September 21, 2011

Southwest Climate Outlook

Vol. 10 Issue 9

Credit: Daniel Griffin, Laboratory of Tree-Ring Research, University of Arizona.

A monsoon thunderstorm soaks a small part of the Gila River Valley west of Safford, Arizona, on July 19, 2011. Photograph is taken from the Pinaleño Mountains.

Would you like to have your favorite photograph featured on the cover of the Southwest Climate Outlook? For consideration send a photo representing Southwest climate and a detailed caption to: zguido@email.arizona.edu

In this issue...

September Climate Summary

Drought-Monsoon precipitation during the past 30 days provided some drought relief to parts of New Mexico and Arizona, but overall moderate drought or a more severe category persists across most of the region and even expanded and intensified across parts of Arizona.

Temperature-Record warmth continues across the Southwest. Temperatures have been 2–4 degrees F above average throughout most of the region.

Precipitation-The monsoon ramped up in mid-September, delivering copious rain to many parts of the Southwest; the monsoon as a whole, however, has delivered below-average precipitation.

ENSO-La Niña is back and is expected to deliver below-average precipitation to much of Arizona and New Mexico through the upcoming fall and winter seasons.

Climate Forecasts-Seasonal climate outlooks call for above-average temperatures through the new year, while below-average rainfall is forecasted for this winter.

The Bottom Line-The monsoon is nearly over and extreme and exceptional drought conditions remain ensconced in the region, particularly in the southeastern corners of Arizona and New Mexico. Widespread and intense monsoon storms flared up for a week in mid-September, but the total amount of rainfall since June 15 has been slightly below average for most of the region. Scant rain in some parts of the Southwest in conjunction with region-wide, warmer-than-average temperatures caused drought to expand and intensify in Arizona. The Southwest likely will continue to experience drier-than-average conditions because a La Niña event officially has returned. There is uncertainty about how long and how strong this La Niña will be, but forecasts suggest at least a weak event will persist through the winter.

This Winter May Not Be As Dry As the Last

A climatology equivalent of an economic double dip in the Southwest is back-to-back La Niña events. In September, the National Oceanic and Atmospheric Administration (NOAA) made it official: La Niña has returned after a short hiatus, bringing with it the expectation for dry conditions for a second straight winter in most of Arizona and New Mexico. If the past is a window into the future, however, southeast Arizona and southern New Mexico may not be as dry as last winter.

There have been four La Niña events lasting two consecutive winters or more since 1955. The second winter in each of these events delivered less than 75 percent of average rainfall to most of Arizona, with the least amount of rain and snow falling in southern Arizona. In all but one of these events, New Mexico was generally drier than average. This does not bode well for a region already mired in widespread and severe drought. However, in all four events southern New Mexico received up to 1 inch more rain than it did during the winter of 2010-2011, and in three out of the four events southeast Arizona also received up to an inch more. While a sample size of four is insufficient to draw robust conclusions, there is reason to suspect that parts of the Southwest will receive more rain and snow than last winter.

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This work is published by the Climate Assessment for the Southwest (CLIMAS) project, the University of Arizona Cooperative Extension, and the Arizona State Climate Office.

Extreme Events in the Southwest

By Zack Guido

Raging fires, mile-high walls of dust, bone-dry drought, and pipe-bursting freezes wreaked havoc across the Southwest this year. By the end of August, drought and fires alone cost New Mexico, Arizona, Texas, and other western states more than $5 billion, which does not include the recent blazes that destroyed more than 1,000 of houses in Texas. Ten disasters across the country have cost more than $1 billion already this year, breaking the previous record of nine set in 2008, according to the National Oceanic and Atmospheric Administration (NOAA). In fact, CNN dubbed 2011 the year of billion-dollar disasters (August 20).

Viewed through the lens of global warming, the weather events of the year beg the question: Is the intensity, frequency, and duration of extreme events increasing? Research suggests a link between rising temperatures and increasing trends in extreme events for some climate-related phenomena, but natural variability also comes into play.

Figure 1. Fires in the Southwest have run rampant this year and have run up an enormous fire-fighting bill in an unprecedented year of disasters. Texas, where the fire in this photo burned on July 5, has had a particularly active fire season. Photo credit: Zack Guido.

A year of wacky weather

This year has shaped up to be unprecedented in Arizona and New Mexico for extreme weather and climate conditions. January was the driest on record, which dates back to 1895. In February, frigid Arctic air swept into the Southwest, sending temperatures in Tucson plummeting to 18 degrees Fahrenheit on February 3—only one degree warmer than the coldest February day in the city's history. The mercury in Albuquerque dipped to -7 degrees F, an all-time record there for that date.

By the end of the winter, persistent dry weather had caused widespread and intense drought across the region, including exceptional drought in southeastern Arizona and New Mexico, the kind of drought that occurs, on average, only once in every 50 years. In the spring, the parched landscape conspired with blustery conditions to fuel rampant fires, priming the land for the largest fire in the recorded history of Arizona. By September 12, more than 2.1 million acres had burned in the two states combined, surpassing the previous record of about 1 million acres set in 2006.

The monsoon also has brought rare weather. Six dust storms raced through the Phoenix metropolitan region, with sand billowing as high as a mile into the sky. New Mexico had its driest August on record, and temperatures were hotter in August in both Arizona and New Mexico than they were during the previous 117 years. Average temperatures for the June–August period also were the hottest on record in New Mexico.

Elsewhere in the U.S., 180 tornados ripped across the Midwest in a six-day period, killing 177 people. Heavy rain and melting snow in the Ohio Valley caused historic flooding along the Mississippi River and its tributaries. And Hurricane Irene drenched the northeast in late August and led to the deaths of more than 40 people in 13 states.

continued on page 4

Extreme Events, *continued*

Are extreme events increasing?

Extreme weather and climate events, by their nature, generally have not occurred within collective memory, and there can be a tendency to explain these events by linking them to human-caused climate change. There is scientific reason to make this connection.

Temperatures in most places have been climbing, giving rise to expectations that temperature-related events such as heat waves and cold snaps will increase and decrease, respectively. Also, warmer air can hold more moisture. According to the physical principle known as the Clausius-Clapeyron relation, the air can hold about 7 percent more moisture for each 1 degree Celsius increase, or about 4 percent for every degree Fahrenheit increase. This relationship implies that precipitation and attendant hydrological events will intensify in a warming world.

Single extreme events, however, cannot be attributed simply to anthropogenic climate change. The event may have occurred naturally as a consequence of inherent fluctuations in the climate system. When a pattern of extreme weather persists for some time, however, it may be classified as an extreme climate event, according to the Intergovernmental Panel on Climate Change (IPCC).

Observations in the U.S. suggest the link between recent climate change and extreme events is discernable for some climate phenomena, but not all. The most recent synthesis of extreme events in the U.S. was published in 2008 by the U.S. Global Change Research Program (USGCRP), which coordinates and integrates 18 federal institutions studying changes in the global environment and their implications for society. Their key findings:

- Heat waves lasting longer than four days and characterized by average temperatures that exceed the warmest 10 percent of all the four-day periods on record have significantly increased since 1960.
- The number of days in which temperatures exceeded the warmest 10 percent of days on record has increased since 1950 for both maximum (daytime highs) and minimum (warmest nighttime lows) temperatures when averaged over all of North America. The largest increases have occurred in the West, from northern Mexico through the western U.S. In most of Arizona, the number of days exceeding the warmest 10 percent of days has increased by five to 10 days, or between 0.9 and 1.8 days per decade.
- The number of frost days decreased by four days per year in the U.S. during the 1948–1999 period, with the largest decreases—as many as 13 days per year—occurring in the western U.S.
- There are recent regional tendencies toward more severe droughts in the southwestern U.S.
- Atlantic tropical cyclone (hurricane) activity—which can help feed the monsoon in the Southwest—has increased substantially since about 1970. However, there have not been clear trends in monsoon rainfall for Arizona or New Mexico.
- Heavy downpours have become more frequent and intense in recent decades than during any other time in the historical record in many parts of the U.S. This trend, however, has not been observed in the Southwest.

Human-caused climate change is influencing these trends to some degree, but natural climate variability also plays a role. The El Niño–Southern Oscillation (ENSO) cycle that brings recurring La Niña and El Niño events affects extreme precipitation in the Southwest. A paper published in the *Journal of Climate* in 1999 by Daniel Cayan and co-authors stated that winter precipitation and streamflow events greater than the highest 10 percent of flows on record occur more often during an El Niño, and the frequency of storms lasting two and three consecutive days increased by as much as two times during these events. As a result, several basins in the Southwest are at least 10 times more likely to experience extremely high flows during El Niño than La Niña years.

More extreme events to come

A few perfect storms that create sudden, catastrophic events such as the flood of the century or more slowly developing conditions such as an extreme drought will undoubtedly occur each year regardless of climate change. The expectation, however, is that a warming world will cause more of some of these events, particularly the ones tied to temperature, according to the IPCC.

The changing frequency and duration of extreme events may be the largest consequence of climate change. As a result, more emphasis is being placed on spotting and diagnosing these events. Most of the research has characterized extreme events using peak values or values greater than a threshold, such as the highest daily precipitation total and number of days above 100 degrees F.

In recent years, however, more sophisticated statistical theories have crept into analyses that have facilitated the better use of existing observations. Also, these extreme values may or may not be relevant to society, and more effort is being placed on analyzing those most useful for assessing and projecting impacts.

The upshot of this attention is that as extreme events continue to destroy lives and property, more information on past, present, and future extremes will surface, helping better prepare and forecast these events.

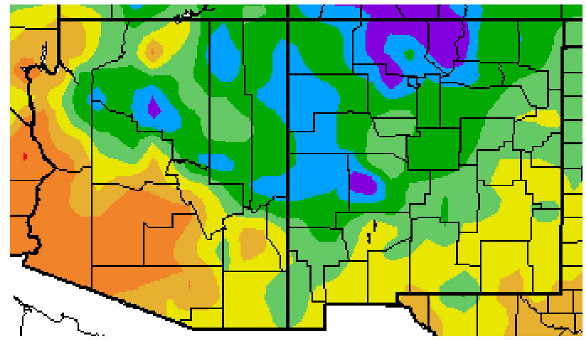
Temperature (through 9/14/11)

Data Source: High Plains Regional Climate Center

Temperatures since the water year began on October 1 are averaging between 65 and 75 degrees Fahrenheit in the southwest deserts and along the Arizona-California border, 60 to 65 degrees F in southeastern Arizona and in southern New Mexico, and 45 to 60 degrees F in central and northwestern New Mexico and Arizona (*Figure 1a*). The highest elevations have experienced average temperatures, between 40 and 45 degrees F, that are within 1 degree F of average across the northern half of Arizona and northwestern New Mexico (*Figure 1b*). Southern Arizona and central New Mexico generally have been 1–2 degrees F warmer than average, while eastern New Mexico has been 2–4 degrees F warmer than average.

In the last month, the persistent high pressure ridge over Texas that was present in July and August has lingered into September, bringing record-high temperatures to Texas, New Mexico, and Arizona. Temperatures during the past 30 days have been 2–4 degrees F warmer than average across most of the Colorado Plateau of Arizona and northern New Mexico; temperatures in southern and western Arizona and southern and eastern New Mexico have been 4–6 degrees F warmer than average (*Figures 1c–d*). High temperatures in the region are in part caused by the position of the high pressure ridge, which has been parked farther east than normal, suppressing monsoon precipitation in many parts of the Southwest.

Figure 1a. Water year '10–'11 (October 1 through September 14) average temperature.



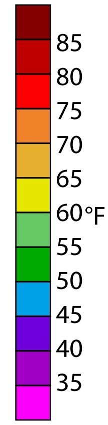
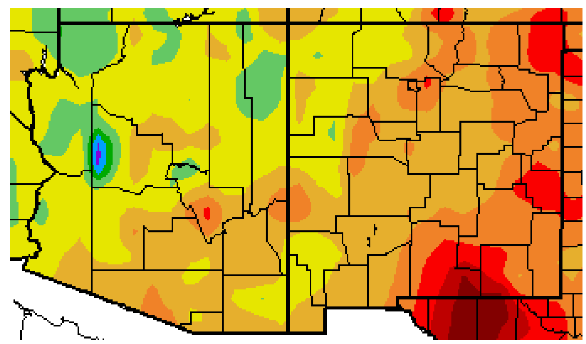


Figure 1b. Water year '10–'11 (October 1 through September 14) departure from average temperature.



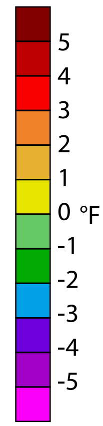
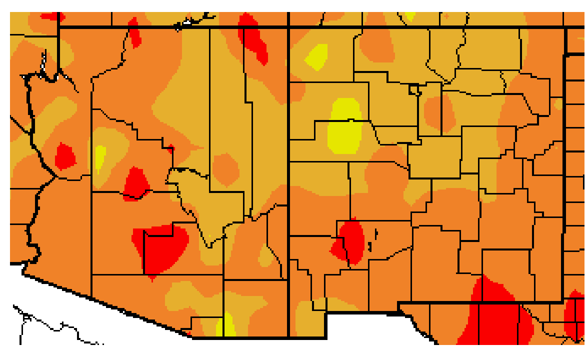


Figure 1c. Previous 30 days (August 16–September 14) departure from average temperature (interpolated).



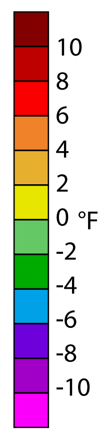
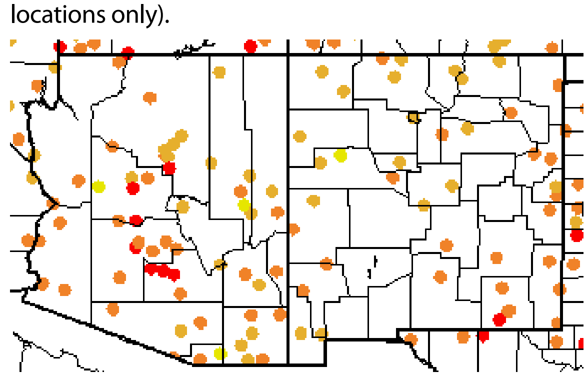
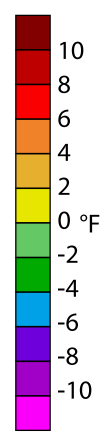


Figure 1d. Previous 30 days (August 16–September 14) departure from average temperature (data collection locations only).





Notes:

The water year begins on October 1 and ends on September 30 of the following year. Water year is more commonly used in association with precipitation; water year temperature can be used to measure the temperatures associated with the hydrological activity during the water year.

Average refers to the arithmetic mean of annual data from 1971–2000. Departure from average temperature is calculated by subtracting current data from the average. The result can be positive or negative.

The continuous color maps (Figures 1a, 1b, 1c) are derived by taking measurements at individual meteorological stations and mathematically interpolating (estimating) values between known data points. The dots in Figure 1d show data values for individual stations. Interpolation procedures can cause aberrant values in data-sparse regions.

These are experimental products from the High Plains Regional Climate Center.

On the Web:

For these and other temperature maps, visit
http://www.hprcc.unl.edu/maps/current/

For information on temperature and precipitation trends, visit
http://www.cpc.ncep.noaa.gov/trndtext.shtml

Precipitation (through 9/14/11)

Data Source: High Plains Regional Climate Center

Precipitation since the water year began on October 1 ranges from more than 130 percent of average in the northwest corner of Arizona to less than 25 percent of average in the southeastern corner of New Mexico (*Figures 1a–b*). Most of Arizona and northwestern New Mexico have received 25–90 percent of average precipitation. The southeastern half of New Mexico, however, has received less than 50 percent, with the driest conditions occurring in the southeastern corner. The dry conditions began in the winter during the moderate to strong La Niña event that helped push storms to the north. For most of the Southwest, monsoon precipitation has been below average. The exceptions have been in southeastern Arizona and the Four Corners region where rainfall since June 15 has been above average (see page 12).

In the past 30 days many regions in New Mexico and Arizona have received more than 130 percent of average precipitation, though large dry areas stretch across the Southwest (*Figures 2c–d*). The copious precipitation came during a wet week, when a low pressure system helped create favorable conditions for widespread and heavy monsoon precipitation. The recent rainfall in southeastern Arizona and southwestern New Mexico has brought some relief from exceptional short-term drought in both states. However, as has been the story in the last year, the southeastern third of New Mexico generally has been dry, receiving between 5 and 50 percent of average precipitation.

Figure 2a. Water year '10–'11 (October 1 through September 14) percent of average precipitation (interpolated).

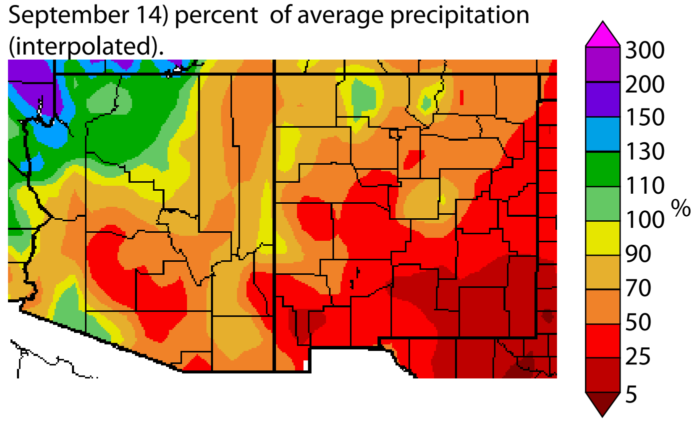


Figure 2b. Water year '10–'11 (October 1 through September 14) percent of average precipitation (data collection locations only).

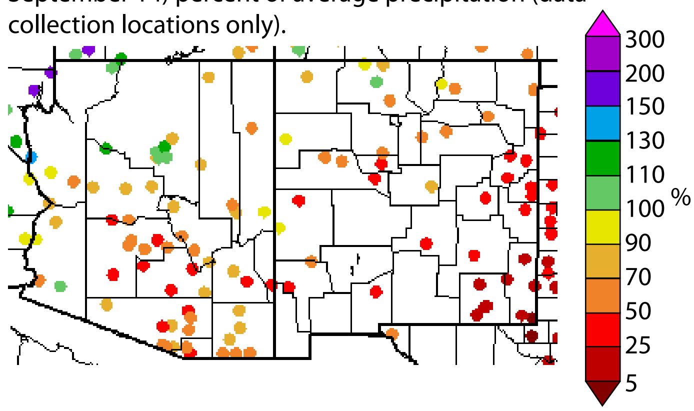


Figure 2c. Previous 30 days (August 16–September 14) percent of average precipitation (interpolated).

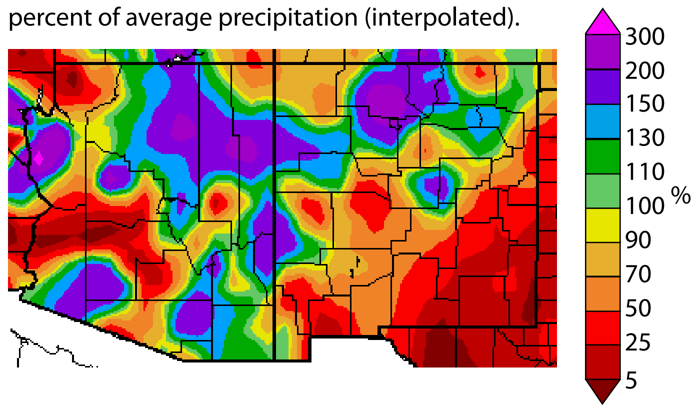
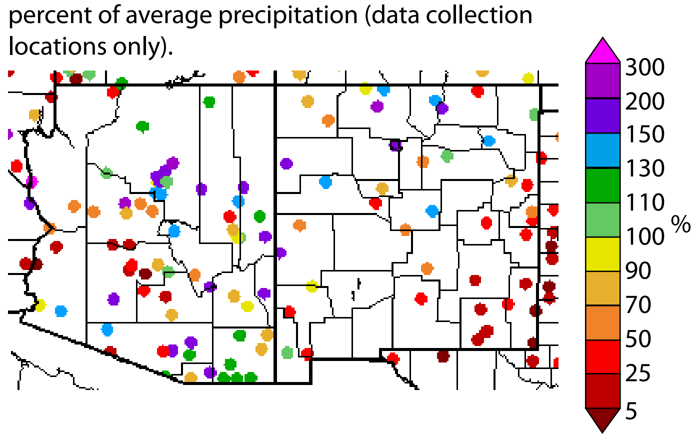


Figure 2d. Previous 30 days (August 16–September 14 percent of average precipitation (data collection locations only).



Notes:

The water year begins on October 1 and ends on September 30 of the following year. As of October 1, 2010, we are in the 2011 water year. The water year is a more hydrologically sound measure of climate and hydrological activity than is the standard calendar year.

Average refers to the arithmetic mean of annual data from 1971–2000. Percent of average precipitation is calculated by taking the ratio of current to average precipitation and multiplying by 100.

The continuous color maps (Figures 2a, 2c) are derived by taking measurements at individual meteorological stations and mathematically interpolating (estimating) values between known data points. Interpolation procedures can cause aberrant values in data-sparse regions.

The dots in Figures 2b and 2d show data values for individual meteorological stations.

On the Web:

For these and other precipitation maps, visit
http://www.hprcc.unl.edu/maps/current/

For National Climatic Data Center monthly precipitation and drought reports for Arizona, New Mexico, and the Southwest region, visit
http://lwf.ncdc.noaa.gov/oa/climate/research/2003/perspectives.html#monthly

U.S. Drought Monitor (data through 9/13/11)

Data Sources: U.S. Department of Agriculture, National Drought Mitigation Center, National Oceanic and Atmospheric Administration

Drought conditions in the U.S. remain largely confined to southern states and the Southwest (*Figure 3*). This national pattern reflects the dry conditions brought on by La Niña last winter.

In the last month, abnormally dry conditions expanded into southern Nevada and eastern Colorado due to a couple of hot and dry spells. Meanwhile, monsoon precipitation, albeit spotty, helped provide some short-term relief in parts of New Mexico and southern Colorado. The rest of the western U.S. remains drought-free, as it has since last January when record precipitation started to fall across areas from California to Montana. The NOAA-Climate Prediction Center has issued a La Niña Advisory, which means that La Niña conditions have developed and are expected to persist for the at least the next six months (see page 16).

NOAA will issue its official winter outlook in mid-October, but La Niña winters often mean drier-than-average conditions across the southern tier of the U.S. and wetter-than-normal conditions in the Pacific Northwest and Ohio Valley.

Notes:

The U.S. Drought Monitor is released weekly (every Thursday) and represents data collected through the previous Tuesday. The inset (lower left) shows the western United States from the previous month's map. The U.S. Drought Monitor maps are based on expert assessment of variables including (but not limited to) the Palmer Drought Severity Index, soil moisture, streamflow, precipitation, and measures of vegetation stress, as well as reports of drought impacts. It is a joint effort of several agencies; the author of this monitor is Mark Svoboda, Natoinal Drought Mitigatoin Center.

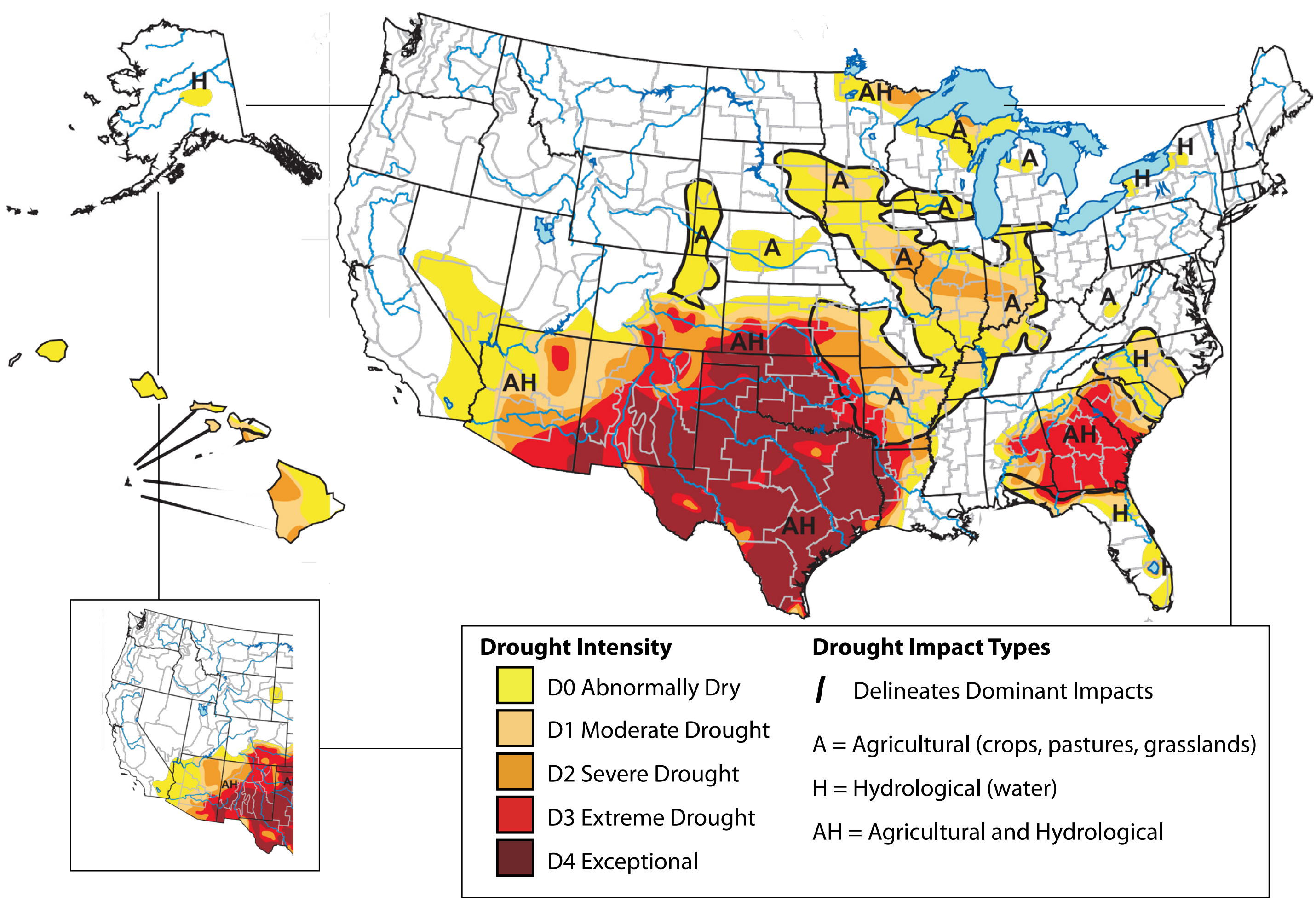


Figure 3. Drought Monitor data through September 13, 2011 (full size), and August 16, 2011 (inset, lower left).

On the Web:

The best way to monitor drought trends is to pay a weekly visit to the U.S. Drought Monitor website http://www.drought.gov/portal/server.pt/community/current_drought/208

Arizona Drought Status

(data through 9/13/11)

Data Source: U.S. Drought Monitor

Despite an active monsoon system during the second week in September, record-high temperatures in the past month and sporadic rain have led to the expansion and intensification of drought conditions across Arizona, according to the September 13 update of the U.S. Drought Monitor (*Figure 4a*). Currently the entire state is characterized by abnormally dry conditions or a more severe drought category. About 25 percent of the state is experiencing moderate and severe drought conditions, 17 percent is blanketed in extreme drought, and about 2 percent falls into the exceptional drought category (*Figure 4b*). Extreme and exceptional droughts are defined as droughts that occur, on average, once in every 20 and 50 years, respectively. In the last month, extreme drought expanded by about 8 percent, while exceptional drought decreased by less than a half percent. Since the monsoon began on June 15 drought in Arizona has expanded and intensified in all regions except the southeast corner, where monsoon storms have been most vigorous.

Some of the negative impacts associated with drought and reported on Arizona DroughtWatch (http://azdroughtwatch.org) include poor range conditions, unusually low flow in streams and springs, and increased wildfire danger.

Figure 4a. Arizona drought map based on data through September 13, 2011.

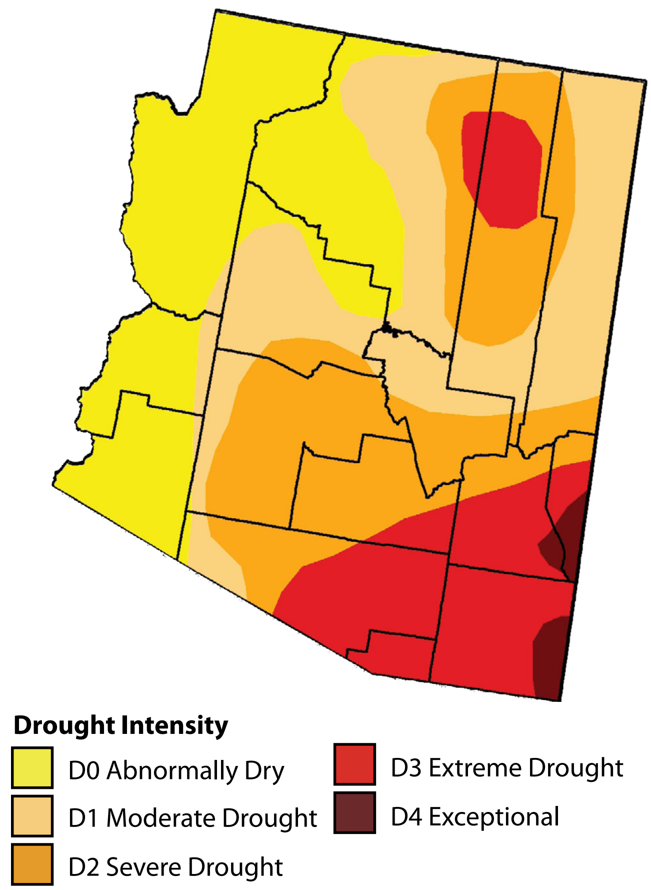


Figure 4b. Percent of Arizona designated with drought conditions based on data through September 13, 2011.

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.01	99.99	71.50	45.86	19.15	1.67
Last Week (09/06/2011 map)	0.01	99.99	70.40	39.34	19.15	1.67
3 Months Ago (06/14/2011 map)	22.51	77.49	56.26	28.69	18.27	5.62
Start of Calendar Year (12/28/2010 map)	31.40	68.60	32.45	0.00	0.00	0.00
Start of Water Year (09/28/2010 map)	40.00	60.00	18.58	3.23	0.00	0.00
One Year Ago (09/07/2010 map)	40.00	60.00	12.49	3.23	0.00	0.00

Notes:

The Arizona section of the U.S. Drought Monitor is released weekly (every Thursday) and represents data collected through the previous Tuesday. The maps are based on expert assessment of variables including (but not limited to) the Palmer Drought Severity Index, soil moisture, streamflow, precipitation, and measures of vegetation stress, as well as reports of drought impacts. It is a joint effort of several agencies.

On the Web:

For the most current drought status map, visit http://www.drought.unl.edu/dm/DM_state.htm?AZ,W

For monthly short-term and quarterly long-term Arizona drought status maps, visit http://www.azwater.gov/AzDWR/StatewidePlanning/Drought/DroughtStatus.htm

New Mexico Drought Status

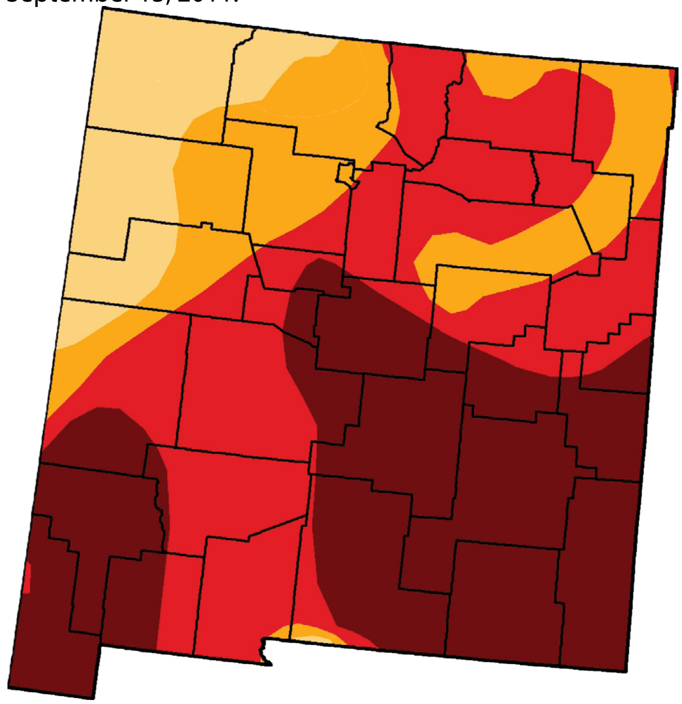
(data through 9/13/11)

Data Source: New Mexico State Drought Monitoring Committee, U.S. Drought Monitor

Above-average monsoon precipitation was observed across many parts of western and northern New Mexico in the past 30 days, bringing some drought relief to these regions. However, exceptional drought conditions—defined as droughts that occur, on average, once in every 50 years—continue to cover large swaths of the state (*Figure 5a*). More than 70 percent of the state continues to experience extreme to exceptional drought conditions with little relief provided by a relatively poor monsoon to date (*Figure 5b*). Since the summer rainy season began, drought conditions have virtually remained the same.

La Niña has returned, which doesn't bode well for improving drought conditions. Precipitation forecasts issued by NOAA-Climate Prediction Center indicate increased chances for below-average rain and snow across all of New Mexico through the winter. These forecasts are based in part on the historical precipitation patterns during La Niña events.

Figure 5a. New Mexico drought map based on data through September 13, 2011.



Drought Intensity

- D0 Abnormally Dry
- D1 Moderate Drought
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional

Figure 5b. Percent of New Mexico designated with drought conditions based on data through September 13, 2011.

	Drought Conditions (Percent Area)					
	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.00	100.00	100.00	89.33	72.20	38.22
Last Week (09/06/2011 map)	0.00	100.00	100.00	89.27	72.19	38.37
3 Months Ago (06/14/2011 map)	0.75	99.25	93.98	87.35	67.86	44.90
Start of Calendar Year (12/28/2010 map)	6.16	93.84	40.40	0.00	0.00	0.00
Start of Water Year (09/28/2010 map)	76.66	23.34	0.00	0.00	0.00	0.00
One Year Ago (09/07/2010 map)	79.95	20.05	0.00	0.00	0.00	0.00

Notes:

The New Mexico section of the U.S. Drought Monitor is released weekly (every Thursday) and represents data collected through the previous Tuesday. The maps are based on expert assessment of variables including (but not limited to) the Palmer Drought Severity Index, soil moisture, streamflow, precipitation, and measures of vegetation stress, as well as reports of drought impacts. It is a joint effort of several agencies.

This summary contains substantial contributions from the New Mexico Drought Working Group.

On the Web:

For the most current drought status map, visit http://www.drought.unl.edu/dm/DM_state.htm?NM,W

For the most current Drought Status Reports, visit http://www.nmdrought.state.nm.us/MonitoringWorkGroup/wk-monitoring.html

Arizona Reservoir Levels

(through 8/31/11)

Data Source: National Water and Climate Center

Combined storage is Lakes Mead and Powell decreased slightly in August by about 125,000 acre-feet; a decrease is typical for this time of year. As of August 31, combined storage in both lakes was at 61 percent of capacity (*Figure 6*), which is around 10 percent more than a year ago. Storage in other reservoirs within Arizona's borders decreased by more than 110,000 acre-feet in August, including more than 84,000 acre-feet in the Salt River Basin. San Carlos Reservoir in drought-stricken southeastern Arizona had less than a half percent of its capacity. In contrast, storage in Salt River Basin system reservoirs, which supply the Phoenix metropolitan area, was at 77 percent of capacity.

In water-related news, the proposed Blue Ridge pipeline project and other related projects that will bring water to Payson is stalled due to a delay in the environmental review process for the project (*Payson Roundup*, September 13). A proposed college campus in Payson matriculating 6,000 students is contingent on the pipeline project.

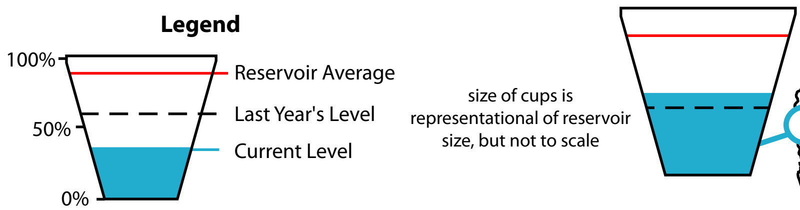
Notes:

The map gives a representation of current storage levels for reservoirs in Arizona. Reservoir locations are numbered within the blue circles on the map, corresponding to the reservoirs listed in the table. The cup next to each reservoir shows the current storage level (blue fill) as a percent of total capacity. Note that while the size of each cup varies with the size of the reservoir, these are representational and not to scale. Each cup also represents last year's storage level (dotted line) and the 1971–2000 reservoir average (red line).

The table details more exactly the current capacity level (listed as a percent of maximum storage). Current and maximum storage levels are given in thousands of acre-feet for each reservoir. One acre-foot is the volume of water sufficient to cover an acre of land to a depth of 1 foot (approximately 325,851 gallons). On average, 1 acre-foot of water is enough to meet the demands of 4 people for a year. The last column of the table list an increase or decrease in storage since last month. A line indicates no change.

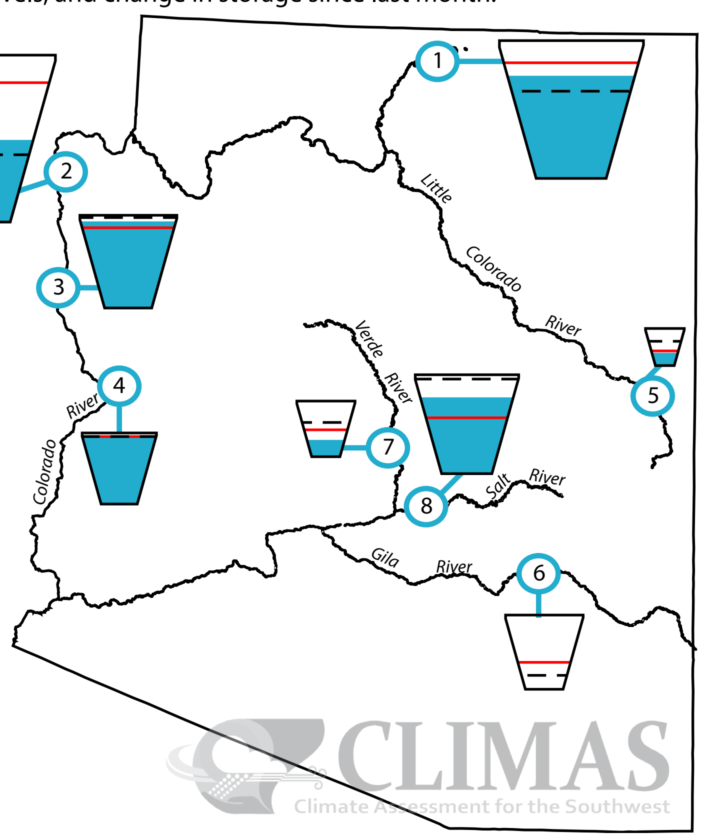
These data are based on reservoir reports updated monthly by the National Water and Climate Center of the U.S. Department of Agriculture's Natural Resource Conservation Service (NRCS). For additional information, contact Dino DeSimone, Dino.DeSimone@az.usda.gov.

Figure 6. Arizona reservoir levels for August as a percent of capacity. The map depicts the average level and last year's storage for each reservoir. The table also lists current and maximum storage levels, and change in storage since last month.



Reservoir Name	Capacity Level	Current Storage*	Max Storage*	Change in Storage*
1. Lake Powell	74%	17,890.0	24,322.0	-721.0
2. Lake Mead	49%	12,730.0	26,159.0	597.0
3. Lake Mohave	93%	1,681.8	1,810.0	-19.9
4. Lake Havasu	94%	582.5	619.0	-1.8
5. Lyman Reservoir	34%	10.1	30.0	-1.5
6. San Carlos	0%	3.6	875.0	-5.1
7. Verde River System	30%	87	287.4	-2.9
8. Salt River System	77%	1,563.3	2,025.8	-84.1

*** thousands of acre-feet**



CLIMAS
Climate Assessment for the Southwest

On the Web:

Portions of the information provided in this figure can be accessed at the NRCS website
http://www.wcc.nrcs.usda.gov/wsf/reservoir/resv_rpt.html

New Mexico Reservoir Levels

(through 8/31/11)

Data Source: National Water and Climate Center

The total reservoir storage in New Mexico declined by an estimated 110,000 acre-feet in August (*Figure 7*). This estimate does not include storage changes from Heron and El Vado reservoirs, which also decreased according to the Bureau of Reclamation. Storage in all but two of the state's reservoirs reported in Figure 7 fell during August. Of particular note is the very low storage in Elephant Butte Reservoir, which had about 200,000 acre-feet and stood at only about 9 percent of full capacity. Pecos River Reservoir (reservoirs 9-12) storage was also exceedingly low.

In water-related news, the Middle Rio Grande Conservancy District board of directors has decided to conserve the remaining irrigation water stored in El Vado Reservoir (dchieftain.com, September 3). This move is to ensure that the farmers have enough water for the 2012 irrigation season. Beginning September 15, only the natural flow of the Rio Grande will be available to irrigators.

Notes:

The map gives a representation of current storage levels for reservoirs in New Mexico. Reservoir locations are numbered within the blue circles on the map, corresponding to the reservoirs listed in the table. The cup next to each reservoir shows the current storage level (blue fill) as a percent of total capacity. Note that while the size of each cup varies with the size of the reservoir, these are representational and not to scale. Each cup also represents last year's storage level (dotted line) and the 1971–2000 reservoir average (red line).

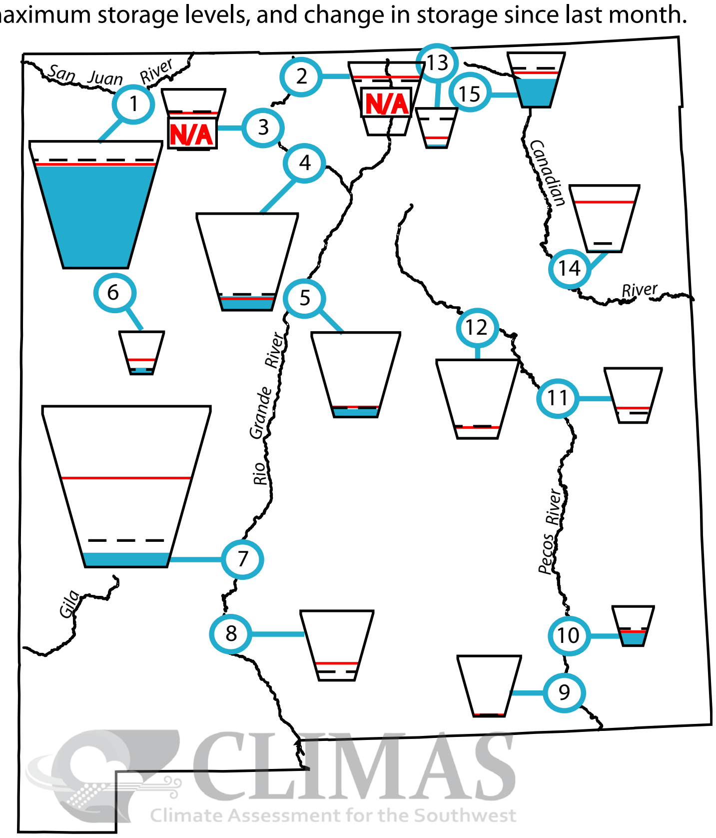
The table details more exactly the current capacity level (listed as a percent of maximum storage). Current and maximum storage levels are given in thousands of acre-feet for each reservoir. One acre-foot is the volume of water sufficient to cover an acre of land to a depth of 1 foot (approximately 325,851 gallons). On average, 1 acre-foot of water is enough to meet the demands of 4 people for a year. The last column of the table list an increase or decrease in storage since last month. A line indicates no change.

These data are based on reservoir reports updated monthly by the National Water and Climate Center of the U.S. Department of Agriculture's Natural Resource Conservation Service (NRCS). For additional information, contact Wayne Sleep, wayne.sleep@nm.usda.gov.

Figure 7. New Mexico reservoir levels for August as a percent of capacity. The map depicts the average level and last year's storage for each reservoir. The table also lists current and maximum storage levels, and change in storage since last month.

Legend

Reservoir Name	Capacity Level	Current Storage*	Max Storage*	Change in Storage*
1. Navajo	80%	1,462.2	1,356.0	-67.0
2. Heron	N/A**	296.2	N/A**	N/A**
3. El Vado	N/A**	154.7	N/A**	N/A**
4. Abiquiu	14%	151.0	163.5	14.8
5. Cochiti	10%	49.9	49.5	-0.6
6. Bluewater	14%	5.4	5.3	0.0
7. Elephant Butte	9%	283.1	200.8	-22.2
8. Caballo	2%	37.5	7.0	-25.2
9. Brantley	1%	9.5	7.2	-1.4
10. Lake Avalon	33%	1.3	1.3	0.2
11. Sumner	3%	7.1	2.7	-1.8
12. Santa Rosa	2%	20.4	8.5	-0.2
13. Costilla	8%	6.2	1.3	-1.5
14. Conchas	3%	12.6	7.7	-1.9
15. Eagle Nest	51%	45.1	40.2	-2.5



* thousands of acre-feet **NRCS has not reported reservoir storage

On the Web:

Portions of the information provided in this figure can be accessed at the NRCS website
http://www.wcc.nrcs.usda.gov/wsf/reservoir/resv_rpt.html

Monsoon Summary
(through 9/12/2011)

Data Source: Western Regional Climate Center

The monsoon season is ending like it began: with a bang. Between September 9 and 16, a low pressure system parked over the region and brought cool air high in the atmosphere. This created atmospheric instability that combined with ample moisture to generate widespread and intense monsoon storms—many parts of both states received more than 200 percent of average during this period. The recent storms helped southeast Arizona experience its wettest September on record. Despite this activity, however, total monsoon rainfall has been below average for most of the rest of Arizona and New Mexico (*Figures 8a–c*). This has been especially true for southeast New Mexico, where moisture incursions from the south were blocked by the persistence of a high pressure ridge centered over Oklahoma and Texas—too far east to continuously funnel moisture into the region. The position of the ridge is both a cause and consequence of the exceptionally dry conditions in Texas and southeast New Mexico. The lack of rain also contributed to soaring temperatures. Both Arizona and New Mexico posted their warmest August on record. Temperatures that month were about 6–10 degrees above average in southwest New Mexico and between 2 and 6 degrees F above average in Arizona.

Precipitation in the Southwest has not been sufficient to improve drought conditions. Since the monsoon began on June 15, drought in Arizona has expanded and intensified in all regions except the southeast corner, where storms have been most vigorous. In New Mexico, drought conditions have remained virtually the same since the monsoon began (see page 9).

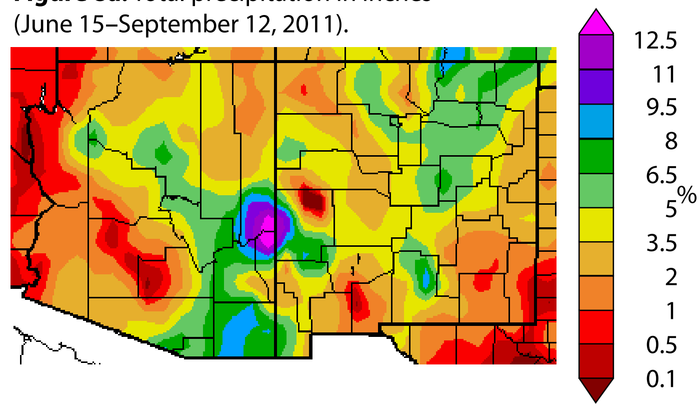


Figure 8a. Total precipitation in inches (June 15–September 12, 2011).

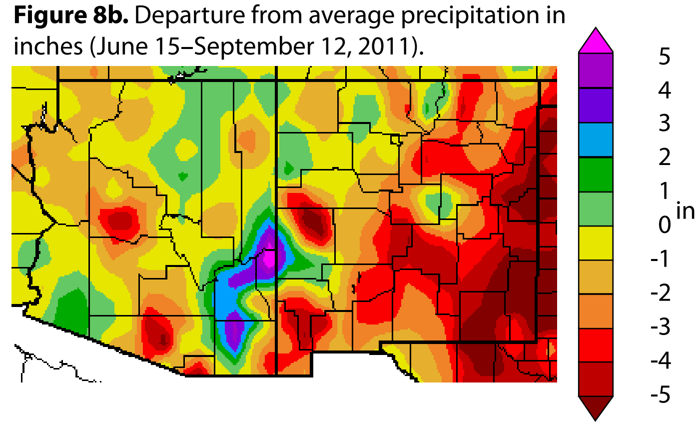


Figure 8b. Departure from average precipitation in inches (June 15–September 12, 2011).

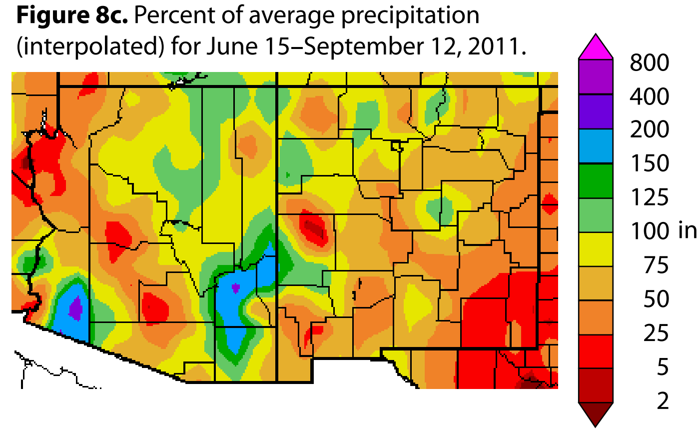


Figure 8c. Percent of average precipitation (interpolated) for June 15–September 12, 2011.

Notes:

The continuous color maps (figures above) are derived by taking measurements at individual meteorological stations and mathematically interpolating (estimating) values between known data points. Interpolation procedures can cause aberrant values in data-sparse regions.

Average refers to the arithmetic mean of annual data from 1971–2000. Percent of average precipitation is calculated by taking the ratio of current to average precipitation and multiplying by 100. Departure from average precipitation is calculated by subtracting the average from the current precipitation.

On the Web:

These data are obtained from the National Climatic Data Center:
http://www.hprcc.unl.edu/maps/current/

Temperature Outlook
(October 2011–March 2012)
Data Source: NOAA-Climate Prediction Center (CPC)

The seasonal temperature outlooks issued by the NOAA-Climate Prediction Center (CPC) in September call for increased chances for temperatures to be similar to those of the warmest 10 years of the 1981–2010 period through January. There is at least a 40 percent chance of above-average temperatures in eastern New Mexico and Arizona for the October–November period (*Figure 9a*). Forecasts for November–January also show greater than a 40 percent chance of warmer-than-average conditions in all of New Mexico, with slightly lower odds in Arizona (*Figure 9b*). Forecasts for the December–February and January–March periods show increased odds of warmer-than-average temperatures in New Mexico, but equal chances for above-, below-, or near-average conditions in Arizona (*Figures 9c–d*). Equal chances forecasts are given to those areas where the temperature is forecast to be similar to the 1981–2010 average.

Notes:

These outlooks predict the likelihood (chance) of above-average, average, and below-average temperature, but not the magnitude of such variation. The numbers on the maps do not refer to degrees of temperature.

The NOAA-CPC outlooks are a 3-category forecast. As a starting point, the 1981–2010 climate record is divided into 3 categories, each with a 33.3 percent chance of occurring (i.e., equal chances, EC). The forecast indicates the likelihood of one of the extremes—above-average (A) or below-average (B)—with a corresponding adjustment to the other extreme category; the "average" category is preserved at 33.3 likelihood, unless the forecast is very strong.

Thus, using the NOAA-CPC temperature outlook, areas with light brown shading display a 33.3–39.9 percent chance of above-average, a 33.3 percent chance of average, and a 26.7–33.3 percent chance of below-average temperature. A shade darker brown indicates a 40.0–50.0 percent chance of above-average, a 33.3 percent chance of average, and a 16.7–26.6 percent chance of below-average temperature, and so on.

Equal Chances (EC) indicates areas where no forecast skill has been demonstrated or there is no clear climate signal; areas labeled EC suggest an equal likelihood of above-average, average, and below-average conditions, as a "default option" when forecast skill is poor.

Figure 9a. Long-lead national temperature forecast for October-December 2011.

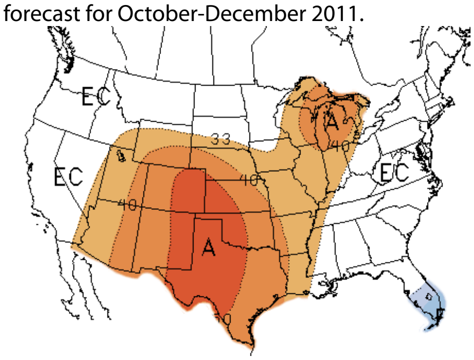
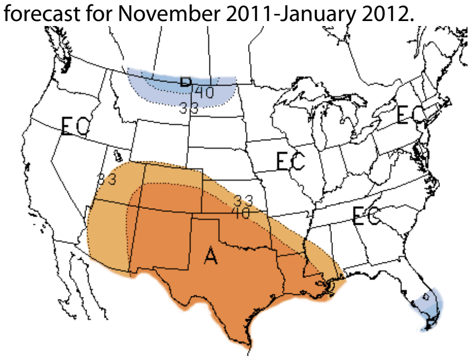


Figure 9b. Long-lead national temperature forecast for November 2011-January 2012.



A = Above
50.0–59.9%
40.0–49.9%
33.3–39.9%

B = Below
50.0–59.9%
40.0–49.9%
33.3–39.9%

EC = Equal chances. No forecasted anomalies.

Figure 9c. Long-lead national temperature forecast for December 2011-February 2012.

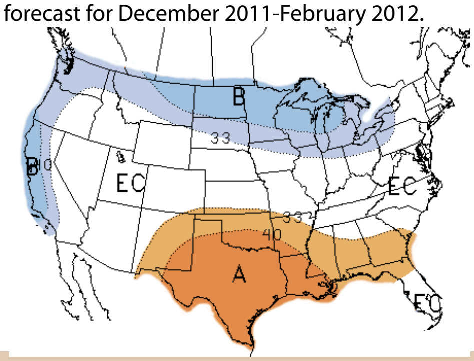
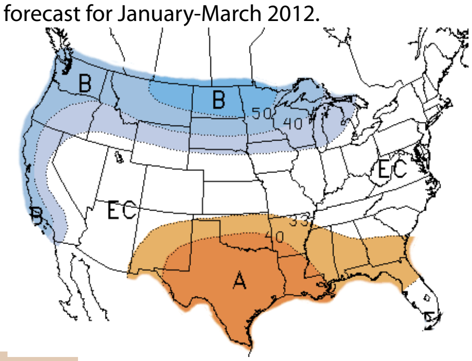


Figure 9d. Long-lead national temperature forecast for January-March 2012.



On the Web:

For more information on CPC forecasts, visit http://www.cpc.ncep.noaa.gov/products/predictions//multi_season/13_seasonal_outlooks/color/churchill.php

For seasonal temperature forecast downscaled to the local scale, visit http://www.weather.gov/climate/l3mto.php

For IRI forecasts, visit http://iri.columbia.edu/climate/forecast/net_asmt/

Precipitation Outlook
(October 2011–March 2012)

Data Source: NOAA-Climate Prediction Center (CPC)

The seasonal precipitation outlooks issued by the NOAA-Climate Prediction Center (CPC) in September call for increased chances that precipitation through the fall and winter will be similar to the driest 10 years of the 1981–2010 period (*Figures 10a–d*). In September the CPC issued a La Niña Advisory, which means that a La Niña event has developed and likely will persist for the next six months. Because La Niña events historically bring dry conditions to the Southwest, this tendency has heavily influenced the forecasts. The odds for drier-than-average conditions are highest for the January–March period (*Figure 10d*). There is uncertainty in the ultimate strength and longevity of the La Niña event. Forecasts issued by the International Research Institute for Climate and Society state a 52 percent chance that La Niña will continue through the November–January period, with a 48 percent chance that neutral conditions will emerge (see page 16).

Notes:

These outlooks predict the likelihood (chance) of above-average, average, and below-average precipitation, but not the magnitude of such variation. The numbers on the maps do not refer to inches of precipitation.

The NOAA-CPC outlooks are a 3-category forecast. As a starting point, the 1981–2010 climate record is divided into 3 categories, each with a 33.3 percent chance of occurring (i.e., equal chances, EC). The forecast indicates the likelihood of one of the extremes—above-average (A) or below-average (B)—with a corresponding adjustment to the other extreme category; the "average" category is preserved at 33.3 likelihood, unless the forecast is very strong.

Thus, using the NOAA-CPC precipitation outlook, areas with light green shading display a 33.3–39.9 percent chance of above-average, a 33.3 percent chance of average, and a 26.7–33.3 percent chance of below-average precipitation. A shade darker green indicates a 40.0–50.0 percent chance of above-average, a 33.3 percent chance of average, and a 16.7–26.6 percent chance of below-average precipitation, and so on.

Equal Chances (EC) indicates areas where no forecast skill has been demonstrated or there is no clear climate signal; areas labeled EC suggest an equal likelihood of above-average, average, and below-average conditions, as a "default option" when forecast skill is poor.

Figure 10a. Long-lead national precipitation forecast for October-December 2011.

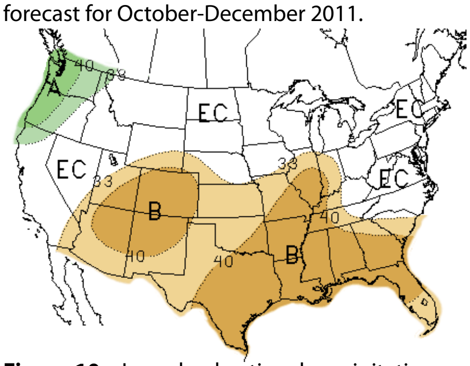


Figure 10b. Long-lead national precipitation forecast for November 2011-January 2012.

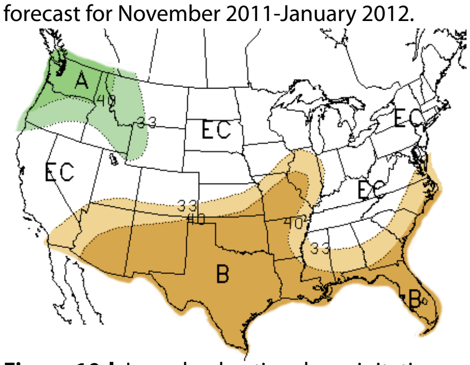


Figure 10c. Long-lead national precipitation forecast for December 2011-February 2012.

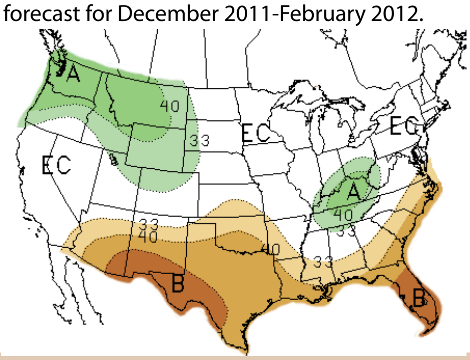
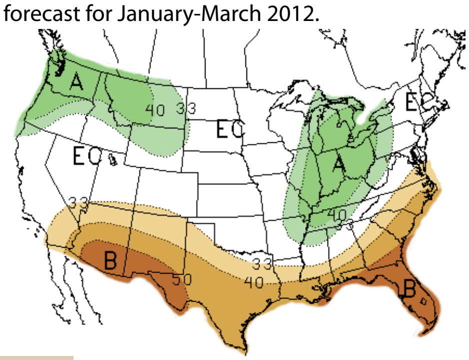


Figure 10d. Long-lead national precipitation forecast for January-March 2012.



A = Above
40.0–49.9%
33.3–39.9%

B = Below
60.0–69.9%
50.0–59.9%
40.0–49.9%
40.0–49.9%

EC = Equal chances. No forecasted anomalies.

On the Web:

For more information on CPC forecasts, visit
http://www.cpc.ncep.noaa.gov/products/predictions//multi_season/13_seasonal_outlooks/color/churchill.php
(note that this website has many graphics and March load slowly on your computer)

For IRI forecasts, visit http://iri.columbia.edu/climate/forecast/net_asmt/

Seasonal Drought Outlook

(through December)

Data Source: NOAA–Climate Prediction Center (CPC)

This summary is partially excerpted and edited from the September 15 Seasonal Drought Outlook technical discussion produced by the NOAA-Climate Prediction Center (CPC) and written by forecaster B. Pugh.

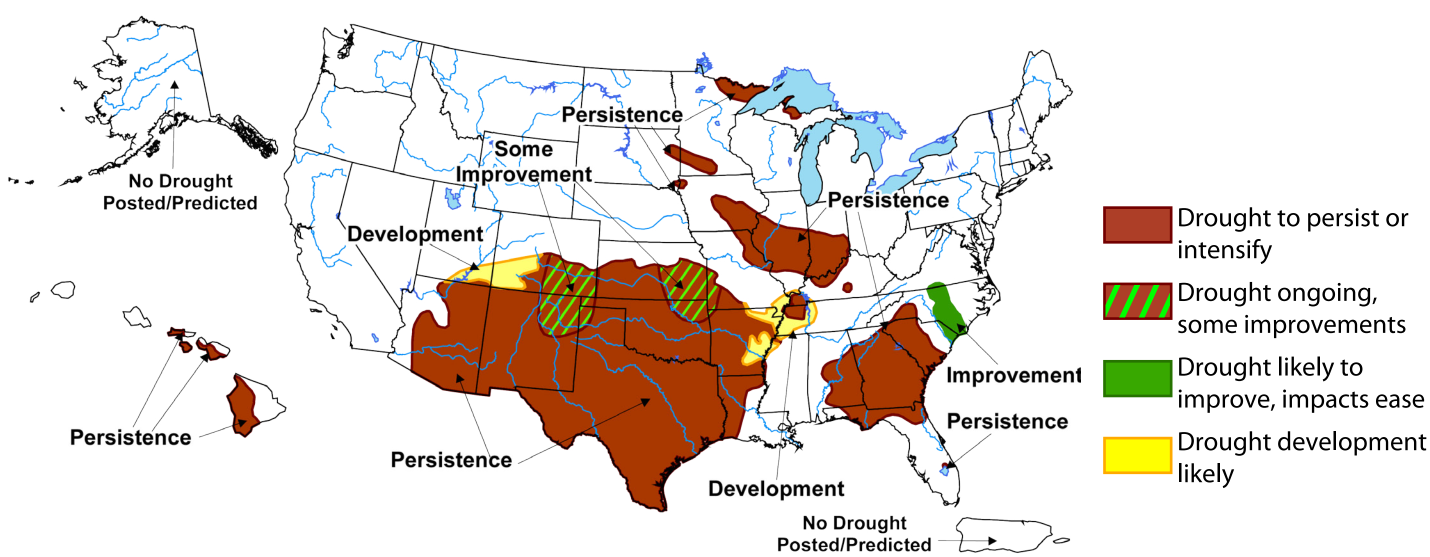
Monsoon rainfall provided some drought relief to eastern Arizona and western New Mexico in recent weeks. However, the monsoon is ending and the expectation that the newly developed La Niña event will persist for the next six months—which will likely deliver below-average rainfall to the Southwest—favors the persistence or development of drought across Arizona, southeast Utah, southwest Colorado, and much of New Mexico (*Figure 11*). Some improvement in drought conditions is forecast southeast Colorado and northeast New Mexico based on the expectation that storms will dump moderate to heavy rainfall in the next few weeks. The CPC has moderate confidence in this forecast. Elsewhere, a persistent ridge of high pressure sustained hot and dry conditions across the south-central U.S. for most of the summer, maintaining a large area of extreme to exceptional drought that developed during last winter. Texas had its driest summer on record, and both Texas and Oklahoma had the hottest summer on record. Little relief is expected for drought conditions in the two states as a result of the La Niña event.

Forecasts indicate enhanced odds for below-average precipitation and, therefore, drought is forecast to persist. However, tropical cyclone activity usually extends through the end of November and these storms can bring large amounts of rain.

Notes:

The delineated areas in the Seasonal Drought Outlook are defined subjectively and are based on expert assessment of numerous indicators, including the official precipitation outlooks, various medium- and short-range forecasts , models such as the 6-10 day and 8-14 day forecasts, soil moisture tools, and climatology.

Figure 11. Seasonal drought outlook through December (released September 15).



On the Web:

For more information, visit http://www.drought.gov/portal/server.pt

For medium- and short-range forecasts, visit http://www.cpc.ncep.noaa.gov/products/forecasts/

For soil moisture tools, visit http://www.cpc.ncep.noaa.gov/soilmst/forecasts.shtml

El Niño Status and Forecast

Data Sources: NOAA-Climate Prediction Center (CPC), International Research Institute for Climate and Society (IRI)

It's official. La Niña is back after a brief, four-month hiatus. A La Niña Advisory recently was issued by the NOAA-Climate Prediction Center (CPC), signaling La Niña conditions have developed and are expected to persist for at least the next six months.

Sea surface temperatures continued to decline across the eastern equatorial Pacific Ocean during the past month, crossing the -0.5 degree Celsius threshold for a La Niña event. Weak atmospheric circulation patterns that began during last winter's La Niña event have continued all summer and have helped drive the redevelopment of the current La Niña. Southern Oscillation Index (SOI) values remain low but are expected to strengthen in the coming months (*Figure 12a*).

Official forecasts issued by the International Research Institute for Climate and Society (IRI) put the chance of La Niña conditions persisting through the upcoming winter season at greater than 50 percent (*Figure 12b*). There is a 48 percent chance of ENSO-neutral conditions returning and only a remote chance of an El Niño event forming through the November–January period.

Notes:

The first figure shows the standardized three month running average values of the Southern Oscillation Index (SOI) from January 1980 through August 2011. The SOI measures the atmospheric response to SST changes across the Pacific Ocean basin. The SOI is strongly associated with climate effects in the Southwest. Values greater than 0.5 represent La Niña conditions, which are frequently associated with dry winters and sometimes with wet summers. Values less than -0.5 represent El Niño conditions, which are often associated with wet winters.

The second figure shows the International Research Institute for Climate and Society (IRI) probabilistic El Niño-Southern Oscillation (ENSO) forecast for overlapping three month seasons. The forecast expresses the probabilities (chances) of the occurrence of three ocean conditions in the ENSO-sensitive Niño 3.4 region, as follows: El Niño, defined as the warmest 25 percent of Niño 3.4 sea-surface temperatures (SSTs) during the three month period in question; La Niña conditions, coolest 25 percent of Niño 3.4 SSTs; and neutral conditions where SSTs fall within the remaining 50 percent of observations. The IRI probabilistic ENSO forecast is a subjective assessment of current model forecasts of Niño 3.4 SSTs that are made monthly. The forecast takes into account the indications of the individual forecast models (including expert knowledge of model skill), an average of the models, and other factors.

On the Web:

For a technical discussion of current El Niño conditions, visit http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/

For more information about El Niño and to access graphics similar to the figures on this page, visit http://iri.columbia.edu/climate/ENSO/

While forecast models are uncertain about the strength of the current La Niña event, most agree a weak event will persist through the winter at the very least. It is interesting to note that the chance of ENSO-neutral conditions returning by the January–March period is 49 percent, and only 1 percent greater than the chance of La Niña conditions continuing during this period. This is an indication of how weak the La Niña conditions are at this point, and how much uncertainty there is in the ability of this event to carry through until the spring.

Weak La Niña conditions are expected to expand and intensify drought conditions across the southern tier of the U.S., including Arizona and New Mexico. Official seasonal precipitation forecasts issued by the CPC indicate increased chances for below-average precipitation in the Southwest until the spring.

Figure 12a. The standardized values of the Southern Oscillation Index from January 1980–August 2011. La Niña/El Niño occurs when values are greater than 0.5 (blue) or less than -0.5 (red) respectively. Values between these thresholds are relatively neutral (green).

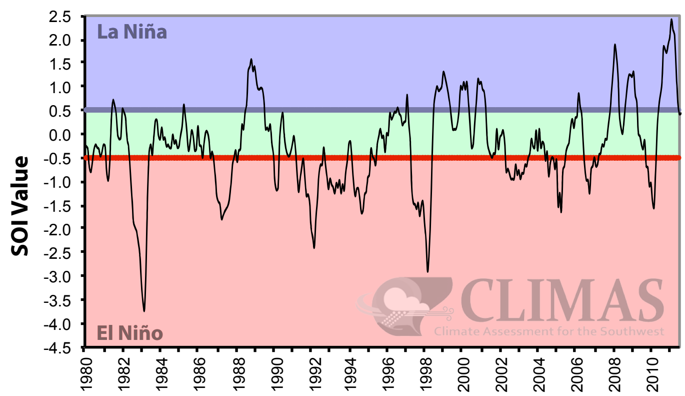


Figure 12b. IRI probabilistic ENSO forecast for El Niño 3.4 monitoring region (released September 15). Colored lines represent average historical probability of El Niño, La Niña, and neutral.