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Winter storms in December coated the higher elevations of Arizona and New Mexico in snow, much like they did in Romero Canyon in Catalina State Park near Tucson, Arizona, in 2010. In recent weeks, dry weather has returned.
Photo source: Mindy Butterworth

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In this issue...

CLIMAS Climate Assessment for the Southwest

ARIZONA COOPERATIVE EXTENSION THE UNIVERSITY OF ARIZONA • COLLEGE OF AGRICULTURE AND LIFE SCIENCES

ARIZONA

OFFICE OF THE STATE CLIMATOLOGIST

NM STATE UNIVERSITY

January Climate Summary

Drought: Warm and dry conditions reigned in Arizona in the past 30 days, and moderate or a more severe drought category covered more than 60 percent of the state. In eastern New Mexico, drought conditions slightly improved.

Temperature: Temperatures were warmer than average in many regions in the Southwest in the last month. Most of Arizona was at least 3 degrees F above average, and temperatures across a large section of the Colorado Plateau were up to 6 degrees F warmer than average.

Precipitation: Conditions generally have been dry in the past 30 days, which reflects the typical La Niña pattern that was not present during the first three weeks of December.

ENSO: The La Niña event remains weak to moderate, and most forecasts call for the persistence of La Niña through April.

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

The Bottom Line: Dry conditions returned to Arizona and the western half of New Mexico after a wet and cool December. These conditions are more representative of typical La Niña events, in which the jet stream and the storms it ferries are often pushed north. Like last winter, December was wet and January has been dry. The key difference, however, is that this winter the Upper Colorado River Basin did not benefit from the December storms that blanketed the high elevations of Arizona and New Mexico in snow. Rather, snow has been sparse and most snowpacks in this region are well below average. Consequently, early spring streamflow forecasts for the Colorado River call for inflow into Lake Powell to be about 64 percent of average. Conditions can rapidly change, and there likely will be more wet spells. However, using past La Niña events as a guide, forecasters expect dry conditions to be more common than wet ones.

Scientists to Host Climate Book Club

For those book lovers with a thirst for keeping pace with rapid advances in climate science, you're in luck: the Southwest Climate Change Network (SWCCN) is starting a new climate book club. Interactive online discussions with scientists will provide unique access to some of the minds working to understand the intricacies of climate variability and change as well as how it all interacts with people.

Here's how it works. Once every month SWCCN book club leaders will choose (with your help, once the process is humming) a timely and relevant climate-related book to read. Leaders will provide a brief introduction to the book in a SWCCN blog post, as well as a few discussion questions to guide the reading. About a month later, one or more climate scientists, authors, or other scholars will begin the discussion with another blog post. You can then follow and join the discussion on the blog. In addition, SWCCN plans to host in-person discussions for some of the books, as logistics permit.

To learn about the first book selected, read more details, and join the conversation, visit: http://www.southwestclimatechange.org/blog/13686

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Table of Contents:

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Western States Seed Clouds in Search of New Water

By Melissa Lamberton

On a remote mountaintop in the Sierra Nevada, as thunderheads gather in a dark mass above the peaks, a thin propane flame burns against the pale backdrop of snow. The generator, perched on top of a spindly tower, vaporizes a solution of silver iodide, wafting invisible particles upward into the clouds.

From his office at the Desert Research Institute (DRI) in Reno, Nevada, Associate Research Scientist Arlen Huggins eyes the temperature and wind direction as the data stream across his computer screen. He's not waiting for the weather to change. He's changing it.

Huggins' project, funded by Nevada water users, is one of dozens of operational programs that resumed cloud-seeding efforts in November 2011. Generators placed upwind of a target area cast silver iodide particles into winter clouds, where their crystalline structure encourages the formation of ice that otherwise might not occur.

For more than half a century, cloud-seeding has captured the imaginations of scientists and water managers alike. Its effects have proven elusive—difficult to measure and little understood despite decades of putting the process into practice. Yet cloud seeding continues to tantalize western states with the promise of more water for the tenuous supply in the Colorado River Basin.

Figure 1. A generator blasts silver iodide into clouds over the Sierra Nevada Mountains in California. *Source: Arlen Huggins*

Diminishing water

Six of the seven U.S. states that rely on water from the Colorado River—Nevada, New Mexico, Utah, Colorado, California, and Wyoming—practice cloud seeding. Arizona, the one remaining state, has no projects of its own, but agencies there fund cloud-seeding efforts in upstream states.

The urgency to supplement the natural water supply stems from recent climate change studies that predict higher temperatures will increase evaporation and decrease mountain snowpack in the Southwest. That is bad news for the Colorado River system, which already is over-allocated between the seven U.S. states and Mexico.

Scientific research on the effectiveness of weather modification remains scarce. Federal funding for scientific studies, largely driven by interest in military applications, declined sharply after the 1970s. In 2003, the National Academy of Sciences published a report stating "there still is no convincing scientific proof of the efficacy of intentional weather modification efforts," even though 66 operational programs existed in 10 U.S. states.

The report prompted a backlash from researchers, who pointed out the authors demanded a level of proof rarely achieved in atmospheric research. Scientists reduce uncertainty by repeating

continued on page 4

Cloud Seeding, continued

and randomizing experiments, a difficult task when they have to wait for the right weather to arrive.

Dan Breed, project manager of weather modification projects for the National Center for Atmospheric Research (NCAR), labeled the 2003 report as "pessimistic." The report focused primarily on seeding convective clouds, dramatic thunderheads common in spring and summer. Breed agrees that convective cloud seeding remains controversial, but points toward orographic clouds, which form in winter as air is pushing over mountainous terrain, as far more promising.

Wyoming experiment

As part of his research, Breed analyzes data from a Wyoming experiment designed to tease out the subtle differences in snowpack, if any exist, between a mountain range that receives silver iodide and a nearby range left alone. Researchers began collecting case studies in the winter of 2008 and hope to receive another year of funding to obtain five seasons of data. Scientists herald the project as one of the most rigorously designed experiments on cloud seeding ever undertaken in the U.S.

Breed points out that an observer on the ground can't tell the difference between seeded and unseeded snowfall. "The randomization is needed because you're looking for a small signal in a fairly large natural variability," he said.

Wyoming's geography allows for a close comparison between two mountain ranges that experience the same winter storms. When favorable conditions exist in both the Sierra Madre and Medicine Bow ranges, located in south-central Wyoming, generators randomly seed one or the other. The arrangement allows scientists—who are not told which range has received silver iodide particles—to complete a statistical analysis and quantify any differences they find. A third mountain range, Wind River, will provide corroborating case studies.

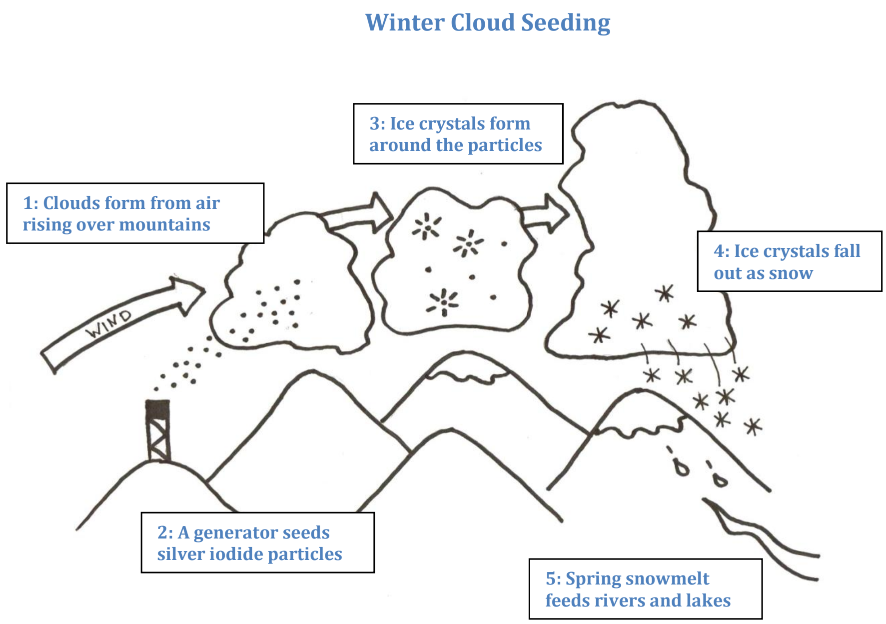

Figure 2. Silver iodide is projected into moisture-laden clouds to help wring out more snow than would otherwise fall. *Source: Melissa Lamberton*

Breed's team at NCAR will lead the statistical analysis, while Huggins and other scientists at DRI will look for elevated levels of silver in snowpack. That will help them understand where the seeding material falls so operational programs can improve the placement of their generators. Weather Modification, Inc., a private corporation based in Fargo, ND, controls the satellite-operated, solar-powered generators.

Breed says the data so far shows "strong suggestions of positive seeding effects," but it is too soon to know the magnitude. "What we want to do is provide a quantitative idea, or at least a range of effects, so a hydrologist could use that to figure out streamflow," Breed said.

Challenges

Cloud seeding doesn't create rain. It merely enhances natural storms. That means it will not work effectively when there is not enough moisture in the air to form around the silver iodide particles. In addition, Breed cautions that not all winter storms have the correct conditions to make cloud seeding successful. In the past, operational programs have seeded any storm in the area with little regard to its suitability, because the technology costs very little. At best, nothing happens, but Breed said scientists still don't know if seeding in the wrong conditions creates unintended effects.

Another unanswered question involves the downwind effects. "It's extremely hard to look in a place where you're affecting [the weather] and see it change," Breed said. "If you're looking downwind, it's something that may be 10 times smaller."

Areas downwind of generators typically fall within the mountain's rainshadow, where weather patterns are naturally drier. That makes comparisons difficult, but studies that model cloud formation show that only a fraction of the moisture contained in a winter cloud actually falls out as precipitation. For this reason, researchers think cloud-seeding operations are unlikely to affect downwind regions, or will slightly increase precipitation.

Residents downwind of cloud-seeding projects also worry about floods, mudslides, and weather damage that could result from enhanced winter storms.

Most programs have cut-off points where they cease operations if snowpack levels are high to prevent excessive flooding in the spring. Public perception remains a major obstacle to cloud-seeding programs, Breed said, because damage caused by weather cannot clearly be attributed to natural causes or human interference.

How much water?

Quantifying the amount of water created by cloud seeding remains "a tricky deal," said Don Griffith, president of North American Weather Consultants and the Weather Modification Association. Studies suggest cloud seeding creates a 5–15 percent increase in precipitation, but those numbers fall well within the range of normal weather variability.

The Wyoming experiment may answer longstanding questions about how cloud seeding works. Water managers, however, rarely require the high level of certainty demanded by scientists. "When water managers have a chance to make a relatively small investment to get very inexpensive water compared to any other alternative approach, they're willing to take that risk," Griffith said.

As Breed explained, "They're already believers. They don't need to know the specific numbers."

A 2006 study by Griffith estimates that new cloud-seeding programs could create 154,000 acre-feet annually for the Colorado River Basin, or slightly less than half the water used annually by Phoenix in 2007, according to the most recent data available. (An acre-foot is 325,851 gallons.) Griffith emphasizes that this water, while modest in amount, costs only a few dollars per acre-foot, compared to more than $1,000 for an expensive alternative like desalination.

Another alternative source of water is simply conserving more. In the Colorado River Basin, Huggins said, "the water entities have instituted a lot of conservation measures that probably do as much or more as cloud seeding." Yet cloud seeding remains on the table because water is so valued in the Southwest that even a small increase in precipitation seems worthwhile. Hydroelectric power companies and ski resorts commonly seed clouds, as do agencies charged with supplying water to growing cities and sprawling agricultural fields.

States rarely fund intensive research projects like the one in Wyoming, which require much more money than simply operating a cloud-seeding program on faith. That makes the final results from the project all the more valuable, because the data can either justify cloud seeding as a cost-effective way to increase water supply or point to other solutions as more viable.

"I think it will have a fairly big impact on how western states proceed with cloud seeding," Breed said. As desert states like Arizona, New Mexico, and Nevada plan for a future with growing populations and an uncertain climate, they look for new water supplies untouched by current claims. For now, cloud-seeding programs play a small but hopeful role in this search, and experiments like the one in Wyoming will help decide how the Southwest prepares to meet future demands.

For more information on NCAR's weather modification project visit http://www.ral.ucar.edu/projects/wyoming.

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Melissa Lamberton is an MFA candidate at Iowa State University and a previous contributor to the Southwest Climate Outlook.

Temperature (through 1/18/12)

Data Source: High Plains Regional Climate Center

Temperatures since the water year began on October 1 ranged from 35 to 45 degrees Fahrenheit on the Colorado Plateau in northeastern Arizona, and from 30 to 40 degrees F in many parts of Northern New Mexico (*Figure 1a*). In southern New Mexico, temperatures have been between 40 and 50 degrees F, with areas along the Mexico border in the low 50s. The southwestern half of Arizona has been between 50 and 65 degrees F, with the warmest areas in Maricopa County, southern Yuma County, and along the Southern California border. Most areas in both states experienced temperatures within 2 degrees F of average (*Figure 1b*). Only a few areas have experienced colder-than-average temperatures, generally at the higher elevations, with the coldest spots in southern Guadalupe and central McKinley and Cibola counties.

In the past 30 days, temperatures have been warmer than average in many regions in the Southwest (*Figures 1c–d*). All of Arizona has been at least 3 degrees F above average, and a large section of the Colorado Plateau has been as much as 6 degrees F warmer than average. In New Mexico, the northern half has been generally 0–3 degrees F warmer than average, while areas in southern and central New Mexico have been 3 degrees F colder than average. McKinley and Cibola counties have been up to 15 degrees colder than average, in part because these areas have experienced more precipitation.

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 January 18) average temperature.

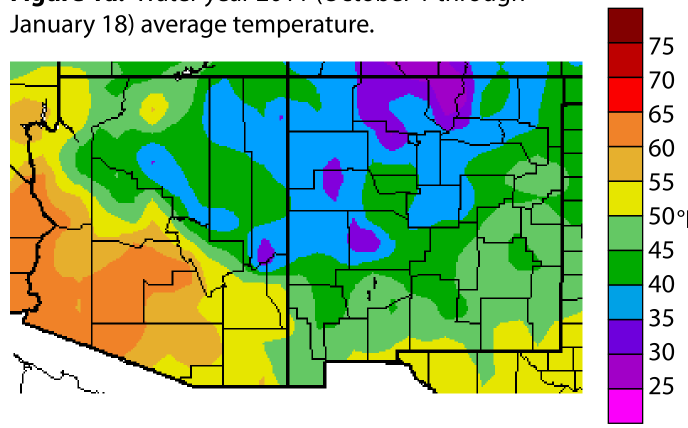


Figure 1b. Water year 2011 (October 1 through January 18) departure from average temperature.

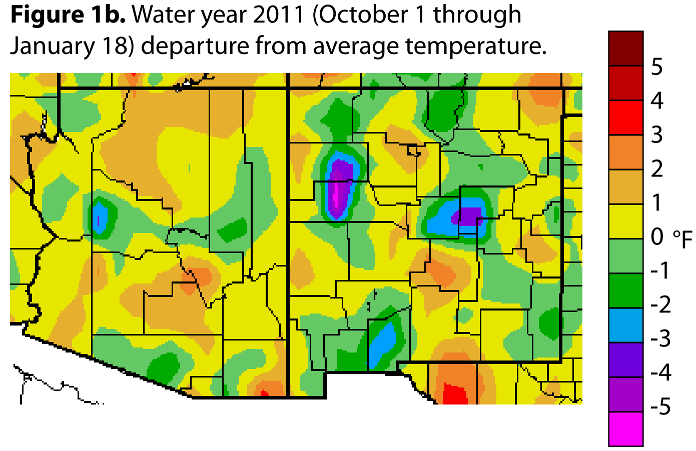


Figure 1c. Previous 30 days (December 20–January 18) departure from average temperature (interpolated)

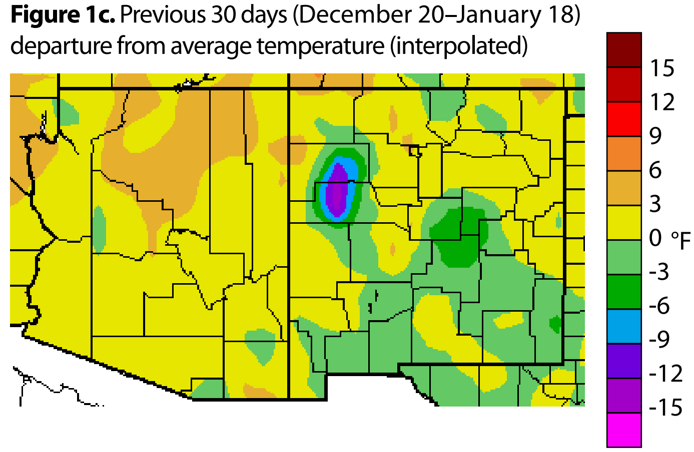
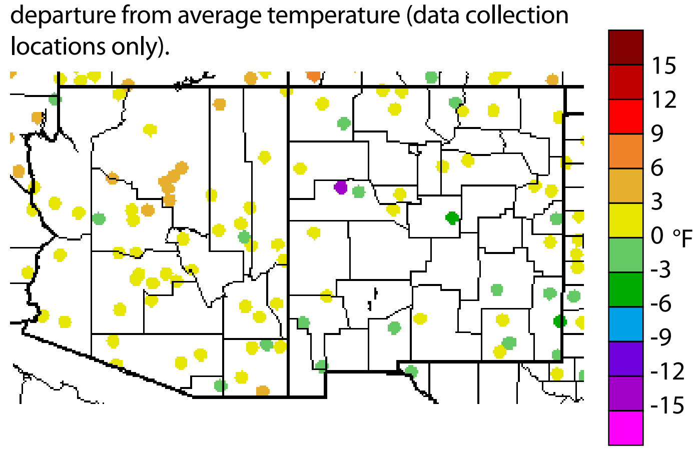


Figure 1d. Previous 30 days (December 20–January 18) departure from average temperature (data collection locations only).



Precipitation (through 1/18/12)

Data Source: High Plains Regional Climate Center

Precipitation since the water year began on October 1 generally has been slightly below average in most of Arizona, with exceptionally dry spots in northern Mohave, Navajo, and Apache counties. In these regions, rain and snow have totaled between 25 and 50 percent of average (*Figures 2a–b*). Southern Coconino County, on the other hand, experienced between 100 and 130 percent of average precipitation, mostly the result of copious snowfall in early December. The southwest corner of the state also has been wet, with precipitation measuring between 110 and 200 percent of average. Precipitation has been patchy in New Mexico; southern areas have experienced 50–90 percent of average, while northern and central parts of the state have received more than 150 percent of average. These wet spots cover parts of McKinley, Cibola, and Guadalupe counties, and correspond to the places that also experienced colder-than-average temperatures.

During the last 30 days, conditions generally have been dry, which is more reflective of the typical La Niña pattern that was not present in the first three weeks of December (*Figures 2c–d*). Precipitation has been very sparse in the western half of Arizona, which received between 2 and 25 percent of average precipitation. A small area in east-central Arizona was the only region that received above-average precipitation in the state. Western and northern New Mexico have been dry, while wetter conditions have covered most of the southeast corner, where rain and snow have totaled between 150 and 800 percent of average. The wet weather in this region is fortuitous, because it is the area experiencing the most severe drought.

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 January 18) percent of average precipitation (interpolated).

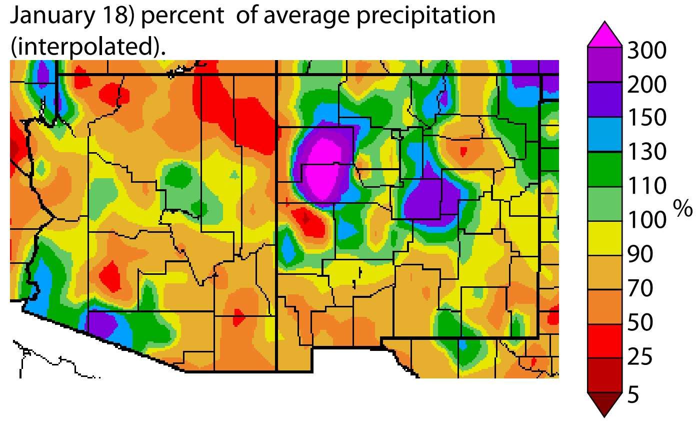


Figure 2b. Water year 2011 (October 1 through January 18) percent of average precipitation (data collection locations only).

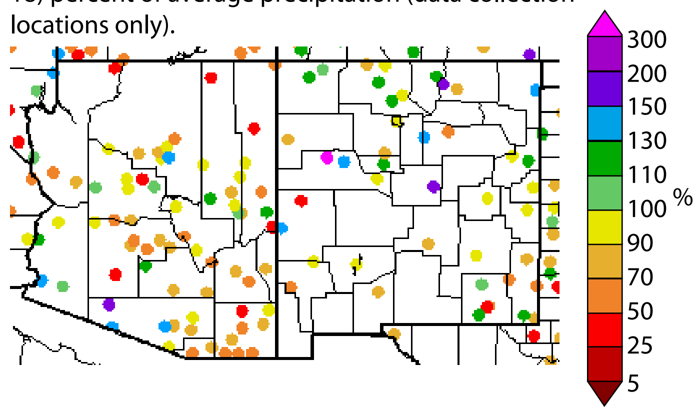


Figure 2c. Previous 30 days (December 20–January 18) percent of average precipitation (interpolated).

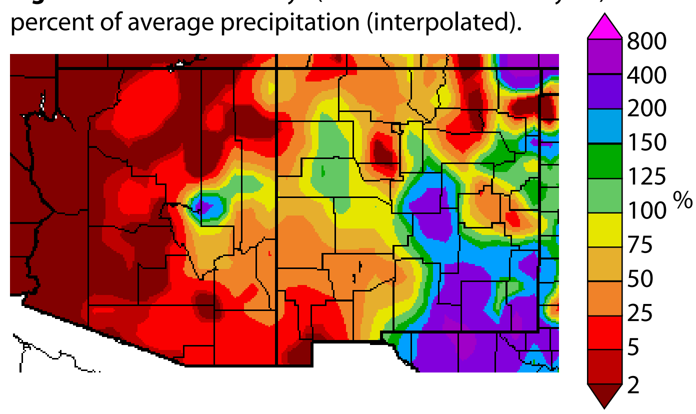
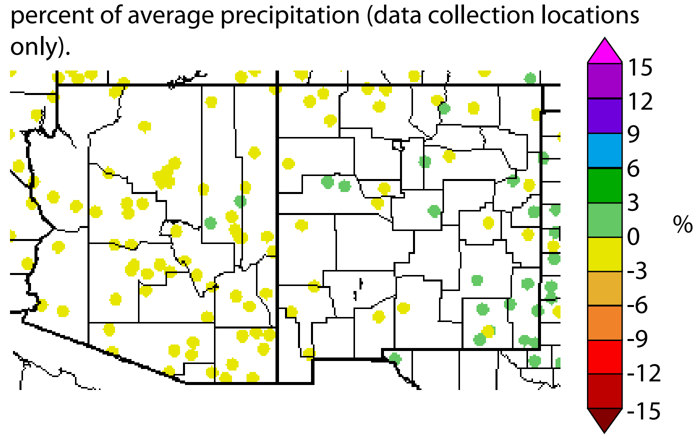


Figure 2d. Previous 30 days (December 20–January 18) percent of average precipitation (data collection locations only).



U.S. Drought Monitor (data through 1/17/12)

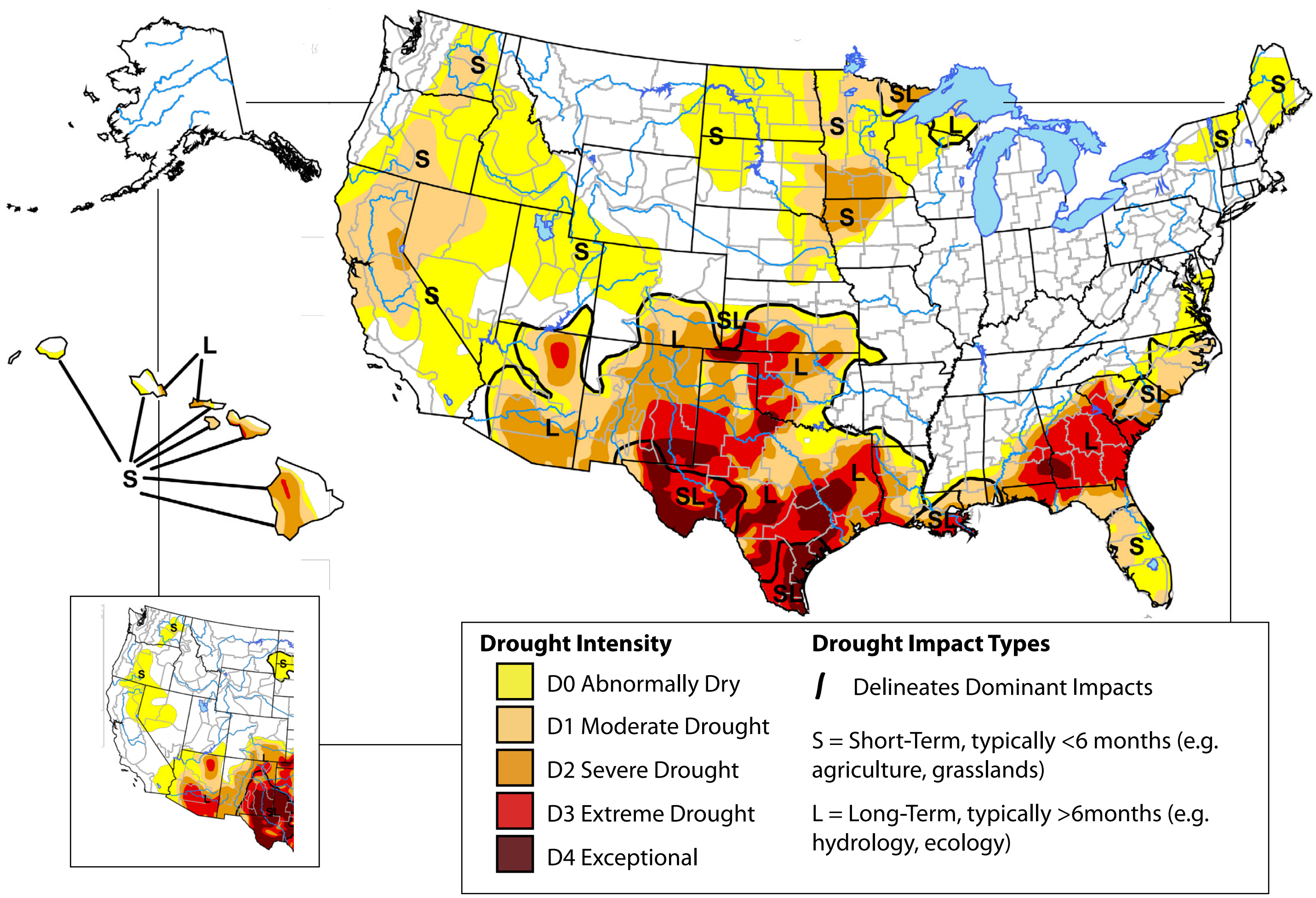
Data Sources: U.S. Department of Agriculture, National Drought Mitigation Center, National Oceanic and Atmospheric Administration

In the West, drought substantially expanded in the last month as dry conditions moved in across most of the region, according to the January 17 U.S Drought Monitor (*Figure 3*). Drought still remains most severe in Arizona and New Mexico, but a large swath of moderate drought has emerged in northern California, western Nevada, and southern Oregon. In these regions, precipitation has been less than 50 percent of average in the last 60 days, and negative impacts associated with the dry weather are mostly seen in agriculture, ranching, and other sectors influenced by shorter-term fluctuations in the weather. Impacts to water supply, on the other hand, respond to climate changes on timescales typically longer than six months because reservoirs buffer acute dry periods. In the Upper Colorado River Basin, snow has been scant for parts of Colorado, southern Wyoming, and Utah. Abnormally dry conditions now characterize these regions.

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.

Figure 3. Drought Monitor data through January 17, 2012 (full size), and December 13, 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 1/17/12)

Data Source: U.S. Drought Monitor

Dry weather settled over Arizona in the last month, with western areas receiving between 2 and 25 percent of average. The state also was warmer than average, with temperatures as much as 6 degrees F above-average on the Colorado Plateau in northwest Arizona. Despite these conditions, Arizona saw slight improvements in its drought status during the last 30 days, a delayed effect of a wet December (*Figure 4a*). Drought, however, is still the norm.

Currently, 93 percent of Arizona is categorized with abnormally dry conditions or a more severe drought category, with severe or extreme drought covering about 37 percent of the state (*Figure 4b*). Although several impressive early winter storms in late November and early December helped improve short-term drought conditions, longer-term precipitation deficits remain. Much of Arizona, particularly parts of central and southern Arizona, has accumulated precipitation deficits during the past six months of 2 to 4 inches below average. More winter rain and snow will be needed to make substantial improvements in many areas in Arizona. However, with the expectation that a weak to moderate La Niña will continue through the spring, forecasts still suggest drier-than-average conditions.

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

Figure 4a. Arizona drought map based on data through January 17.

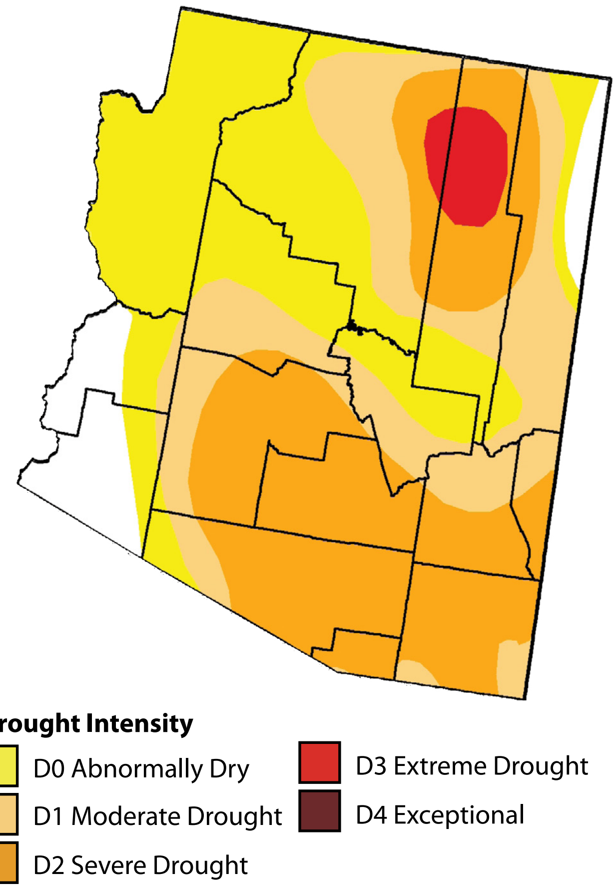


Figure 4b. Percent of Arizona designated with drought conditions based on data through January 17.

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	7.36	92.64	60.34	36.56	2.78	0.00
Last Week (01/10/2012 map)	16.70	83.30	60.34	36.56	2.78	0.00
3 Months Ago (10/18/2011 map)	1.43	98.57	68.57	42.81	15.12	1.24
Start of Calendar Year (12/27/2011 map)	16.70	83.30	60.34	36.56	2.78	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 (01/11/2011 map)	40.34	59.66	31.93	0.00	0.00	0.00

New Mexico Drought Status

(data through 1/17/12)

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

Drought conditions have improved slightly from one month ago, particularly in southeast and northeast New Mexico, where precipitation generally has been above average. Extreme drought is no longer present in the northeast corner, although severe conditions still remain. In the southeast, exceptional drought covers less than half the area it did 30 days ago, largely because winter storms delivered more than 150 percent of average in the last month. Drought, however, continues to blanket the majority of the state (*Figure 5a*). As of January 17, about 91 percent of the state was still classified with abnormally dry conditions or a more severe drought category (*Figure 5b*).

While the eastern half of the state has been generally wetter than average, the western half has been drier than average. In these regions, rain and snow have measured less than 75 percent of average. This weather is likely influenced by the ongoing weak to moderate La Niña event, which often helps divert storms from the west farther north. With the expectation that the La Niña will continue into spring, drier-than-average conditions are still favored in most of New Mexico for the next few months.

Figure 5a. New Mexico drought map based on data through January 17.

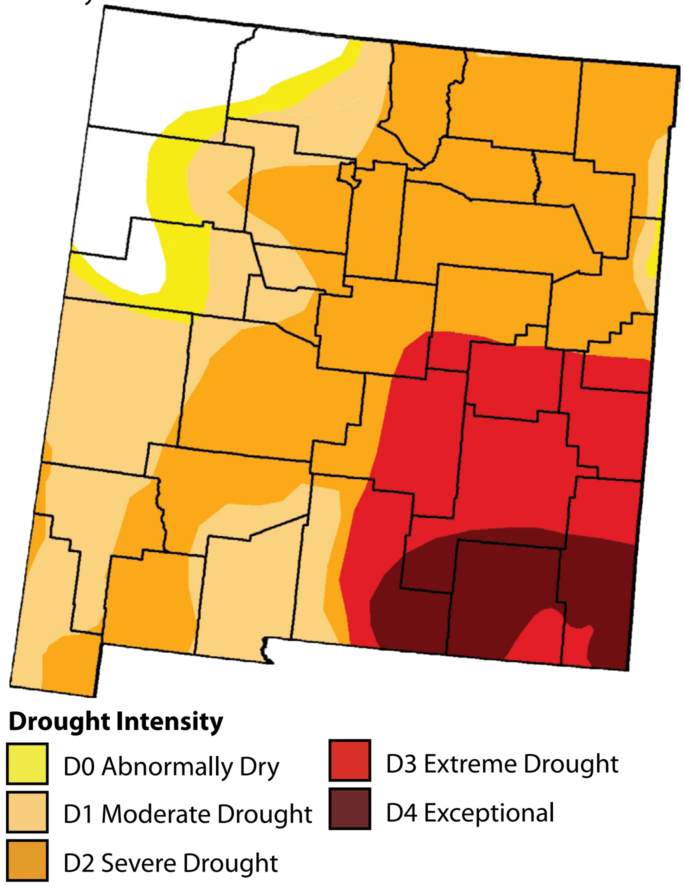


Figure 5b. Percent of New Mexico designated with drought conditions based on data through January 17.

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	8.63	91.37	87.20	63.73	23.37	7.56
Last Week (01/10/2012 map)	8.63	91.37	87.60	72.13	23.37	7.56
3 Months Ago (10/18/2011 map)	6.24	93.76	90.71	85.90	63.02	26.35
Start of Calendar Year (12/27/2011 map)	8.63	91.37	87.60	72.15	23.37	7.57
Start of Water Year (09/27/2011 map)	0.00	100.00	96.40	88.99	69.61	35.13
One Year Ago (01/11/2011 map)	8.60	91.40	42.69	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 12/31/11)

Data Source: National Water and Climate Center

Combined storage in Lakes Mead and Powell increased slightly, by 240,000 acre-feet, in December. As of December 31, combined storage in both lakes was about 61 percent of capacity (*Figure 6*), which is about 12 percent more than a year ago. While Lake Powell declined by 724,000 acre-feet, Lake Mead increased by 964,000 acre-feet. The discrepancy is because joint management of the two lakes under current conditions sends water from Lake Powell to Lake Mead. Storage in other reservoirs within Arizona's borders reported in Figure 6 rose by about 80,000 acre-feet in December, driven primarily by increased volume in Lake Mohave and the Salt River Basin, which rose by about 80,000 and 23,000 acre-feet respectively; Lake Havasu fell by about 30,000 acre-feet. San Carlos Reservoir remains very low, at 2 percent of capacity.

In water-related news, the Arizona Department of Water Quality (ADEQ) released a draft assessment report that describes the status of surface water in Arizona in relation to state water quality standards. The report is open to public comment and can be accessed at www.azdeq.gov/environ/water/assessment/assess.html.

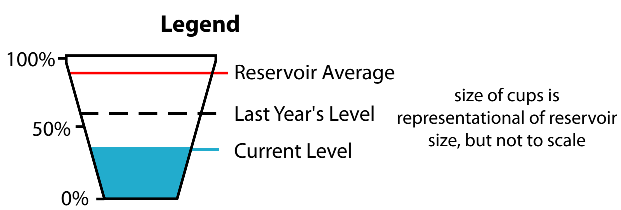
Notes:

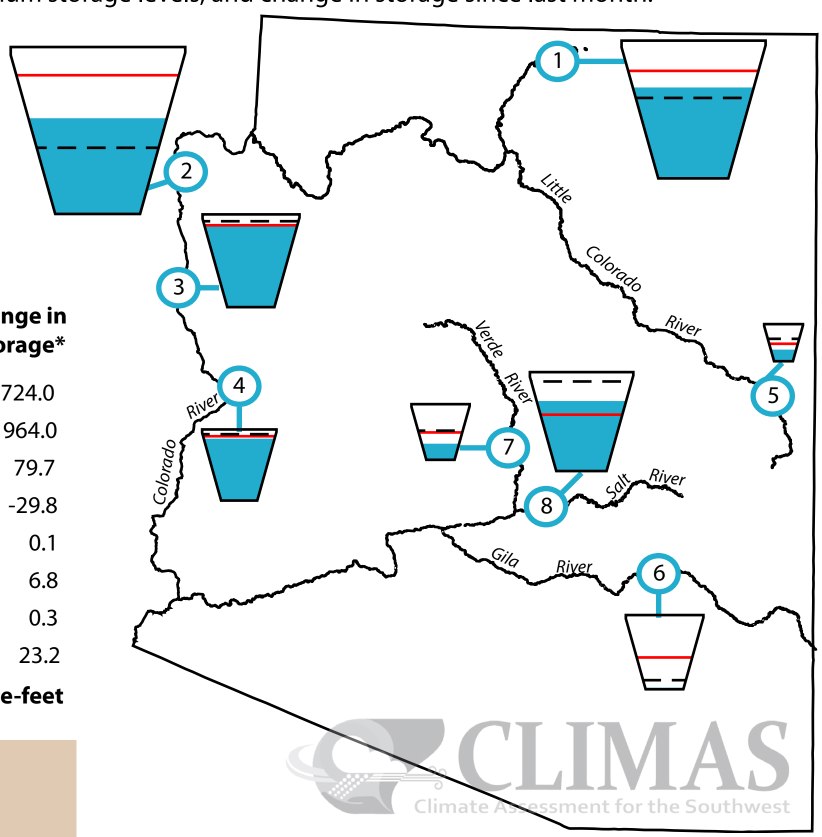
The map gives a representation of current storage levels for reservoirs in Arizona. Reservoir locations are numbered within the blue circles on the map, corresponding to the reservoirs listed in the table. The cup next to each reservoir shows the current storage level (blue fill) as a percent of total 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 Resources Conservation Service (NRCS).

Figure 6. Arizona reservoir levels for December 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	66%	15,959.0	24,322.0	-724.0
2. Lake Mead	57%	14,897.0	26,159.0	964.0
3. Lake Mohave	88%	1,591.1	1,810.0	79.7
4. Lake Havasu	87%	537.3	619.0	-29.8
5. Lyman Reservoir	31%	9.4	30.0	0.1
6. San Carlos	2%	14.2	875.0	6.8
7. Verde River System	29%	82.1	287.4	0.3
8. Salt River System	71%	1,434.9	2,025.8	23.2

*** 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 12/31/11)

Data Source: National Water and Climate Center

The total reservoir storage in New Mexico increased by an estimated 47,000 acre-feet in December (*Figure 7*). This estimate does not include storage changes from Heron and El Vado, which did not report in December. Storage in New Mexico's largest reservoir, Elephant Butte, increased by about 54,000 acre-feet. Despite this increase, Elephant Butte is only about 13 percent full, down from 20 percent of capacity one year ago. Storage in the Navajo Reservoir had the largest decline, losing about 16,000 acre-feet in December. Also, Pecos River Reservoir storage (*reservoirs 9–12 on Figure 7*) remained exceedingly low, despite modest increases in storage that totaled about 9,000 acre-feet.

The first spring streamflow forecasts (*see Figure 12*) suggest some rivers will experience below-average flows while others may experience above-average streamflow. For example, there is a 50 percent chance that the March–July flow in the Rio Grande will be 88 percent of average, while above-average flows are expected in the Mimbres and Pecos rivers. These forecasts are expected to become more accurate as the winter progresses.

Notes:

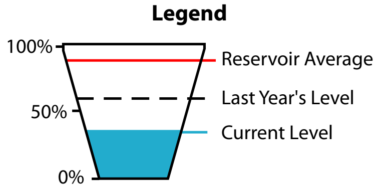
The map gives a representation of current storage levels for reservoirs in New Mexico. Reservoir locations are numbered within the blue circles on the map, corresponding to the reservoirs listed in the table. The cup next to each reservoir shows the current storage level (blue fill) as a percent of total 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 Resources Conservation Service (NRCS).

Figure 7. New Mexico reservoir levels for December 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.

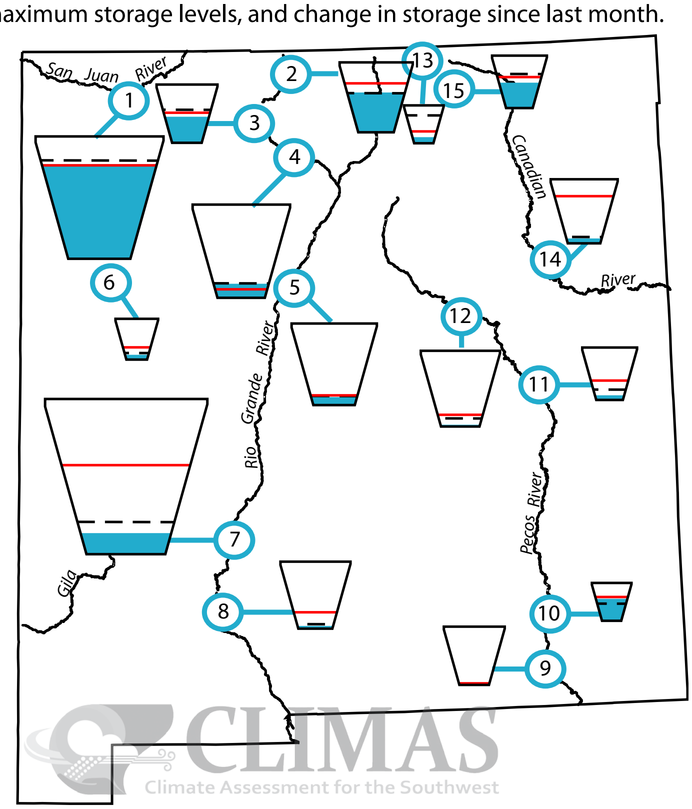
Legend



size of cups is representational of reservoir size, but not to scale

Reservoir Name	Capacity Level	Current Storage*	Max Storage*	Change in Storage*
1. Navajo	77%	1,310.9	1,696.0	-15.8
2. Heron	57%	226.9	400.0	N/A**
3. El Vado	45%	86.2	190.3	N/A**
4. Abiquiu	15%	181.6	1,192.8	-0.2
5. Cochiti	10%	50.8	491.0	-0.4
6. Bluewater	12%	4.6	38.5	0.0
7. Elephant Butte	13%	294.5	2,195.0	53.5
8. Caballo	4%	13.6	332.0	2.0
9. Brantley	1%	11.1	1,008.2	2.8
10. Lake Avalon	58%	2.3	4.0	0.6
11. Sumner	9%	8.8	102.0	4.3
12. Santa Rosa	2%	10.1	438.3	0.2
13. Costilla	16%	2.6	16.0	0.4
14. Conchas	7%	16.6	254.2	-0.2
15. Eagle Nest	48%	38.1	79.0	-0.1

*** 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 1/16/12)

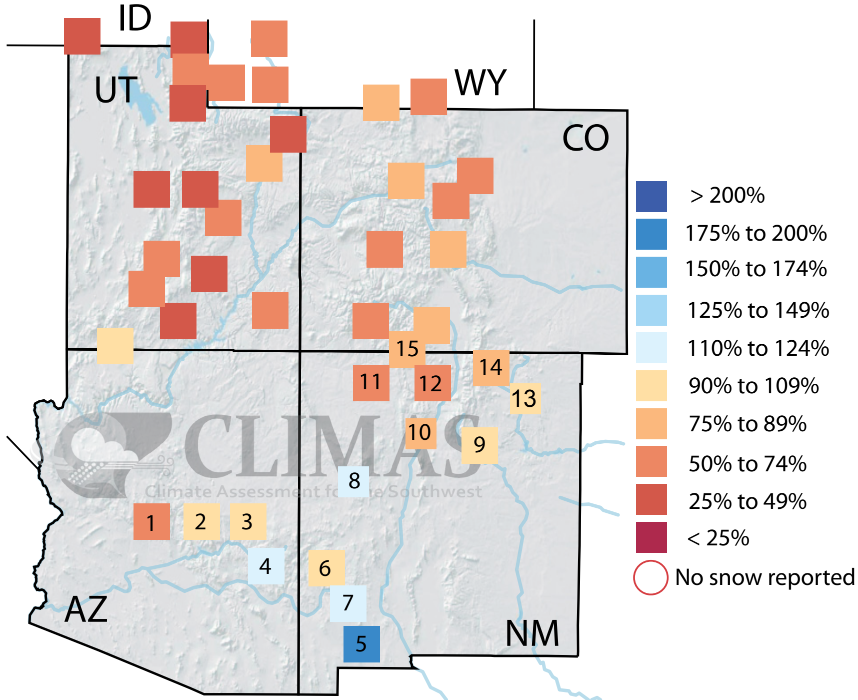
Data Sources: National Water and Climate Center, Western Regional Climate Center

A string of storms in early to mid-December brought substantial snow to portions of the Southwest, especially in central and southern Arizona and New Mexico. One month ago, nearly all of the basins reported above-average snowpacks. Since the beginning of 2012, however, storms have been few and far between, causing the amount of water contained in snowpacks, or snow water equivalent (SWE), to decline. As of January 16, SWE measured by snow telemetry (SNOTEL) stations ranged from 74 percent of average in the Verde River Basin to 110 percent of average in both the Upper Salt and Upper Gila river basins (*Figure 8*). SWE in New Mexico had a larger range, from 62 percent of average in the Animas River Basin to 177 percent in the Mimbres River Basin.

December storms that dropped copious precipitation on the Southwest did not pack the same punch in Colorado, Wyoming, and Utah—states that supply most of the water to the Colorado River and Rio Grande—as much. In addition, dry conditions have reigned in these regions and in the Southwest during the last few weeks. As a result, SWE values were predominantly below average across the Upper Colorado River Basin as of January 16. For example, SWE in all of the basins in Colorado measured less than 83 percent of average, and some stations in Utah reported values as low as 37 percent of average, with 10 of 14 basins reporting less than 60 percent of average. These conditions are contributing to below-average spring streamflow forecasts for the Colorado River.

Seasonal precipitation and temperature outlooks issued by the NOAA-Climate Prediction Center (CPC) show increased chances for above-average temperatures and below-average precipitation across Arizona and New Mexico (see *Figures 9 and 10*). These forecasts reflect expected impacts of the current weak to moderate La Niña event.

Figure 8. Average snow water equivalent (SWE) in percent of average for available monitoring sites as of January 16, 2012.



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

(February–July 2012)

Data Source: NOAA-Climate Prediction Center (CPC)

The seasonal temperature outlooks issued by the NOAA–Climate Prediction Center (CPC) in January call for increased odds that temperatures for the three-month seasons spanning February to July will be similar to the warmest 10 years in the 1981–2010 period (*Figures 9a–d*). The seasonal temperature outlooks for the February–April period reflect typical late winter La Niña conditions, which favor above-average temperatures across the southern continental U.S., according to the CPC. For this period, there is a 50 percent chance that temperatures will be 0.2–0.4 degrees F above average in the western half of Arizona and between 0.4 and 1.0 degree F above average in New Mexico.

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.

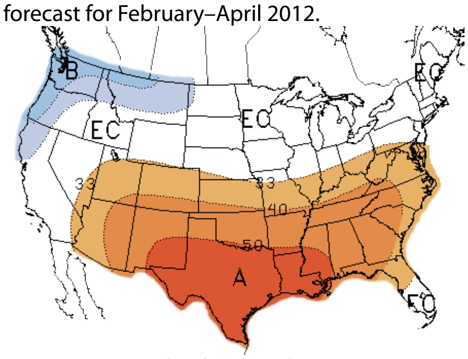


Figure 9a. Long-lead national temperature forecast for February–April 2012.

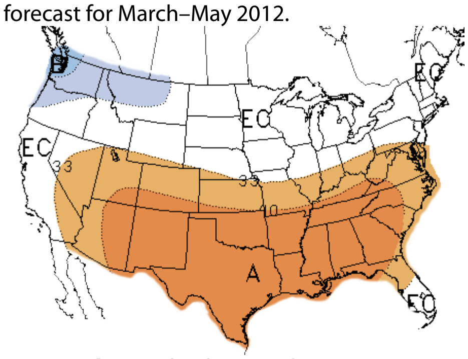


Figure 9b. Long-lead national temperature forecast for March–May 2012.

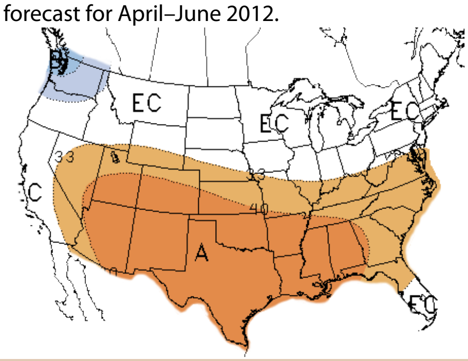


Figure 9c. Long-lead national temperature forecast for April–June 2012.

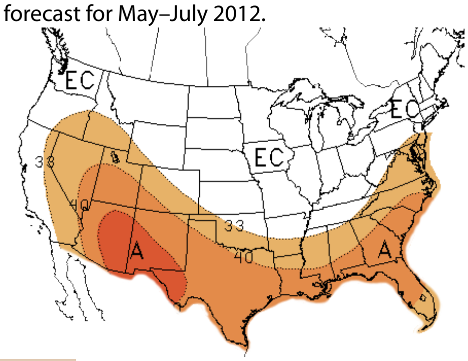


Figure 9d. Long-lead national temperature forecast for May–July 2012.

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.

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
(February–July 2012)

Data Source: NOAA-Climate Prediction Center (CPC)

The seasonal precipitation outlooks issued by the NOAA–Climate Prediction Center (CPC) in January call for increased chances that precipitation will be similar to the driest 10 years of the 1981–2010 period for the February–April and March–May periods in all of Arizona and New Mexico (*Figures 10a–b*). A primary driver for these forecasts is the 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. Outlooks call for equal chances for above-, below-, or near-average conditions in Arizona and most of New Mexico for April-June and equal chances in both states for May-July (*Figure 10c–d*). For February–April, there is a 50 percent chance that precipitation will be between 0.4 and 1.0 inches below average in Arizona and between 0.2 and 0.6 inches below average in New Mexico.

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.

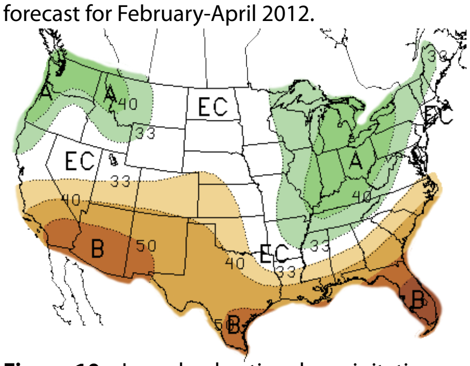


Figure 10a. Long-lead national precipitation forecast for February-April 2012.

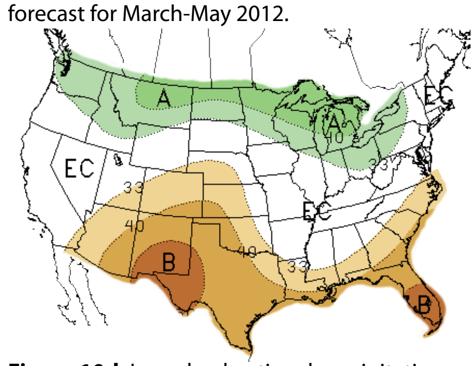
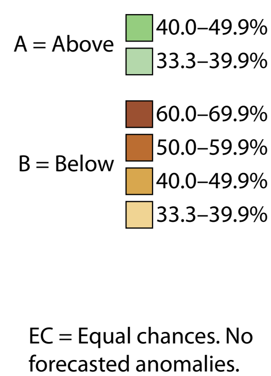


Figure 10b. Long-lead national precipitation forecast for March-May 2012.



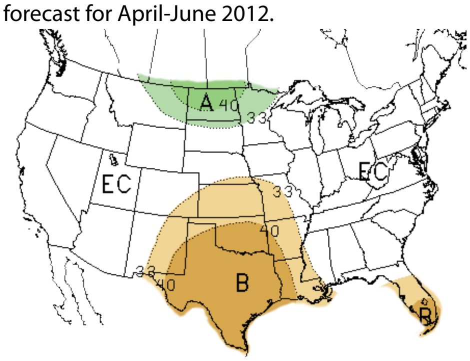


Figure 10c. Long-lead national precipitation forecast for April-June 2012.

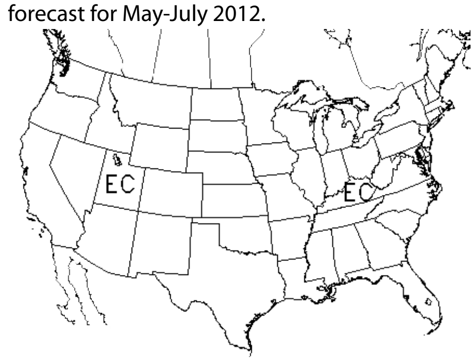


Figure 10d. Long-lead national precipitation forecast for May-July 2012.

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
(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 April)

Data Source: NOAA–Climate Prediction Center (CPC)

This summary is partially excerpted and edited from the January 19 Seasonal Drought Outlook technical discussion produced by the NOAA-Climate Prediction Center (CPC) and written by forecaster D. Miskus.

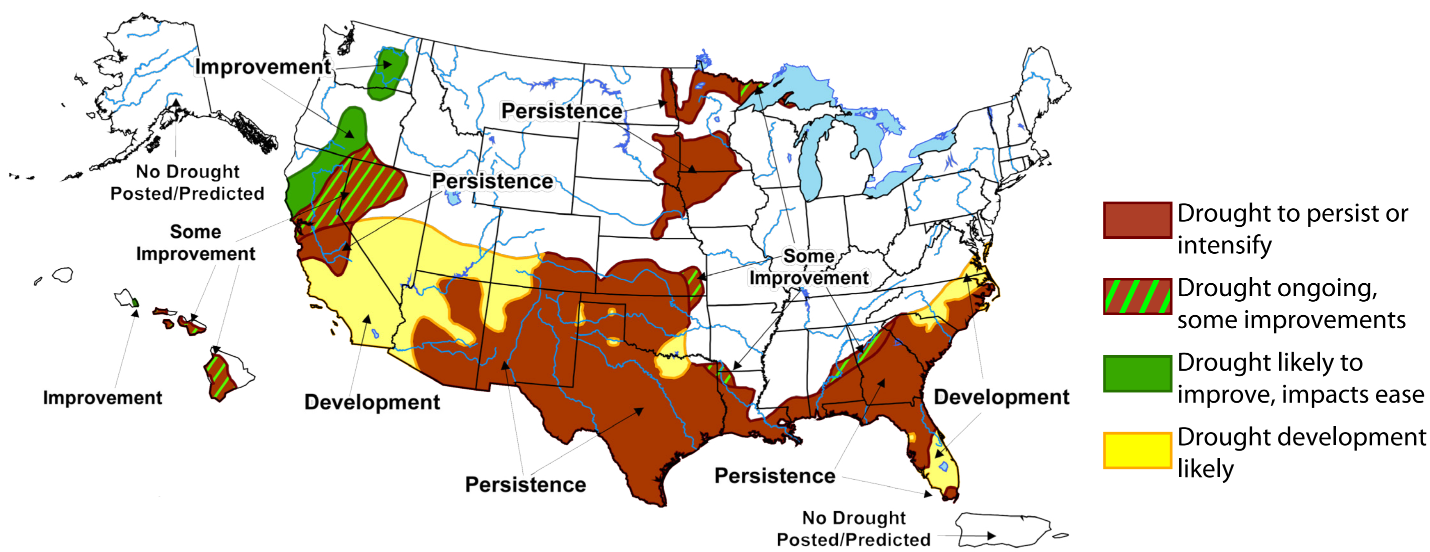
Widespread moderate to heavy snow fell in the high elevations of Arizona and New Mexico between mid-November and mid-December, while above-average precipitation soaked lower areas. As a result, snow water equivalent (SWE) and precipitation since the water year began on October 1 are above average. In recent weeks, however, little precipitation has fallen and both SWE and average precipitation has declined. Despite the early winter rain and snow across Arizona and New Mexico, forecast tools on all time scales favor a continuation of drier-than-average conditions, which is typical for a La Niña winter. In addition, the odds favor above-average February–April temperatures, especially in eastern sections of the Southwest. As a result, drought is forecast to persist, intensity, and develop across the Southwest (*Figure 11*). The CPC assigns a moderate confidence in this forecast.

Elsewhere, La Niña threw a curveball to parts of California and the Great Basin, which have been hit by an unexpected lack of early winter precipitation. In the Sierra Nevada Mountains, SWE values were less than 15 percent of average as of January 16. Also, precipitation deficits have exceeded 4 inches across northern and central California during the past 30 days. Currently, moderate drought occupies a swath between central California, central Washington, and northwestern Nevada. Fortunately, short-term forecasts call for wet conditions, as do some of the longer-term forecasts. As a result, drought improvement is forecast for parts of Washington, Oregon, California, and Nevada. The persistence of drought is favored across central California, and drought development is likely in southern sections of California and Nevada. The CPC assigns a moderate confidence in these forecasts.

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 April (released January 19).



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

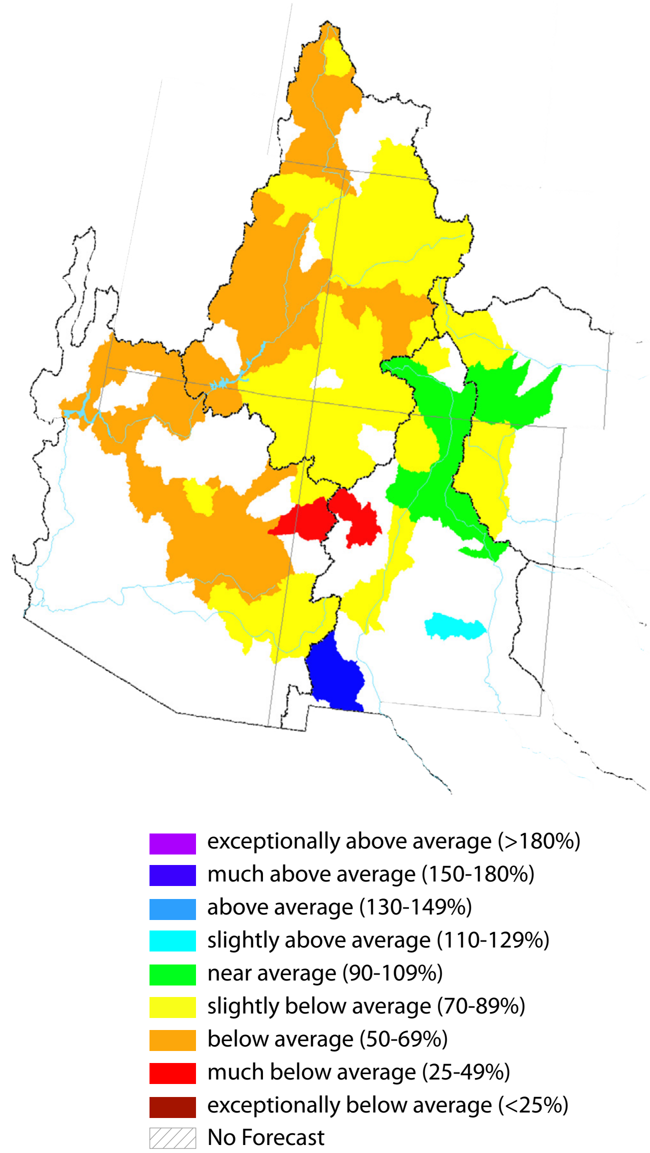
Streamflow Forecast
(for spring and summer)

Source: National Water and Climate Center

The first spring–summer streamflow forecast for the Southwest, issued on January 1, shows a 50 percent chance that flows in most basins in Arizona and New Mexico will be below average (*Figure 12*). There is a 50 percent chance that the Salt, Verde, and Gila rivers in Arizona will experience streamflows amounting to 65, 64, and 83 percent of the January–May average, respectively. Although widespread and copious rain and snow soaked many mountain regions during November and December, dry conditions have largely prevailed in the last month. These conditions are expected to continue for the most part because the La Niña event is forecast to persist into spring. The La Niña also is influencing forecasts in New Mexico. There is a 50 percent chance that the March–July flow in the Rio Grande, measured at Otowi Bridge, and the Gila River, measured near Virden, will be 88 and 78 percent of average, respectively. On the other hand, above-average flows are expected in the Mimbres and Pecos rivers. Streamflow forecasts are issued every month for New Mexico and every two weeks for Arizona and become progressively more accurate as the winter progresses.

Spring inflow to Lake Powell is forecast to be about 64 percent of the 1971–2000 average for April–July, or about 3.2 million acre-feet. The forecast also indicates a 30 and 10 percent chance that Lake Powell inflow will be 81 and 109 percent of average, providing an indicator that above-average flows are unlikely. Last winter's exceptionally high streamflows, which increased combined storage in Lakes Mead and Powell by about 7 million acre-feet between April and July—or about 2 million more than average—will buffer below-average flows in the Colorado River this year.

Figure 12. Spring and summer streamflow forecast as of January 1 (percent of average).



Notes:

Water supply forecasts for the Southwest are coordinated between the National Water and Climate Center, part of the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS), and the Colorado Basin River Forecast Center (CBRFC), part of NOAA. The forecast information provided in Figure 12 is updated monthly by the NWCC. Unless otherwise specified, all streamflow forecasts are for streamflow volumes that would occur naturally without any upstream influences, such as reservoirs and diversions. The coordinated forecasts by NRCS and NOAA are only produces for Arizona between January and May, and for New Mexico between January and May.

The NRCS provides a range of forecasts expressed in terms of percent of average streamflow for various exceedance levels. The forecast presented here is for the 50 percent exceedance level, and is referred to as the most probable streamflow. This means there is at least a 50 percent chance that streamflow will occur at the percent of average shown in Figure 12. The CBRFC provides a range of streamflow forecasts in the Colorado Basin ranging from short fused flood forecasts to longer range water supply forecasts. The water supply forecasts are coordinated monthly with NWCC.

On the Web:

For state river basin streamflow probability charts, visit:
http://www.wcc.nrcs.usda.gov/cgibin/strm_cht.pl

For information on interpreting streamflow forecasts, visit:
http://www.wcc.nrcs.usda.gov/factpub/intrpret.html

For western U.S. water supply outlooks, visit:
http://www.wcc.nrcs.usda.gov/wsf/westwide.html
http://www.cbrfc.noaa.gov

El Niño Status and Forecast

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

In the last 30 days, the average temperature in the upper 300 meters (about 1,000 feet) of the eastern Pacific Ocean cooled. The most recent average weekly sea surface temperature (SSTs) across parts of the tropical Pacific Ocean was about 1 degree Celsius below average, indicative of a weak to moderate La Niña event. Also, in this region the near-surface easterly winds strengthened over the central and west-central Pacific, and the Southern Oscillation Index (SOI), which measures the atmospheric circulation in the tropical Pacific Ocean, increased (*Figure 13a*). These conditions suggest the ocean and atmosphere are working in concert to maintain the La Niña event. This evolution is consistent with past events, in which the atmospheric components of La Niña become strongest and most well defined during the winter.

There is a strong likelihood that the weak to moderate strength of this event will continue for a month or more before it begins to weaken in late February and March, according to the International Research Institute for Climate and Society (IRI). Based on both statistical and dynamical forecast models, there is greater than a 95 percent chance that the La Niña will continue during the January–March period (*Figure 13b*). In the March–May period, chances become about equal for either a neutral event or a La Niña; by April–June it is likely that neutral conditions will return. Continued La Niña conditions likely will cause dry conditions in Arizona and New Mexico, according to the NOAA-Climate Prediction Center.

Notes:

The first figure shows the standardized three month running average values of the Southern Oscillation Index (SOI) from January 1980 through December 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 13a. The standardized values of the Southern Oscillation Index from January 1980–December 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).

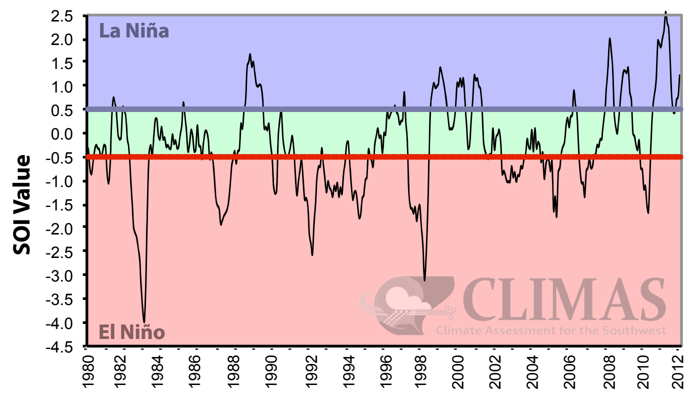


Figure 13b. IRI probabilistic ENSO forecast for El Niño 3.4 monitoring region (released January 19). Colored lines represent average historical probability of El Niño, La Niña, and neutral conditions.