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The invisible hand: as human activity warms the earth, El Nino grows more violent.

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"Acts of God" are what people call the calamities the world suffered at the hands of El Nino last winter. Freak tornadoes killed more than three dozen people in Florida. Thirty-five-foot waves battered the California coast, while a numbing procession of torrential rains brought widespread flooding and mud slides, driving hundreds of people from their homes and causing up to \$1 billion in damage. Hundreds more were killed in Peru and Ecuador by floods and slides, and thousands left homeless. Canada and the northeastern United States were hit by a catastrophic ice storm, which knocked out power to 4 million people. Brazil and Indonesia, on the other hand, are tinder dry; 12 million acres of their precious rainforest burned last year. "This was the year the world caught fire," concluded a report by the World Wildlife Fund.

But it may not be fair to blame these disasters on the Deity. We now know that human activity--mostly the burning of fossil fuels--is warming the earth. The Intergovernmental Panel on Climate Change, a gathering of 2,000 of the world's top climatologists, has declared that "the balance of evidence suggests a discernible human influence on global climate."

How will that influence manifest itself: Warmer air temperatures, ironically, may ultimately not be the most significant aspect of global warming. According to the U.S. Global Change Research Program, "Widespread increases in the intensity of the hydrologic cycle may have more immediate and far-reaching ecological and socioeconomic impacts than elevated temperature alone."

And one of the most intense manifestations of that hydrologic cycle is the weather pattern known as El Nino. Every four to seven years, a band of water 2 to 10 degrees warmer than the surrounding ocean bulges toward the Pacific coast of South America, spawning enormous storms, altering currents, changing wind patterns, and causing droughts all around the world. Because it often appears around Christmas, it's called El Nino, "The Child."

The system that arrived in March 1997 came only two years after a five-year El Nino, the longest ever documented. The new system gathered power at record speed until its force exceeded that of 1982/83, previously the most powerful El Nino on record. With the ocean's heat valve shifting into overdrive at the same time the planet is experiencing the warmest year on record, we naturally have to ask: Have we brought this on ourselves? Are we parents to The Child?

Typically, El Nino is followed by its cooling counterpart, La Nina. But over the past two decades a hothouse Pacific has generated five El Ninos, and only one La Nina of any size. "You can think of El Nino and La Nina as the ticktock," notes University of Washington climate-ocean scientist Richard Gammon. "Lately we've been having more ticks than tocks."

Meteorologists call this ticktock the El Nino Southern Oscillation, or ENSO. Pioneer El Nino researcher Kevin Trenberth was the first to nail down ENSO's four- to seven-year cycle; he is now trying to determine whether there is a connection between the unprecedented string of El Ninos since 1976 and the fact that they coincided with the ten hottest years on record. As the head of the climate analysis section at the National Center for Atmospheric Research, Trenberth and fellow NCAR scientist Timothy Hoar have applied statistical methods to the seeming skew in the cycle over the past 20 years. They concluded that such an odd sequence would occur naturally only once every 2,000 years. "Is this pattern of change a manifestation of global warming [or] a natural variation?" Trenberth and Hoar wrote in the peer-reviewed Geophysical Research Letters. "We have shown that the latter is highly unlikely."

"Something is going on," Trenberth says. "I think El Ninos are being changed by global warming."

Some scientists have found Trenberth's conclusions less persuasive because El Nino has been statistically tracked for only the past 120 years. Even so, Trenberth points out, "If you take the first 20 years and compare it with the second 20 years, and the third, fourth, and 95th, they don't look greatly at odds with one another. It's only in the last 20 years that things seem to have been different."

"Attempting to lengthen the historical record, Oregon State University oceanographers William Quinn and Victor Neal have studied anecdotal accounts by Spanish explorers and colonists. Doing so has allowed them to tally eight very strong ENSOs from 1525 to 1982. Since 1728 very strong ENSOs appeared about every 42 years; before that, only one was detected. Quinn and Neal concluded that the 1982/83 event was the most powerful in nearly 500 years. The 1997/98 El Nino, apparently even stronger, followed only 14 years later--the briefest time between very strong El Ninos, they say, in five centuries.

Ice cores provide physical evidence of climate change in the same period. This data stretches back thousands of years, notes Nicholas Graham, a climate-ocean researcher at Scripps Oceanographic Laboratory, but recent warm temperatures have melted away the evidence of the past several decades. "This suggests very strongly that the temperatures in the mid-nineteen seventies to early nineties were the warmest in the last five hundred years."

According to the IPCC, global warming has raised world ocean temperatures by one degree in the past century. The world's warmest patch of ocean is the tropical Pacific; when its heat reservoir fills to the brim, El Nino acts as the discharge valve. "The climate system is a giant heat engine," explains Nathan Mantua, a climate researcher at the University of Washington who focuses on the Pacific. "An excess of energy comes in at low latitudes relative to the high latitudes; winds and currents try to wipe out this imbalance." The workings of this engine shape the earth's standard weather patterns. The most prominent effect of solar energy striking the earth is not to heat the atmosphere but to evaporate water from the surface of the ocean. The warm, moist air rises to form clouds, where water condenses and falls back as cooling rain. The heat that evaporated the water continues to ascend, and is carried for thousands of miles by high winds.

The tropical western Pacific is the hottest stretch of open ocean on Earth--"the warm pool," scientists call it. In normal years, heat rises from the region, creating a low pressure zone. Rising in the atmosphere, it blows east until it descends off the coast of South America, creating a high pressure zone. In an effort to achieve equilibriums, the atmosphere pumps surface winds west along the equator back toward the warm pool--the famous trade winds. The winds push warm water west, allowing cool water to rise to the surface in the east. This upwelling of nutrient-rich water is crucial to South American fisheries; though upwelling areas cover only one-tenth of one percent of the earth's oceans, they account for 40 percent of the commercial fish catch.

This normal cycle, however, cannot dissipate all the excess heat in the tropical Pacific. When too much accumulates, El Nino kicks in. The warm pool's system of clouds and heavy rainfall expands toward the central Pacific, blunting the trade winds. Consequently, the warm water piled up in the western Pacific rushes east until it hits the coast of South America, blocking the cool upwelling and collapsing fisheries.

In addition to disrupting the trade winds, El Nino's storm track is powerful enough to divide the jet stream, which normally courses over the Pacific Northwest. During El Nino one branch blows farther north, while the other is drawn south across vast expanses of heat-pumping warm ocean, where it picks up abnormally large amounts of water. In North America, this leaves the Northwest warmer and drier, California and the Southwest sodden and cooler. The storms that walloped California grew strong on El Nino's heated waters, and the powerful southern branch of the jet stream energized a low-pressure zone in the Southeast, giving rise to Florida's killer tornadoes.

While El Nino blows cold and wet in California, it causes drought in India, Southeast Asia, Brazil, and parts of Africa. Besides devastating agriculture, the disruption of normal rain patterns sets the stage for huge fires such as those last year in Australia, Indonesia, and Amazonia. Should El Nino conditions persist, entire regions could see their natural features radically altered and economies shaken to their root.

A rule of thumb is that every 2 degree increase in temperature puts 6 percent more water vapor into the air. And according to the U.S. Global Change Research Program, more water vapor in the atmosphere means "a significant increase in the energy available to drive storms and associated weather fronts."

From 1973 to 1993, notes Trenberth, atmospheric moisture over the United States increased by 5 percent per decade. In 1995 the National Climatic Data Center found that precipitation over temperate regions of the Northern Hemisphere had increased 10 percent over the past century, while extreme rain and snowstorms have gone up 20 percent.

Other studies have connected warmer tropical oceans with the retreat of mountain glaciers around the world. (At the current rate of retreat, there will be no glaciers left in Glacier National Park in 30 years.) The National Oceanic and Atmospheric Administration's Climate Diagnostics Center reports that its research "strongly suggests that the recent observed changes in freezing-level heights are related to a long-term increase in sea surface temperature in the Tropics."

If global warming continues, El Nino-like weather may become the norm. A computer simulation run by Gerald Meehl and Warren Washington of NCAR shows El Nino-like conditions persisting as greenhouse gases increase. With a doubling of the amount of carbon dioxide in the atmosphere, their model shows trade winds slackening while the eastern Pacific warms, increasing rainfall and kicking on the heat machine. And, Meehl warns, should El Nino become the norm, global warming might also ratchet up the ENSO cycle to an even more intense level.

Washington and other researchers caution that science is far from a consensus on the relationship between ENSO and global warming. While El Ninos and ocean temperatures "are increasing in a way . . . consistent with the idea that climate change is making El Nino more intense," says Nathan Mantua, "it's not quite a bulletproof statement at this time."

The scientific method demands not only that theory be backed by solid evidence, but that the evidence hold up under repeated experiments. For climate scientists, those experiments are conducted using computer simulations. While some models show an ENSO-climate change connection, many do not. In fact, the first success in predicting El Nino didn't come until 19X6. A number of models accurately forecast the next ENSO in 1991, but of seven major models, not one predicted the extreme magnitude of the 1997/98 event.

"Computer models used for global climate change don't do a great job of simulating natural variability," Mantua notes. "The models that do, don't do a good job on global climate change." Part of the difficulty is that studies of El Nino and global warming are, for the most part, taking place in separate scientific venues. "The El Nino people are really meteorologists who work in forecasts out from two weeks to a month to a season," says Richard Gammon. "The climate people are coming at it from a much longer perspective. There's not enough communication between those two groups. Most scientists are in their own very small corner of the sandbox."

Public policy should not necessarily wait for scientific consensus, however. "The level of proof scientists need is much higher than what you would think is important in public policy," says Gammon. "If you knew with even seventy percent certainty that something bad was going to happen, as a civil servant you would ring the bell."

If humans are indeed influencing El Nino, it brings the disruptive potential of global warming into immediate focus. Our response, says Trenberth, comes down to a value judgment: "How much we pay attention to the future generations and what kind of stewards we are to the planet."

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What You Can Do To Curb Global Warming

IT'S NOT TOO LATE to slow global warming and the violent weather changes that come with it. The single biggest step we can take to stop climate change is to raise the fuel-economy standards for cars and light trucks. You can lobby for these changes by mailing a photo of your children or grandchildren to The White House, 1600 Pennsylvania Ave. N.W., Washington, DC 20500, along with a note asking the president to guarantee their future by raising fuel-efficiency standards. While you're at it, make the same request by writing, faxing, phoning, or e-mailing your senators and representative. Also ask them to support President Clinton's green tax incentives to cut global-warming pollution. These tax proposals will help consumers buy clean cars and more energy-efficient homes, and will promote the technology we need to curb global warming.

You can also take personal steps to reduce greenhouse gases:

- * Buy the most efficient vehicle that suits your needs. Avoid sport utility vehicles, pickups, and minivans, and aim for a vehicle that gets at least 35 miles per gallon.
- * Drive smart. Combine trips, and carpool when you can. Better yet, take public transit, bicycle, or walk.
- * Be efficient. Use compact fluorescent lightbulbs. When you replace appliances, look for those that carry the EPA's "Energy Star" logo.

PATRICK MAZZA edits Cascadia Planet, a Pacific Northwest bioregional Web site at www.tnews.com. A longer version of this article, "El Nino's Growing Ferocity: Ocean in the Greenhouse?" is available from the Atmosphere Alliance, 2103 Harrison Ave. N.W., Suite 2615, Olympia, WA 98502; (360) 352-1763; e-mail atmosphere@olywa.net.

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