March 21, 2012

Southwest Climate Outlook

Vol. 11 Issue 3

Storms have been few and far between in the Southwest this winter, leaving most of the region drier than average. A storm beginning on March 18, however, delivered much needed moisture to Tucson, where this photo was taken, and many other parts of Arizona. The event also brought several spurts of graupel, or soft hail. *Photo source: Bob Maddox*

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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

March Climate Summary

Drought: Drought conditions continue to expand and intensify across Arizona, while severe drought continues to grip much of New Mexico.

Temperature: Several storms in February resulted in slightly below-average temperatures in Arizona and western New Mexico. The storms dodged eastern New Mexico, causing warmer-than-average temperatures there.

Precipitation: Precipitation in most of Arizona and New Mexico has been less than 75 percent of average in the past month.

ENSO: The current La Niña event is running out of steam and is expected to end by late April. ENSO-neutral conditions are forecast to hold sway through the spring and summer seasons.

Climate Forecasts: Warming trends in recent decades are driving forecasts for above-average spring and summer temperatures in the Southwest. Precipitation forecasts for these periods, however, are less definitive—monsoon season forecasts have historically been about as accurate as a coin flip.

The Bottom Line: Below-average rain and snow is almost guaranteed for many parts of the Southwest this winter in large part because of La Niña's influence. Despite a recent winter storm that brought much needed moisture to the Southwest around March 18, snowpacks and precipitation across most of the region are mostly below average. Similar to last year, January and February were dry, and rain and snow tallied less than 50 percent of average in these months in many parts of the Southwest. As a result, drought has expanded and intensified, most notably in Arizona. The scant precipitation is also driving forecasts that call for a 40 percent chance that spring flows in the Verde, Salt, and Gila rivers will be less than 60 percent of average, while the Rio Grande likely will be less than 90 percent of average. The Upper Colorado River Basin, which received historically high snowpacks during last winter's La Niña event, also likely will experience well below-average streamflows this spring and summer. While the La Niña event is expected to end in April, spring storms in the Southwest—most notably in Arizona—are often few and far between, presenting few opportunities to overcome shortfalls in precipitation before the monsoon begins.

Comprehensive report on climate change in the Southwest open to public comment

The most comprehensive assessment on climate changes, impacts, and adaption strategies for the Southwest will be ready for public review on March 28. In the report, "Assessment of Climate Change in the Southwest United States: A Technical Report Prepared for the U.S. National Climate Assessment," 100 experts focused exclusively on the links between climate, environment, and people in the Southwest, including Arizona and New Mexico. In this region, climate changes will continue to affect water supply, agriculture, energy production, vast stretches of coastline, an international border, and more. The report will make critical scientific contributions that help communities create more sustainable and environmentally sound plans for the future.

This report conforms to the Global Change Research Act of 1990, a federal mandate to synthesize climate-related information every four years. The editors and authors seek public comments on the report's content and evidence used to support assessments. The open review will be held online beginning at 12 p.m. (PDT) Wednesday, March 28, and ending at 11:59 p.m. (PDT) Wednesday, April 11.

Learn more at http://swcarr.arizona.edu.

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

Warmer Led to Drier: Dissecting the 2011 Drought in the Southern U.S.

By Jeremy L. Weiss[1], Jonathan T. Overpeck[1,2,3], Julia E. Cole[1,3]

When prolonged high temperatures combine with scant precipitation, droughts intensify. This potent combination struck the southern U.S. in spring and summer of 2011—and may again in coming months—causing crops to wither and turning trees and shrubs into tinder. Record-setting wildland fires raced across parts of the Southwest and southern Plains. By the end of September, exceptional drought covered about half of Arizona, New Mexico, Texas, and Oklahoma combined. When all was said and done, damages exceeded $1 billion, according to the National Oceanic and Atmospheric Administration (NOAA).

Research has shown that unusually warm temperatures can conspire with low precipitation to intensify droughts and worsen their impacts (Breshears et al. 2005; Weiss et al. 2009). We set out to assess how much temperatures exacerbated the dry spell in 2011, and our analysis showed that the widespread warmth experienced in the southern U.S. substantially compounded conditions brought about by the shortfall of moisture.

With the expectation that warmer temperatures will be a mainstay of future climate, our results highlight the potential that the Southwest will experience intensified droughts. Warmer temperatures, in other words, can lead to drier conditions.

Vapor Pressure Deficit: The Roles of Temperature and Moisture

We distinguished the roles of low moisture and high temperatures during the April–September 2011 period by determining the moisture- and temperature-dependent contributions to vapor pressure deficit, or VPD. VPD is an estimate of the atmospheric demand for both evaporation and transpiration, or evapotranspiration, and can be thought of as the atmosphere's ability to act like a sponge and wick moisture from soils and vegetation.

VPD is the difference between saturation and actual vapor pressure (Campbell and Norman 1998). Larger differences signal greater evapotranspirational demand and can lead to more intense drought conditions. While air temperature controls saturation vapor pressure (SVP), the maximum water vapor that the atmosphere can hold, atmospheric moisture sets the dewpoint that governs actual vapor pressure (AVP). VPD can increase from either higher SVP—driven by warmer temperatures—or decreases in AVP, which results from lower dewpoints.

Extreme Conditions in 2011

From April through September 2011, warmer temperatures extended from southern Arizona to the southern Atlantic coast, with temperatures greater than 1.5 degrees Celsius above average for many parts of the Southwest and southern Plains (*Figure 1a*). Several areas in these regions experienced relatively extreme temperatures, ranked in the highest one percent (*Figure 1b*).

At the same time, below-average dewpoints occurred almost exclusively over the Southwest and southern Plains, reflecting the shortage of moisture in these regions. Most areas from central Texas westward experienced dewpoints that were greater than 1.5 degrees C below average (*Figure 1c*). In many of these areas, dewpoints were also relatively extreme, falling in the lowest 1 percent (*Figure 1d*).

VPDs in the highest 1 percent blanketed almost all of Texas, western Oklahoma, and eastern New Mexico and covered substantial parts of several adjacent states

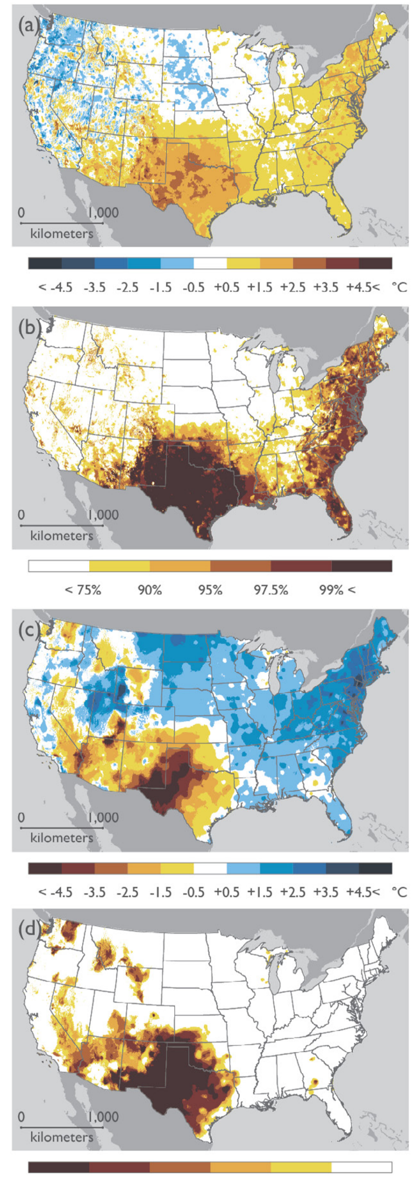

Figure 1. (a) Temperature anomalies (°C) in the U.S. for 2011 April–September. (b) Areas with temperatures above upper percentiles. (c) Dewpoint anomalies (°C) for 2011 April–September. (d) Areas with dewpoints below lower percentiles. Anomalies are relative to and percentiles are derived from the 1951–1980 April–September average. The PRISM Group at Oregon State University. provided gridded observational data for temperature and dewpoint.

continued on page 4

Warmer Led to Drier, continued

during this period, including Arizona (*Figure 2a*). The geographic extent of relatively extreme VPD matches areas that experienced the most severe drought impacts during this time.

Dissecting the 2011 Drought

The combined effects of temperature and scant moisture are presented in figure 2b. We then calculated VPD under two scenarios to examine the relative contributions of temperature and atmospheric moisture to 2011 VPD during April–September (*Figure 2b*). In the first, we calculated VPD using 2011 temperature and the 1951–1980 average dewpoint (*Figure 2c*). In the second, we used the 1951–1980 average temperature and 2011 dewpoint (*Figure 2d*). These two scenarios represent the contributions of above-average temperature, or higher SVP, and below-average dewpoint, or lower AVP, respectively, to the observed 2011 evapotranspirational demand.

Splitting VPD into SVP and AVP anomalies shows that below-normal dewpoints in 2011 produced greater evapotranspirational demand over southern and eastern New Mexico, western Oklahoma, and most of Texas (*Figure 2d*). Above-average temperatures during the drought played a widespread role in exacerbating the influence of the lower moisture (*Figure 2c*). This one-two punch of lower moisture and higher temperatures created extraordinary evapotranspirational demand over many parts of the southern U.S.

The effect of feedbacks between the land surface and atmosphere in elevating temperature and lowering atmospheric moisture during drought in the Southwest and southern Plains is unclear in our study (Schubert et al. 2004). However, extensive warmth across much of the southern U.S. suggests that such feedbacks in these regions were not the sole reason for higher evapotranspirational demand.

This analysis illustrates the potent influence that higher temperatures can have on current and future droughts in our region. Even though changes in future moisture are sometimes subject to notable uncertainty, particularly for the monsoon season, the potential for greater evapotranspirational demand and, as a result, intensified droughts, will grow as the Southwest continues to warm (Solomon et al. 2007; Karl et al. 2009).

Further Reading

Breshears, et al. 2005. Regional Vegetation Die-off in Response to Global-change-type Drought. *Proc. Natl. Acad. Sci.* U.S.A. 102, 15,144-15,148.

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Karl, T.R., J.M. Melillo, and T.C. Peterson. 2009. *Global Climate Change Impacts in the United States*. Cambridge University Press.

Schubert, S.D., M.J. Suarez, P. J. Pegion, R.D. Koster, and J.T. Bacmeister. 2004. On the Cause of the 1930s Dust Bowl. *Science* 303, 1855-1859.

Solomon, et al. 2007. *Climate Change 2007: The Physical Science Basis. Contributions of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press.

Weiss, J.L., C.L. Castro, and J.T. Overpeck. 2009. Distinguishing Pronounced Droughts in the Southwestern United States: Seasonality and Effects of Warmer Temperatures, *J. Climate* 22, 5918-5932.

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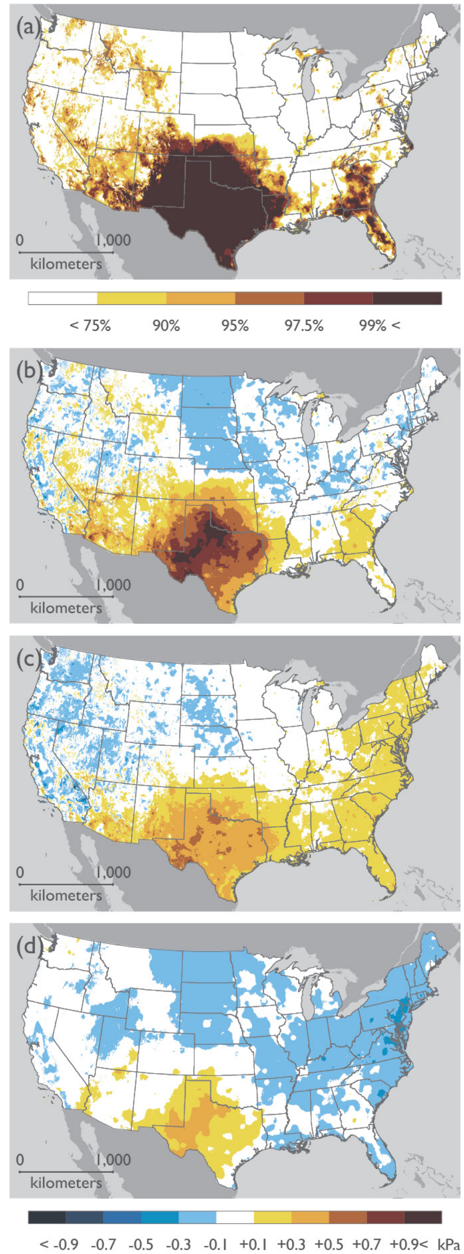


Figure 2. (a) Areas of the U.S. where 2011 April–September vapor pressure deficit (VPD) was above upper percentiles, derived from 1895–2011 April–September VPD. Panels b–d show VPD anomalies for April–September computed with (b) 2011 temperature and 2011 dewpoint; (c) 2011 temperature and 1951–1980 dewpoint (which represents the temperature contribution to 2011 evapotranspirational demand); and (d) 1951–1980 temperature and 2011 dewpoint (which shows the atmospheric moisture contribution to 2011 evapotranspirational demand). Anomalies are relative to the 1951–1980 average April–September VPD.

Temperature (through 3/14/12)

Data Source: High Plains Regional Climate Center

Temperatures since the water year began on October 1 have averaged between 30 and 50 degrees Fahrenheit in New Mexico and the Colorado Plateau, while the southwest deserts of Arizona have averaged between 50 and 65 degrees F (*Figure 1a*). The coldest temperatures have been in the higher elevations in Arizona and in the northern counties of New Mexico. Temperatures have been mostly within 1 degree F of average across both states (*Figure 1b*). The distribution of warmer- and colder-than-average areas is related to the winter storm tracks, which have been highly variable throughout this winter. For the most part, cold air has stayed far to the north, which is in part related to positive Arctic Oscillation (AO) values—cold air is generally confined in the Arctic region during a positive AO. A few cold storms have wafted as far south as northern Mexico, catching southern Arizona and New Mexico as they past.

In the past 30 days, two winter storms have moved across the Southwest, bringing cold air and 1–6 degree F below-average temperatures in Arizona and western New Mexico (*Figures 1c–d*). Eastern New Mexico was the only area with above-average temperatures; the jet stream looped farther north and into Canada, which allowed temperatures to rise 10–20 degrees F above average over many parts of the central U.S.

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.

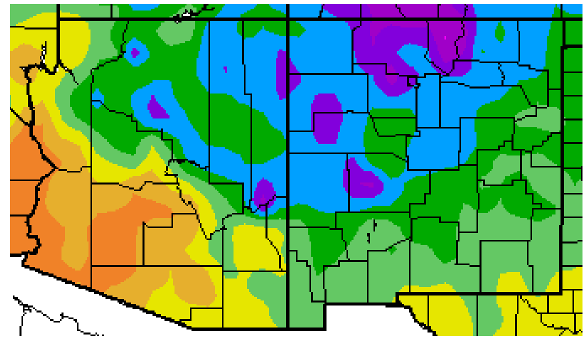
These are experimental products from the High Plains Regional Climate Center.

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 March 14) average temperature.



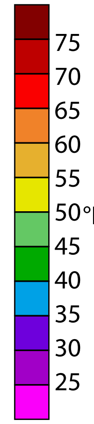
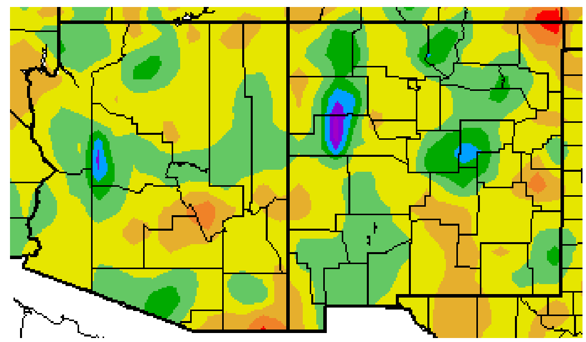


Figure 1b. Water year 2011 (October 1 through March 14) departure from average temperature.



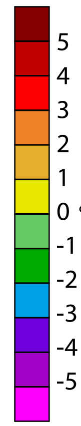
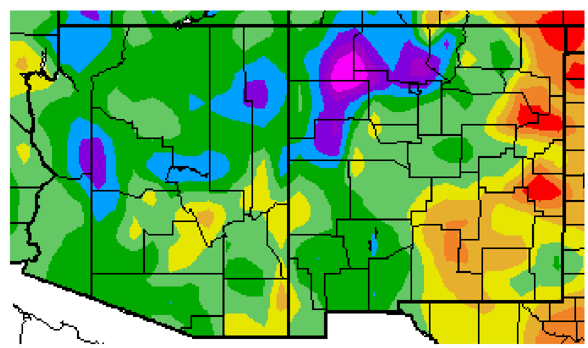


Figure 1c. Previous 30 days (February 14–March 14) departure from average temperature (interpolated).



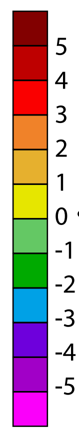
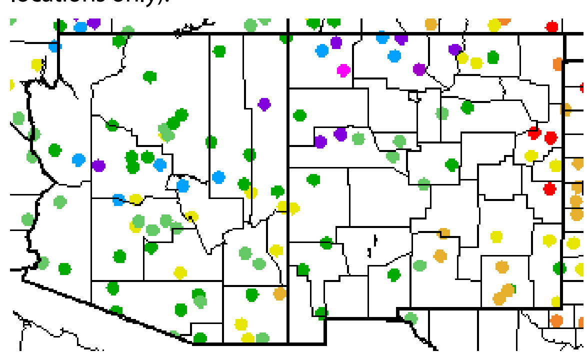
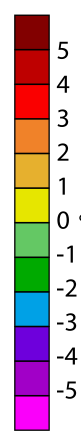


Figure 1d. Previous 30 days (February 14–March 14) departure from average temperature (data collection locations only).





Precipitation (through 3/14/12)

Data Source: High Plains Regional Climate Center

Precipitation since the water year began on October 1 generally has been between 50 and 70 percent of average in Arizona and southern and eastern counties of New Mexico (*Figures 2a–b*). Maricopa and Mohave counties and northern Apache County have been particularly dry, measuring less than 50 percent of average. Most of Southern California also has seen scant rain and snow. The cause of the dry weather in Arizona and California has been the position of the storm track. Generally, storms have either moved south into Mexico before wafting northeast through New Mexico, or they have tracked through Nevada and Utah before dropping down into New Mexico. Both of these trajectories have been a boon to northern and central New Mexico, however, as precipitation there has been between 100 and 300 percent of average.

In the past 30 days, only two winter storms passed through Arizona. The first dumped precipitation across the northern counties in Arizona and northwestern New Mexico, while the other wafted south into Mexico, dropping precipitation on the southeast corner of Arizona and the southwest corner of New Mexico. Most of the Southwest experienced precipitation totaling less than 75 percent of average, but several areas received well-above average rain and snow. The high variability in the past month—from 2 percent of average in many areas to more than 400 percent of average in others—is not unusual during La Niña winters. La Niña events tend to bring drier, more variable conditions, while El Niño events often more consistently deliver wet conditions.

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 March 14) percent of average precipitation (interpolated).

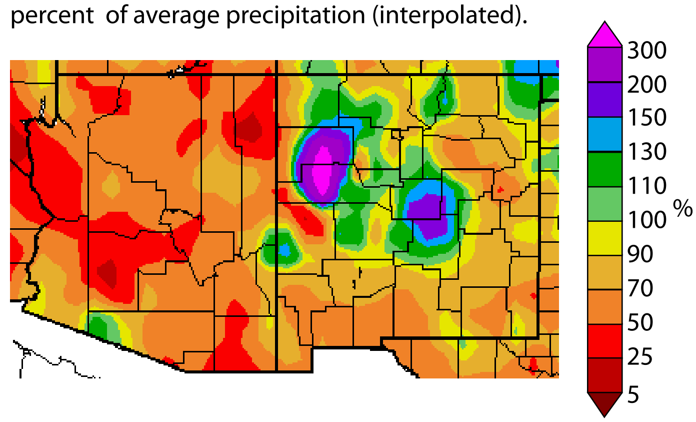


Figure 2b. Water year 2011 (October 1 through March 14) percent of average precipitation (data collection locations only).

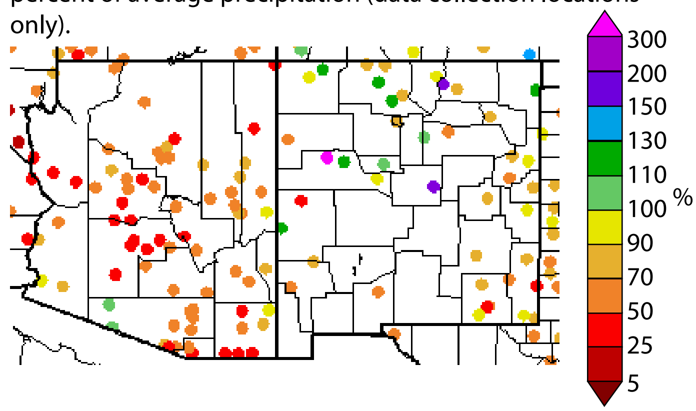


Figure 2c. Previous 30 days (February 14–March 14) percent of average precipitation (interpolated).

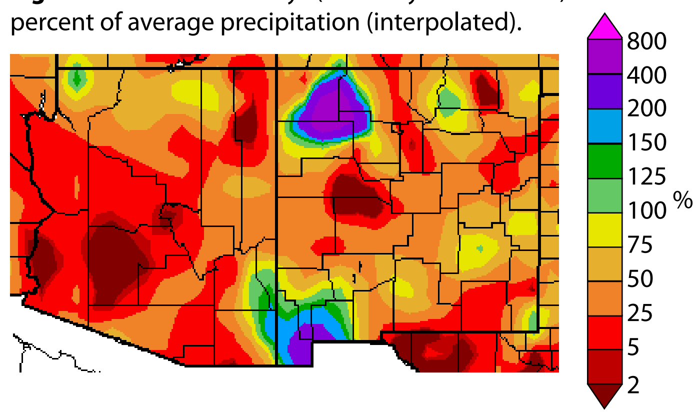
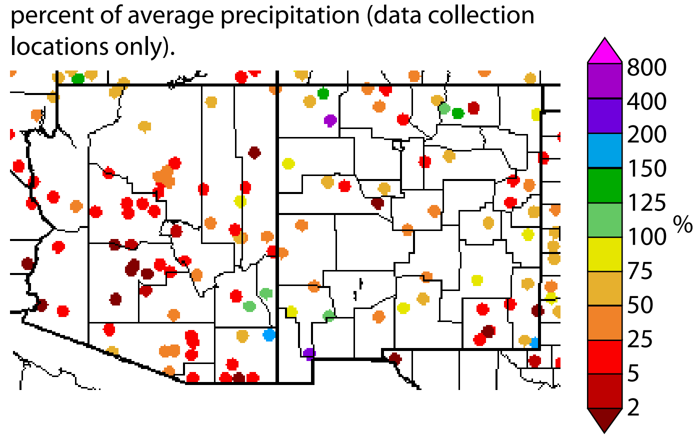


Figure 2d. Previous 30 days (February 14–March 14) percent of average precipitation (data collection locations only).



U.S. Drought Monitor (data through 3/13/12)

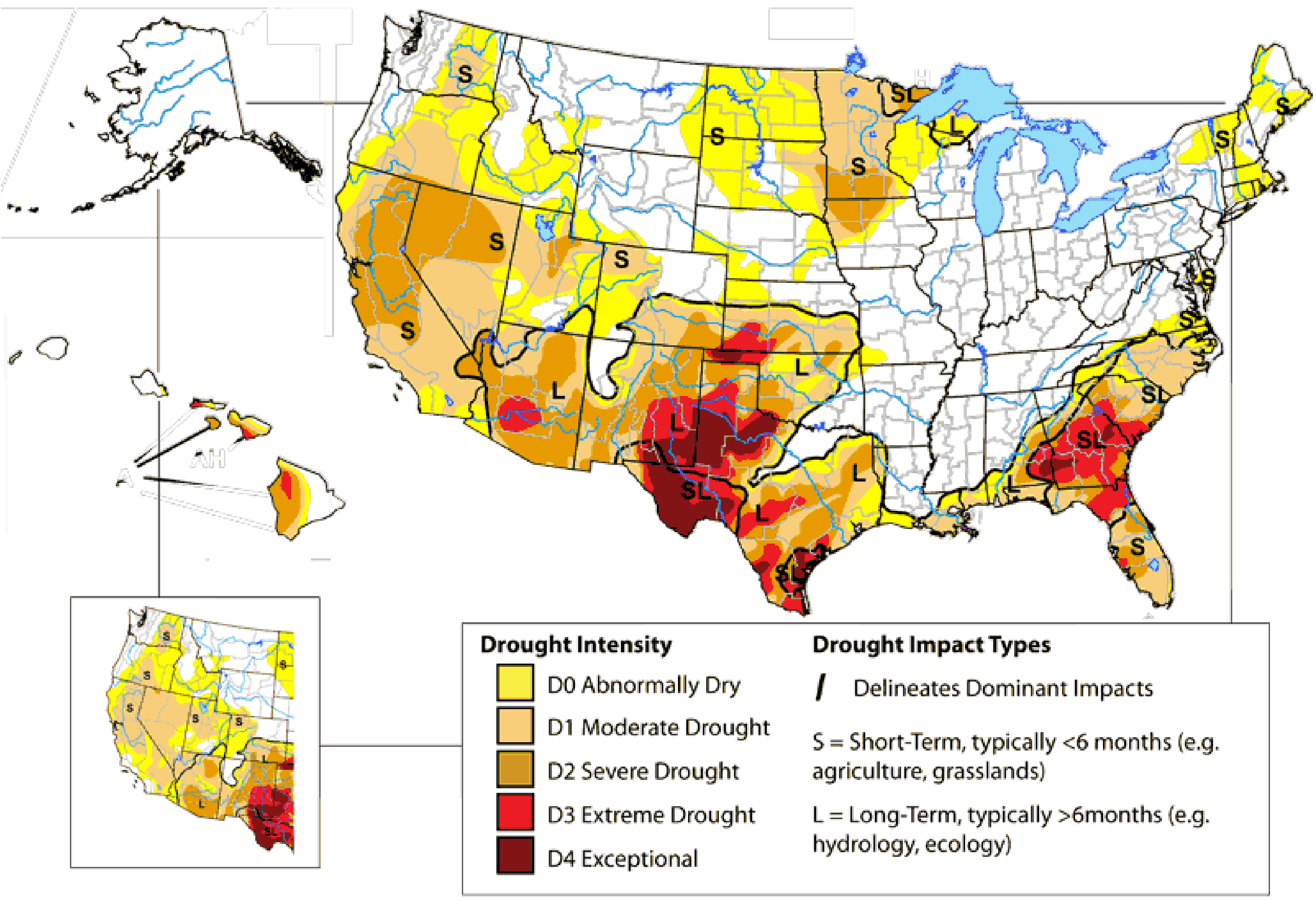
Data Sources: U.S. Department of Agriculture, National Drought Mitigation Center, National Oceanic and Atmospheric Administration

Much of the western U.S. received below-average precipitation during the past 30 days, causing drought conditions to expand and intensify across many regions, according to the March 13 update of the U.S. Drought Monitor (*Figure 3*). Parts of the Pacific Northwest and northern Rockies experienced wet conditions where a few late winter storms delivered heavy snow to the mountains and copious rains elsewhere. Precipitation in these areas was 150–200 percent above average and helped maintain drought-free conditions. The biggest downgrades in short-term drought conditions occurred across Arizona, Nevada, and central California, where dry conditions prevailed from late December to mid-March. Drought has intensified from moderate to severe in many parts of these states. Upcoming months offer few opportunities for precipitation as the spring season is normally dry.

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 March 13, 2012 (full size), and February 14, 2012 (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 3/13/12)
Data Source: U.S. Drought Monitor

Drought conditions have expanded and intensified across Arizona during the past 30 days, according to the March 13 update of the U.S. Drought Monitor. Although a few storms moved across the Southwest in late February and early March, they ferried scant rain and snow, causing precipitation deficits to mount across the region. A much-needed winter storm struck many parts of Arizona and New Mexico around March 18, but more rain and snow is needed to compensate for a dry January and February.

As of March 14, precipitation across Arizona during the previous 30 days was less than 50 percent of average for all of the state, with many central and western locations recording no precipitation at all. This late winter dry spell caused severe drought conditions to expand north and west. Drought now occupies more than 60 percent of the state, an increase of about 27 percent from one month ago (*Figures 4a–b*). Extreme drought conditions also have developed over Maricopa and Pinal counties, where total winter precipitation values are less than 10 percent of average. About 92 percent of the state was classified with moderate or a more severe drought category as of March 13.

Notes:

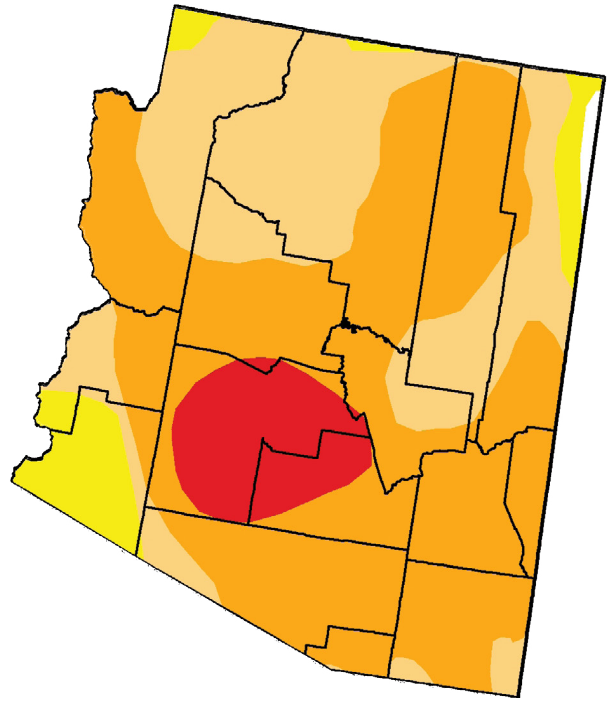
The Arizona section of the U.S. Drought Monitor is released weekly (every Thursday) and represents data collected through the previous Tuesday. The maps are based on expert assessment of variables including (but not limited to) the Palmer Drought Severity Index, soil moisture, streamflow, precipitation, 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 March 13.



Drought Intensity

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

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

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	0.47	99.53	92.82	62.25	8.52	0.00
Last Week (03/06/2012 map)	0.47	99.53	91.72	46.23	0.00	0.00
3 Months Ago (12/13/2011 map)	1.53	98.47	71.18	48.80	29.06	0.00
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 (03/08/2011 map)	29.07	70.93	40.88	12.59	5.60	0.00

New Mexico Drought Status
(data through 3/13/12)

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

Drought conditions across New Mexico did not substantially change from one month ago, according to the March 13 update of the U.S. Drought Monitor. A few spots of above-average precipitation occurred in the last month, but most of New Mexico received less than 75 percent of average precipitation. Some decent precipitation in the southwest corner of the state in late February helped upgrade severe drought conditions to moderate drought levels (*Figure 5a*). In spite of this, almost 80 percent of the state is experiencing moderate or a more severe drought category (*Figure 5b*). This pattern of widespread and intense drought conditions across New Mexico has persisted for almost 14 consecutive months. The last time New Mexico was generally drought-free was in October 2010, when abnormally dry conditions covered only 23 percent of the state.

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

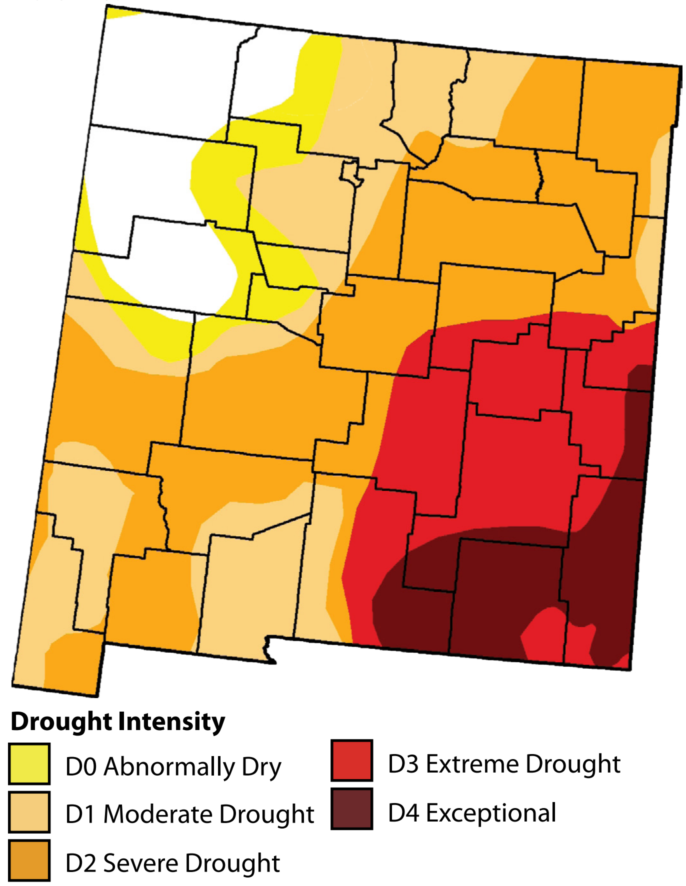


Figure 5b. Percent of New Mexico designated with drought conditions based on data through March 13.

	Drought Conditions (Percent Area)					
	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	11.31	88.69	81.79	60.06	24.94	9.13
Last Week (03/06/2012 map)	11.31	88.69	81.79	58.04	24.94	9.13
3 Months Ago (12/13/2011 map)	8.63	91.37	87.83	81.59	39.47	17.93
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 (03/08/2011 map)	7.97	92.03	62.56	33.32	0.17	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 2/29/12)

Data Source: National Water and Climate Center

Combined storage in Lakes Mead and Powell decreased by 310,000 acre-feet in February, but combined storage is still about 12 percent greater than it was one year ago due to copious winter snow in 2010–2011. Storage fell more in Lake Powell because the interim guidelines on coordinated operations of both reservoirs dictate equalizing storage. In other reservoirs in Arizona, the Salt River Basin system, which supplies water to the Phoenix metropolitan area, increased by about 5,000 acre-feet in February and is 72 percent full and 12 percent above average for this time of year (*Figure 6*). However, Verde River Basin reservoirs declined by 8,000 acre-feet in February and are at 23 percent of capacity.

In water-related news, construction is underway at Lake Mead to build a third intake pipe, which will ensure that water can be directed to the Las Vegas valley even in times of severe storage decline (*Las Vegas Review Journal*, March 6). The intake pipe will be the deepest of the three. Completion of the $800 million project is slated for 2014.

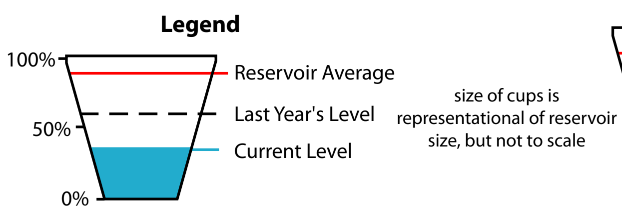
Notes:

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.

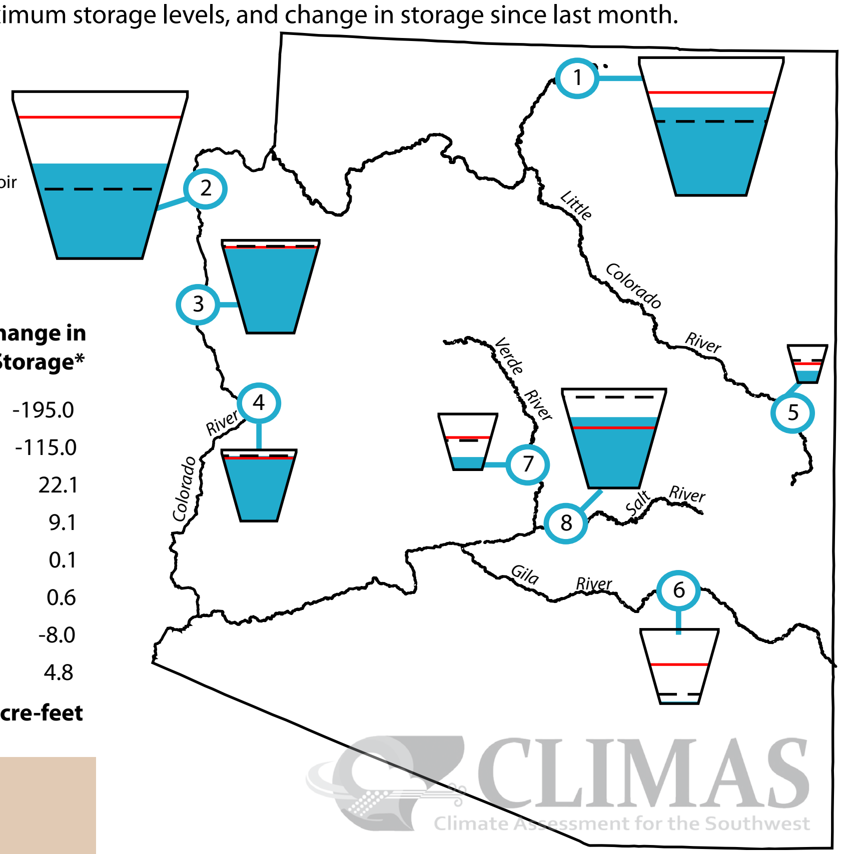
These data are based on reservoir reports updated monthly by the National Water and Climate Center of the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS).

Figure 6. Arizona reservoir levels for February 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	64%	15,453.0	24,322.0	-195.0
2. Lake Mead	57%	14,907.0	26,159.0	-115.0
3. Lake Mohave	91%	1,649.8	1,810.0	22.1
4. Lake Havasu	91%	563.0	619.0	9.1
5. Lyman Reservoir	32%	9.6	30.0	0.1
6. San Carlos	3%	24.3	875.0	0.6
7. Verde River System	23%	65.4	287.4	-8.0
8. Salt River System	72%	1,458.0	2,025.8	4.8

*** 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 2/29/12)

Data Source: National Water and Climate Center

Total reservoir storage in New Mexico increased by 16,000 acre-feet in February (*Figure 7*). Storage in Elephant Butte Reservoir is 367,000 acre-feet, only 17 percent of capacity, but increased by about 35,000 acre-feet in February. On the other hand, Pecos River reservoir storage decreased by 5,700 acre-feet during the last month and all reservoirs on the river have below-average storage (reservoirs 9–12).

In water-related news, Albuquerque's daily water usage dropped below 150 gallons per person in 2011, meeting a state regulatory goal 13 years ahead of the deadline (*Albuquerque Journal*, March 13). In 1994, daily per capita usage was about 252 gallons. Despite population growth, 6 billion gallons were saved in comparison to consumption in 1994. Awareness campaigns, lawn removal rebates, and new house appliance standards were among the strategies used to reduce water use.

Notes:

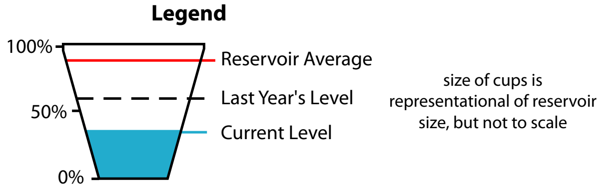
The map gives a representation of current storage levels for reservoirs in New Mexico. Reservoir locations are numbered within the blue circles on the map, corresponding to the reservoirs listed in the table. The cup next to each reservoir shows the current storage level (blue fill) as a percent of total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

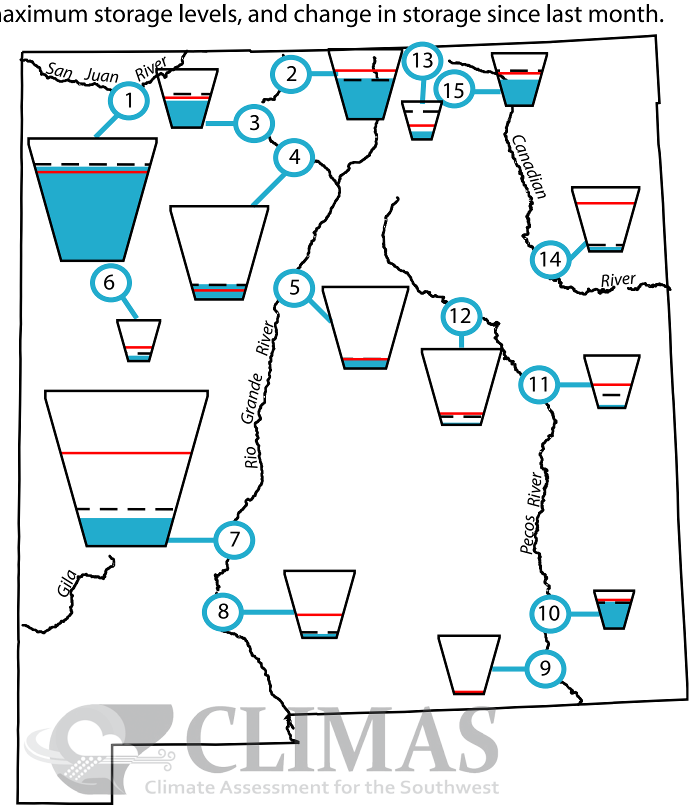
Figure 7. New Mexico reservoir levels for February as a percent of capacity. The map depicts the average level and last year's storage for each reservoir. The table also lists current and maximum storage levels, and change in storage since last month.

Legend



Reservoir Name	Capacity Level	Current Storage*	Max Storage*	Change in Storage*
1. Navajo	76%	1284.9	1,696.0	-11.0
2. Heron	57%	226.6	400.0	0.0
3. El Vado	45%	86.2	190.3	-0.1
4. Abiquiu	15%	175.3	1,192.8	-3.1
5. Cochiti	10%	50.9	491.0	-0.3
6. Bluewater	12%	4.7	38.5	0.1
7. Elephant Butte	17%	367.0	2,195.0	35.1
8. Caballo	5%	16.3	332.0	1.5
9. Brantley	1%	14.9	1,008.2	1.7
10. Lake Avalon	70%	2.8	4.0	0.2
11. Sumner	5%	4.6	102.0	-7.5
12. Santa Rosa	2%	10.1	438.3	-0.1
13. Costilla	20%	3.2	16.0	0.3
14. Conchas	6%	14.5	254.2	-1.1
15. Eagle Nest	49%	38.8	79.0	0.3

*** 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

Southwest Snowpack

(updated 3/15/12)

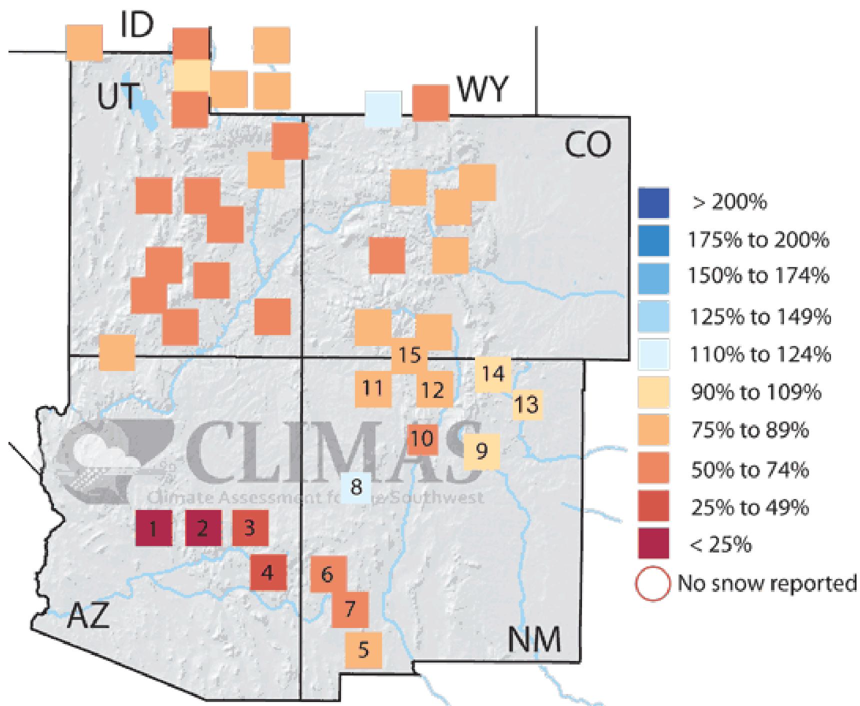
Data Sources: National Water and Climate Center, Western Regional Climate Center

Below-average precipitation across most of the region in the last month caused snowpacks to decrease in Arizona and New Mexico. In Arizona, the amount of water contained in snowpacks, or snow water equivalent (SWE), measured by snow telemetry (SNOTEL) stations was less than 50 percent of average in all but one river basin as of March 15 (*Figure 8*). The central Mogollon Rim and the Verde River Basin measured only 15 and 20 percent of average, respectively. The San Francisco Peaks had the highest SWE, at 81 percent of average—down 14 percent from one month before. A recent storm beginning on March 18 and not reflected in the SWE values reported here will help boost snowpacks in Arizona but likely will not push values above average in many places.

In New Mexico, seven of the 11 river basins reported in Figure 8 had well below-average snowpacks. The San Francisco and the Gila river basins, located in the southwest corner of the state, measured 50 percent of average. The Zuni/Bluewater River Basin in central New Mexico was the only basin with above-average SWE, measuring 121 percent of average. Northern areas benefited from a few storms in February, but high winds increased sublimation, especially at lower elevations. Sublimation is the transformation of snow to water vapor, which reduces snowpacks.

Colorado and Utah also have below-average SWE, with all but one basin reporting below-average snowpacks. Snowpacks may melt earlier than average this year, as the NOAA-Climate Prediction Center (CPC) forecasts above-average spring temperatures. There is still ample time for spring storms to blanket the mountains in snow, although forecasts call for equal chances for above-, below,- or near-average precipitation.

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

(April–September 2012)

Data Source: NOAA-Climate Prediction Center (CPC)

The seasonal temperature outlooks issued by the NOAA-Climate Prediction Center (CPC) in March call for increased odds that temperatures for the three-month seasons spanning April to September will be similar to the warmest 10 years in the 1981–2010 period (*Figures 9a–d*). The above-average temperatures for the April–June period reflect recent warming trends that override cooler temperatures often brought on by La Niña events—La Niña is currently weak. For this period, there is a 50–60 percent chance that temperatures will be 1.0–1.5 degrees F above average in southeastern Arizona and southwestern New Mexico. The outlooks also forecast more than a 50 percent chance of above-average temperatures in the summer months, also reflecting recent warming trends for the monsoon season.

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 April–June 2012.

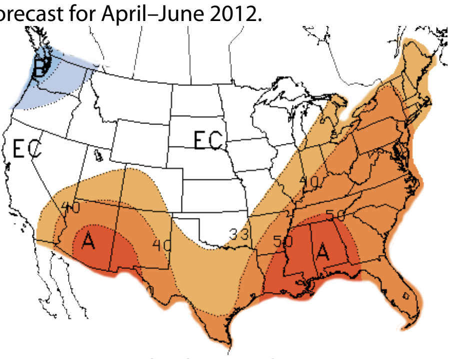
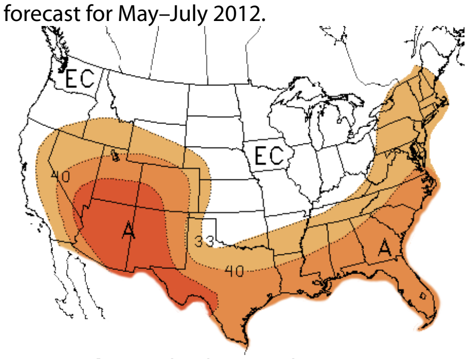
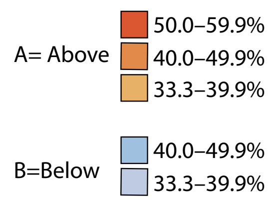


Figure 9b. Long-lead national temperature forecast for May–July 2012.





EC= Equal chances. No forecasted anomalies.

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

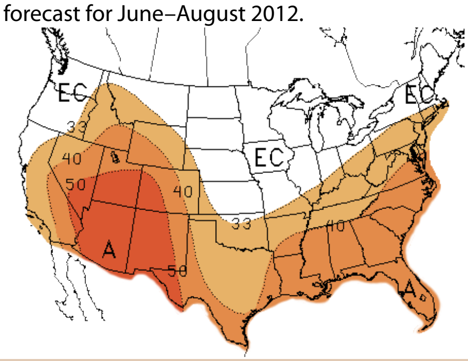
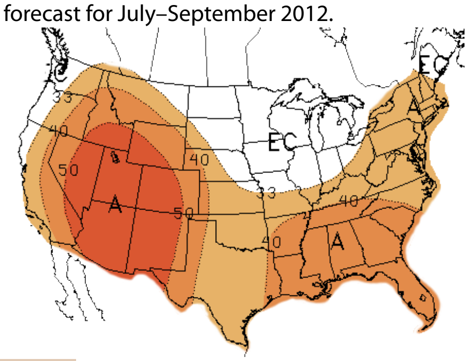


Figure 9d. Long-lead national temperature forecast for July–September 2012.



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
(April–September 2012)

Data Source: NOAA-Climate Prediction Center (CPC)

The seasonal precipitation outlooks issued by the NOAA-Climate Prediction Center (CPC) in March call for equal chances that precipitation will be above, below, or near average in most of Arizona and New Mexico (*Figures 10a–b*). While La Niña may give way to ENSO-neutral conditions in the tropical Pacific Ocean, enhanced probabilities for below-median precipitation continue in the April–June period in most of the Upper Colorado River Basin and parts of northern Arizona. This forecast is based in part on the delay response of the atmosphere to waning La Niña conditions and below-average soil moistures, which limit evaporation that would otherwise enhance precipitation.

For the summer months, forecasts have been less accurate during the monsoon season. Consequently, the CPC has no basis to favor wetter- or drier-than-average conditions and gives an equal chances outlook for the May–July, June–August, and July–September periods.

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 April–June 2012.

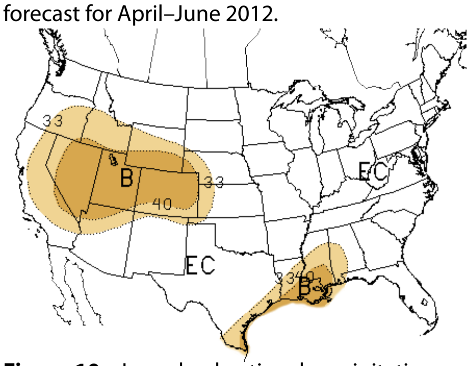


Figure 10b. Long-lead national precipitation forecast for May–July 2012.

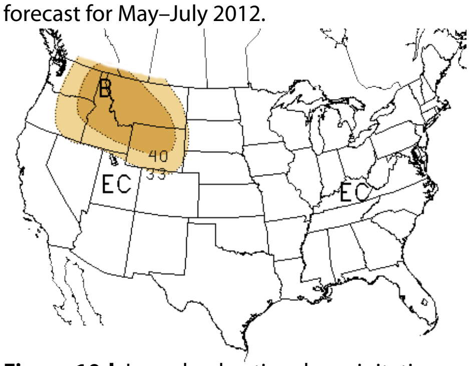


Figure 10c. Long-lead national precipitation forecast for June–August 2012.

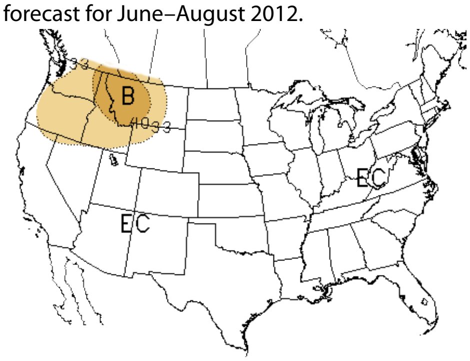
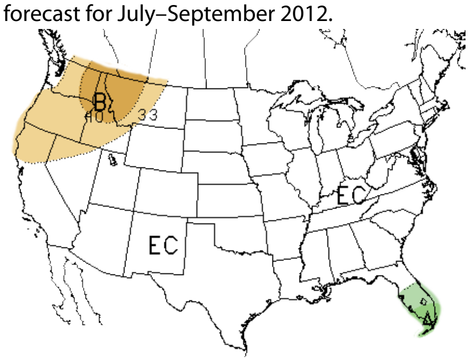
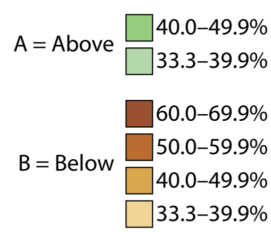


Figure 10d. Long-lead national precipitation forecast for July–September 2012.





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 June)

Data Source: NOAA–Climate Prediction Center (CPC)

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

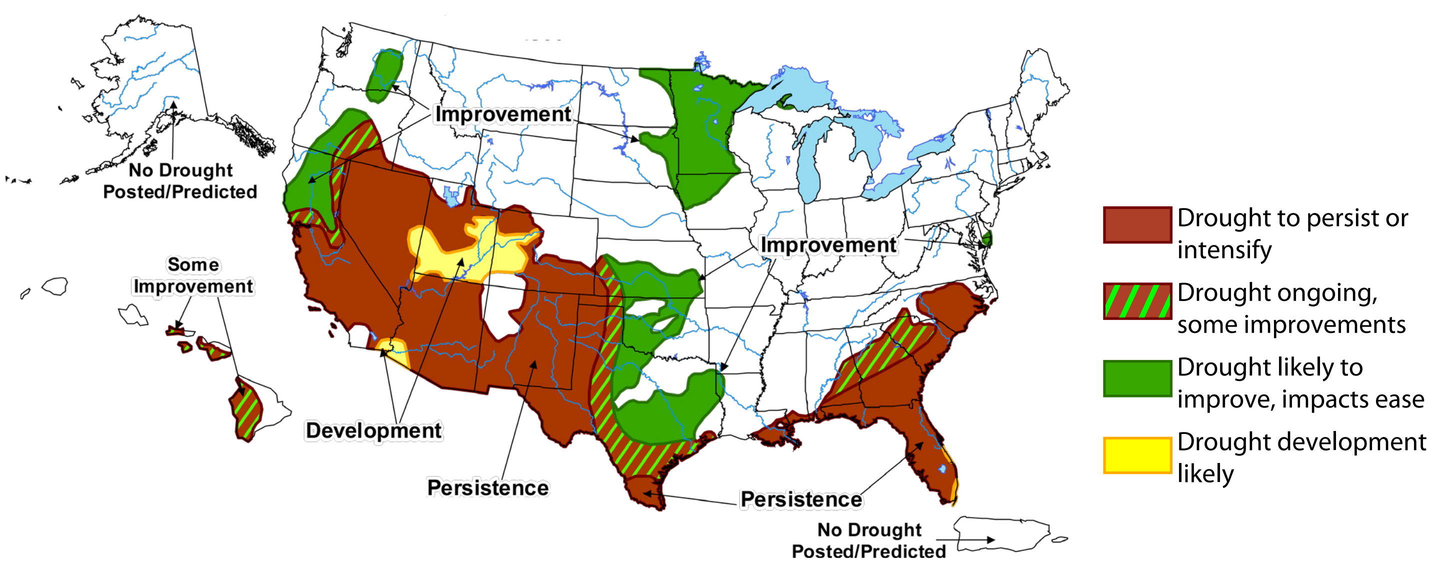
Precipitation has been below average for many parts of the Southwest since the water year began on October 1. As of March 13, water contained in snowpacks, or snow water equivalent (SWE), was between 75 and 130 percent of average across southwest Colorado and New Mexico, 60 to 80 percent of average across Utah, and 30 to 50 percent of average in Arizona. These numbers were boosted by a winter storm that hit the region on March 18, but was not sufficient to erase precipitation deficits that accumulated during the winter. As a result of the drier-than-average conditions, recent decreasing precipitation trends in April, and below-median precipitation forecasts for April, forecasts call for drought persistence, intensification, or development across the Southwest (*Figure 11*). The CPC assigns a moderate to high confidence in this forecast. Although not depicted on the map, an early onset of the monsoon in the Southwest could bring some drought improvement by the end of June—currently, there is no clear indication of an early or late start to the monsoon.

Elsewhere in the West, while the Pacific Northwest and northern California are expected to be wet, scant precipitation is more likely in Southern California. In addition, a recent decreasing precipitation trend in April favors the persistence of drought across the southern half of California. Persistence is also forecast for the northern Great Basin due to current dry conditions and few indications that the remainder of March will be wet. The CPC assigns a moderate confidence in the forecast for California and lower confidence for the outlook for the northern Great Basin and Washington.

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 June (released March 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

Streamflow Forecast
(for spring and summer)

Source: National Water and Climate Center

The March 1 spring-summer streamflow forecast for the Southwest shows a 50 percent chance that all but one basin in the upper and lower Colorado River and Arkansas watersheds will be below average (*Figure 12*). Only a few basins in the Rio Grande are expected to have above- or near-average flows.

In Arizona, the likelihood that the Salt, Verde, and Gila rivers will have streamflows of 37, 31, and 27 percent of the February–May average, respectively, is 50 percent. Although widespread and copious rain and snow fell in many basins in mid-March, this boost likely will not substantially increase spring streamflows. The La Niña helped deliver a dry spell that extended from late December to mid-March. This protracted period has all but ensured below-average streamflows for most of the Southwest, unless powerful and frequent late winter storms soak the region.

Winter precipitation in New Mexico has been more frequent and has delivered more rain and snow than in Arizona, but most streamflow forecasts also project below-average flows. There is a 50 percent chance that the March–July flow in the Rio Grande will be between 70 and 89 percent of average. On the other hand, near-average flows are expected in the Canadian River in northeast New Mexico. Streamflow forecasts are issued every month for New Mexico and every two weeks for Arizona. The forecasts become progressively more accurate as the winter progresses.

In the Upper Colorado River Basin, spring inflow to Lake Powell is forecast to be about 67 percent of the 1971–2000 average for April–July, or about 5.3 million acre-feet. This is a slight increase from forecasts issued on February 1 but is about 2.5 million acre-feet below average. The forecast also indicates only about a 10 percent chance that Lake Mead inflow will be above average. Last winter's exceptionally high streamflows, which delivered about 7 million acre-feet more than average to Lakes Mead and Powell, will help buffer below-average flows in the Colorado River this year.

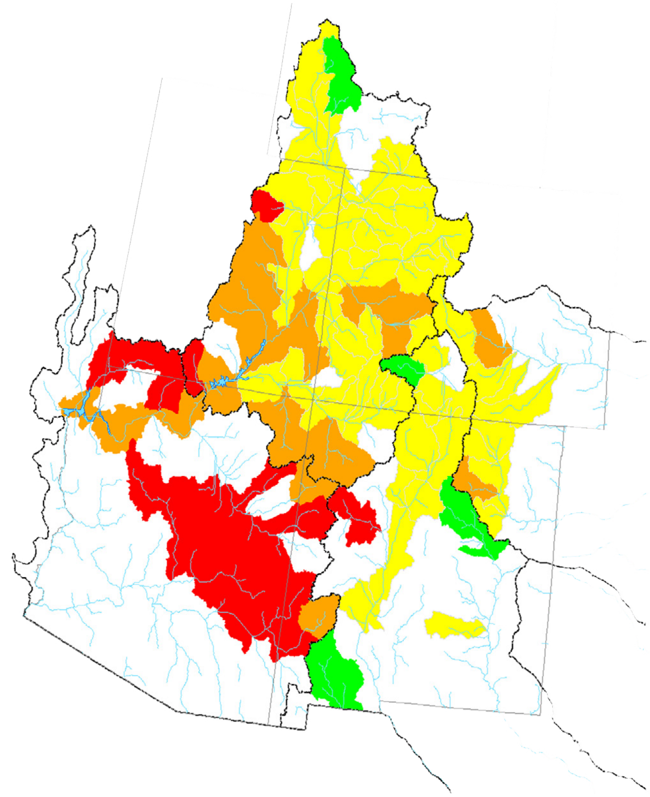
On the Web:

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

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



- exceptionally above average (>180%)
- much above average (150-180%)
- above average (130-149%)
- slightly above average (110-129%)
- near average (90-109%)
- slightly below average (70-89%)
- below average (50-69%)
- much below average (25-49%)
- exceptionally below average (<25%)
- No Forecast

Notes:

Water supply forecasts for the Southwest are coordinated between the National Water and Climate Center, part of the U.S. Department of Agriculturwwe'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.

El Niño Status and Forecast

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

La Niña conditions weakened substantially during the past 30 days and the NOAA-Climate Prediction Center (CPC) states that March will probably be the last month with an active La Niña Advisory, as ENSO-neutral conditions are expected to return by the end of April.

During the last couple of months, a pool of cold water below the sea surface has been critical in supporting the La Niña. This below-surface water has substantially warmed in the eastern Pacific over the past 30 days and, in combination with rising sea surface temperatures (SSTs), indicate the days are numbered for the La Niña event. Ocean water is usually the leading indicator of changes in ENSO conditions and it will take the atmosphere several months to catch up. Current atmospheric circulation patterns remain very La Niña-like, with enhanced easterly winds and suppressed convection in the central Pacific. Consequently, the Southern Oscillation Index (SOI) remains positive (*Figure 13a*). This pattern should yield to typical atmospheric circulation patterns by the late spring and summer.

Official forecasts issued jointly by NOAA-CPC and the International Research Institute for Climate and Society (IRI) indicate greater than a 70 percent chance that ENSO-neutral conditions will develop in the April–June period (*Figure 13b*). Forecasts also indicate that ENSO-neutral conditions will likely persist through the upcoming summer and fall seasons. The chance of an El Niño event returning also rises by late summer, but confidence is low in the forecast. However, since 1900 there have been 10 two-year La Niña events. In four of these events, La Niña endured for a third consecutive winter, while El Niño developed in the other six winters.

Figure 13a. The standardized values of the Southern Oscillation Index from January 1980–February 2012. 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).

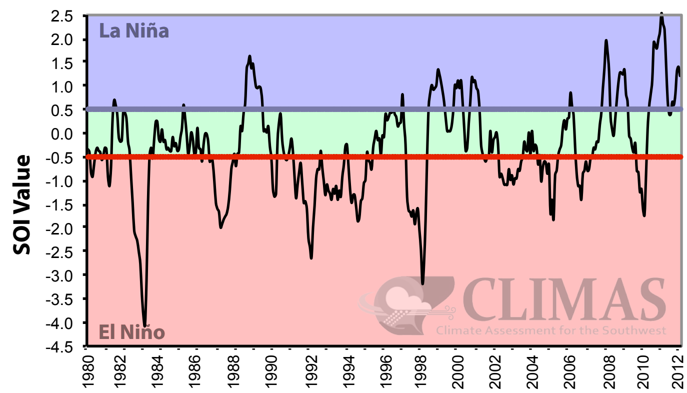
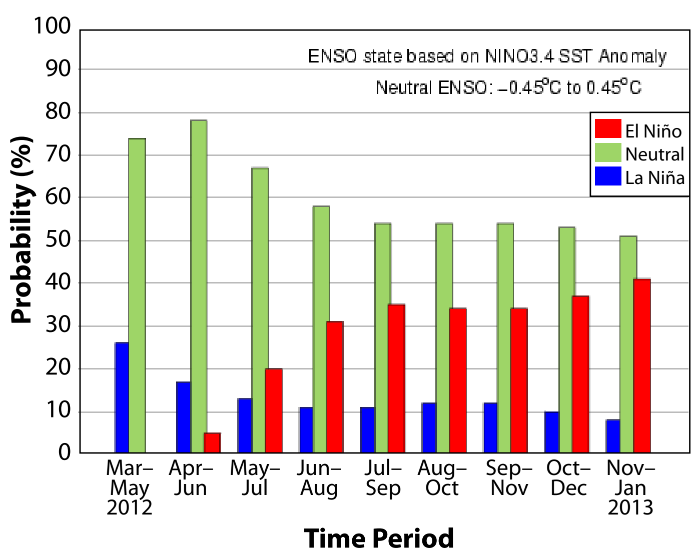


Figure 13b. IRI probabilistic ENSO forecast for El Niño 3.4 monitoring region (released March 15). Colored lines represent average historical probability of El Niño, La Niña, and neutral conditions.



Notes:

The first figure shows the standardized three month running average values of the Southern Oscillation Index (SOI) from January 1980 through February 2012. 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/