ENSO-Neutral: Another Dry Winter?

By Zack Guido

A once-promising winter forecast for an El Niño—and the wet conditions it often brings to the Southwest—has dissipated. Now, it appears a neutral phase of the El Niño–Southern Oscillation, or ENSO, is moving in, diminishing chances for copious winter rain and snow in the region.

"Our latest forecast for January–March is for below-average precipitation over most of the Southwest," said David Unger, a NOAA-Climate Prediction Center (CPC) meteorologist.

This is particularly bad news for the region's water supply. Irrigation water in the Elephant Butte Reservoir on the Rio Grande—the lifeblood for farmers in New Mexico's most productive agricultural region—is completely exhausted, while the four reservoirs on the Pecos River have dwindled down to only 1 percent of their total capacity. In Arizona, storage on the Salt and Verde rivers, which supply water to the Phoenix metropolitan area, have plummeted about 36 percent in the last two years, containing only about half of their 2.3 million acre-feet capacity.

Contributing to the forecast for below-average precipitation is the combination of a neutral ENSO event with warmer-than-average sea surface temperatures (SSTs) in the northwest Pacific Ocean, which have in the past brought a robust dry signal to the West. With that situation playing out again this year, another winter drought could further jeopardize water supply.

ENSO Briefly Explained

El Niño and La Niña are part of ENSO, a natural seesaw in oceanic SSTs and surface air pressure between the eastern and western tropical Pacific Ocean.

ENSO's inner workings are complex. The rotation of the Earth causes trade winds in low latitudes to blow hard from the east, pushing warm surface water in the tropical Pacific Ocean westward near the northern coast of Australia like a snow plow. As the warm water pools, it works in tandem with intense solar rays to heat the surrounding air.

The hot air then rises like a balloon, creating a zone of low air pressure. As the air ascends, it cools and condenses, forming clouds that burst with rain. That air then travels east, where it descends and piles on the Earth's surface, forming a high pressure zone that acts like a vice.

The pressure difference squeezes air in the east toward the west, where it fills the void created by the hot, rising air. In this way, a large circular and continuous pattern known as the Walker cell is completed, with its vigor tuned by

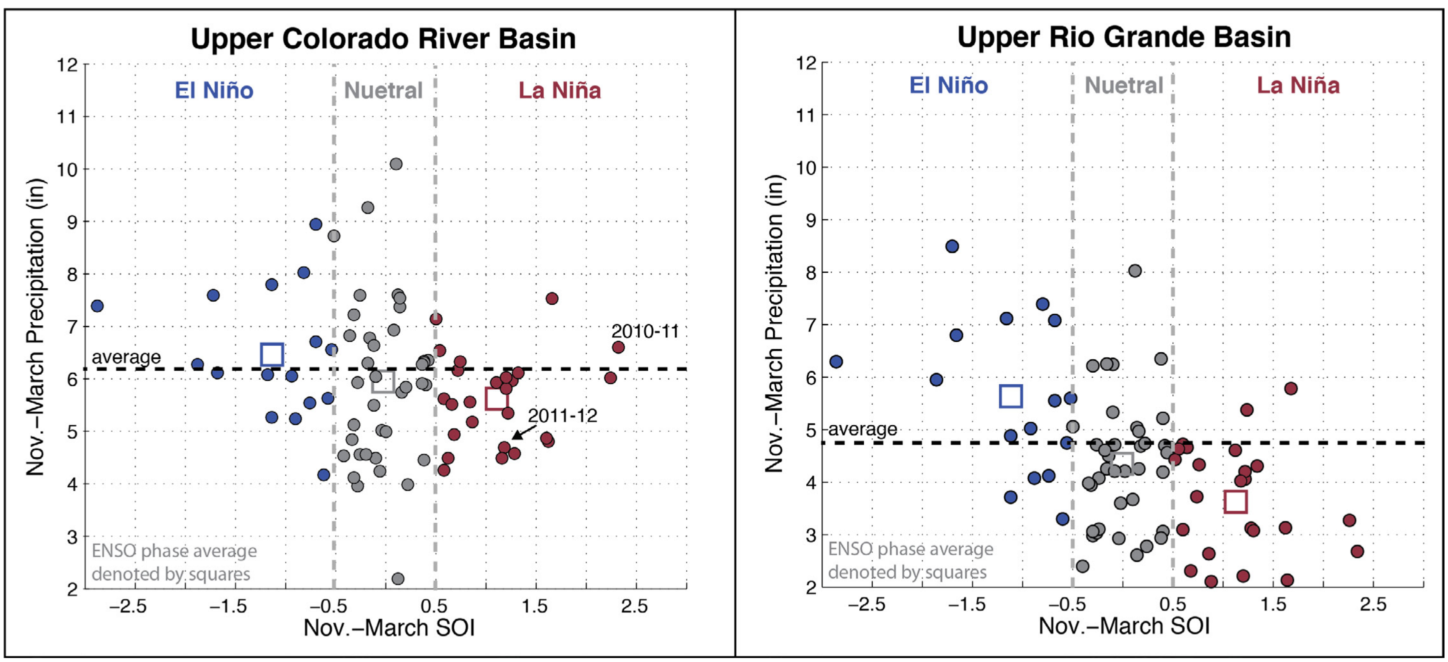

Figure 1. Precipitation during the November–March period in the Upper Colorado and Rio Grande basins during different ENSO phases between 1934 and 2011. The squares denote the average values for each phase. For the Upper Colorado River Basin, monthly PRISM data was averaged over the hydrologic units corresponding to the Upper Green and Lower Green, White-Yampa, Gunnison, San Juan, Lower Dirty Devil, Colorado River Headwaters, and Dolores. For the Rio Grande, precipitation data was averaged over the Rio Grande headwaters and the Upper Rio Grande hydrologic units. PRISM (Parameter-elevation Regressions on Independent Slopes Model) data was obtained from Westmap.

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ENSO's adjustments of SSTs and wind speed.

Changes in ENSO have far-reaching effects. During El Niño events, for example, surface waters warm and easterly winds weaken, which sends waves through the atmosphere that impact weather around the globe, much like a stone dropped in a placid pool creates ripples. In the U.S., El Niño events often cause more storms to waft over southern regions, generally leaving the Pacific Northwest dry. La Niña events, on the other hand, pull the atmospheric strings to shift storm tracks away from southern regions, often causing winter droughts, while delivering wetter conditions in the Pacific Northwest.

2011–2012 Evolution of ENSO

This year, SSTs began to warm in February, marking the beginning of the end for the existing La Niña. By mid-April, surface water temperatures in the tropical Pacific Ocean were near average and a pool of warm water began to accumulate just below the surface. This was the first hint of the development of an El Niño event.

It usually takes months for an event to fully materialize, and in July and August forecasters at the CPC were still confident that an El Niño would form by early winter. But by September, doubt crept in. The gradual warming of SSTs had slowed and easterly winds maintained strength similar to the historical average. This developing El Niño was sputtering like a cold car, and forecasters suggested that even if an El Niño formed, it would likely be weak and short-lived. In mid-November, CPC called off its El Niño Watch.

"It looks as though ENSO-neutral conditions are the best estimate now," Unger said. "The El Niño event was becoming established, but then it stalled."

Hedging Toward Dry

Of the three ENSO phases—La Niña, neutral, and El Niño—La Niña tips its hand the most in terms of what it will bring to the Southwest. It nearly always ushers in below-average rain and snow to the region, making forecasts more accurate.

"We pretty much know by November if it is going to be a dry winter in a La Niña year," said Gregg Garfin, deputy director for science translation and outreach at the University of Arizona's Institute of the Environment. "The percent we're wrong is in the single digits."

In ENSO-neutral years, however, foresight is harder to come by, in part because the variability is higher. Neutral years have delivered scant rainfall—most recently in 2002, when Arizona and New Mexico together received only about 46 percent of average precipitation—as well as a dousing. In 1995, for example, both states received about 142 percent of average precipitation combined.

"During ENSO-neutral years, we have a tendency to be just below the average in many regions in the Southwest," said Michael Crimmins, an associate professor and extension specialist in the UA's department of soil, water and environmental science. "It's also more variable

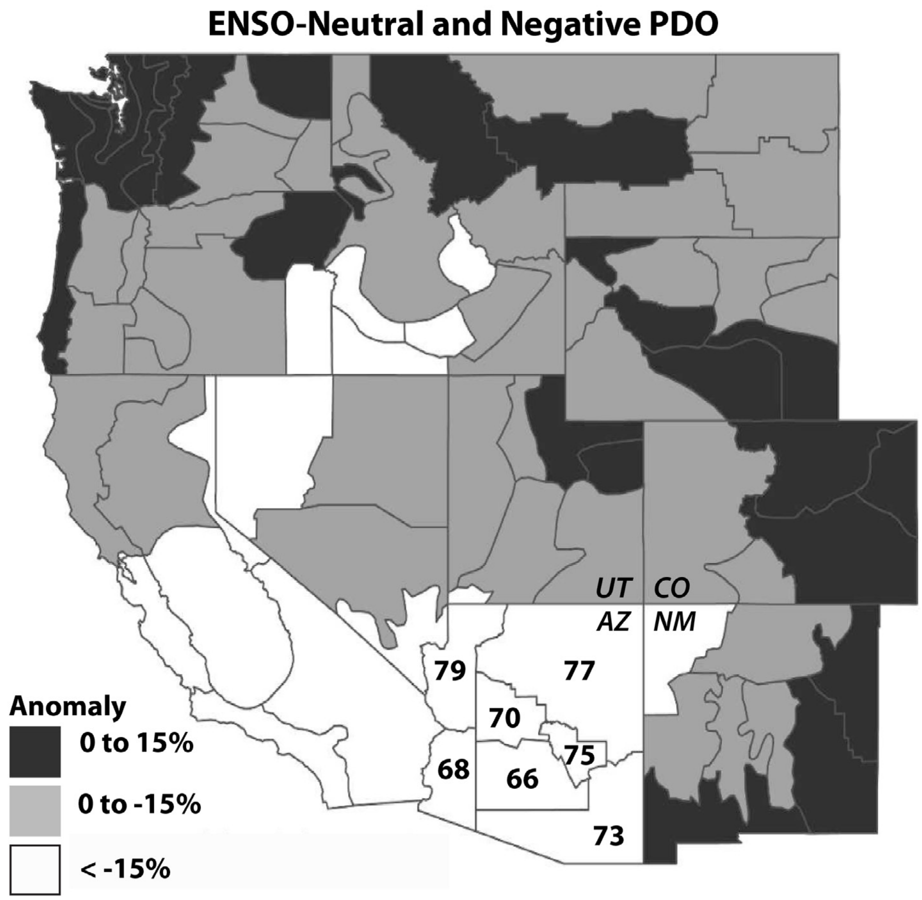

Figure 2. Winter precipitation for all December–March periods for each climate division in the West between 1925 and 1998 in which ENSO was neutral (defined as when the SST average over the Niño 3.4 region falls between -0.5 and 0.5 degrees Celsius) and the PDO was negative. Results from this analysis show that 68 of 84 climate divisions generally experienced below-average precipitation. The map is modified from Goodrich (2007) and the numbers in Arizona correspond to the percent of average winter precipitation calculated for each of the state's climate divisions during the same periods noted above; the numbers were obtained from Goodrich (2004).

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and we can get really wet years or really dry years."

This also holds true for part of the Rocky Mountains, where most of the water in the region's two most important rivers—the Colorado and Rio Grande—originates (*Figure 1*). About 55 and 73 percent of the ENSO-neutral winters, for example, have delivered below-average rain and snow in the Upper Colorado River and Rio Grande basins, respectively. In neutral years, however, the tug of ENSO isn't as strong, and other forces come into play.

"The ENSO signal is almost the only signal we can hang our hat on in the Southwest," Unger said. "But this year, the forecast is also based on the PDO."

The Pacific Decadal Oscillation, or PDO, is another seesaw in SSTs between the western and eastern Pacific Ocean north of 20 degrees north latitude. The PDO appears to be strongly influenced by ENSO events, according to often-cited research by Newman and others in 2003,[1] and remains in either its positive or negative phase for 20 to 30 years, perhaps sticking there because El Niño and La Niña events tend to cluster. In the last 10 years, for example, there were more La Niña events than El Niño events, and the PDO was generally negative.

"This winter the phase of the PDO is strongly negative, which tends to have La Niña-like atmospheric circulation," Unger said. "Our forecast models are picking up on this pattern."

Consequently, the CPC is hedging the January–March precipitation forecast toward dry conditions in many parts of the West, including nearly all of Arizona and California. Recent observations also support this outlook.

Analysis of data between 1925 and 1998 when winters had both ENSO-neutral conditions and a negative PDO phase—the current situation—revealing that, on average, precipitation in the western U.S. was 8.9 percent below normal, with 68 of 84 climate divisions (geographic divisions within each state) receiving below-average rain and snow.[2] In fact, ENSO-neutral phases during a negative PDO shows the largest precipitation deficits in the western United States.

In the Southwest, the picture is similar. Precipitation in all of Arizona was less than 80 percent of the 1971–2000 average (*Figure 2*), according to another Goodrich publication,[3] while the Upper Colorado and Rio Grande basins also were generally below average. Collectively, this does not bode well for reservoirs with low storage in the Southwest.

The answer to why the PDO exerts an influence, however, has been elusive.

"We know that ENSO forces the atmosphere to respond in different ways," Crimmins said. "We haven't yet found a causal link between the PDO and seasonal climate. Right now, its just statistics."

Without knowing the root cause of the statistics, it's difficult to assess how well they will hold up this year. Nonetheless, the forecast models see PDO-like patterns and call for drier-than-average conditions.

"We don't understand how the PDO teleconnects with other regions," Unger said. "But, because the models are showing a PDO signal, it gives us encouragement that there's something there. I guess the proof in the pudding will be known in a few months."

Further Readings:

1. Newman, Matthew, Gilbert P. Compo, Michael A. Alexander. 2003:. ENSO-forced variability of the pacific decadal oscillation. *Journal of Climate*, 16, 3853–3857. (Abstract)

2. Goodrich, Gregory B., 2007: Influence of the Pacific Decadal Oscillation on Winter Precipitation and Drought during Years of Neutral ENSO in the Western United States. *Weather and Forecasting* 22, 116-124. (Abstract)

3. Goodrich, Gregory B., 2004: Influence of the Pacific Decadal Oscillation on Arizona Winter Precipitation during Years of Neutral ENSO. *Weather and Forecasting* 19, 950-953. (Abstract)