The 2009 southwest monsoon: El Niño's heavy hand

By Zack Guido

Anvil-shaped cumulous clouds dotted the sky in early June, occasionally bursting with heavy rains in many parts of New Mexico and southeastern Arizona. The much-needed moisture turned the stalks of blue and black gramma grasses a light green, filled stock ponds, and flushed torrents of water down sandy washes. The monsoon rains had arrived. This year they moistened the landscape earlier than usual and in quantities that exceeded average years.

But soon after the rains arrived, the clouds evaporated. The wet June turned into a dry July then a parched August and then a dehydrated September. Not even tropical storm Jimena, which blew into the Southwest in early September, could dampen the effects of drought. Impacts of the dry conditions were reported all over Arizona. Ranchers in southern portions of the state sold livestock in droves, sections of streams with perennial flow dried to a trickle, and Blue Oak trees aborted their buds. In the Four Corners region springs dried and corn stalks withered.

About half of the yearly precipitation in Arizona and New Mexico pelts the ground between the beginning of June and the end of September—but not this year. A close examination at rainfall amounts from this summer reveals that most of Arizona experienced the driest summer in the last 60 years, causing the entire state to be plagued with drought conditions. Although New Mexico fared better, it also was not spared. Climatologists point to El Niño as the principal cause of scant rains. But while El Niño stonewalled summer rains and brought short-term drought conditions to most of the Southwest, El Niño often enhances winter precipitation. A wet winter, however, is not guaranteed.

Monsoon Recap

Prior to the monsoon season, climate scientists noted low snowpack in the Rocky Mountains, dry conditions on the southern plains, and Pacific Ocean sea surface temperatures with a pattern in space that was similar to last year. These clues contributed to the prediction that the monsoon storms would arrive early and unload above-average rainfall during the first part of the season. This forecast came true for many parts of southeastern Arizona and New Mexico. Some areas received more than 300 percent of their average rain between June 15—the official start date of the monsoon season in Arizona—and July 15 (Figure 1a).

"The beginning of the monsoon season looked good," said Erik Pytlak, Science and Operations Officer at the National Weather Service in Tucson.

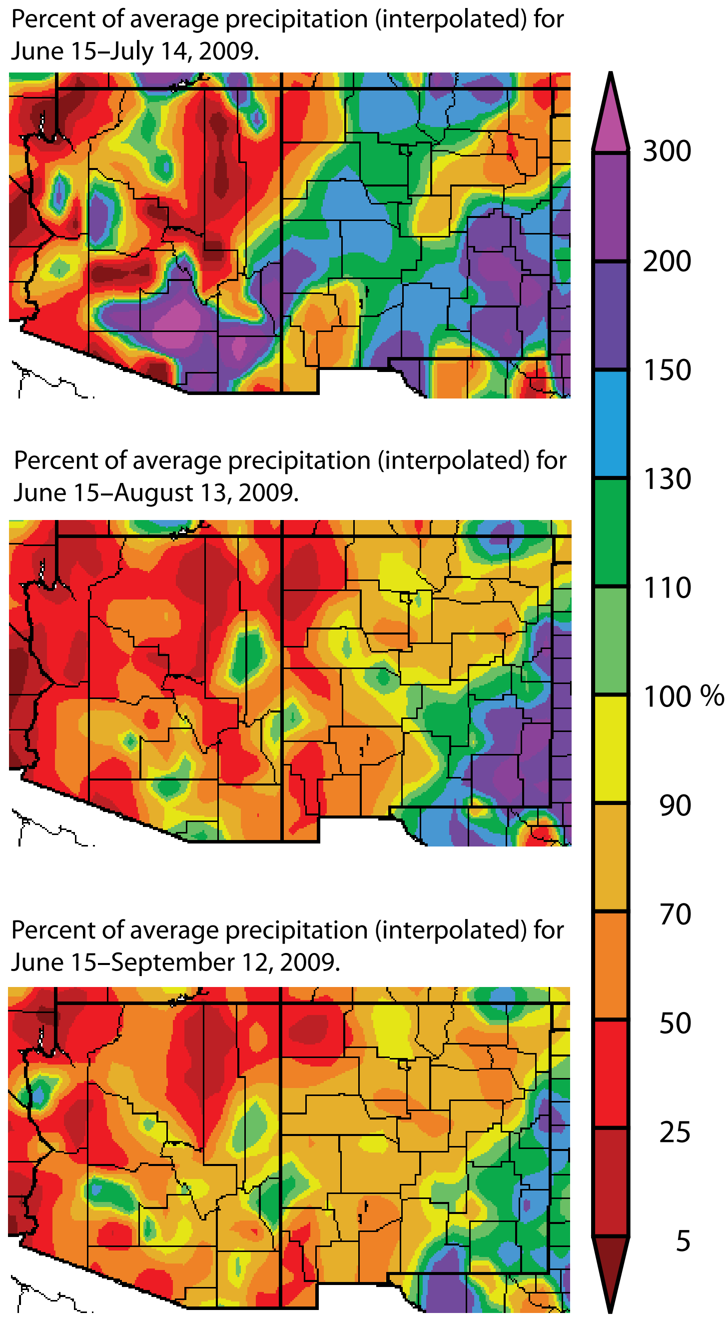

Figure 1. Monsoon rainfall in the Southwest was characterized by an early and wet beginning in some parts of the region with dry conditions that began soon thereafter. The maps display the evolution of summer rains during the 30-day period beginning on June 15—the official start of the monsoon in Arizona—and September 12. Rainfall is expressed as the percent of the 1971–2000 average.

In the first month of the monsoon season, southern Arizona, southeastern New Mexico, and parts of central and northern New Mexico received above-average precipitation. The Four Corners region, however, was dry, a normal occurrence at this time of year because rain usually begins in earnest in late July. While the dryness in the northern region was not out of the ordinary, it was unusual for

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Arizona's Mogollon Rim country to have received less than 50 percent of average precipitation. According to the National Weather Service in Tucson, this likely occurred because hot and dry weather in south Texas stalled the high pressure system south of its typical location over the Four Corners region which prevented moisture aloft in the atmosphere from passing over the Mogollon Rim.

At the beginning of July, however, climate scientists were skeptical that the rains would continue. The official seasonal forecasts issued by the National Oceanic and Atmospheric Administration (NOAA) stated that there was an equal chance that August–October precipitation would be above average, below average, or average for all of Arizona and the southwestern half of New Mexico. This uncertainty resided in the rapidly forming El Niño event which often causes two phenomena that have opposite effects on precipitation in the Southwest. On one hand, El Niño events can stifle summer rains because they weaken and/or reposition the subtropical high that guides moisture into the Southwest. On the other hand, El Niño events also can foment a higher number of tropical storms, some of which blow into the Southwest and deliver torrential rains.

Although tropical storms formed in the eastern Pacific Ocean this year more often than in average years, most storms wafted westward away from land, and the Southwest saw little benefit from the enhanced storm activity.

"To make a long story short, the primary driver in shutting down the monsoon was El Niño," said Pytlak.

By July the sea surface temperatures in the tropical Pacific Ocean were about 1 degree fahrenheit warmer than average, the temperature threshold for an El Niño event. The warm ocean water then influenced atmospheric circulation. The high pressure system that usually sets up over the Four Corners region was pulled southward, blocking the flow of moist air into southern Arizona and New Mexico. The Jet Stream wind current, ripping through the atmosphere at an altitude of about 30,000 feet, also was accelerated and flowed in a more southerly path across the U.S. This caused surface winds to originate out of the southwest instead of the southeast where the tap for much of monsoon moisture resides.

While scientific research has yet to pin down exactly why El Niño causes these changes to atmospheric circulation, it is a good bet that El Niño is to blame.

"Monsoon precipitation this year was so far below normal rainfall amounts that El Niño certainly played a role," said Mike Crimmins, Climate Science Extension Specialist at The University of Arizona.

Data gathered from weather stations throughout the Southwest place this summer's aridity in perspective. In each of the seven climate divisions in Arizona [climate divisions lump regions with similar agricultural productivity and are divided in part based on watersheds] July precipitation calculated by using the Parameter-elevation Regressions on Independent Slopes Model (PRISM) dataset was below the 1971–2000 average. July, however, seemed wet compared to August (Figures 1b–c). In the Northeast (Four Corners region) and East Central climate divisions in Arizona, August experienced the least amount of rainfall in the last 60 years (Figure 2). The five other climate divisions experienced conditions that ranked in the top eight driest Augusts on record. New Mexico had a similar story. Five of the eight climate divisions experienced the second, third, or fourth driest August, while the other three divisions were in the top thirteen. On August 20, the severe dry conditions lead the U.S. Drought Monitoring Committee to classify 96 percent of Arizona with abnormally dry conditions or worse, an increase of 36 percent from the previous month. The area in New Mexico classified as abnormally dry or worse was around 45 percent and had increased about nine percent from mid-July.

In September dry conditions continued to prevail. Rainfall in each of Arizona's climate divisions was again below average—five of the seven divisions received half the 1971–2000 September average (Figure 2). New Mexico, however, received near-average rainfall during the month in six of its eight climate divisions; the exceptions were in the Northeastern Plains and the Southeastern Plains regions where rainfall was about 60 percent of the 1971–2000 average. Had it not been for hurricane Jimena, which struck Baja, California and Mexico on September 2 and soaked parts of Arizona and New Mexico soon thereafter, rainfall in the Southwest would have been even less.

By the end of the summer, the verdict was in. The monsoon was a dud. In many parts of the Southwest, particularly in Arizona, El Niño had become this monsoon season's Grinch.

According to the PRISM dataset, Arizona experienced the driest June–September between 1950–2009—all seven climate divisions ranked in the top five driest summers; four of them ranked as the driest. Although New Mexico fared considerably better, the summer of 2009 still experienced below-average precipitation.

"Our worst fears that we had in May came true. El Niño took over," said Pytlak.

A look ahead

Climatologists cite El Niño as a leading cause for the scant rainfall in the Southwest this summer. But El Niño also has a tendency to bring wetter-than-average conditions to the Southwest in the winter. Although this bodes well for the prospect

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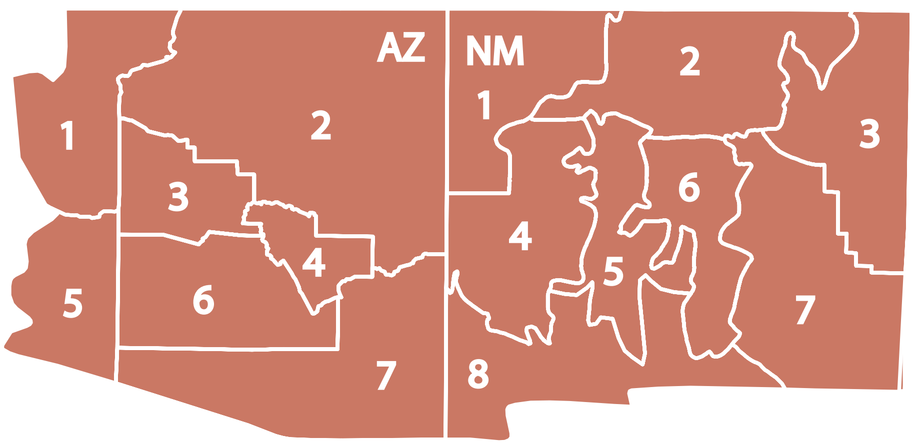
of much needed rain and snow, it is not a sure thing.

A cursory look at winter precipitation during El Niño events reveals that all climate divisions in Arizona and New Mexico tend to receive above-average precipitation. However, the amount of precipitation during the winter changes by location, and the possibility exists for a dry winter. In Arizona between 1896 and 2002, about 50 percent of the winters experiencing an El Niño event received more than 115 percent of the average precipitation and about 25 percent of the winters received less than 85 percent of the average precipitation.

Critical winter precipitation for the Southwest also falls as snow in the headwaters of the Colorado River in Utah, Wyoming, and Colorado. In fact, about 70 percent of the water that flows in the region's most important river originates in the mountains to the north. However, El Niño is more likely to bring drier conditions to those regions because storm tracks carrying vital moisture are deflected southward. Typically, when the southern regions of the Southwest are wet, the Upper Colorado River Basin is dry. For example, during El Niño events between 1896 and 2002, the Colorado portion of the Upper Colorado River Basin received less than 85 percent of average precipitation nearly one-third of the time. El Niño events during the same period delivered more than 115 percent of average precipitation only 27 percent of the time. If history plays out this year, the Upper Colorado River Basin has roughly the same odds for a wet or dry winter.



Climate Division	Jun (%)	Jul (%)	Aug (%)	Sep (%)	Summer Total (%)	Summer Rank (1950-2009)
AZ1–Northwest	65	60	23	51	46	3
AZ2–Northeast	106	56	27	55	49	1
AZ3–North Central	46	62	20	49	42	1
AZ4–East Central	97	76	21	77	55	1
AZ5–Southwest	50	58	22	55	41	5
AZ6–South Central	33	65	33	48	46	1
AZ7–Southeast	136	76	47	70	68	5
NM1–NW Plateau	236	50	30	99	73	13
NM2–Northern Mtns	142	84	36	124	86	21
NM3–NE Plains	77	135	48	60	84	20
NM4–SW Mtns	193	71	71	115	92	31
NM5–Central Valley	122	101	50	104	86	27
NM6–Central Highlands	101	98	45	104	121	15
NM7–SE Plains	105	174	30	58	88	30
NM8–Southern Desert	116	89	53	101	82	18

Figure 2. The percentage of average monthly precipitation in Arizona and New Mexico varied by climate division during the monsoon season. The summer rank indicates the relative dryness of each climate division compared to other summers during the 60-year period between1950–2009.

Even in Arizona, where the likelihood of a wet winter during an El Niño event is higher, there are regional differences in the amount of precipitation. The Four Corners region, for example, experiences high rain and snow amounts only 44 percent of the time compared to southeast and southwest Arizona, which receive higher precipitation 56 and 59 percent of the time.

"The important lesson is that El Niño does not mean a slam dunk for a wet winter," Pytlak said. "In 2002–2003," he continued, "the last time we had an El Niño event with similar strength as the current El Niño, the winter was dry."

In that year, however, El Niño peaked in October and fizzled out early in the winter. This year may be different.

"We are seeing a build-up of warm water just below the surface [in the Pacific Ocean]," said Pytlak. "We are seeing more and more evidence that water temperatures will warm and the El Niño event will increase in strength."

A longer lasting event may bring much needed rains. Fortunately, all indications point to El Niño continuing through the winter months.

"Right now, the National Weather Service is cautiously optimistic," said Pytlak.