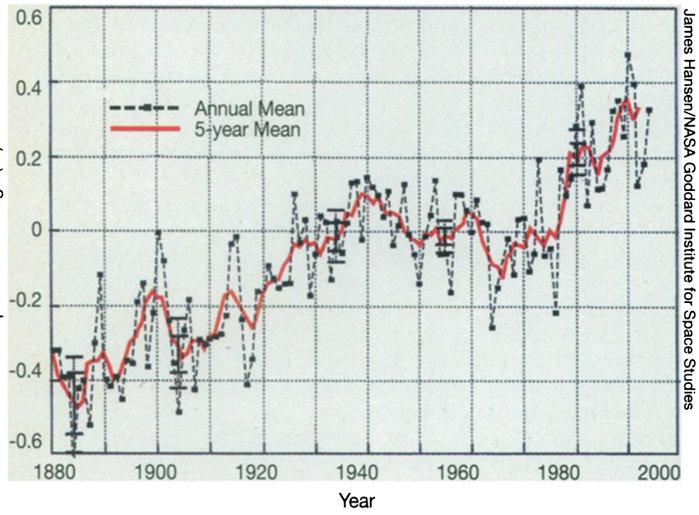
Tropical Trouble

Two decades of Pacific warmth have fired up the globe

By RICHARD MONASTERSKY

The fever is back. Two years after Mt. Pinatubo's 1991 eruption cooled it down, Earth's temperature has once again soared.

According to the British Meteorological Office, which tracks land and sea surface conditions, Earth's average temperature in 1994 climbed 0.31°C above the mean for 1951 to 1980. That makes last year the third warmest since the late 1800s, as far back as global records reach. First and second place belong to 1990 and 1991, which followed on the heels of a marked rise that began in the mid-1970s. Global warming has officially returned.



James Hansen/NASA Goddard Institute for Space Studies

Dotted line tracks the rise in global surface air temperatures recorded at land-based stations. Red line shows 5-year mean.

In seeking to explain why temperatures have hit the red zone, several researchers blame Earth's waistline. They propose that something within the tropical ocean belt, especially the Pacific, has caused a warming of the entire globe during the last 2 decades. The same tropical heat wave may explain why precipitation patterns have changed dramatically across much of the planet during the same period.

"There was a big change in the climate in the mid-1970s. A lot of things changed, and you can make a coherent case for it being forced from the tropical Pacific, by sea surface temperature changes in the tropical Pacific," says oceanographer Nicholas E. Graham of the Scripps Institution of Oceanography in La Jolla, Calif.

There's no doubt the unrelenting grip of El Niño has caused the tropical Pacific to take a turn for the warm recently. For three of the last four winters, successive episodes of this devilish climate pattern have steamed up the central Pacific near the international date line, most recently last fall.

El Niños knock normal weather patterns askew, and this one must shoulder much of the blame for California's tremendous storms in early January, as well as other oddities in North American weather. Not since the span from 1911 to 1915 has El Niño maintained a 4-year hold on the ocean.

Even before the 1990s, however, unusually balmy conditions persisted in the Pacific. Historically, El Niños recur every 3 to 7 years; the intervening periods are sometimes punctuated by a cold spell known as La Niña. While these coolings do not follow every El Niño, temperatures normally tend to see-saw above and below normal. Yet that pattern fell apart in the mid-1970s, when the Pacific's equatorial thermostat stuck on warm. Since then, five El Niños have brewed, but only once did the ocean cool off to a certified La Niña.

Graham has been pursuing this strange Pacific character change for several years. He grew convinced that temperature formed only part of the story; precipitation centers also appeared to change dramatically in the mid-1970s, as did air pressure patterns across the North Pacific. Many other scientists, citing questions about data quality, dismissed some of the evidence of Pacific changes.

A question by Thomas J. Crowley of Texas A&M University in College Station gave Graham the chance to solidify his case. Crowley noted that the Pacific warming occurred at the same time as the major jump in global temperatures and wondered whether computer climate models could discern any relation between the two.

So Graham ran a series of simulations on an atmospheric general circulation model for the period 1970 to 1992. The model uses equations to simulate how different components of the atmosphere change over time. In his experiment, Graham plugged actual records of sea surface temperatures into the model and watched the digital atmosphere evolve in response to the ocean warming. The model contained no information about rising atmospheric concentrations of carbon dioxide or other greenhouse gases.

Despite the absence of greenhouse gas data, the modeled atmosphere warmed up. In fact, the computerized climate closely paralleled the actual temperature rise since the mid-1970s. "I just about fell out of my chair," says Graham, who reports his results in the Feb. 3 SCIENCE.

Graham is not alone in finding hints that warm tropical waters fired the recent global temperature rise. His findings dovetail with the conclusions of a modeling study conducted by Arun Kamar and his colleagues at the National Meteorological Center in Camp Springs, Md.

Like Graham, Kumar and his coworkers plugged actual tropical ocean temperatures into a global circulation model and tested the atmosphere's response. But instead of looking at globally averaged atmospheric temperatures, as Graham did, they examined temperature patterns over the continents.

Their map of simulated temperatures closely matches the actual observations, they report in the Oct. 28, 1994 SCIENCE. Because only water temperatures were allowed to stray from average values, such results also finger the tropical ocean as the cause of the recent atmospheric global warming trend.

Kevin Trenberth of the National Center for Atmospheric Research in Boulder, Colo., says he's not surprised that the ocean pushes the atmosphere around. When it comes to storing heat, the atmosphere is a lightweight compared to the ocean, he explains. In fact, the upper 3 meters of ocean water hold as much heat as the entire atmosphere. It makes sense, therefore, that the atmosphere will follow the ocean's lead.

Graham's study delves even deeper to explain how the tropical ocean warmed the atmosphere. "The interesting thing is that since this is a model, you can take it apart," he says. "You can ask, How did the air get hot? Where is the heat coming from?"

The model works somewhat like a bank account, with various sources depositing and withdrawing heat from the atmosphere. By auditing the account, Graham could find which factor had boosted the balance.

The depositor turned out to be tropical rainfall. In the computer model, precipitation amounts increased substantially after 1975 in equatorial ocean regions, especially in the central Pacific around the international date line. According to Graham, as ocean temperatures climbed, they stimulated evaporation and storm formation, which led to enhanced moisture over the central equatorial Pacific. When that moisture condensed into rain droplets, it gave off heat to the atmosphere, warming the globe.

Rainfall did not increase everywhere, however. Indeed, the model showed a distinct trade-off, with equatorial land areas drying out even as precipitation over the ocean climbed.

Such results should intrigue meteorologists, who have seen hints of decreasing precipitation over equatorial land areas and are now beginning to document increases over the tropical ocean. In the last 40 years, and especially since the late 1970s, precipitation has declined across much of Indonesia, south China, India, and Africa.

"What is remarkable is that he [Graham] was able to reproduce some of these changes in precipitation that we see," says Thomas R. Karl of the National Climatic Data Center in Asheville, N.C.

According to Graham's modeling work, a warming of the tropical ocean can explain most of the broad precipitation and temperature changes observed globally in the last 20 years. But it fails to answer the obvious question: What warmed the tropical oceans?

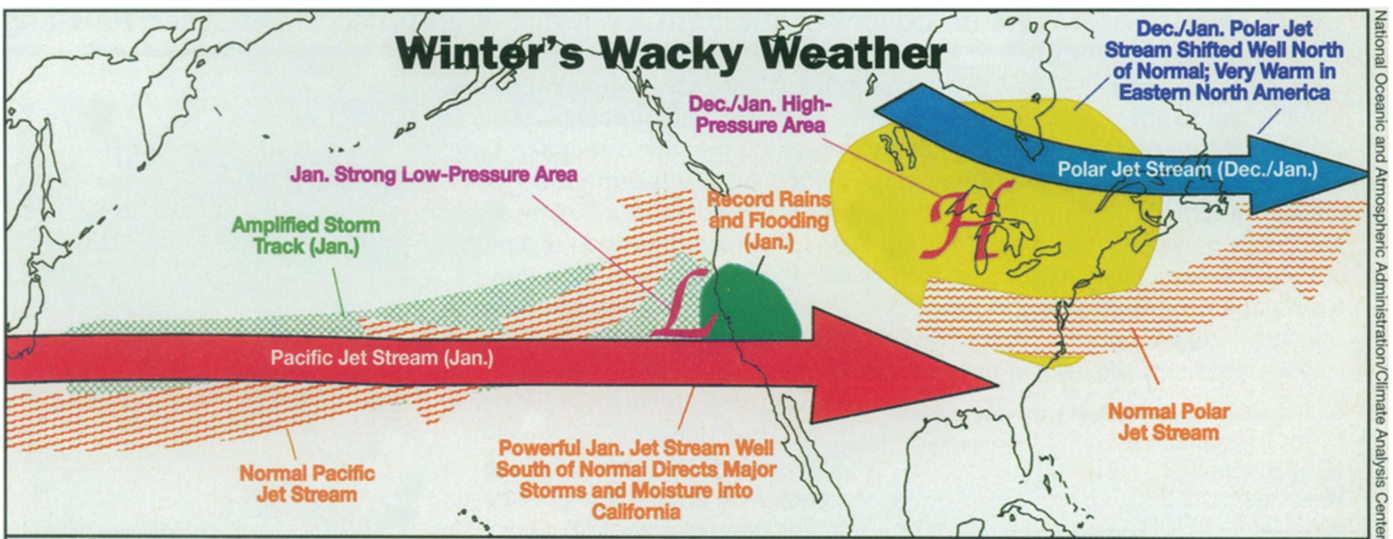
"I have no idea," Graham admits. "But I know some bogeyman words," he says with a chuckle.

That fearsome term is greenhouse warming, created by increased atmospheric concentrations of carbon dioxide and other heat-trapping gases.

In model simulations of greenhouse warming, climate experts have seen patterns of enhanced ocean temperatures, evaporation, and precipitation. Because such results match actual meteorological records, contends Graham, they implicate greenhouse gases as a cause of the tropical changes. While Graham calls these similarities troubling, he notes that natural climate cycles could just as easily account for the ocean warmth.

Whatever the cause of past climate changes, Karl says, Graham's model raises some important questions about how future warming will affect precipitation. If global temperatures continue to march upward, precipitation amounts should also climb around the world. But according to Graham's study, the most recent burst of global warming actually dried equatorial land areas — a result that causes Karl to wonder about future droughts.

"When you talk about this global warming issue, changes in precipitation are far more important and significant than changes in temperature," he says. "It's simply that people have been frustrated by the observations, and it's a more difficult quantity [to study], so you haven't heard as much about it." □



National Oceanic and Atmospheric Administration/Climate Analysis Center

It hit the United States with a vengeance early this winter, but the El Niño Pacific warming is rapidly losing steam.

"All of the trends, both in the ocean and atmosphere, are indicating a weakening of the El Niño," says Vernon Kousky of the National Weather Service's Climate Analysis Center in Camp Springs, Md.

At its height in December and January, the El Niño contributed to the balmy conditions in eastern North America and fed the howling rains that hit California. The Pacific warming exerted such a strong effect by pumping moisture into atmospheric storms and by altering the positions of the jet streams that steer such storms.

The northern and eastern states enjoyed warm weather in early winter because a displaced polar jet stream kept cold Arctic air from reaching as far south as it normally does during winter (see diagram). In the west, the Pacific jet stream ran south of its usual route in January, driving El Niño-fed storms directly into California. While the El Niño can claim credit for the enhanced Pacific storminess, other, unrelated weather patterns also helped determine the path of the jet stream.

Since mid-January, the equatorial Pacific has cooled and storm generation has slowed. "I think a lot of people are surprised at the rapidity with which things changed," says Kousky.

— *R. Monastersky*