December 20, 2011

Southwest Climate Outlook

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Credit: Walter Freeman

Winter storms often blanket Arizona and New Mexico mountains with snow. In late November and early December, several storms dumped copious precipitation across the Southwest.

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

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Feature Article

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Atmospheric rivers (ARs) deliver torrential precipitation that causes punishing floods. Some ARs, such as the Pineapple Express, strike Arizona in the winter, and initial research suggests climate change will intensify these events, in addition to other alterations.

Recent Precipitation

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In the past 30 days, several moist and cold early winter storms delivered copious rain and snow, and many parts of the Southwest have experienced more than 150 percent of average precipitation.

El Niño Status and Forecast

pg 16

A weak La Niña event continues and forecasts suggest a high probability that either a weak or moderate event will persist through April.

December Climate Summary

Drought-Drought conditions in Arizona and New Mexico have improved slightly as a result of several early winter storms. Drought conditions remain widespread, however, due to significant precipitation deficits that have accumulated since the start of last winter.

Temperature-Temperatures have been colder than average in the last 30 days, but near average since the water year began on October 1.

Precipitation-Several winter storms tapped subtropical moisture and moved across Southern California and into Arizona and New Mexico in the past 30 days. As a result, many areas have received more than 150 percent of average rain and snow.

ENSO-Weak to moderate La Niña conditions persist in the tropical Pacific Ocean. Forecasts suggest the event will peak in January or February, with half of the models suggesting it will increase to moderate intensity.

Climate Forecasts-Seasonal precipitation outlooks call for drier-than-average conditions through April in New Mexico and Arizona, with southern regions drier than northern areas. Temperature outlooks call for increased odds of warmer-than-average conditions in New Mexico in the next three months.

The Bottom Line-A weak to moderate La Niña event remains entrenched in the tropical Pacific Ocean and continues to influence below-average precipitation outlooks for the winter. However, several wet and cold early winter storms moved through the region, dumping rain and snow in the Southwest that improved drought conditions in some areas. These storms tapped tropical moisture and chilly polar air, creating ripe conditions for snow to fall at mid-elevations. However, these storms missed the southeast corner of New Mexico, where precipitation in the last month has been below 75 percent of average. Exceptional and extreme drought continue to grip this region. The atmospheric circulation that ferried several early winter storms into the Southwest is somewhat abnormal for a La Niña, which often pushes storms north of the region this time of year. However, weak La Niña events tend to be wetter than moderate or strong events. 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.

Human actions play a role in extreme events

It's been called the year of billion dollar disasters. In 2011, extreme drought, heat waves, floods, and wildfires have contributed to a record 12 weather and climate catastrophes, each of which caused more than $1 billion in damages, according to the National Oceanic and Atmospheric Administration. While researchers caution against linking a single event to human-caused climate change, a recent international report states human actions collectively are indeed increasing the intensity and frequency of some extreme events.

On November 18 the Intergovernmental Panel on Climate Change (IPCC) released its *Summary for Policymakers*, a condensed version of a special report on climate extremes. Publication of the panel's full report, written by 220 climate experts from 62 countries, is expected in February 2012.

Through activities that increase heat-trapping gases in the atmosphere, the report states, human actions have contributed to raising the lowest and highest daily temperatures and have caused extreme precipitation to become more intense in some regions. Although the extent of damage caused by disasters has been mounting, the report attributes that trend to people increasingly putting themselves and their property in harm's way.

Read the summary report at: http://www.ipcc-wg2.gov/SREX/

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SWCO Staff:

Mike Crimmins,
UA Extension Specialist
Stephanie Doster,
Institute of the Environment Editor
Dan Ferguson,
CLIMAS Program Director
Gregg Garfin,
Institute of the Environment Deputy Director of Outreach
Zack Guido,
CLIMAS Associate Staff Scientist
Gigi Owen,
CLIMAS Assistant Staff Scientist
Nancy J. Selover,
Arizona State Climatologist

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Atmospheric Rivers: Harbors for Extreme Winter Precipitation

By Zack Guido

Fierce winds loaded with moisture blasted into the Southwest on December 18, 2010, dumping record-setting rain and snow from Southern California to southern Colorado. Fourteen inches of rain drenched St. George, Utah, over six days, while 6 inches soaked parts of northwest Arizona in a torrent that single-handedly postponed drought.

Behind this wet weather was a phenomenon called atmospheric rivers, a term first coined in 1998. ARs, as they are known to scientists, often deliver extreme precipitation, mostly to the West Coast, but sometimes inland as well, prompting researchers to probe how they form and the effects they have in a changing climate.

ARs have caused nearly all of the largest floods on record in California, accounting for most of the $400 million the state spends each year to repair flood damage. The high price tag, not to mention the lives they disrupt, makes assessing potential changes in AR intensity and frequency critical to informing long-term planning, including water infrastructure upgrades such as levees and culverts. Initial research suggests that global warming may boost AR intensity and slightly increase the number of times ARs occur.

The Nuts and Bolts of ARs

Atmospheric rivers are thin ribbons of strong winds near the Earth's surface that funnel moist air over long stretches of ocean. They are common in the Pacific, where research has been focused, but are global. At any given time, approximately three to five ARs are occurring in each hemisphere.

ARs are the movers and shakers in the global hydrologic cycle, transporting about 90 percent of the water vapor.

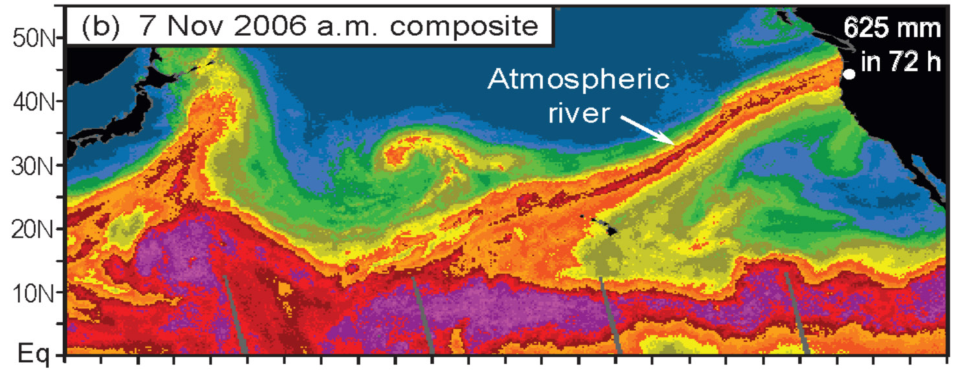


Figure 1. A satellite image of an atmospheric river striking the Pacific Northwest on November 7, 2006. This event produced about 25 inches of rain in three days. Warm colors in the image represent moist air and cool colors denote dry air. The horizontal band of red and purple at the bottom of the image is the Intertropical Convergence Zone (ITCZ), a normally moist area that some of the strongest ARs can tap into, as happened in this case. Photo credit: Marty Ralph.

They are products of an unevenly heated Earth and form during winter, when the temperature difference between the tropics and the poles is greatest.

In an attempt to equilibrate this temperature difference, the climate system forms extratropical cyclones that spin off the westerly jet stream. When they form in the North Pacific Ocean, their counterclockwise motion pulls warm, dank air from the low latitudes and hurls it north toward the U.S. West Coast.

"The biggest AR events happen when cyclones form that allow tapping tropical moisture," said Marty Ralph, chief of the Water Cycle Branch of the National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory.

Pineapple Express storms are a form of ARs that draw moisture from the tropics, although not all ARs follow this pattern.

ARs tend to strike the northern West Coast of the U.S. earlier in the winter and progress south. Alaska often is hit in early fall, with storms pounding the Pacific Northwest in early winter. January through March is the peak season for ARs that drench Southern California.

The most intense ARs can transport an amount of water vapor equal to the flow of 15 Mississippi Rivers measured at the river's mouth, according to NOAA. Most of the water vapor remains entrained in the air until it flows over land, where mountains force it upwards. The vapor cools as it rises and is wrung from the air like a sponge.

"The perfect storm for heavy rain is to have moisture-laden, low-level winds hit mountains," Ralph said.

The mountains along the West Coast often act as a protective shield for inland states like Arizona.

"If you look at the big picture, ARs often don't pass the coastal mountains," said Mike Dettinger, research hydrologist at the U.S. Geological Survey at the Scripps Institution of Oceanography in Southern California.

However, some do move over Arizona. In January 2010, for example, an AR

continued on page 4

Extreme Events, continued

delivered 5 inches of rain to parts of the Phoenix area—about 34 percent of the area's total annual precipitation. The storms that strike Arizona seem to have the right orientation to slip past mountain ranges that otherwise would sap the moisture from the air. ARs very rarely hit New Mexico.

Future ARs

Knowledge gained about ARs in the past decade has paved the way for scientists to investigate their fate in a warming world. Understanding how climate variability and human-caused change may alter ARs, as well as the record-breaking floods they spur, can help regions prepare for and adapt to potential changes.

"Flooding is likely to be an acute symptom of climate change in the future," Dettinger said. "People have built on floodplains, and I don't think we're well prepared for increased floods in the future."

Dettinger is leading the charge on trying to understand how global warming will alter ARs. He published one of the first climate change impacts studies focused on AR events in the June 2011 issue of *Journal of the American Water Resources Association*.

"Generally speaking, what makes AR events strong and dangerous is how much water vapor they transport and how fast it moves," he said.

To assess how the intensity and character of ARs will change in the future, Dettinger analyzed seven global climate models (GCMs) used in the Fourth Assessment Report by the Intergovernmental Panel on Climate Change (IPCC). The models were driven by a high greenhouse gas (GHG) emission scenario, known as the A2 trajectory. That scenario projects a roughly 7-degree Fahrenheit global temperature change by 2100, which is considered dangerously high by many scientists and policy experts. It is nonetheless plausible given current emissions, which presently outpace this scenario.

Results from Dettinger's study suggested counteracting changes: while modeled ARs will carry more water vapor, the winds will slacken, with the increases in moisture more significantly influencing the character of ARs.

"The upshot is that in all seven models increased water vapor wins out over decreasing winds, so overall the number of ARs increase by about 20 percent," Dettinger said. "Arguably more ominous is that although the average increase in number of events is moderate, there is a tendency to see an increase in the frequency of years with a lot of ARs and a decrease in the years with few events."

His analysis also found the most intense AR storms become stronger in a warmer world. The physical explanation for this is warmer air temperatures hold more moisture, and the models suggest the air within the ARs will warm by about 3.2 degrees F by the end of the 21st century. In addition to increasing the moisture content, warmer temperatures also elevate snowlines in the mountains. This subjects more area to rain instead of snow, and, all else being equal, causes larger floods.

The season in which ARs occur also lengthens in four of the seven models. This would likely force decision makers to alter some resource management strategies.

"Flood managers expect to see bigger storms, but a lot of how they manage water presupposes that big storms will be over by March, [which may not occur]," Dettinger said.

He cautions his results are a first crack at assessing future changes in ARs and their attendant impacts.

"I hope my analysis encourages others to dive into the issue and take a deeper look. I think I have the story right, but I'm absolutely convinced there's more work to be done before we have a lot of confidence [in future changes to ARs]," Dettinger said.

Analysis of more GHG emission scenarios, including lower emission scenarios, will help refine estimates, as will improvements in models. For Arizona, more on-the-ground research is needed to quantify how and where ARs have affected the region, and more related model queries are necessary to explore implications.

What we know is although ARs predominantly strike the West Coast, a few stream into the Southwest. And for those that squat over the region, like the two that struck Arizona in 2010, continued global warming might bring more megastorms and flooding.

Temperature (through 12/14/11)

Data Source: High Plains Regional Climate Center

Average temperatures since the water year began on October 1 generally have ranged from 30 to 50 degrees Fahrenheit on the Colorado Plateau and across the northern two-thirds of New Mexico (*Figure 1a*). Average temperatures have been 45–55 degrees F in southern New Mexico; 55–70 degrees F in southwestern Arizona, and 30–35 degrees F in the highest elevations in northern New Mexico. These temperatures have been within 2 degrees F of the 30 year average across most of Arizona (*Figure 1b*). Central and southern Arizona have been slightly cooler than average, while south-central Arizona and the northeastern corner have been warmer than average. The southeastern quarter of New Mexico has been 0–3 degrees F warmer than average, while the rest of the state has been 0–4 degrees F cooler than average.

The past 30 days have been 0–4 degrees F colder than average across most of both southwestern states. The only areas with warmer-than-average temperatures have been around the southern border of Arizona and New Mexico, northwestern Arizona, and the Four Corners region (*Figures 1c–d*). Parts of the high elevation areas in northern New Mexico and Pima County in southern Arizona have been 4–6 degrees F colder than average. The recent chilly temperatures are attributed to several unusually cold winter storms that tapped polar air as they wafted south along the West Coast. This is unusual for a La Niña circulation pattern, which tends to push storms north of the region. However, last winter also had numerous cold winter storms through December before conditions dried and warmed in January.

Notes:

The water year begins on October 1 and ends on September 30 of the following year. As of October 1, 2011, we are in the 2012 Water 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

Figure 1a. Water year 2011 (October 1 through December 14) average temperature.

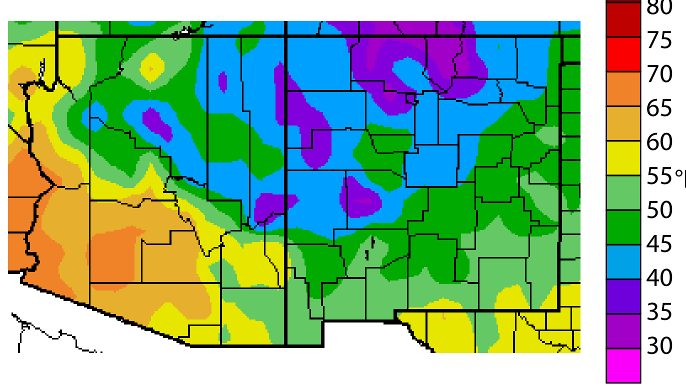


Figure 1b. Water year 2011 (October 1 through December 14) departure from average temperature.

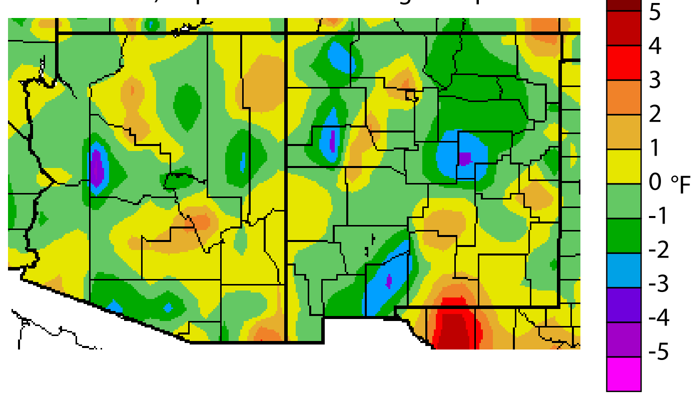


Figure 1c. Previous 30 days (November 15–December 14) departure from average temperature (interpolated)

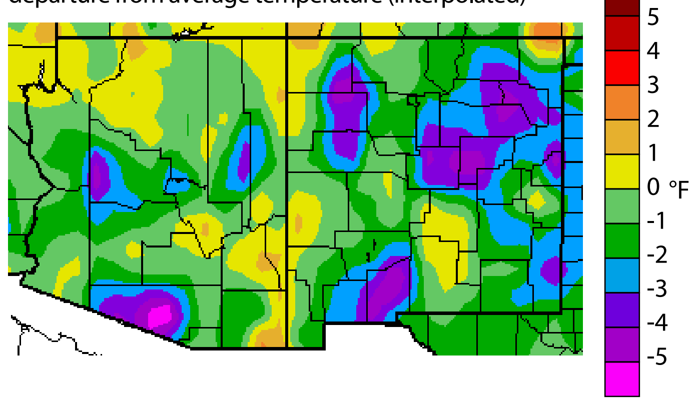
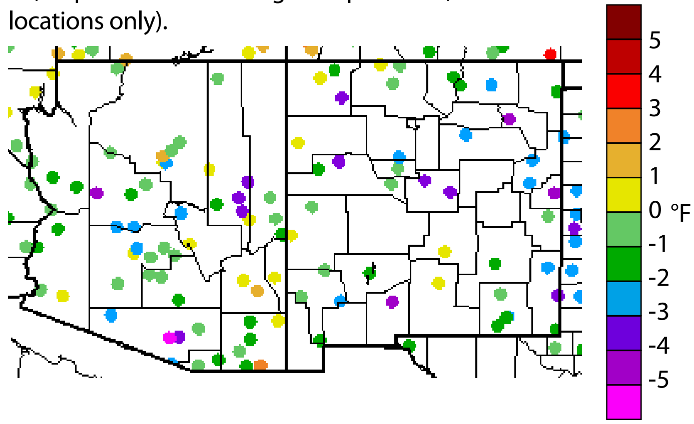


Figure 1d. Previous 30 days (November 15–December 14) departure from average temperature (data collection locations only).



Precipitation (through 12/14/11)

Data Source: High Plains Regional Climate Center

Precipitation in the Southwest since the water year began on October 1 generally has been above 70 percent of average, with many areas receiving copious rain and snow (*Figures 2a–b*). In northwestern New Mexico, for example, precipitation has been more than 300 percent of average. It has been more than 150 percent of average in parts of southwest New Mexico, the Sangre de Cristo Mountains of north-central New Mexico, and along the western border of Arizona. A small swath of slightly wetter-than-average conditions also is located in central Arizona, including parts of Pima, Pinal, Maricopa, Gila, Yavapai, and Coconino counties. The driest areas have been in southeastern New Mexico, where less than 70 percent of average precipitation has fallen since October 1.

In the past 30 days, several winter storms that tapped subtropical moisture moved across Southern California and into Arizona and New Mexico. They also entrained cold polar air that lowered snow lines, prompting Arizona's ski resorts to open. Many parts of Arizona and New Mexico experienced 150 percent of average precipitation during this period. Only the northwest corner of Arizona, the Colorado Plateau of northern Arizona, and northwestern New Mexico experienced drier-than-average precipitation, amounting to 5–75 percent of average (*Figures 2c–d*). An isolated spot in northeastern New Mexico received less than 50 percent of average precipitation. The circulation pattern that has brought these storms may soon break down and give way to high pressure, which will be accompanied by dry conditions. The expectation is that the winter will be drier than average.

Notes:

The water year begins on October 1 and ends on September 30 of the following year. As of October 1, 2011, we are in the 2012 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

Figure 2a. Water year 2011 (October 1 through December 14) percent of average precipitation (interpolated).

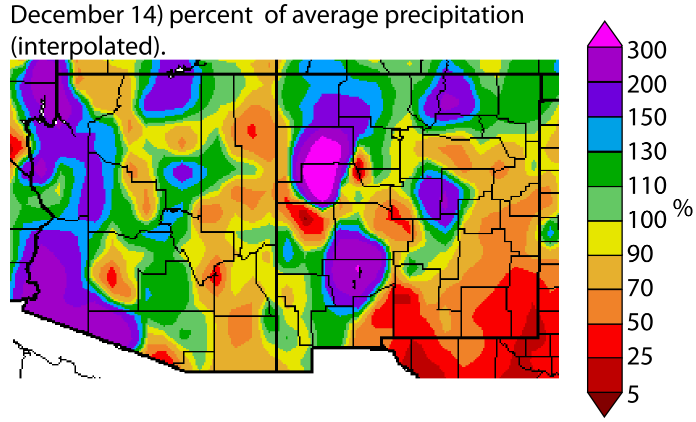


Figure 2b. Water year 2011 (October 1 through December 14) percent of average precipitation (data collection locations only).

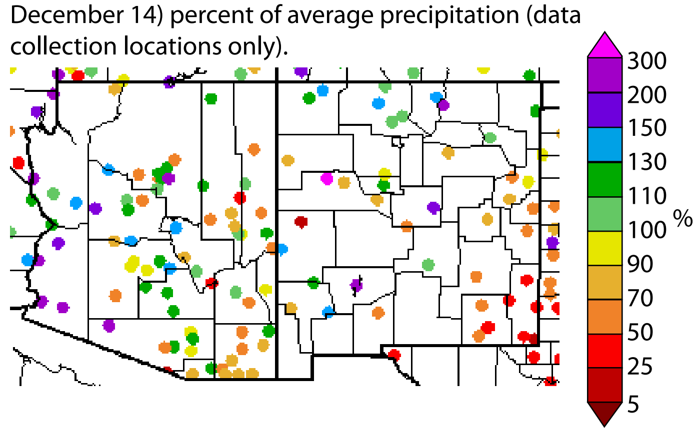


Figure 2c. Previous 30 days (November 15–December 14) percent of average precipitation (interpolated).

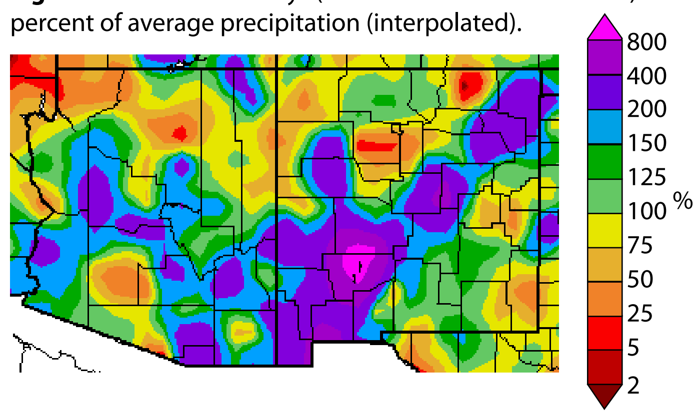
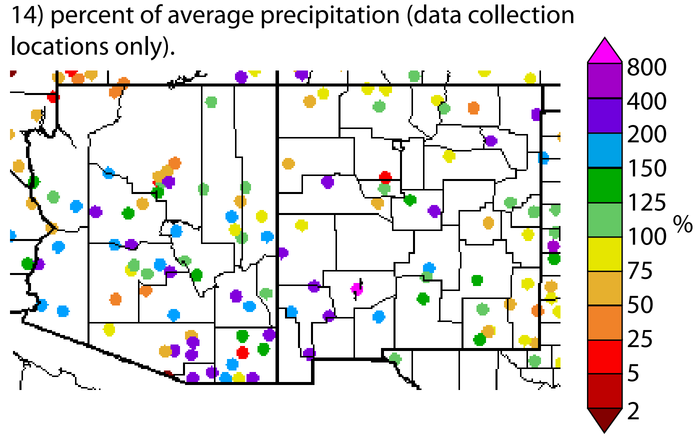


Figure 2d. Previous 30 days (November 15–December 14) percent of average precipitation (data collection locations only).



U.S. Drought Monitor (data through 12/13/11)

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

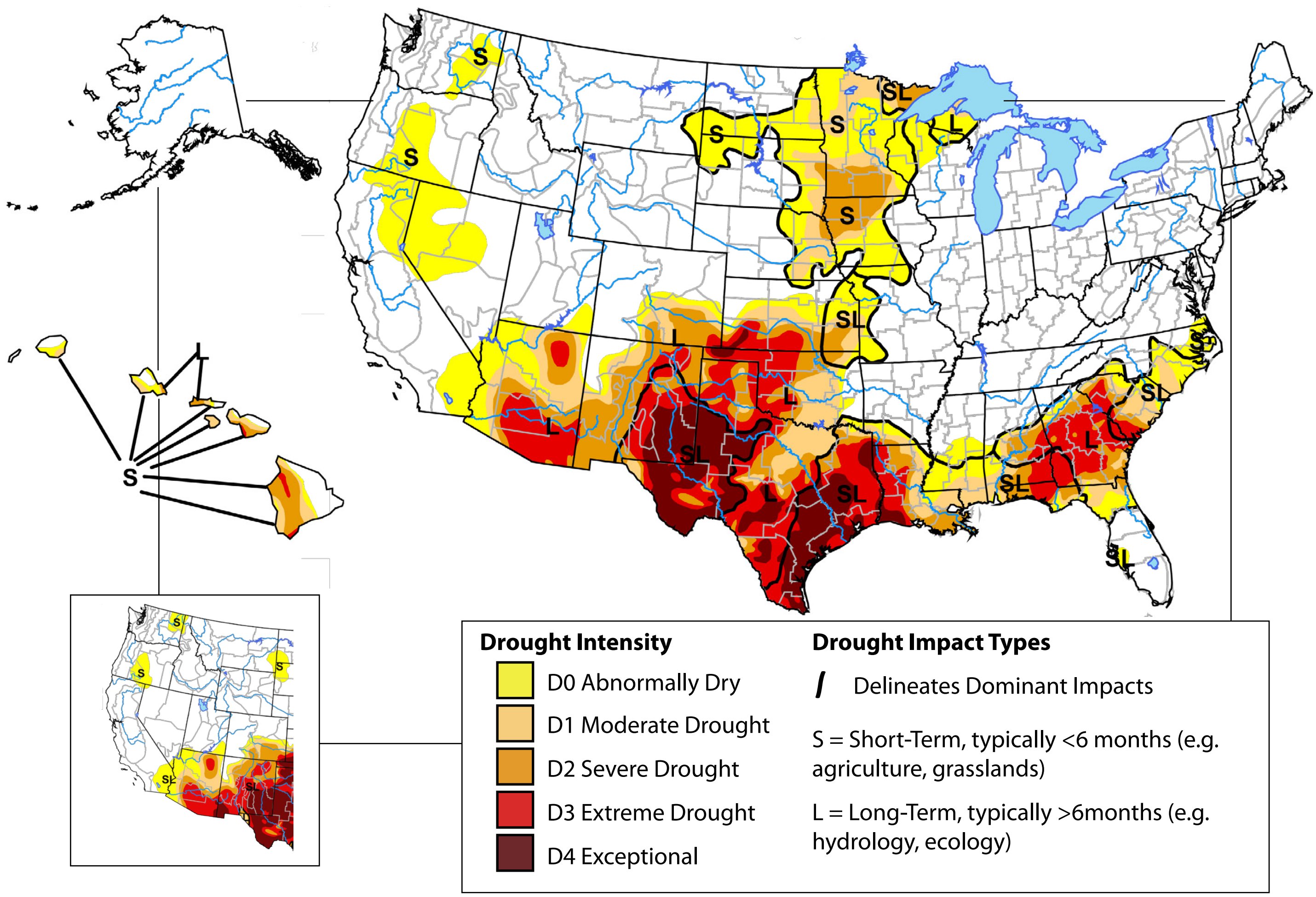
In the West, drought is confined to the Southwest U.S. due to the moderate to strong La Niña event that brought very dry conditions to the region during last winter(*Figure 3*). Drought is improving, however. The jet stream had a more southerly trajectory recently and ferried several early winter storms through Southern California and Arizona. This, consequently, has caused storms to be scant in the Pacific Northwest and northern California. Precipitation in northern California, Oregon, and eastern Washington in the past 30 days has been less than 25 percent of average, causing abnormally dry conditions in these regions. The northern Rockies also have been drier than average.

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 Mathew Rosencrams, NOAA/NWS/NCEP/CPC.

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.

Figure 3. Drought Monitor data through December 13, 2011 (full size), and November 15, 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 12/13/11)

Data Source: U.S. Drought Monitor

Wet and cool weather during the past 30 days has slightly improved drought conditions, according to the December 13 update of the U.S. Drought Monitor (*Figure 4a*). Exceptional drought, defined as a drought that occurs, on average, once in every 50 years, no longer grips southeast Arizona. Exceptional drought developed in this region in early June and covered up to 7 percent of Arizona.

Currently, 98 percent of Arizona is categorized with abnormally dry conditions or a more severe drought category, with about 49 percent classified as severe or extreme (*Figure 4b*). Several impressive early winter storms in late November and early December have helped improve short-term drought conditions, but longer-term precipitation deficits remain. Much of Arizona is still several inches behind average precipitation levels for the year. More winter rain and snow will be needed to make substantial drought improvements in many areas in Arizona. With the expectation that a weak to moderate La Niña will continue into next year, forecasts still suggest drier-than-average conditions (see page 14).

Figure 4a. Arizona drought map based on data through December 13.

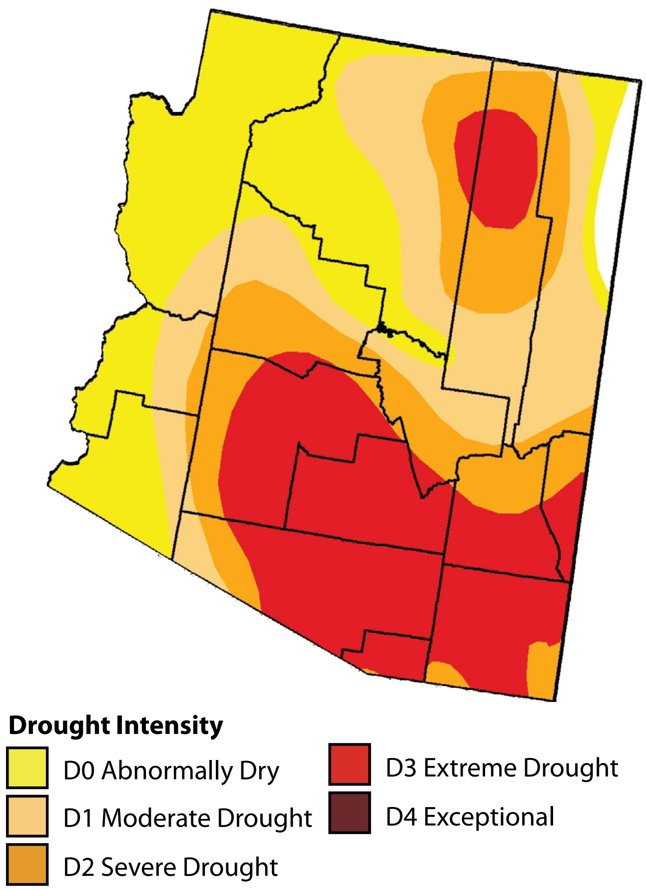


Figure 4b. Percent of Arizona designated with drought conditions based on data through December 13.

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	1.53	98.47	71.18	48.80	29.06	0.00
Last Week (12/06/2011 map)	1.53	98.47	71.18	48.80	29.99	0.38
3 Months Ago (09/13/2011 map)	0.01	99.99	71.50	45.86	19.15	1.67
Start of Calendar Year (12/28/2010 map)	31.40	68.60	32.45	0.00	0.00	0.00
Start of Water Year (09/27/2011 map)	0.02	99.98	69.76	42.81	15.34	1.67
One Year Ago (12/07/2010 map)	0.13	99.88	6.76	0.00	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 12/13/11)

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

Drought conditions have improved slightly from one month ago, particularly in southwest New Mexico. In this region, exceptional drought is no longer present, and extreme drought only covers a sliver on the Arizona-New Mexico boarder (*Figure 5a*). However, 91 percent of the state is still classified with abnormally dry conditions or a more severe drought category, according to the December 13 update of the U.S. Drought Monitor (*Figure 5b*).

Several early winter storms in late November and early December dropped several inches of precipitation on parts of Grant and Luna counties in far southwest New Mexico. These amounts are two to four times above average for this time of year and have helped improve drought conditions that had been classified as extreme since last winter. These storms, however, missed eastern parts of the state. In the last 30 days, less than a quarter-inch of precipitation, or less than 25 percent of average, has fallen in this region. With the expectation that a weak to moderate La Niña will continue into next year, drier-than-average conditions are still favored in most of New Mexico into the spring (see page 14).

Figure 5a. New Mexico drought map based on data through December 13.

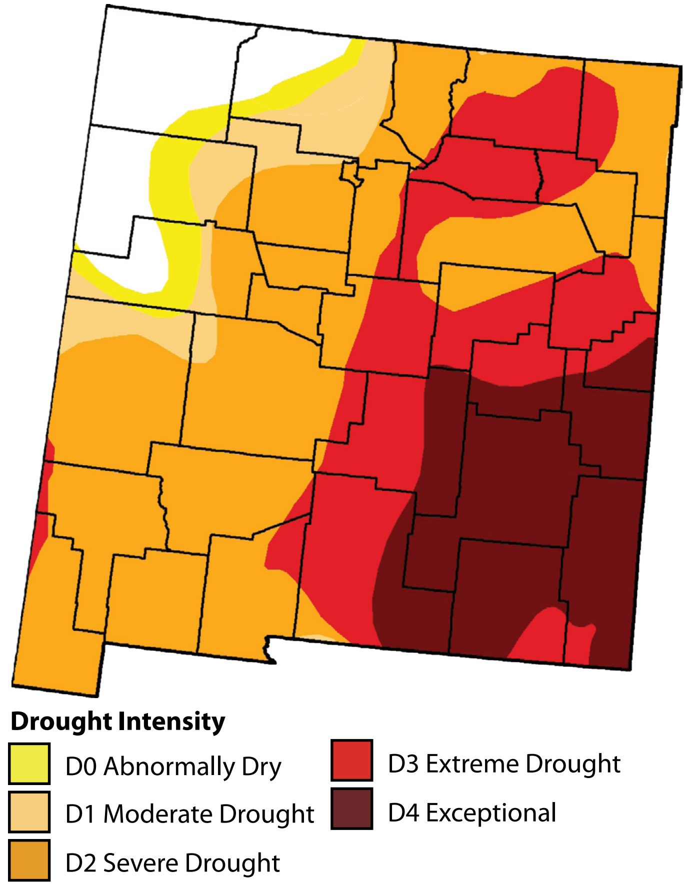


Figure 5b. Percent of New Mexico designated with drought conditions based on data through December 13.

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	8.63	91.37	87.83	81.59	39.47	17.93
Last Week (12/06/2011 map)	8.33	91.67	87.88	81.60	58.70	18.39
3 Months Ago (09/13/2011 map)	0.00	100.00	100.00	89.33	72.20	38.22
Start of Calendar Year (12/28/2010 map)	6.16	93.84	40.40	0.00	0.00	0.00
Start of Water Year (09/27/2011 map)	0.00	100.00	96.40	88.99	69.61	35.13
One Year Ago (12/07/2010 map)	41.12	58.88	8.07	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 11/31/11)

Data Source: National Water and Climate Center

Combined storage is Lakes Mead and Powell decreased slightly in November by about 100,000 acre-feet. As of November 30, combined storage in both lakes was at 61 percent of capacity (*Figure 6*), which is about 12 percent more than a year ago. While Lake Powell declined by about 566,000 acre-feet, Lake Mead increased by about 467,000 acre-feet. The discrepancy is because joint management of the two lakes under current conditions sends water from Lake Powell, which was at 69 percent of capacity, to Lake Mead, which was only 53 percent full. Storage in other reservoirs within Arizona's borders rose by about 47,000 acre-feet in November, driven primarily by increased volume in Lake Mohave. Reservoir storage in the Salt and Verde river basins decreased by 4.7 and 17.7 acre-feet and are at 70 and 28 percent of capacity, respectively. San Carlos Reservoir in drought-stricken southeastern Arizona is about 1 percent full.

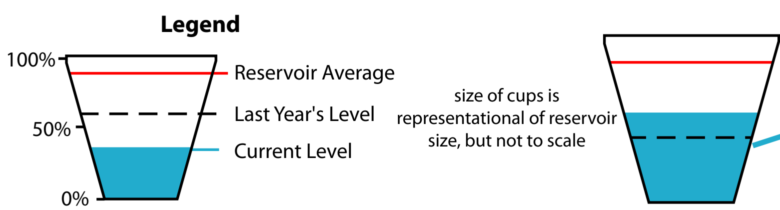
Notes:

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.

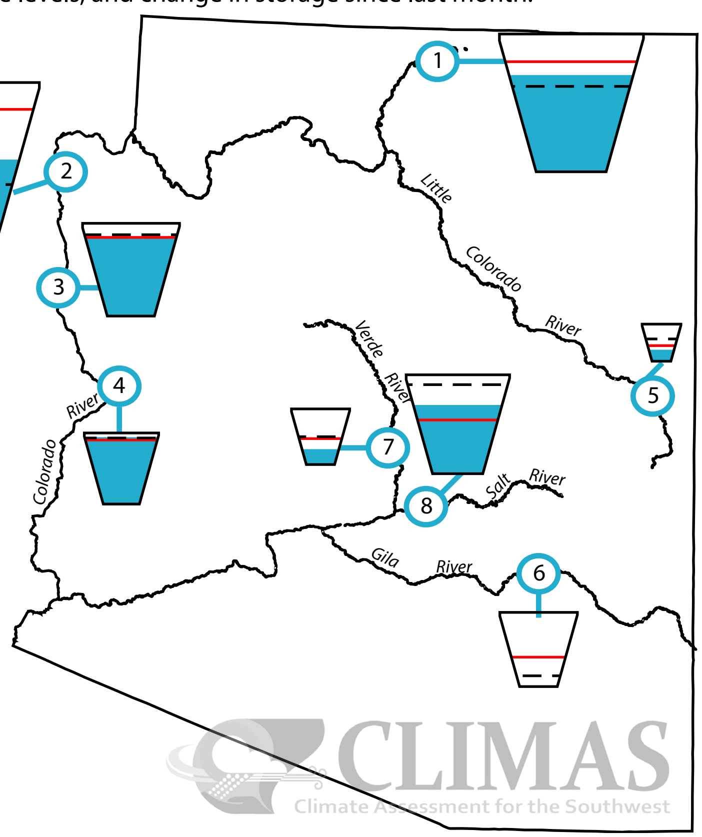
These data are based on reservoir reports updated monthly by the National Water and Climate Center of the U.S. Department of Agriculture's Natural Resource Conservation Service (NRCS). For additional information, contact Dino DeSimone, Dino.DeSimone@az.usda.gov.

Figure 6. Arizona reservoir levels for November 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	69%	16,683.0	24,322.0	-566.0
2. Lake Mead	53%	13,933.0	26,159.0	467.0
3. Lake Mohave	84%	1,511.4	1,810.0	76.2
4. Lake Havasu	92%	567.1	619.0	-12.3
5. Lyman Reservoir	31%	9.3	30.0	-0.3
6. San Carlos	1%	7.4	875.0	1.0
7. Verde River System	28%	81.8	287.4	-4.7
8. Salt River System	70%	1,411.7	2,025.8	-17.7

*** thousands of acre-feet**



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 11/31/11)

Data Source: National Water and Climate Center

The total reservoir storage in New Mexico increased by an estimated 48,000 acre-feet in November (*Figure 7*). This estimate does not include storage changes from Heron, El Vado, and Blue Water reservoirs. Storage in all of the state's reservoirs reported in Figure 7 except Conchas increased during November. The largest increase occurred in Elephant Butte Reservoir, which added 241,000 acre-feet. Despite this increase, Elephant Butte storage is only about 11 percent of full capacity. Reservoirs on the Pecos River also were exceedingly low, and three of the four reservoirs (reservoir 9, 11, and 12 on Figure 7)stood at less than 5 percent of capacity.

In water-related news, a new federal study projects that demand on the Colorado River Basin, which provides water to Albuquerque and Santa Fe, will outpace supply by about 13 percent by 2035 (*Journal North*, December 11). While New Mexico is not yet using its full share, the risk for the state is that others may seek the unused portion as supply-demand tension grows.

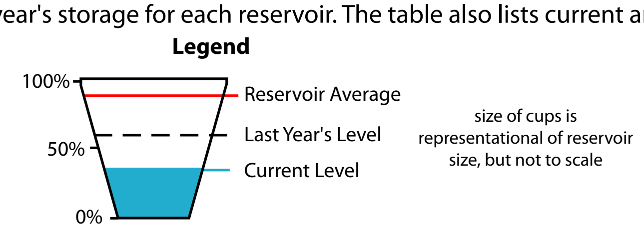
Notes:

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.

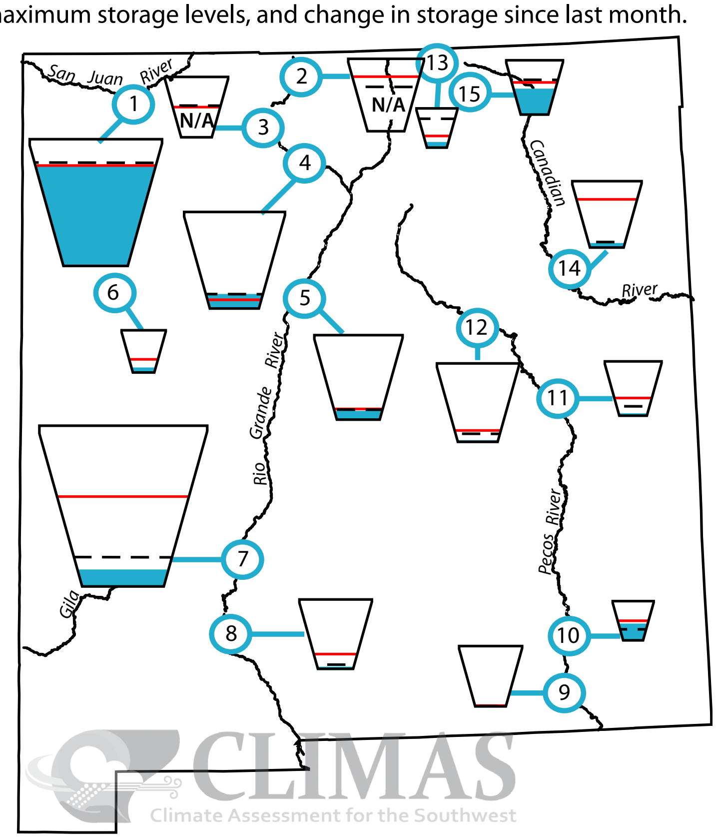
These data are based on reservoir reports updated monthly by the National Water and Climate Center of the U.S. Department of Agriculture's Natural Resource Conservation Service (NRCS). For additional information, contact Wayne Sleep, wayne.sleep@nm.usda.gov.

Figure 7. New Mexico reservoir levels for November 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. Navajo	78%	1,326.7	1,696.0	0.2
2. Heron	N/A**	N/A**	400.0	N/A**
3. El Vado	N/A**	N/A**	190.3	N/A**
4. Abiquiu	15%	181.8	1,192.8	1.2
5. Cochiti	10%	51.2	491.0	0.7
6. Bluewater	12%	4.6	38.5	N/A**
7. Elephant Butte	11%	241.0	2,195.0	241.0
8. Caballo	3%	11.6	332.0	1.5
9. Brantley	1%	8.3	1,008.2	1.5
10. Lake Avalon	43%	1.7	4.0	0.6
11. Sumner	4%	4.5	102.0	2.7
12. Santa Rosa	2%	9.9	438.3	0.0
13. Costilla	14%	2.2	16.0	0.4
14. Conchas	7%	16.8	254.2	-2.0
15. Eagle Nest	48%	38.2	79.0	0.0

*** 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

Southwest Snowpack

(updated 12/15/11)

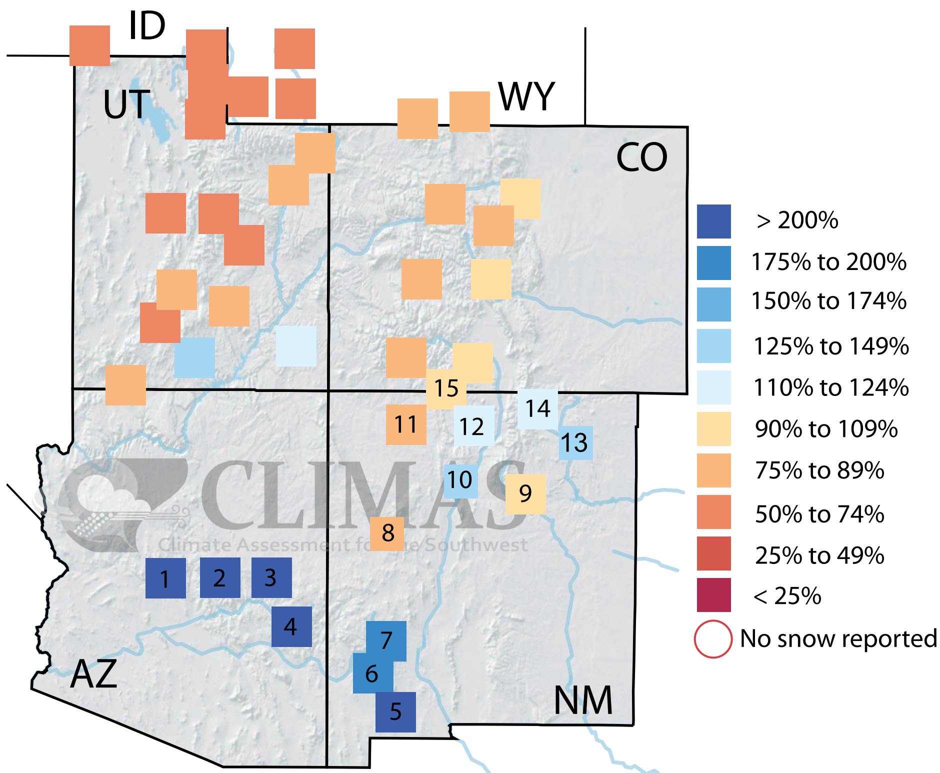
Data Sources: National Water and Climate Center, Western Regional Climate Center

Several wet and cold early winter storms have helped boost the amount of water contained in snowpack, or snow water equivalent (SWE), across the Southwest (*Figure 8*). SWE measured by snow telemetry (SNOTEL) stations in Arizona was all above 210 percent of average, with as much as 284 percent measured in the Central Mogollon Rim as of December 15. Snowpack in New Mexico has been slightly more variable, with southern mountains having more SWE than northern basins. SWE measured 331 percent of average in the Mimbres River Basin in southwest New Mexico and 88 percent in the Zuni-Bluewater River Basin in west-central New Mexico.

States to the north of Arizona and New Mexico, which supply most of the water to the Colorado River and Rio Grande, experienced a drier-than-average fall. The majority of SNOTEL stations in Colorado, Wyoming, and Utah measured less than 90 percent SWE as of December 15.

La Niña events usually deliver below-average rain and snow to the Southwest but do not as strongly influence precipitation totals in the Upper Colorado River Basin. Current forecasts issued by the NOAA-Climate Prediction Center (CPC) indicate a weak La Niña event will persist through the winter, increasing the odds of below-average rain and snow in Arizona, New Mexico, and southern Colorado. There are equal chances of above-, below-, or near-average precipitation for most of Utah, Wyoming, and parts of Colorado for the December–February and January–March periods (see page 14).

Figure 8. Average snow water equivalent (SWE) in percent of average for available monitoring sites as of December 15, 2011.



Arizona Basins
1 Verde River Basin
2 Central Mogollon Rim
3 Little Colorado - Southern Headwaters
4 Salt River Basin

New Mexico Basins
5 Mimbres River Basin
6 San Francisco River Basin
7 Gila River Basin
8 Zuni/Bluewater River Basin
9 Pecos River
10 Jemez River Basin
11 San Miguel, Dolores, Animas, and San Juan River Basins
12 Rio Chama River Basin
13 Cimarron River Basin
14 Sangre de Cristo Mountain Range Basin
15 San Juan River Headwaters

Notes:

Snowpack telemetry (SNOTEL) sites are automated stations that measure snowpack depth, temperature, precipitation, soil moisture content, and soil saturation. A parameter called snow water equivalent (SWE) is calculated from this information. SWE refers to the depth of water that would result by melting the snowpack at the SNOTEL site and is important in estimating runoff and streamflow. It depends mainly on the density of the snow. Given two snow samples of the same depth, heavy, wet snow will yield a greater SWE than light, powdery snow.

This figure shows the SWE for selected river basins, based on SNOTEL sites in or near the basins, compared to the 1971–2000 average values. The number of SNOTEL sites varies by basin. Basins with more than one site are represented as an average of the sites. Individual sites do not always report data due to lack of snow or instrument error. CLIMAS generates this figure using daily SWE measurements made by the Natural Resources Conservation Service.

On the Web:

For color maps of SNOTEL basin snow water content, visit:
http://www.wrcc.dri.edu/snotelanom/basinswe.html

For NRCS source data, visit:
http://www.wcc.nrcs.usda.gov/snow/

For a list of river basin snow water content and precipitation, visit:
http://www.wrcc.dri.edu/snotelanom/snotelbasin

Temperature Outlook

(January–June 2012)

Data Source: NOAA-Climate Prediction Center (CPC)

The seasonal temperature outlooks issued by the NOAA–Climate Prediction Center (CPC) in December call for equal chances for above-, below-, or near-average conditions in Arizona and increased chances for above-average temperatures in New Mexico for the January–March period (*Figure 9a*). During the February–April and March–May periods, eastern Arizona and all of New Mexico have increased odds for above-average temperatures (*Figures 9b–c*). The highest chances are in southern New Mexico, with odds as much as 50-60 percent. For the April–June period, all of Arizona and New Mexico have elevated chances for above-average temperatures (*Figure 9d*). La Niña conditions, which are expected to persist through early spring, and recent warming trends influence these forecasts.

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 January–March 2012.

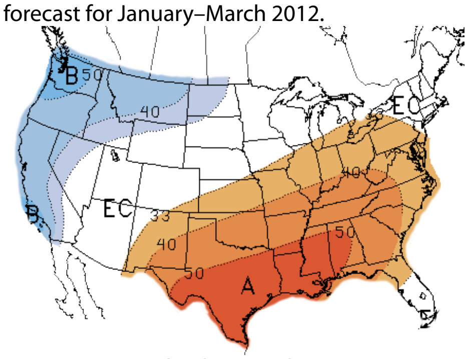
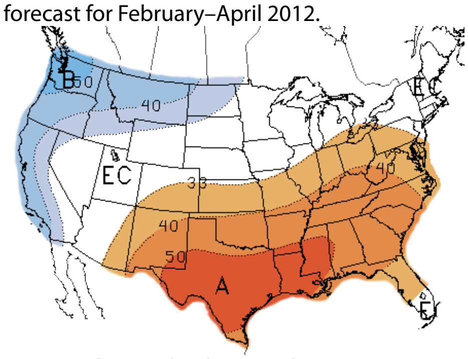


Figure 9b. Long-lead national temperature forecast for February–April 2012.



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

B=Below: 40.0–49.9%, 33.3–39.9%

EC= Equal chances. No forecasted anomalies.

Figure 9c. Long-lead national temperature forecast for March–May 2012.

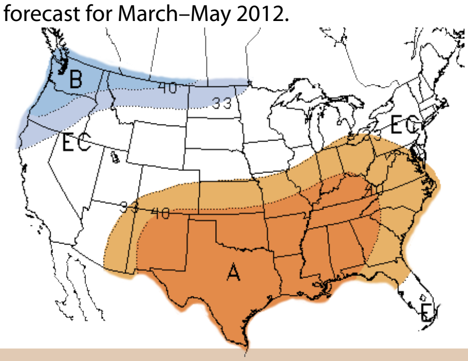
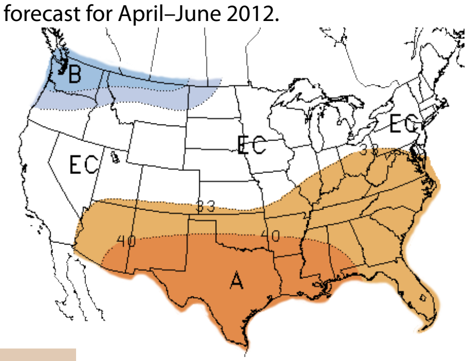


Figure 9d. Long-lead national temperature forecast for April–June 2012.



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

(January–June 2012)

Data Source: NOAA-Climate Prediction Center (CPC)

The seasonal precipitation outlooks issued by the NOAA-Climate Prediction Center (CPC) in December call for increased chances that precipitation will be similar to the driest 10 years of the 1981–2010 period for the January–March and February–April periods in all of Arizona and New Mexico (*Figures 10a–b*). A primary driver for these forecasts is La Niña event, which likely will persist into spring. La Niña events historically bring dry conditions to the southern tier of the U.S., including Arizona and New Mexico, and wetter-than-average conditions to the Pacific Northwest. The southern areas of both states have more than a 40 percent chance of seeing dry conditions, with some areas having more than a 50 percent chance. Outlooks for the March–May and April–June periods call for equal chances for above-, below-, or near-average conditions in most of Arizona and slightly increased odds for dry conditions in New Mexico (*Figures 10c–d*).

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 January-March 2011.

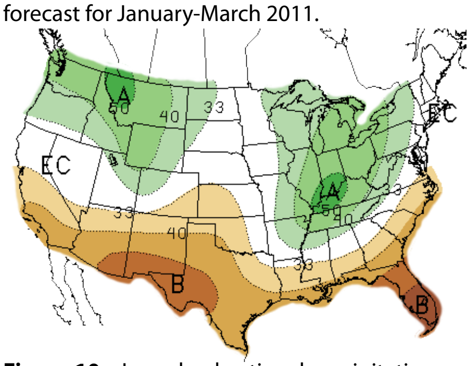


Figure 10b. Long-lead national precipitation forecast for February-April 2012.

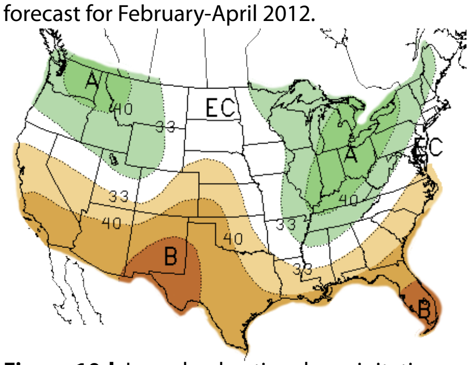


Figure 10c. Long-lead national precipitation forecast for March-May 2012.

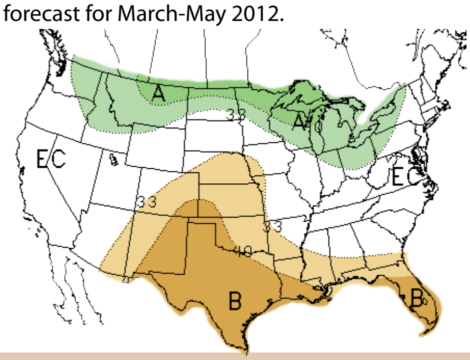
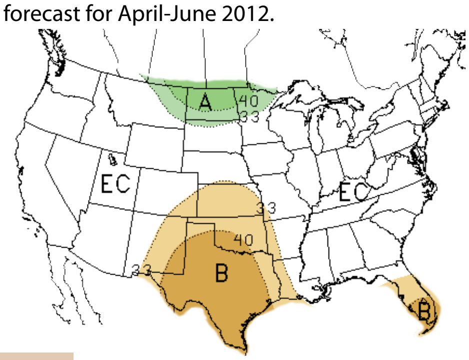


Figure 10d. Long-lead national precipitation forecast for April-June 2012.



A = Above: 40.0–49.9%, 33.3–39.9%

B = Below: 60.0–69.9%, 50.0–59.9%, 40.0–49.9%, 33.3–39.9%

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 December 13 Seasonal Drought Outlook technical discussion produced by the NOAA-Climate Prediction Center (CPC) and written by forecaster B. Pugh.

Since mid-November, a looping jet stream has carried moist air and cool temperatures into the Southwest, resulting in widespread snow across the higher elevations. As of December 15, the water contained in the snowpacks, or snow water equivalent (SWE), was more than 190 percent of average across the mountains of Arizona and north-central New Mexico. Despite the recent wet conditions, tools used to forecast precipitation favor below-median rain and snow on all time scales. La Niña heavily influences this outlook because the Southwest experiences below-average precipitation during most La Niña events. As a result, drought is forecasted to persist (*Figure 11*); there is moderate confidence in this outlook.

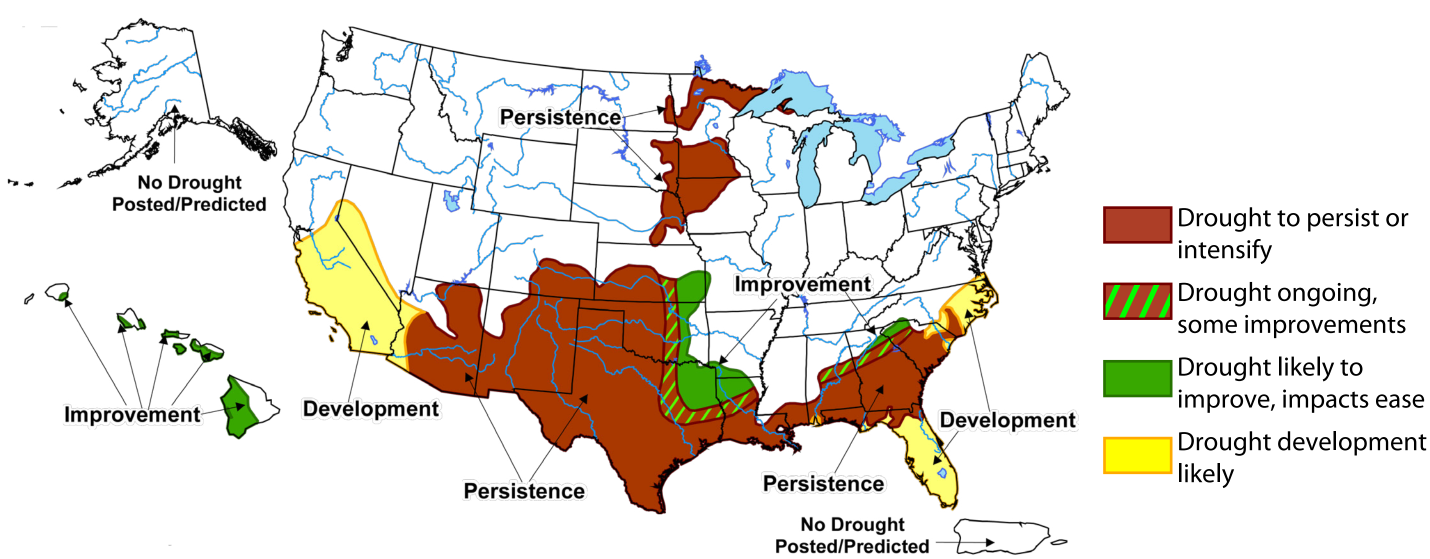
Elsewhere in the West, rain and mountain snow have brought near-average precipitation to Southern California since mid-November. Scant precipitation, however, fell in northern and central California and the northern Great Basin. Average SWE in the snowpacks in the Sierra Nevada was less than 25 percent of average as of December 1.

Tools used to forecast precipitation suggest a tilt in the odds towards below-median precipitation across the southern half of California and southern Nevada. Drought development is expected in areas of California and Nevada by the end of March.

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 March (released December 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)

Below-average sea surface temperatures (SSTs) across the equatorial Pacific Ocean continued during November, with the most recent weekly SST in the Niño 3.4 region measuring about -1.0 degrees Celsius below average. The cooler-than-average temperatures indicate a weak to moderate La Niña event. Stronger-than-average easterly winds along the equator and suppressed convection in the eastern Pacific are also occuring. The three-month average of the Southern Oscillation Index (SOI) value is currently +1.3, indicating that the atmosphere is fully engaged with the current La Niña SST pattern (*Figure 12a*). Both the atmospheric conditions and the presence of a large pool of cooler-than-average temperatures in the upper 300 meters of the ocean suggest that La Niña conditions will continue, according to the NOAA-Climate Prediction Center (NOAA-CPC).

Forecasts issued by the International Research Institute for Climate and Society (IRI) indicate La Niña conditions have more than a 60 percent chance of persisting through the February–April period (*Figure 12b*). Chances for a return of neutral conditions increase to almost 60 percent by the March–May period. There is still some uncertainty about the final strength of the event. About half of the forecast models suggest La Niña will reach moderate strength, while the other half indicate it will remain weak. Most of the models project it will peak in intensity between December and January.

It is expected that a La Niña will bring dry conditions to the Southwest, and seasonal precipitation forecasts issued by NOAA-CPC reflect this. Outlooks call for increased chances for below-average precipitation in all of Arizona and New Mexico through the February–April period (see page 14).

Notes:

The first figure shows the standardized three month running average values of the Southern Oscillation Index (SOI) from January 1980 through November 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/

Figure 12a. The standardized values of the Southern Oscillation Index from January 1980–November 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).

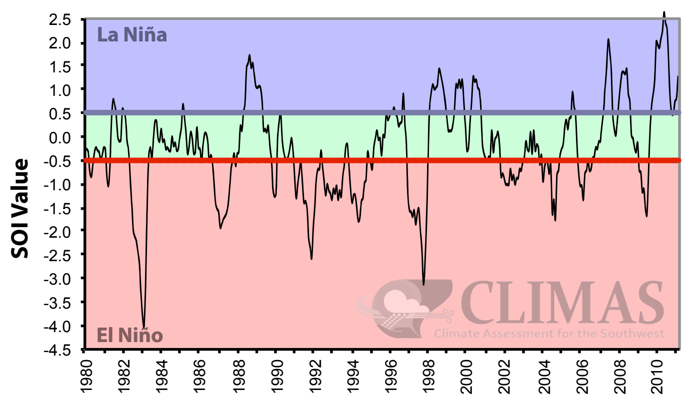


Figure 12b. IRI probabilistic ENSO forecast for El Niño 3.4 monitoring region (released December 20). Colored lines represent average historical probability of El Niño, La Niña, and neutral conditions.