# Research News

# Greenhouse Skeptic Out in the Cold

*A prominent meteorologist says the greenhouse warming will probably be a bust; experts in and out of the climate community staunchly disagree with this latest iconoclast*

IF THE LONG, HOT SUMMER OF '88 sparked the greenhouse revolution, the near normal weather of 1989 is bringing on the counterrevolution. A small but growing cadre of skeptics is now decrying predictions that the greenhouse warming of the next century will surely be severe enough to cause drought, agricultural disaster, and inundation by rising seas.

The computer models producing such doomsday predictions are rife with uncertainty, the skeptics say, the alarm is unwarranted at this point, and the rush to reduce the emissions of carbon dioxide and the other greenhouse gases that cause atmospheric warming is ill-advised. The warming in the next century may well be negligible or even benign, a few maintain.

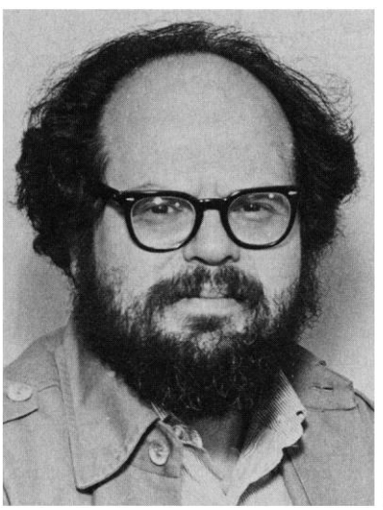
Richard Lindzen, if not the commander-in-chief of these counterrevolutionary forces, is a top general. His troops, at least the outspoken ones, number less than a dozen and are drawn from the ranks of climatologists, meteorologists, and an assortment of related disciplines. Most have not specialized in greenhouse research and have only recently entered the fray.

The claims of Lindzen and his cohorts have not gone unchallenged, however. They are already drawing return fire from mainstream greenhouse researchers, although even some of these concede that greenhouse warming may be less severe than the worst case predictions (see box on p. 1119).

One reason for Lindzen's prominence among the greenhouse skeptics is his credentials. Educated at Harvard, Sloan Professor of Meteorology at the Massachusetts Institute of Technology, and member of the National Academy of Sciences, Lindzen has made major contributions to the theory of how the atmosphere behaves.

No other U.S. skeptic has such scientific stature. So when he says the greenhouse effect "is the only subject in atmospheric science where a consensus view has been declared before the research has hardly begun," people are going to listen. Among those reportedly listening are President George Bush and White House Chief of Staff John Sununu (*Science*, 24 November, p. 992). In September, Lindzen coauthored a letter to the President in support of a report by the George C. Marshall Institute, a Washington D.C. think tank. That report, which also dismisses current forecasts of greenhouse warming as useless, may have influenced the recent U.S. decision not to commit itself to reducing carbon dioxide emissions.

People are also listening to Lindzen because his latest volley in the greenhouse wars is an extreme and potentially devastating one: he says that the computer models that predict a large greenhouse effect are probably fatally flawed because they neglect to consider that the atmosphere can take care of itself. Greenhouse gases will inevitably increase, he admits. They will even double some time in the next century, but the atmosphere will likely warm by at most a few tenths of a degree, not the 1.5° to 4.5°C that researchers running the models expect.



MIT

**Richard Lindzen**. *The atmosphere can negate most of the greenhouse warming.*

"... both the data and our scientific understanding do not support the present level of concern," he has written in a widely circulated, but as yet unpublished, manuscript on the subject. As Lindzen understands the atmosphere, it will in all likelihood react to the warming effect of additional greenhouse gases with a countereffect of its own, a so-called negative feedback, that will neutralize most of the warming.

Researchers in the computer modeling community under attack by Lindzen disagree—some of them vehemently. One of these is Jerry D. Mahlman, the director of NOAA's Geophysical Fluid Dynamics Laboratory in Princeton, New Jersey. When Mahlman reviewed Lindzen's manuscript for the *Bulletin of the American Meteorological Society*, he "recommended the paper be rejected unless he [Lindzen] wanted to convert it into a paper about science. It came across as a whiny complaint without scientific justification. Dick Lindzen is a friend of mine, so I did not say that lightly. I was very disappointed." The paper is still pending at the *Bulletin*.

Others who run the big climate models join Mahlman in complaining that Lindzen seems to claim he has a better climate model in his head than they have in their supercomputers. But what Lindzen has now is not so much a complete model as an idea about how control of atmospheric temperature works. Indeed, he describes it himself as an idea of a theological or philosophical nature.

"The most likely area to search for severe problems [with the models] is in the interaction of climate with water (in all its phases)," he wrote in his paper. "The remarkable thermodynamic properties of water almost certainly lead to its acting as nature's thermostat."

Where the big greenhouse models go wrong, Lindzen says, is that their water always responds to a warming by amplifying it through positive feedbacks. Water never tends to counteract the warming. For example, a warming would drive more water vapor into the atmosphere, where it can act as a greenhouse gas to trap more heat and further warm the climate. Lindzen finds the absence of counterbalancing negative feedbacks, in which water would respond by cooling climate, to be "highly unlikely."

If water-related negative feedbacks exist, Lindzen argues, they are most likely to occur in the tropics above an altitude of 5 kilometers near towering columns of cloud. They carry air from the lower to the upper troposphere, which is the weather-generating layer of the atmosphere. As air rises, it cools. This cooling wrings out much of the air's burden of moisture, which falls back toward

the surface as rain. Thus dried, the rising air fills the upper troposphere.

Lindzen contends that as carbon dioxide increases and tends to warm the atmosphere, this convection-driven conveyor belt will run faster and more efficiently so that it will carry more and even drier air to the upper troposphere. That would reduce the heat-trapping moisture in the upper atmosphere, allowing more heat to radiate to space. Voilà, a negative feedback—the warmer the climate, the dryer the upper troposphere, the greater the heat loss, the more the atmosphere cools. And, crucial to his argument, Lindzen believes the models do not contain this negative feedback.

"When it is recognized that at least some of these [water-related] feedbacks are likely to be *negative* rather than positive," writes Lindzen in his unpublished manuscript, "it is easy to see that the actual response to a doubling of $CO_2$ may readily be $\frac{1}{8}$ to $\frac{1}{14}$—or even less—of what is suggested" by the consensus view. " . . . one may reasonably expect that corrected models may very well end up predicting greenhouse warmings of only a few tenths of a degree Centigrade" for the next century.

The modelers, perhaps predictably, object. "He says water is a negative feedback, but how does he know that?" asks Stephen Schneider of the National Center for Atmospheric Research (NCAR) in Boulder. "Does he have a calculation, or is his brain better than our models? You can't just sit there and build a model of one sector of the atmosphere, then extrapolate to the globe. That's why you build global models."

Lindzen's negative feedback mechanism "is true in a qualitative sense," says Mahlman, "but the magnitude of the effect is tiny. I know of no [observational] evidence supporting it. I could be wrong; Lindzen is a smart person, but I'm afraid he's confused."

Rebuttals from the modelers might be predictable, but none of Lindzen's meteorology colleagues contacted by *Science* will take the extreme stance he has. Their reservations about Lindzen's ideas on negative feedback mechanisms harken back to the modelers' complaints. "He's focused on one aspect," says Peter Stone of Lindzen's own department at MIT, "but if you look at the whole of it, I don't think you'd have a negative feedback."

Alan Betts, a respected independent specialist in the mechanics of convection who works near Middlebury, Vermont, agrees that Lindzen's argument ignores too many of the atmosphere's complexities. According to Betts, moisture is transported into the tropical atmosphere at all levels, and not just near the bottom, as in Lindzen's scheme. "His argument depends very heavily on moisture distribution with height and how it would change with a warming," Betts says. "We don't fully understand moisture transport, but the model studies I have done would not support his arguments. I personally doubt they would hold."

At best, meteorologists take a noncommittal stance on Lindzen's ideas. For example, MIT meteorologist Kerry Emanuel points out that currently no one can estimate how much of the water that goes up in clouds precipitates and how much is left over to moisten the upper troposphere. "It's conceivable that the drying effect could outweigh the moistening effect," Emanuel remarks.

Whether this particular negative feedback counteracts the greenhouse warming or not, Lindzen argues, other negative feedbacks must be operating. In another of his philosophical assertions, Lindzen believes that negative feedbacks, whether his drying effect or others, dominate any positive, warming feedbacks. On timescales of a few hundred years and less, he says, even the hardest push from whatever quarter would not drive the relatively insensitive climate system into a distinctly warmer stage.

Lindzen's confidence in the insensitivity and stability of climate is not shared by many modelers. Skeptics "count all the negative feedbacks we don't know about," says Schneider, "and forget about the positive ones we don't know about."

There are a dozen or so potentially positive, warming feedbacks that, even in their current rudimentary forms, have yet to be included in the models. Increased temperatures would, for example, melt permafrost ice, thereby releasing methane (a greenhouse gas). Whether the net effect of such neglected feedbacks will drive the warming beyond even the range predicted by the models, no one knows. And with that kind of uncertainty remaining, the modeling community is in no mood to entertain Lindzen's criticisms, not in their present philosophical guise. ■ **RICHARD A. KERR**

# Turning Down the Heat

Greenhouse researchers may not be willing to accept Richard Lindzen's thesis that atmospheric warming over the next century will be next to nothing (see accompanying story). But some of them are willing to concede right now that things may not turn out quite as badly as some of the models have predicted. If these researchers are proven right, the scenarios that forecast everything for the next century from a new dust bowl in the American West to beachfront properties being swept away by a rising sea would have to be toned down. However, as often is the case in this business, there is enough lingering uncertainty to give everyone pause.

One major indication that greenhouse warming may be less than expected is the modest rise in global temperatures that occurred during the past 100 years or so. It was only 0.5°C, or perhaps less. And a number of greenhouse skeptics, including meteorologist Lindzen of the Massachusetts Institute of Technology, have argued that the temperature record is so fraught with uncertainties that even this apparent warming is as good as zero. If that is the case, then temperatures are likely to go up only a few tenths of a degree Centigrade by the middle of the next century. Hardly the stuff of cataclysmic drought and coastal inundation.

But even Lindzen has admitted that the observed warming is also consistent with a future temperature increase of as much as 2°C. That still falls in the range predicted by the models, but at the lower end, not the 4° to 5°C increases of the upper end on which the scariest scenarios are based.

This middle ground is becoming more popular. "I agree the past 100 years of warming may not strongly suggest the climate sensitivity is 4°C, but it is consistent with 2°C," says Syukuro Manabe of NOAA's Geophysical Fluid Dynamics Laboratory, where he runs one of the five world-class greenhouse models. Michael MacCracken, who runs another one at Lawrence Livermore National Laboratory in Livermore, California, tends to settle on 2° ± 1°C as well (*Science*, 6 January, p. 28). A 2°C global warming would still have significant social and ecological effects, however.

But there is a catch to these efforts to use the past to predict the future. The past behavior could be misleading because the mechanisms capable of amplifying an increase in global temperatures can be slow to take hold. And so, a big warming could be awaiting us in the next century without having revealed itself up until now.

We may know soon. The models that predict the largest warmings call for the upward trend to become obvious by the early 1990s, barring non-greenhouse changes in climate (*Science*, 2 June, p. 1041). ■ **R.A.K.**