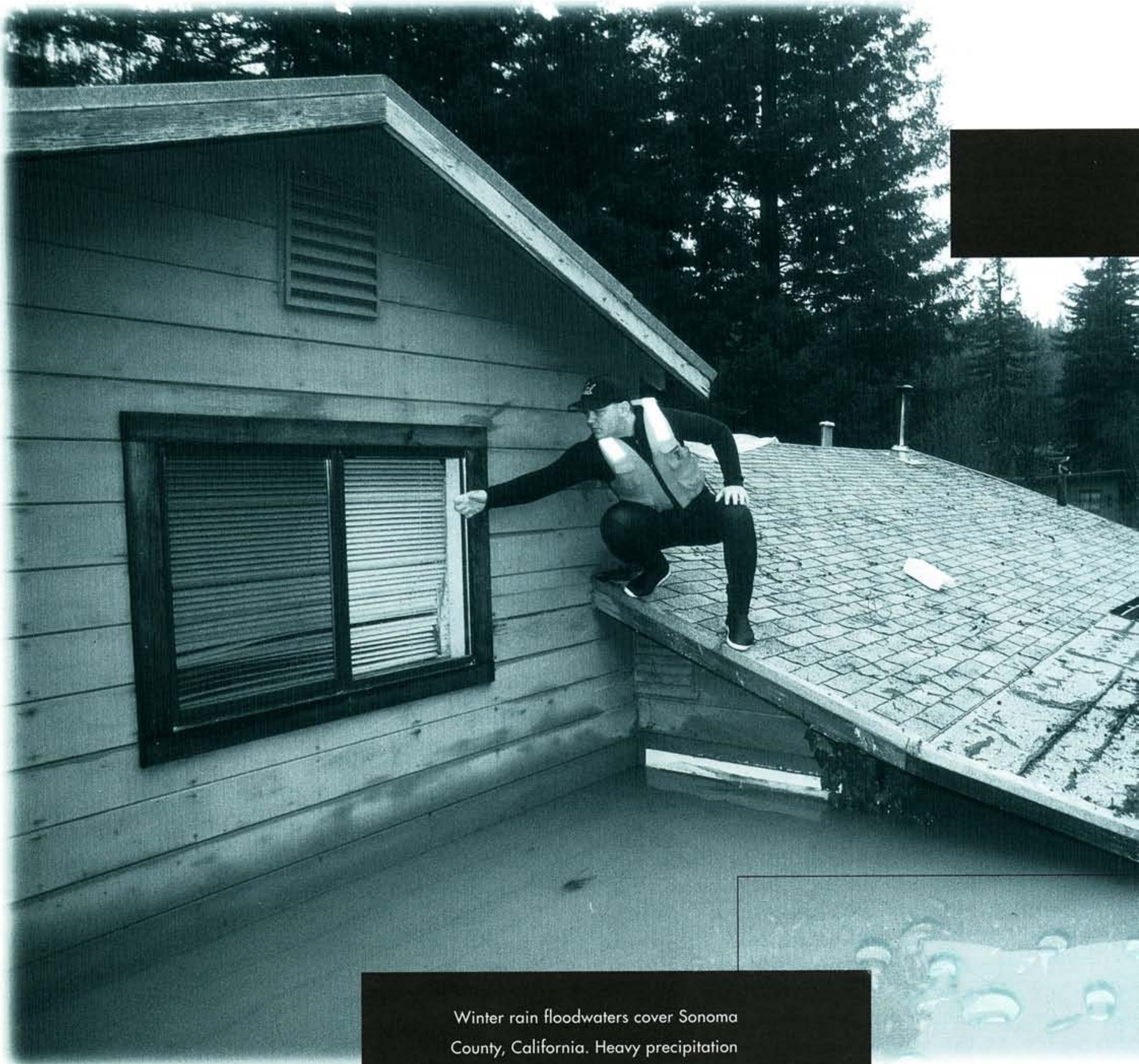


Winter rain floodwaters cover Sonoma County, California. Heavy precipitation along the West Coast was one of the extreme weather conditions that accompanied the 1982-1983 El Niño event. But El Niños can also cause lower-than-normal rainfall over the western United States.

Predicting the Climate:

BY CHUCK COLGAN

Scientists See El Niño Likely This Winter

The winter of 1982-1983 was devastating worldwide. And if a Scripps Institution of Oceanography experimental climate forecast is correct, we could be headed for a replay of those extreme weather conditions.

- Drought in Australia fueled widespread wildfires
- Tens of thousands of starved sea birds littered tropical islands
- Tons of dead fish washed up along the coastline of Peru
- Torrential rains flooded California, sweeping homes off muddy hillsides

Blame it all on El Niño, a periodic climatic condition that warms Pacific Ocean surface temperatures along a broad band of the equator and shifts wind patterns that cover a quarter of the globe. Among the greatest climatic events of the century, the 1982-1983 El Niño spread havoc around the Pacific Rim, breaking worldwide weather records and trailing damages in excess of $13 billion. The phenomenon became a household word, with everyone from network TV talk-show hosts to pet therapists blaming El Niño for mishaps and misfortunes.

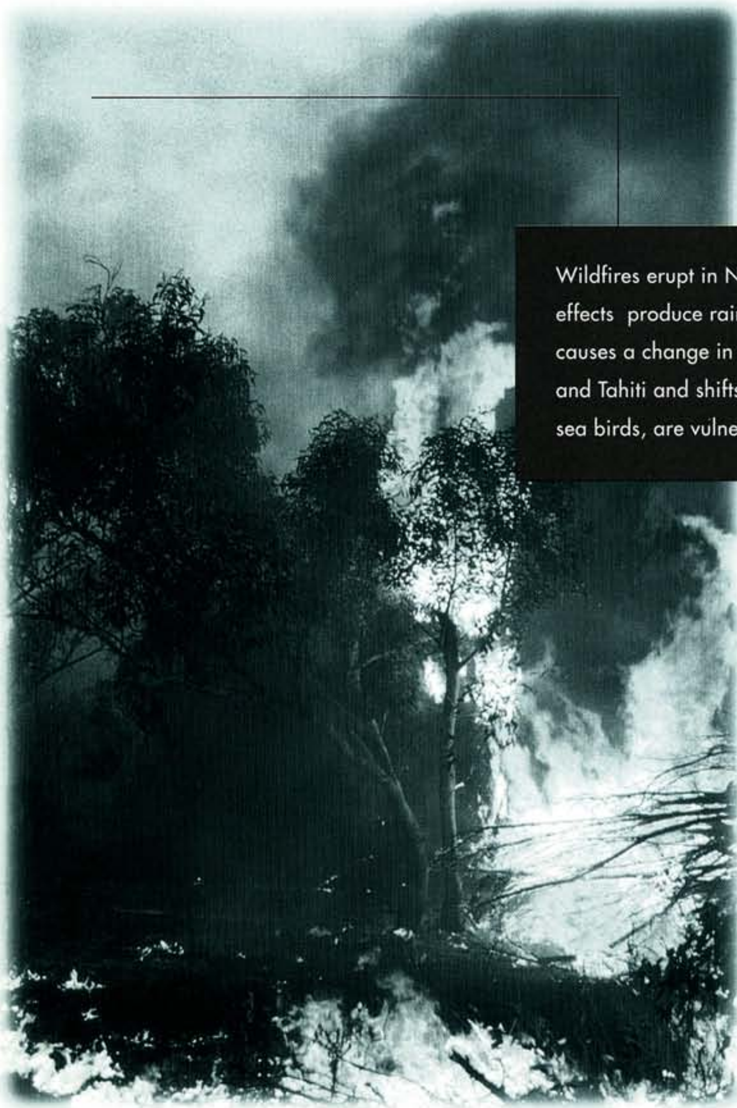
"El Niño is the most significant short-term natural climate fluctuation on the planet"

"El Niño is the most significant short-term natural climate fluctuation on the planet," noted Tim Barnett, a marine physicist in Scripps's Climate Research Division (CRD). "El Niño affects billions of people—mostly adversely—and can cause drought and famine in one area while causing extremely heavy rains and flooding in other areas."

Barnett leads a research effort at Scripps that utilizes global environmental data and super-computer capabilities to develop models for forecasting El Niños. The Scripps model, as well as several others, is calling for a moderate to severe El Niño for winter 1996-1997.

"Right now, several independent groups are looking for an El Niño in 1996," Barnett said. "So if we are wrong, we will be wrong together. And if we are right, it marks a wonderful advancement in our ability to predict events and weigh their global climate consequences at very long range."

According to Barnett, the Scripps prediction is almost outside the range of past occurrences, so the magnitude of the El Niño has to be somewhat uncertain, but he is convinced that it will be substantial. "If it turns out to be as massive as the experimental model shows, it will rival the global impacts of 1982-1983," he said. "But at this time it is premature to rely on these rather astounding forecasts, because our models are still really research tools." Uncertainties about the magnitude of an El Niño stem from complex forces in the atmosphere and ocean that may come together to intensify the event or work at odds to diminish it.



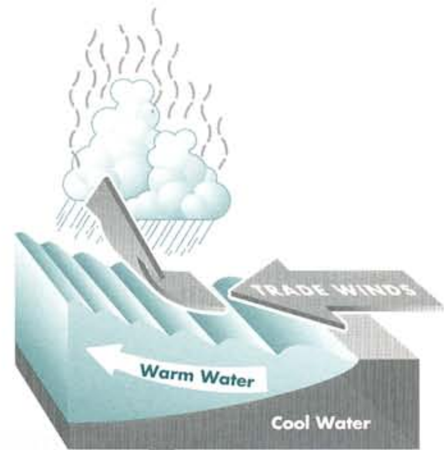
Wildfires erupt in New South Wales, Australia, where El Niño effects produce rainless summers and high-winds. El Niño causes a change in the sea-level air pressure between Australia and Tahiti and shifts the Trade Winds. Marine life, particularly sea birds, are vulnerable throughout the region.

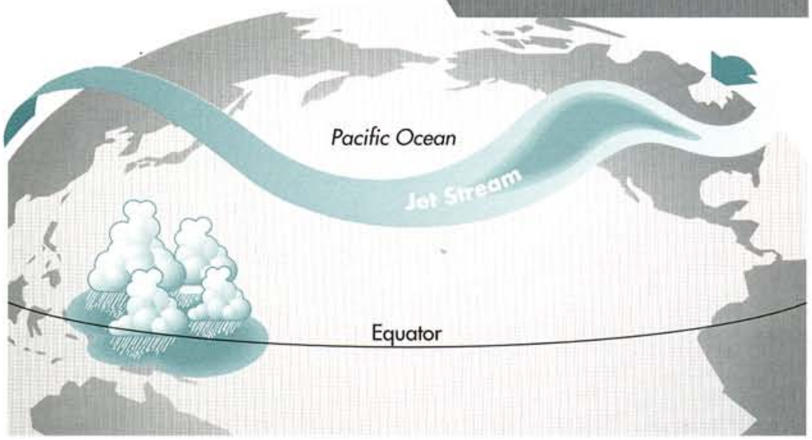
"There are really two parts to the prediction process," said Arthur Miller, a CRD research ocean-ographer. "First you have to predict how much the ocean is going to heat up, and there is uncertainty in such predictions. Then you have to be able to predict what the atmospheric

What is El Niño?

A normal year

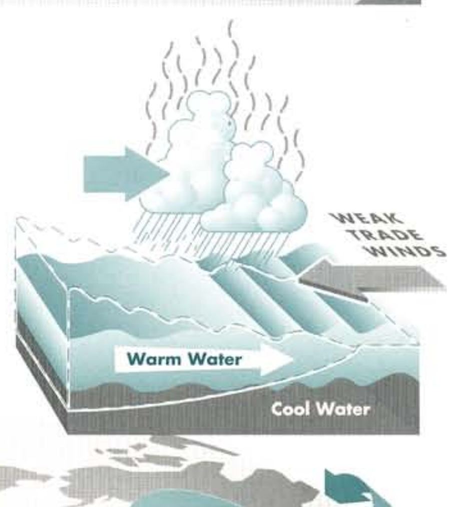
Westerly equatorial trade winds cause warm surface waters to accumulate in the western Pacific. Thunderheads release heat and heavy rainfall, causing an increase in the difference between temperatures in the east and west. This increase, in turn, continues the cycle, and the jet stream flows from north Asia to California.

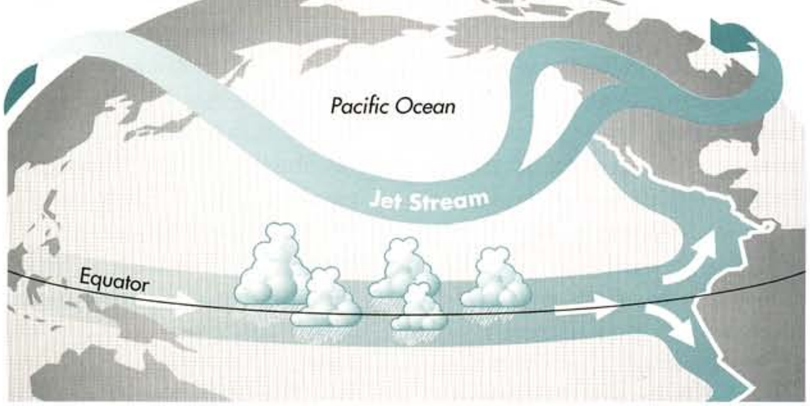




An El Niño year

As the trades weaken, warm waters move east, and the east/west temperature differential is reduced. The jet stream flows farther south than normal, picking up storms along its errant way. As a result, heavy precipitation is dumped on parts of North America, while warm waters flow to South America.





Spanish for "the child," El Niño is so named because it occurs off South America in December, near the Christmas season. During an El Niño sea-surface temperatures rise as much as 10 degrees Fahrenheit above normal across the central and eastern tropical Pacific. This ocean change is accompanied by a shift in sea-level air pressure, called the Southern Oscillation, which weakens the Pacific Trade Winds. Typically, this happens every two to seven years and lasts about six to nine months.

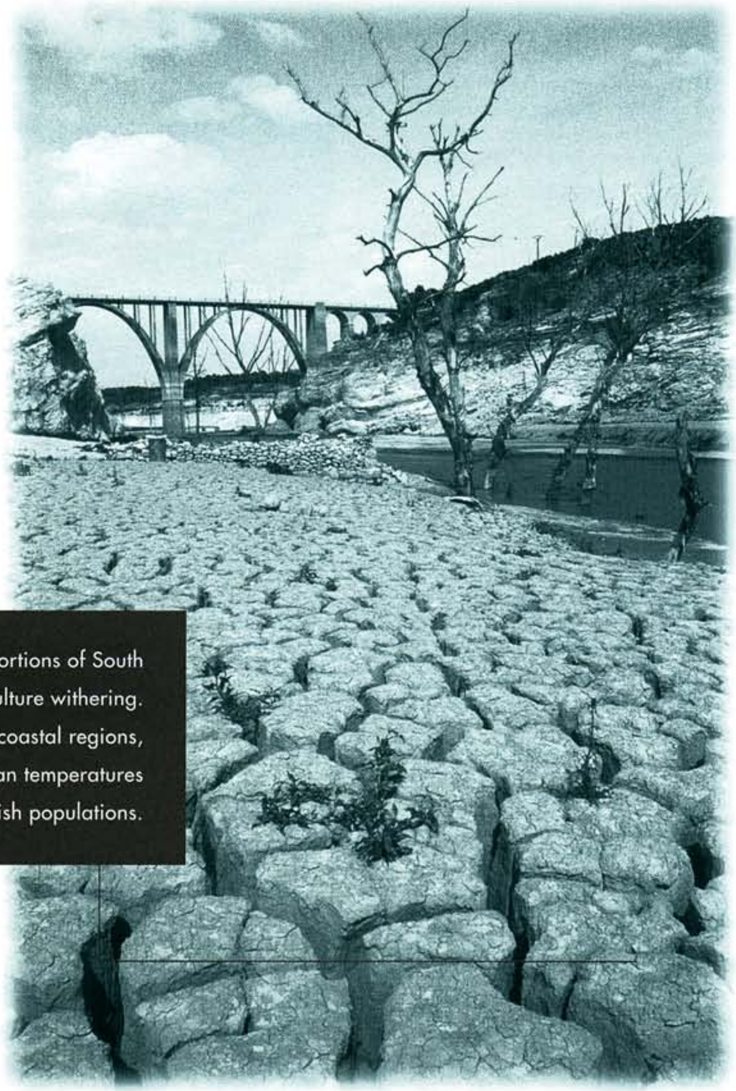
The effects of El Niño are not limited to tropical regions. El Niño causes atmospheric changes over North and South America that displace the subtropical jet stream flowing four miles above earth's surface. This pushes storm patterns that follow the jet stream either north or south of their normal paths. This usually results in increased rains over Peru and Ecuador, and lower-than-normal rainfall over portions of the western United States. However, the pattern is inconsistent—the 1982-1983 El Niño brought record-setting rain to California, Colorado, and Utah, while South America suffered a devastating drought. During major events, El Niño affects weather in Australia, Asia, Europe, and Africa.

Scientists, who refer to the condition as ENSO, (El Niño/Southern Oscillation) are still not sure exactly what triggers the whole process. Changes in the winds alter the movements of the water, and in turn, the water disturbs the winds—there's a circular effect. These air-sea interactions are the chief cause, with lesser influences from climate over the Indian Ocean and shifts in high latitude pressure fields. In the past few years, researchers have turned away from finding a single cause for ENSO and are working to forecast the occurrence and magnitude of these conditions.

"We are not predicting weather—we are predicting climate, which is the statistics of weather."

response will be to ocean warming, and that has even more uncertainty in it."

Reliable forecasting has developed in just the past few years. The huge 1982-1983 El Niño was well under way before experts even realized it was happening. The major factor that made the difference was intensified data-gathering in the tropical and central Pacific. During the past decade, more than a dozen countries invested in large-scale research programs aimed at understanding how the ocean and atmosphere interact to concoct El Niños.



El Niño induced drought in central portions of South America leaves riverbeds drying and agriculture withering. Along the continent's normally dry coastal regions, El Niño delivers heavy rains and warm ocean temperatures that kill plankton and reduce fish populations.

Three major efforts—the Tropical Ocean Global Atmosphere Program (TOGA), the Coupled Atmosphere-Ocean Research Experiment (COARE), and the Central Equatorial Pacific Experiment (CEPEX)—used meteorological stations, automated buoys, surface ships, aircraft, and earth-orbiting satellites to measure precisely oceanic and atmospheric conditions. Scientists collected vast amounts of data on sea-surface temperatures, wind speed and direction, solar radiation, and other factors, before, during, and after El Niños. The results were fed into computers to test how well numerical models of the global climate compare to real-world conditions.

Barnett and Nicholas Graham, a CRD research meteorologist, have developed a long-range forecasting technique that exploits the tropical Pacific's importance in climate. They use a relatively simple atmospheric model merged with an elaborate ocean circulation model to predict ocean temperatures as far as 18 months in advance. Once they get a picture of how the ocean will act, they insert the predicted ocean temperatures into a sophisticated atmospheric global circulation model developed by the Max Planck Institute for Meteorology in Hamburg, Germany. Their goal is to predict ENSO (El Niño/Southern Oscillation) events and their impacts a year or more in advance, "and we're making good progress toward that goal," according to Barnett.

The advantage of having an El Niño forecast a year in advance is

Marine physicist Tim Barnett, a leading El Niño researcher and avid deep-sea fisherman, enjoys one of El Niño's local effects, increased abundance of tuna and other fin fish.

In addition to normal weather variables, their data base will contain details relevant to social and economic impacts of climate, such as water resources, agriculture, and human health.

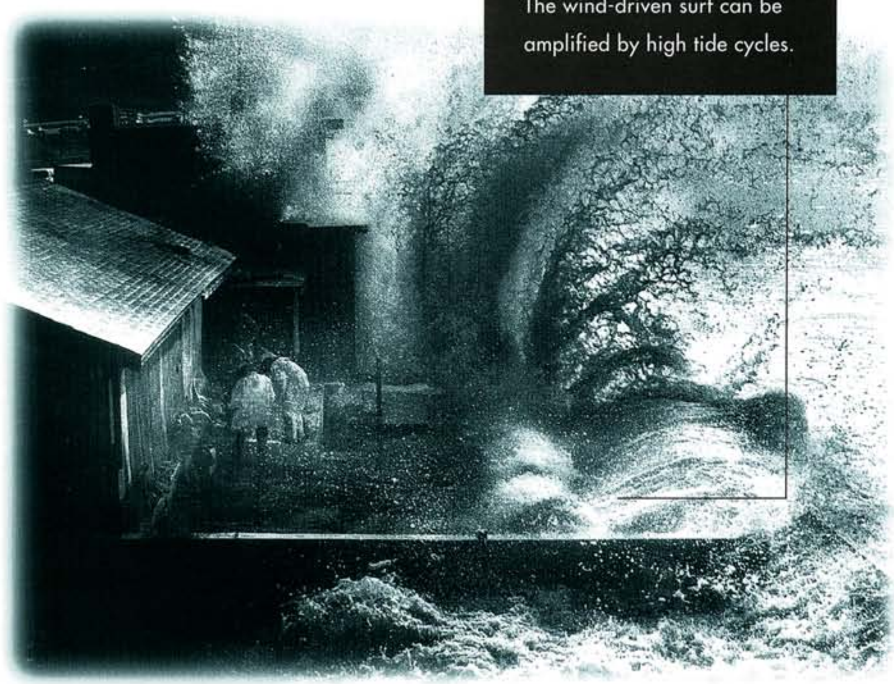
"We are not predicting weather—we are predicting climate, which is the statistics of weather," Graham said. "These models cannot predict that it is going to rain the day after Christmas next year, but that people and governments can consider alternatives for allocating resources, energy policies, and agricultural planning that would minimize the El Niño's impact. Everyone from farmers and fishermen to heating oil suppliers and umbrella manufacturers could benefit from knowing if there is a dry or wet winter ahead.

Some South American countries, where El Niños usually mean heavy rains in the normally dry coastal regions and droughts inland, have already benefitted from the experimental forecasts. In 1991-1992, Peruvian farmers took advantage of predictions for increased rain by planting rice rather than cotton. In northeastern Brazil, cereal grain farmers avoided devastation by adjusting their planting cycles and irrigation patterns to boost production during the dry season.

"Many governments don't yet realize the potential these forecasts have to offer—the economic implications are tremendous," Barnett said. "Our job here in academia is to develop these forecasting tools and hone them to increase their reliability. It's really up to government agencies to apply their usefulness."

Barnett and Graham have joined colleagues at the Lamont-Doherty Earth Observatory in a joint program to make experimental climate forecasts more operational. They will create routine predictions, including El Niño forecasts, by tapping into vast computer networks and global environmental data sets.

Large ocean waves crash over residences along a Los Angeles County beachfront during heavy winter storms generated by El Niño forces. The wind-driven surf can be amplified by high tide cycles.



Long Tradition of Climate Study

Climate studies at Scripps began in the ocean and turned toward the atmosphere as a means of understanding air-sea interactions. In the 1910s, George F. McEwen became interested in finding correlations between ocean temperatures off California and the local weather, particularly winter rainfall. For thirty years, he issued seasonal forecasts as a sideline to physical oceanography studies, but his data were sparse, and the predictions were dubious.

When Harald U. Sverdrup became Scripps director in 1936, he introduced atmospheric science into the teaching program. He initiated local ship cruises to study seasonal changes in the ocean and promoted air-sea research.

In the late 1940s, the California sardine fishery, the largest in the world at that time, suddenly collapsed. Was overfishing to blame, or had the ocean changed? The Marine Life Research Group (MLRG) was part of program that initiated a comprehensive study of the California Current, including extensive sampling of weather over the ocean. (Their ultimate answer was that both conditions led to the sardines' demise.)

In 1957, nature stepped in to help the scientists by simply warming the oceans. It was the first El Niño to be studied intensively, bringing together ocean-ographers and meteorologists to analyze its effects.

The North Pacific Experiment during the 1960s and 1970s supported shipboard studies of air-sea interactions in remote ocean locations. Deployments of surface buoys were made in deep waters to record ocean currents, and weather balloons were launched to collect data on atmospheric conditions.

At right, an expendable bathythermograph, a torpedo-shaped device used to record water temperatures at various depths, sinks from the surface into the ocean's mid-layers.

Meteorologist Jerome Namias joined Scripps in 1968.

By the 1960s, several groups at Scripps were looking into the transfer of heat and energy between the air and sea. During an experiment in the Atlantic off Barbados, Scripps scientists made the first airborne measurements of the heat flow from the sea surface.

Meanwhile, MLRG program scientists extended their California investigations to study large-scale air-sea interactions in the entire North Pacific. Their goal was to record weather parameters continuously over a large ocean area by deploying a network of automated instrument buoys moored in deep water. This developed into the North Pacific Experiment, a multi-institutional buoy project that continued until the mid 1970s.

Scripps's first full-fledged meteorologist was Jerome Namias, who joined the staff in 1968 from the U.S. Weather Bureau where he headed the extended forecast division. He found correlations between North Pacific sea-surface temperature patterns and temperatures across North America and began making seasonal weather forecasts based largely on ocean conditions.

In 1989, Scripps established the Climate Research Division (CRD) under the direction of Richard Somerville. Studies expanded into natural climate variability and the consequences of human-induced atmospheric changes, such as the increase of greenhouse gases. Larger and faster computers, and then supercomputers, advanced research capabilities, both in the analysis of data and the modeling of climate systems. CRD's current research efforts are strengthened by the Center for Clouds, Climate, and Chemistry and the California Space Institute, as well as the Physical Oceanography Research Division.

"Today, Scripps is one of the finest global climate research centers in the world," according to Scripps climatologist Tim Barnett.

One tropical storm after another pounded southern California during the 1982-1983 El Niño, triggering mud slides, flooding, and extensive coastal damage. Scientists continue to debate whether such extreme weather conditions are signs of greenhouse warming or natural climate variation.

they can predict that it will probably rain more than usual next December."

As for predicting when long-term global warming caused by Industrial Age air pollution—known popularly as the greenhouse effect—will occur, Barnett tends to be cautious. He is quick to point out that the historical record of how the atmosphere and oceans have changed over the past century is quite poor. Another issue, he says, is that the large regional temperature increases during the 1980s, such as several hotter-than-normal summers in North America and Europe, are not consistent and may be part of decade-long, or longer, natural temperature cycles. But just because scientists cannot agree on whether global warming is here does not mean that predictions are wrong.

"While there are still shortcomings of the greenhouse prediction models and the data that are used, I think we are edging toward the point where scientists will all agree that humans have impacted the climate," Barnett said.

"Frankly, the implications of global climate change on society are frightening, and we have only two choices," Barnett concluded. "We can address the real potential threat of greenhouse warming and, if found serious, implement whatever action we decide is necessary to ameliorate it. Alternatively, we can do nothing and let future generations find out just how good the model predictions were. . . . We should really be preparing the planet for our children and we are not doing so."

"... We should really be preparing the planet for our children."

Meteorologist Nicholas Graham, El Niño researcher and surfer, regards El Niño enhanced winter waves off the Scripps beach as potentially dangerous, but also possibly fun.