonstrably wrong, but that he fails to hedge his conclusions with the appropriate qualifiers that reflect the imprecise science of climate modeling.

Hansen's critics start with his statement that he has 99% confidence in the reality of the global warming trend. At the workshop, as he already had in the *New York Times*, statistician Andrew Solow of Woods Hole Oceanographic Institution picked on the few quantitative facts involved. Hansen had said in last year's testimony that 1987 had been so hot, so much warmer than the average of the previous 30 years, that its warmth had only a 1% chance of being a random quirk of the climate system.

"That's not a test for the greenhouse in any way," Solow told the workshop. The year "1987 should be assessed against previous data. The key thing is logic, and I think there's a logical problem here." When statistician Solow calculated how unusual 1987 had been, he found that it did not stand much above an underlying upward trend, giving a confidence of just 70% that it was an exceptional year. To statisticians, that is practically no confidence at all.

Climatologist Tom Wigley of the University of East Anglia, though critical, was more sympathetic. "I think his 99% confidence is not justified theoretically. But he's just saying that, relative to 1958, there's been a warming." In his enthusiasm for proper statistical analysis, Wigley was arguing, Solow had removed the trend that Hansen was trying to point out.

Wigley's sympathetic point of view might have some merit, responded Solow, but "this kind of giving a result and not telling the whole story, that's what I'm criticizing."

If many of Hansen's colleagues find his first point about the warming trend regrettable, they view his second—that the warming could, with "high confidence," be linked to the greenhouse effect—as unforgivable. None of the select greenhouse researchers at the meeting could agree with him. "Taken together, his statements have given people the feeling the greenhouse effect has been detected with certitude," says Michael Schlesinger, himself a modeler at Oregon State University. "Our current understanding does not support that. Confidence in detection [of the greenhouse] is now down near zero."

Hansen's third point—that "the green-

Greenhouse Models *vs.* Reality

Climatologists may have a gut feeling that the greenhouse effect is heating up the earth, but they have not been close to proving it. Enter a new generation of greenhouse computer models that are giving scientists some hope that the grossest features of the future greenhouse world are being simulated correctly. But the view ahead promises to be a myopic one for years to come.

The new models, which were described at the Amherst workshop, behave more like the real world than earlier models in two ways. They transfer heat from the atmosphere into the deep sea and carry it in surface waters toward the poles, all in currents that can vary in response to climate change. At best, earlier models had only analogs to surface currents that could not change as climate changed. And while earlier models yielded only a single snapshot of the climate expected toward the middle of the next century when greenhouse gases will have doubled, the new models simulate the effects of gradual, rather than instantaneous, increases of greenhouse gases. This will allow researchers to test the new models against what has actually happened in past decades, as well as to project continuous future climate changes.

The greenhouse worlds of the new models have some aspects in common with those of the old ones, though. In both types of models, the world indeed gets warmer, and the continents also tend to warm faster than oceans. In addition, the new models produce similarities to the real world not seen before. For example, in the model that is run by Warren Washington and Gerald Meehl of the National Center for Atmospheric Research (NCAR), the lower atmosphere warms over North America and Europe as it cools over the North Atlantic and the North Pacific. David Karoly of Princeton University recently reported that this has actually happened in recent decades. And both this NCAR model and the new model developed by Syukuro Manabe and his colleagues at the Geophysical Fluid Dynamics Laboratory (GFDL) in Princeton generate rudimentary El Niños—something previous models could never do.

Analysis of these model results is only just beginning, but the reassuring similarities between them are attended by some disturbing inconsistencies. A relatively greater warming at high latitudes is not so evident in the new models. But the real shocker was the weird behavior of the GFDL model run by Manabe. Its Northern Hemisphere behaved much as in earlier models, but after a few decades of modest warming, its Southern Hemisphere began to cool. "This is a big surprise," said Manabe. A strong cooling of the ocean around Antarctica seems to be the immediate cause. "We really don't understand how the ocean behaves," he added.

While modelers are thinking about the new results, other researchers are using both old and new model results to look for the greenhouse effect in recent climate data. The approach favored at the meeting, called fingerprinting, involves comparing the few reliable aspects of greenhouse climates with recent climate trends. The closer the match between model prediction and recent observations, the more likely that the greenhouse warming is here. Assuming the model predictions are correct, studies presented at the workshop show that any intensification of the greenhouse is not yet detectable above the background of natural climatic noise. Indeed, there was every indication that detection of the greenhouse signal using statistically based fingerprint approaches is perhaps 10 years or more away.

Rigorous, objective detection of the greenhouse may be a ways off, but hints of a greenhouse-like climate change nevertheless continue to accumulate (*Science*, 5 February 1988, p. 559). As reported at the meeting, a new study has confirmed the previously noted contrast between warming near the surface and cooling of the stratosphere. The observed pattern of enhanced precipitation reminiscent of the greenhouse was extended to the Soviet Union. And the amount of water vapor over the tropics was shown to have increased in recent decades, as would be expected. In addition, as reported in the 19 May issue of *Science* by W. R. Peltier and A. M. Tushingham of the University of Toronto, global sea level seems to have risen 2.4 ± 0.90 millimeters per year this century, even after allowing for vertical movements of the land.

How many such hints it would take, combined with the certainty of an eventual greenhouse warming of some magnitude, to convince most climatologists that the greenhouse has arrived cannot be rigorously determined. ■ **R.A.K.**

house effect will [cause] certain changes in climate variability such as the intensity of droughts and storms"—elicits a less vituperative response. Climate modeler Stephen Schneider of the National Center for Atmospheric Research in Boulder reflects the views of others at the meeting, who would only speak privately, when he observes that "where Jim has had some problems with his friends, and I count myself as one, is when he says that the location of specific areas of drought in his model are robust. I can't make the case as strongly as Jim does," Schneider contends, because model particulars such as how the oceans are simulated could make a difference.

"He's not running a realistic ocean," says Schneider. "You don't really know what it's going to do. But he's probably right anyway. The odds are better than 50:50 that the drought areas are robust."

Despite their sharpness, these criticisms do not reflect on Hansen's research abilities, rather they tend to revolve around the interpretation of climate models. "Jim is not the villain that people make him out to be," says Schneider. "He's a state-of-the-art climate modeler. Jim got bad press that was partly deserved and partly envy of other scientists who resent the way he went to Congress. The problem I have is that he has more confidence in his tools than I do."

The primary tool in the greenhouse game is the general circulation model (GCM) of the climate system. Like its cousin that forecasts the daily weather, the climate GCM cranks through equations that calculate the behavior of climate as greenhouse gases increase. Unlike weather forecasting models, a climate GCM must include a simulated ocean whose behavior—such as the way it carries heat around the globe—bears a reasonable resemblance to that of the real ocean. Last year Hansen was the first to publish the results of a GCM that has any kind of a realistic ocean and that also is driven by realistically increasing greenhouse gases. That work provided the best guess up until then of how climate might be responding now and how it will respond in the next few decades.

Despite the relative sophistication of Hansen's model, other modelers remain unconvinced because they feel Hansen gives short shrift to the remaining shortcomings of even newer, more realistic models. "They [Hansen's group] have been coupling their atmospheric model to a pretty hokey ocean," says Schneider, "we all have. But you have to have less confidence because of that."

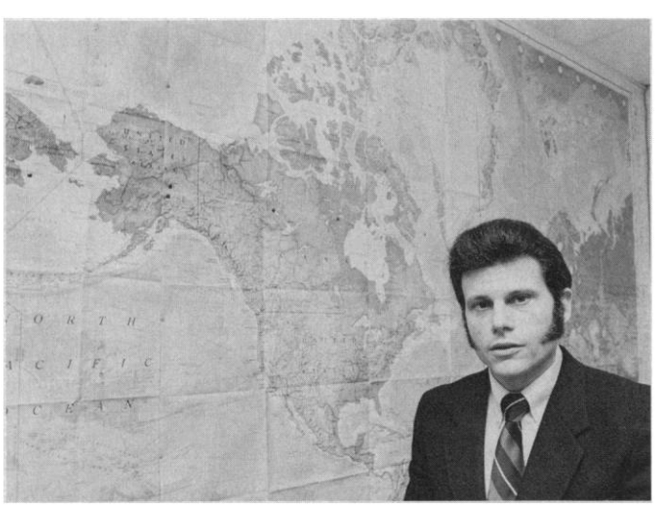
Other uncertainties lessen confidence as well. Researchers must have some idea of the degree to which climate is being

changed by forces other than greenhouse gases. For example, volcanic dust in the stratosphere probably cools Earth, changes in solar activity may change the climate, and climate surely meanders a bit from one state to another with no prompting whatever.

All the climatic variability generated by these natural forces generates noise in the climatic record that, Hansen's critics would argue, has drowned out the poorly known greenhouse warming signal. "The variability of climate from decade to decade is monstrous," said Tim P. Barnett, an oceanographer at Scripps Institution of Oceanography. "To say that we've seen the greenhouse signal is ridiculous. It's going to be a difficult problem."

The detection problem is one that may take decades to solve. Barnett and Schlesinger have their own approach, an objective, statistical test. Through the latest results, it has found no signal.

Hansen was in no position to argue. He arrived at the 5-day meeting a day late and left 3 days early. "That is his habit," noted workshop organizer Schlesinger. "He comes, gives his talk, and he leaves." Even while present, his quiet, retiring manner puts him in the background. These habits have not encouraged mutual understanding. Neither did the audience's polite reticence during Hansen's talk, which contrasted with pot shots from many quarters during his absence. Not that Hansen is unaware of his colleagues' complaints. Last fall, in his lone confrontation with his critics, Hansen endured what one observer described as "a get-Jim-Hansen session" at a climate workshop in Washington. Hansen, as is his style, was unperturbed. "When we're at this level of signal to noise, anyone can disagree with me. I don't argue with that."



One of James Hansen's many critics. *Michael Schlesinger runs computer greenhouse models too, but he does not share Hansen's "high confidence" that the greenhouse is here.*

What gives Hansen high confidence when others hesitate to make any claim is a variety of supporting evidence. The globe has warmed slightly during the past 100 years. His model roughly tracks the warming of the past 30 years. And analyses of polar ice cores suggest that a reduction of the greenhouse effect due to a reduction in atmospheric carbon dioxide contributed to the chill of the last ice age 18,000 years ago.

"The one thing that has the greatest impact on my thinking," says Hansen, "is the increase in atmospheric carbon dioxide from 280 parts per million in the 19th century to its present 350 parts per million. It's just inconceivable that that is not affecting our climate. There's no model that would not say it's affecting it right now."

"It's just a logical, well-reasoned conclusion that the greenhouse is here now," he says. "I think there are a lot of people who agree the warming is probably due to the greenhouse effect, but they are waiting to see."

There's no arguing with Hansen on that point. Stanley Grotch, who has been monitoring the performance of the greenhouse models from Lawrence Livermore National Laboratory, guessed that "if there were a secret ballot at this meeting on the question, most people would say the greenhouse warming is probably there."

Schneider, who was not in Amherst for the meeting but usually testifies to Congress alongside Hansen, is one of those scarce greenhouse researchers who do not need a secret ballot to express their gut feelings. "We need 10 or 20 years to get an absolutely clear signal. I'll be surprised if it doesn't happen, but how do you assign a probability to something when you have no objective means of doing so? You base it on physical intuition and then state your assumptions. By my intuitive reasoning, the greenhouse signal has been detected at an 80% probability. My faith is based on the principle of heat trapping by greenhouse gases and the billions of observations that support it. All that objective stuff rests on assumptions. The future is not based on statistics, it's based on physics. Objectivity is overplayed."

Obviously, certitude sells on Capitol Hill, intuition less so. As a group, those at the Amherst workshop offered neither, only a large dose of uncertainty. On the last day, the 40 participants who stayed to the end gathered en masse to put the finishing touches to a press release. They argued over just about everything except this passage: "It is tempting to attribute [the 0.5°C warming of the past 100 years] to the increase in greenhouse gases. Because of the natural variation of temperature, however, such an attribution cannot now be made with any degree of confidence."

Like it or not, the greenhouse community has a spokesman who is not following the consensus script coming out of Amherst. "What bothers a lot of us," said modeler Alan Robock of the University of Maryland, "is that we have a scientist telling Congress things we are reluctant to say ourselves."

"Jim Hansen has crawled out on a limb," said Danny Harvey of the University of Toronto. "A continuing warming over the next 10 years might not occur." The century-long warming has not been continuous. "If the warming didn't happen, policy decisions could be derailed."

Curiously enough, while researchers worry about the possible down side of the greenhouse's newfound popularity, they are still awaiting the benefits from Hansen's confident testimony. Currently about a dozen people run the four U.S. and one British greenhouse GCMs considered state of the art. Time on supercomputers to run greenhouse simulations is scarce, and most modelers often have to scrounge time wherever they can find it. Hansen ran his transient model nights and weekends on his institute's 1975-vintage Amdahl computer—a relic of the dark ages of supercomputing.

"It's getting done at a rate that will take 25 years to get it right," says Schneider. "I'm hoping we can get the modeling of regional greenhouse changes right before they actually happen. What's depressing is that we aren't seeing more resources."

Will a rapidly changing climate leave researchers forever fiddling with their models, still waiting for a consensus detection of the greenhouse? Hansen thinks so. "I'm confident that we're going to see new global records, but it may not be this year. It may be in a few years. I think these issues will go away in the next few years as the earth gets warmer. There will be no sudden change, there will be those who don't agree, but as soon as the man in the street notices, it won't matter. If the model is correct, the increased frequency of drought will be evident in the 1990s, the early 1990s if there is no large volcanic eruption" to cool the climate. If Hansen is right, an exceptional trust in physical intuition may have won the day. ■ **RICHARD A. KERR**