How can you predict global warming if you can't predict rain?; Peter N Spotts Peter N Spotts Staff writer of The Christian Science Monitor
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How can you predict global warming if you can't predict rain?

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To those of us who are not climate scientists, it may come down to this: How can we be so certain what the climate will be like a century from now if you can't get a decent weather forecast more than two weeks ahead? In the end, isn't climate change just too complex?

True, weather forecasters are fallible, and there is no planet out there similar to Earth so we can truly gauge the effect human activity is having on our climate. But climate researchers are increasingly confident of their models and simulations. Besides, some argue, predicting the weather is tougher than predicting the climate, and scientists have been working on perfecting climate models for more than a century.
In a chilled, windowless room here at the National Oceanic and Atmospheric Administration's GeoA-physical Fluid DyA-A-namics Laboratory (GFDL), a supercomputer is furiously crunching numbers in an attempt to mimic Earth's climate system.

It's a tool Svante Arrhenius could only dream about. In 1896, the mustachioed Swede gave the first detailed description of carbon dioxide's warming effect on climate. He had to solve some 10,000 equations to do it. Armed with his crude climate model, he reckoned that if the amount of CO_2 in the atmosphere doubled, global average temperatures might rise by up to 9 degrees F. Today's modelers say his estimate is high - but not by much.

Today's climate models try to simulate more than one feature - more than Arrhenius's CO_2 - of the climate system and in greater detail. They're still far from perfect and miss important processes.

It's complicated, modelers say. And there will always be uncertainties. But modeling is the only way to tackle some of the questions they and their colleagues are asking about the climate, they add.

Field measurements and observations are critical, notes Michael Winton, a member of the model-development team at the GFDL. They serve as a reality check on models and may spur further observations. In the end, however, "you can't end with observations. At the most basic level, you want to say something about the future. And there isn't any way to put these observations together that would give you any detail about the future."

Moreover, Earth has no identical twin nearby undergoing the same basic physical processes but unaffected by human activity. The only place to approximate that "twin" is inside a supercomputer. Thus, "simulation - and not just in climate and weather but in a lot of different fields - has become a third leg, in addition to theory and observation, to help us figure out what's going on," says Brian Gross, the GFDL's deputy director.

The building blocks for many of today's climate models are modules that simulate conditions in the atmosphere, ocean, on land, and around sea ice. Researchers use historical measurements to set the sea level, as well as levels of atmospheric gases, airborne particles, and sunlight for each year they include in the model.

Then they turn the model loose to calculate how wind, temperature, air pressure, and moisture patterns over a particular period will evolve.

In early models, researchers say, large adjustments were needed to keep climate models from spinning off into the twilight zone. The adjustments had no real-world climate counterpart; they were made to keep the simulations plausible. As models have improved, the need for such intervention has receded, and any tweaking has reflected real-world observation.

Such interventions have led some to say that modelers are merely telling the model to yield a specific result. Dr. Winton dismisses that charge. "People overestimate the control we have," he says.

With more powerful computers, scientists have been able to model climate behavior over shorter timespans. The need to intervene in the models is disappearing but not likely to vanish, says Caroline Katsman, a researcher at the Royal Netherlands Meteorological Institute in De Bilt. No computer can crunch numbers for every point on the globe.

One measure of a model's success is how well it captures the main features of natural climate variation. Assuming it can do that, researchers can then use the model to test ideas about atmospheric conditions and their plausible causes.

Last month, for example, researchers at NOAA's Earth Systems Research Laboratory in Boulder, Colo., concluded that slightly more than half the unusual warmth the United States experienced in 2006 was probably due to the buildup of greenhouse gases in the atmosphere.

The team, led by Martin Hoerling, took on the study when NOAA announced in January that 2006 had been nearly 2 degrees F. warmer than normal. NOAA couldn't say why. It may have been El Nino (a periodic warming of the eastern Pacific that has profound climatic effects); it may have been a rise in greenhouse gases.

How models pointed to CO_2

Dr. Hoerling's team looked at historical data and calculated that the 2006 increase was unlikely to have occurred through natural fluctuations alone. When they looked at temperature data from 10 previous El Nino years, they found that average temperatures over the US had not changed or had cooled slightly. Could El Nino-like conditions cool the US? They ran a climate model, and found the answer was yes. So if El Nino was unlikely to have caused 2006's warming, did greenhouse gases? Using the modeling data the Intergovernmental Panel on Climate Change used in its latest report, the team found that more than half the increase could be attributed to greenhouse gases.

Scientists have used a similar approach to implicate greenhouse- gas emissions from human activities in warming over the past 30 years. In short, the only way to reproduce late 20th-century warming is to include the growth in greenhouse gases. Modeling results are not the only line of evidence, researchers say. But in combination with other lines of evidence, the case becomes more persuasive.

But why should we trust climate models any more than a three- week weather forecast? Roger Pielke Sr., a research scientist at the University of Colorado at Boulder who focuses on land-atmosphere interactions, notes that climate forecasting is more complicated than weather forecasting. Far more processes are involved.

Keith Dixon, who managed the GFDL's contribution to recent IPCC modeling efforts, adds that climate predicting and weather forecasting are much different, as are the measures of success.

The accuracy of a weather forecast depends largely on the quality of the twice-daily global atmospheric measurements used. Weather conditions trigger weather-forecast models, and such conditions are far more susceptible to "the flapping of the butterfly's wings," Dr. Dixon says. He's referring to well-established ideas about how small- scale, chaotic features can grow over time and affect weather at great distances. That's why today's weather forecasts don't have much use beyond two weeks.

Looking at climate over decades or a century or more, "we're dealing more with boundary forcings" external to the climate system, Dixon says - solar radiation, aerosols, changes in atmospheric CO_2. "The key is how the model will respond to changes in these forcing agents," and not whether it will rain in New York on Tuesday.

Global climate models can't predict the next El Nino or volcanic eruption, both of which affect climate. The critical point for climate models, Dixon continues, is to reproduce the climate's random variability over time in a realistic way.

Models can also be checked against their ability to reproduce global temperature trends since the mid-1800s, when the Industrial Revolution began in earnest. The better the models do, the more confidence modelers have in their handiwork.

Regional projections not as good

But if modelers feel confident about their virtual climates on a global scale, confidence falls as global models are drafted to provide regional projections. And it's these narrowly confined projections that policymakers demand.

Hendrik Tennekes, former director of the Royal Netherlands Meteorological Society, has argued that while he agrees with the IPCC that rising CO_2 levels are affecting global temperatures, once models begin focusing on regional projections, they break down. Much of that has to do with how they handle poorly understood features of the climate system such as the Arctic Oscillation, which affects rainfall patterns below the Arctic Circle.

Overinterpreting models can also be a problem, says Tom Delworth, who heads the climate dynamics and prediction group at GFDL.

"The more you know about models," he says, "the better you realize how important it is to make sure that you're using the model for the class of problems it was built to answer. Sometimes people try to use models to answer questions they weren't designed to answer."