El Niño: a wild card for climate change impacts

Place your bets on El Niño's influence in the Southwest

By Melanie Lenart

The Southwest has always had its appeal for gamblers. In the Old West, gunslingers frequented saloons to play poker games like Three Card Monte, undaunted by the prospect of taking a bullet for a questionable winning streak. In modern times, Black Jack players from distant counties flock to the casinos sparkling through the night on tribal lands, praying for a reign at the table.

In the desert, there's another gamble that we all take: Will the rains that have sustained us in modern times continue to replenish our water supplies? Will global warming deal us a losing hand, with the coming decades bringing us more dry wells and shrinking lakes? Place your bets.

If climate is your strong suite, it will come as no surprise that the fate of southwestern water supplies rests largely in the hands of El Niño—and El Niño remains a wild card in the context of climate change. If El Niño events predominate, as they did during a wet period from about the mid-1970s through the mid-1990s, southwestern reservoirs and aquifers alike could benefit from the general boost to winter precipitation (Figure 1). But if La Niña events dominate as they did during the drought years 1998 until 2002, the growing population of the Southwest could be in for some dry times (Figure 2).

When trying to predict the general climate of the next several decades, arguments have been raised for a wide range of scenarios, including dominance by El Niño, an overall trumping by La Niña, stronger fluctuations between the two, and weaker events for both conditions.

Climate models conflict

"The bottom line is we don't know what climate change will do to El Niño," explained Henry Diaz, a climatologist with the National Oceanic and Atmospheric Administration's Climate Diagnostics Center. "Most general circulation models, in fact, don't have a good representation of the El Niño phenomenon—although the latest models are showing substantial improvements."

Modeling El Niño is particularly challenging because it requires "coupling" the ocean and atmosphere into an interactive system. Trade wind activity helps define El Niño, which is why climatologists prefer to call the linked ocean and atmospheric system by one phrase, the El Niño–Southern Oscillation (ENSO). The linkage is easier said than done in climate models.

Several climate models project an eventual dominance by El Niño events, but often for different reasons, as the Intergovernmental Panel on Climate Change noted in its latest report in 2001. This international consortium of scientists resisted reaching a conclusion about whether El Niño will hold sway. The panel pointed to more ambiguous models and an analysis by Mark Cane and his colleagues that showed the potential for a La Niña-like response from the warming temperatures for at least a few decades to come.

While considering how these patterns might fluctuate with global warming—a speculative venture in any case—it's useful to consider how the patterns work now. During El Niño events, the Peruvian side of the tropical Pacific Ocean tends to register higher-than-usual temperatures at the ocean surface along with a slackening off of easterly winds. During La Niña events, the sea surface temperatures in the same region tend to run even cooler than usual, with the associated strong easterly winds pushing away the warm surface layer and exposing the cooler waters below.

Warm sea surface temperatures tend to generate storm clouds, while anchoring winds direct where the clouds travel. Along with the tropical trade winds, which flow east to west near the equator, El Niño fluctuations influence the mid-latitude westerly winds. The westerlies flow from the Pacific across the continental United States, favoring the Pacific Northwest during La Niña years and the Southwest during El Niño years.

A shifty character

However, the degree to which El Niño influences specific regions can change in time, according to a 2001 International Journal of Climate paper by Diaz and two colleagues comparing ENSO impacts on many regions of the globe. Using the most reliable instrumental records for land (and thus going back only to 1948), they saw shifts in the character of El Niño impacts.

"It's not your grandfather's El Niño anymore," as Kevin Trenberth, an atmospheric scientist with the National Center for Atmospheric Research, put it. El Niño could undergo additional character changes as the climate warms, he suggested.

Diaz noted that it could take decades or more before El Niño settles into a mode characteristic of a global warming pattern. "We don't know the exact shape of the form that it will take," he added.

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El Niño, continued

In the meantime, the debate about how the ocean system will react in the next few decades to the ongoing global warming seems to revolve around two alternative lines of thinking: One is that stronger and/or more frequent El Niño events could predominate and serve as a means for cooling the planet in the long run, as much of the heat released from the ocean during El Niño years eventually makes it way out into space. The other is that a predominance of La Niña events could help the planet strive for equilibrium in the face of the global warming, with the ocean basically absorbing some of the incoming heat into deeper waters while presenting a cooler surface to the atmosphere.

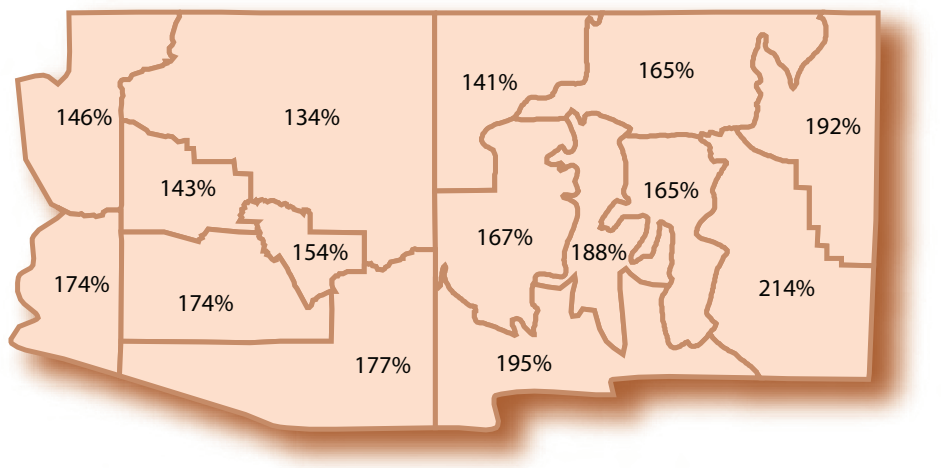

Figure 1. During El Niño years, all climate divisions in Arizona and New Mexico tend to receive above-average winter precipitation, as shown above. Values represent the percentage of December–March precipitation falling during El Niño years compared to non-El Niño years for the period 1895-1996. Source: adapted from NOAA Climate Predition Center material.

El Niño vs. La Niña

Saturday Night Live fans may remember a skit where Chris Farley played El Niño (translation: "The Ninyo") as a leotard-clad boxer ready to rule the ring. Images like this helped popularize the term in the 1990s—as did the dominance of the real El Niño in the Pacific between 1990 and 1995 and again in 1997 through 1998.

The predominance and strength and evolution of El Niño events since about 1976 has been highly unusual in the record since 1880, Trenberth argues. He and others made this case in papers released in 1997 and 1998, before the extreme El Niño event that spanned those years made the record books, and in a subsequent *Journal of Climate* paper in 2001.

Many view the mid-1970s as a turning point, a time when global warming from human activities such as burning petroleum products and forests really took root. Some call this turning point the 1976–1977 climate shift. The predominance in El Niño conditions since the mid-1970s might suggest an influence from human-launched global warming, Trenberth indicated. If so, this could imply that El Niño might remain dominant if the atmosphere continues to heat up as projected.

On the other hand, Mark Cane and others have argued that El Niño events in the late 19th century were on a par with recent decades.

"In many ways, the El Niño of 1877 was certainly far more destructive and had more serious consequences than any of the recent ones," explained Cane, a climatologist with Columbia University's Lamont-Doherty Earth Observatory. He noted that it appears to have contributed to the failure of the Indian monsoon that year, among other deadly disasters.

Cane points to evidence in records of fossil corals to argue that ENSO fluctuations have varied throughout the centuries and even millennia, with the latter based on spotty individual coral segments that date back as far as 130,000 years. Some of the century-scale results imply a predominance of La Niña events during previous warm periods, Cane suggests.

Will El Niño rule?

Several lines of analysis agree that El Niño serves to release heat from the ocean, with the short-term effect of warming the atmosphere but the long-term effect of cooling the planet.

Like others before and after them, Diaz and colleagues found the tropics registered the most warming during El Niño events of the past half a century. The Tropics of Cancer and Capricorn delineate the 40 percent of the planet that seasonally faces the sun head-on, thus receiving the full blast of its power without any angling to soften the blow. Meanwhile, they found the "extratropical" regions showed more variability, typically registering either average or even cooler-than-average temperatures.

Trenberth has pointed out that the record-breaking temperatures of 1998 occurred as an El Niño event that started in 1997 and stretched into 1998 as well. The year 1998 was the warmest year on record globally, with 2005—which featured a weak atmospheric El Niño event—shaping up as a contender for either the top spot or second-hottest year in the instrumental record.

In the long run, though, El Niño eventually releases into space some of the heat that had been stored in the planet's oceans, climatologists agree. In fact,

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El Niño serves to dissipate heat in three apparently coordinated ways, noted Trenberth in a 1998 paper with lead author De-Zheng Sun, with NOAA's Climate Diagnostics Center. These include ocean dynamics that move warm water from the equator to the subtropics; atmospheric dynamics that export heat to the subtropics, sometimes in the shape of thunderstorms; and cloud cover that helps shield more of the eastern Pacific from direct sunlight.

"This raises the question of whether the very existence of El Niño arises from the need to move heat out of the equatorial Pacific," as Sun and Trenberth wrote in *Geophysical Research Letters*. The equatorial region within the tropics takes the most direct hits of sunlight of any region on the globe.

The case for La Niña

Some propose that La Niña conditions could become more prevalent as the climate warms, at least for several decades. Cane's 2004 review paper, *The evolution of El Niño, past and future*, notes some researchers have found an increase in La Niña events during warm periods.

In fact, an analysis he and others conducted found the eastern equatorial Pacific—the location that most clearly signals El Niño events—was one of the few places on Earth that did not register an overall warming during the past century, he said. This implies that upwelling from La Niña events helped counterbalance the global warming that registered almost everywhere else. However, he and others are still teasing out details that hint at differences in patterns that could actually be consistent with a more El Niño-like nature in the latter half of the century, he wrote in an email message.

During the past, ENSO seems to have served as a means for the Earth system to mitigate the effects of short-term warming or cooling from changes in incoming solar energy or volcanic activity. For instance, a Journal of Climate paper Cane wrote with lead author Michael Mann of the University of Virginia and others suggested El Niño events may have kept oceans warmer than expected in the late 17th Century, during the so-called Little Ice Age.

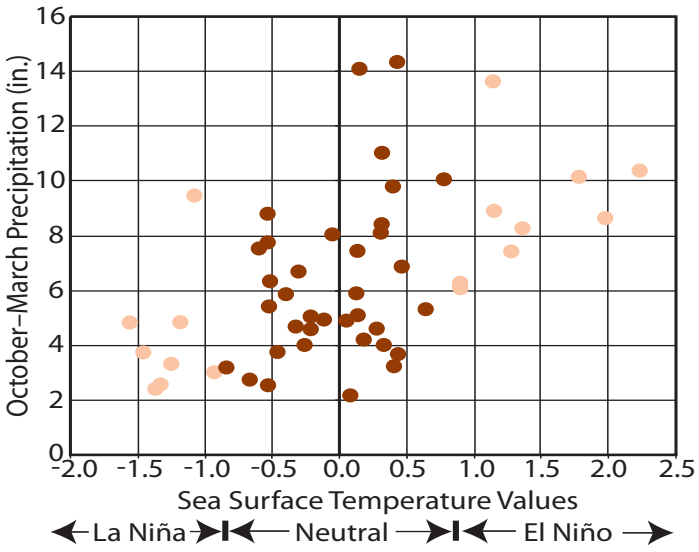

Figure 2: Arizona precipitation. Points represent October–March precipitation tallies, with values from 1951–2003.

Similarly, a predominance of La Niña events may have kept the ocean relatively cool during the late 12th and early 13th Centuries, during the so-called Medieval Warm Period, which appears to coincide with warmer European temperatures at various points during its time span of roughly 900 to 1300 A.D. Tree-ring records show that drought dominated in the West during this time frame, as documented by Edward Cook of Lamont-Doherty Earth Observatory and colleagues in a 2004 paper in *Science*. In fact, one of four lengthy droughts during this time frame centered on 1150, when the ancestors of the modern-day Pueblo Indians abandoned their sophisticated city in Chaco Canyon, New Mexico.

On the other hand, the period from 1950 to 2000 looks a bit different than the trend over the earlier part of the century, Cane acknowledged, making it difficult to draw firm conclusions about how modern climate compares to earlier climate regimes. The general warming during the late 12th and early 13th Century probably resulted from more solar heating combined with fewer volcanic eruptions, he indicated. Meanwhile, climatologists attribute the modern warming mainly to an increase in greenhouse gases like carbon dioxide from burning oil, coal, gas and forests.

"The question is, then, does greenhouse warming work the same way? Is heating just heating, or does it make a difference if it's solar heating or greenhouse heating?" Cane asked.

The fate of El Niño goes beyond a rhetorical question because of its huge impact on precipitation regimes in many regions of the world, including the southwestern United States. Yet there is little we can do to alter El Niño's uncertain fate in the short term. The global warming set in motion particularly since the mid-1970s won't be stopping anytime soon. Even if people changed their ways tomorrow, the extra heat already stored in the deep ocean would carry the warming out for many decades, analyses indicate.

So, what's in the cards for the El Niño, which generally dictates the Southwest's water future? Place your bets.

Melanie Lenart is a postdoctoral research associate with the Climate Assessment for the Southwest (CLIMAS). The SWCO feature article archive can be accessed at the following link: http://www.ispe.arizona.edu/climas/forecasts/swarticles.html