

LETTERS

To the Editors:

We are pleased to see *Scientific American* publicizing the important phenomenon called El Niño [see "El Niño," by Colin S. Ramage; SCIENTIFIC AMERICAN, June]. El Niño is a term used to designate the occasional large and anomalous warmings in the eastern and central tropical Pacific Ocean, which disrupt the marine ecosystem. These warmings tend to occur from three to seven years apart but with varying intensity.

The sea-surface warmings result from changes in the trade winds over the tropical Pacific and the consequent changes in ocean currents and in the upwelling of cold water from the depths. The anomalously warm sea temperatures, in turn, appear to drive further changes in atmospheric circulation, not only in the Tropics but throughout the global atmosphere. These corresponding variations in the atmosphere are known as the Southern Oscillation. In combination El Niño and the Southern Oscillation represent the best example of a coupling between the atmosphere and the oceans that has a significant effect on short-term climate.

In the 1982-83 El Niño event, for instance, devastating anomalies in weather and short-term climate occurred all over the globe, ranging from drought in Australia, India, Indonesia and Africa to floods in Peru and Ecuador, coastal flooding in California and along the west coast of South America, displaced storm tracks across the U.S. and unusual hurricane tracks in the Pacific. Similar changes, although often less dramatic, had occurred in previous El Niño events.

Meteorologists and oceanographers consider El Niño to be scientifically very challenging, as well as of great economic and practical importance. Moreover, because individual El Niño events evolve over a period of about two years in an established manner, once an El Niño is recognized as being under way there is potential for adding skill to seasonal forecasting of weather and climate.

In recognition of the potential for seasonal forecasting, the economic and social value of increased understanding of El Niño itself and the challenge posed by the scientific questions, a major U.S. and international program known as TOGA, for Tropical Oceans and Global Atmosphere, is under way to investigate interannual variability in those oceans and the atmosphere. TOGA is a decade-long en-

deavor (1985-94) under the auspices of the World Climate Research Program. Many countries are very interested and actively involved in this program, and at a meeting in Geneva in May about 20 nations committed resources to it. As a result an intensive period of new observations, analyses, computer modeling and research is beginning. Its object is to determine how the observed relations between variations in sea-surface temperatures in the tropical oceans, of which El Niño is the best example, and the associated fluctuations in the global atmospheric circulation can be utilized to give better weather predictions. The optimism expressed for TOGA by scientists and governments throughout the world was not reflected in Ramage's article. Indeed, it failed to mention TOGA at all.

Contrary to the impression Ramage gives, one potential benefit of TOGA for the U.S. is improved skill in forecasting winter temperatures. Since the waves in atmospheric circulation are affected by El Niño, some places get warmer during El Niño events and some get colder. Simple comparisons of winter temperatures with an index of the Southern Oscillation reveal significant negative correlations over the West Coast, Alaska and Canada and significant positive correlations over the southeastern U.S.

In his article Ramage used temperatures in Illinois as representative of relations between El Niño and U.S. winter temperatures. That comparison is quite misleading. Since Illinois is in the transition zone, the lack of a significant correlation there is not surprising and does not imply that no useful relations exist!

We hope this letter will help to offset Ramage's negative view of the state of knowledge and instead convey some of the excitement felt by scientists around the world as they enter this challenging but promising avenue of research.

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To the Editors:

I am delighted that so many of my distinguished colleagues have called attention to the impressive international programs embodied in TOGA. Since that project has already been widely publicized, however, I chose to discuss individuals and their work rather than plans that were generated by committee.

As designers and justifiers of a big project, my colleagues are officially optimistic. I am therefore not surprised by their statements that "El Niño events evolve over a period of about two years in an established manner" and that the West Coast of the U.S. is one of the places whose winter temperatures are linked to El Niño. The link between the phenomenon and winter temperatures is rather tenuous in California. Seventeen moderate or strong Niños occurred between 1895 and 1983. During the same period California experienced nine cold winters (with temperatures more than one standard deviation below normal) and eight warm winters (with temperatures more than one standard deviation above normal), of which only one (the warm winter of 1939-40) coincided with a Niño.

Far from holding a "negative view of the state of knowledge," I believe even failure of the several confident forecasts of a moderate or strong 1986 Niño could significantly enhance our understanding.

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EDITOR'S NOTE

Elements of the drawing on page 100 of the July issue were based on a flight simulator developed by the HTM Corporation of Orlando, Fla.