Issued: March 24, 2009

Southwest Climate Outlook

THE UNIVERSITY OF ARIZONA.
Arizona's First University.

Source: USDA Forest Service

Photo Description: The Hog Fire burned a 16,802 acres in the Peloncillo Mountains on the Coronado National Forest near Douglas, Arizona. It began around March 2 and burned in grass, oak, and juniper terrain. The fire was human-caused.

Would you like to have your favorite photograph featured on the cover of the *Southwest Climate Outlook*? For consideration send a photo representing Southwest climate and a detailed caption to: knelson7@email.arizona.edu

In this issue...

March Climate Summary

Drought– Above-average precipitation in December–February helped improve short-term drought conditions across northwestern Arizona. In New Mexico, drought conditions worsened with 55 percent of the state experiencing some level of drought.

Temperature– The past 30 days have brought warmer-than-average temperatures. Most of Arizona and nearly all of New Mexico have been 2–8 degrees F warmer than average.

Precipitation– In the past 30 days, most of Arizona and New Mexico has had less than 50 percent of average precipitation, with areas receiving less than 25 percent of average.

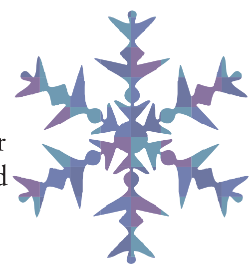
ENSO– The weak La Niña event that developed in December 2008 appears to be winding down.

Snow– Above-average temperatures and below-average precipitation over the past 30 days has led to a dramatic reduction in snowpack levels across much of Arizona and New Mexico.

Climate Forecasts– Long-lead temperature forecasts show increasing chances that spring and summer temperatures in the Southwest will be similar to the warmest 10 years of the 1971–2000 period. Summer precipitation has higher chances of being similar to the wettest 10 years.

The Bottom Line– A warm and dry February has led to a dramatic reduction in snowpack. Arizona has experienced above-average precipitation since December, helping to improve short-term drought conditions across the northwestern part of the state. In New Mexico, drought conditions are worsening. While snowpack in Arizona and New Mexico are well below average, most snow monitoring stations in Colorado measure near-average or slightly below-average snow water content.

Melting snow



Warm and dry conditions in the past month have contributed to the rapid melting of Arizona snow. On March 15, the water content contained in the mountain snows in the state averaged 86 percent of the 30-year average; streamflow forecasts continue to decline.

Below-average snow water content (SWC) at the beginning of April is likely this year in Arizona, continuing a declining trend that has been evident in most of the western states since 1950. Although many people have speculated that human actions are the cause, only recently has scientific research helped attribute the decreasing SWC to greenhouse gases (GHG) and other human activities.

A paper published in December 2008 in the *Journal of Climate* found that approximately half of the observed changes in snowpack over the western U.S. during 1950–1999 are caused by anthropogenic GHGs, ozone, and aerosols. Reducing spring snowpack is likely to continue and even accelerate, according to the paper's authors, Pierce et al.

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Climate data: the ins and outs and where to find what

This article is the first in a two-part series. Part One discusses the National Weather Service's Cooperative observer program and the related Historical Climate Network. In April, Part Two will describe PRISM data, and data from Remote Automated Weather Stations (RAWS) and the Arizona Meteorological Network (AZMET).

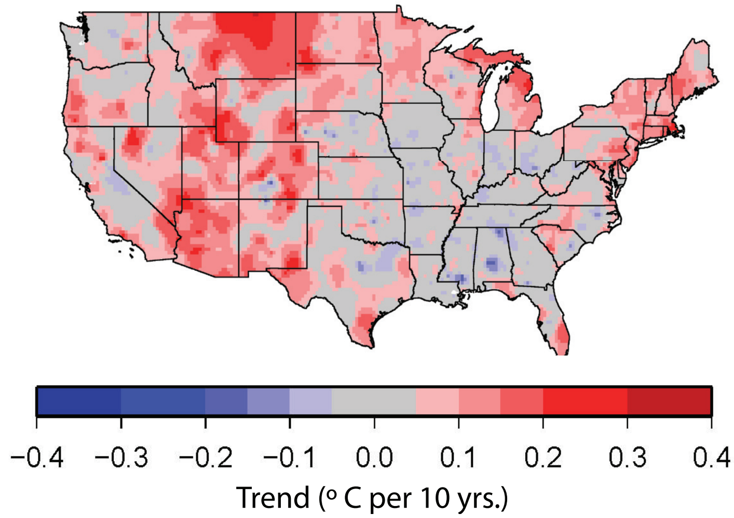


Figure 1. Adjusted maximum temperature in the HCN version 2 data for the period 1895–2007. Every 0.1 degree Celsius equals about 0.18 degrees Fahrenheit.
Source: modified from Menne et al. 2008

Many active weather and climate monitoring networks have collected data for more than 100 years, providing ranchers, forecasters, businesses and others with information they need. But all data are not created equal. Every data set has issues, some more than others. Knowing the details of the data will help match the proper data set to the question at hand.

While some networks bounce information off satellites every minute, others require people to read thermometers once a day and report the values by phone. Some networks have stations in sunny, windy places to monitor fire risk, and others are located in rural areas for farming purposes. And while some have no quality control, others are put through rigorous statistical algorithms and culled into data sets that represent the best and the brightest information.

A wealth of climate data is available, like temperature, precipitation, and snow depth. Learning the advantages, limitations, and Web site locations of each data set is difficult. Two programs in particular, the Cooperative Observer Program (COOP) and the Historical Climate Network (HCN), can help researchers understand climate change and natural variability; influence when ranchers decide to purchase hay and farmers plan crop cycles; aid businesses in correlating product demand and climate; and help resource management agencies allot water to irrigation districts.

Cooperative Observer Program

The Coop network has contributed more to the understanding of climate trends and extremes than any other data source. It contains daily measurements that began in 1890. Since then, the majority of stations have been operated by volunteers. Historically, there have been about 32,000 stations in the U.S. Currently, there are more than 12,000 active sites.

The National Weather Service administers the network, but the National Oceanic and Atmospheric Administration's National Climate Data Center (NCDC) archives it, performs the quality control, produces subsets of the data, and disseminates it in a variety of formats.

Coop observations include once-a-day recordings of the maximum and minimum temperatures, the temperature at observation time, precipitation totals, snowfall totals, and depth of snow at observation time. Many Coop observers provide additional hydrological or meteorological data such as evaporation and soil temperature.

The advantages of the Coop data are the high density of stations, the longevity of the record, daily measurements, and the fact that the data are relatively raw for those who want to perform more rigorous quality control. There are also several shortcomings. First, to analyze changes in the climate through time, more quality control is needed to adjust the data for changes in the time of observation, equipment, and surrounding environment. For example, protocols for the time of observation periodically changed, with pre-1940 recordings occurring at midnight and more recent recordings occurring at 7 am. This change caused jumps in the data. Second, many stations have missing data because measurements are not automated.

While the Coop data is not adjusted for some inconsistencies, NCDC does provide quality control on the raw data. NCDC assures that the minimum temperatures are not greater than the maximum and that the values are reported in the right columns and are not alarmingly greater than neighbor stations.

Accessing daily data costs $2 for each station, or free if the user has a server domain of .edu, .gov, .us, .k12. Monthly data, however, is provided free of charge by the Regional Climate Centers (RCC). This data for Arizona and New Mexico is housed at the Western Regional Climate Center.

continued on page 4

Climate data, continued

U.S. Historical Climate Network

The HCN is a smaller subset of Coop stations that consist of the stations with long and complete records with minimal station changes. The network arose from the need for an accurate and unbiased climate record suitable for detecting and monitoring changes in regional climate. The HCN consists of 1,221 stations; almost all of them have at least 80 years of mean monthly temperature and total monthly precipitation data, were active in 1987, and have experienced few station changes, such as relocations. In some cases, however, these criteria were modified to have a uniform distribution of HCN stations across the U.S. HCN stations span only the 48 contiguous U.S states; a separate data set is available for Alaska, although it lacks the same quality control. There are 25 HCN stations in Arizona and 28 stations in New Mexico.

Like its parent, the HCN data includes daily maximum and minimum temperature, daily precipitation, and daily snowfall totals. Unlike the Coop data, the HCN data have more rigorous quality control, which consists of the following:

1. Using data from surrounding stations to identify potential errors (when values are greater than 3.5 standard deviations from the mean) and outliers (when values are greater than 5.0 standard deviations from the mean).
2. Adjusting temperature data for bias introduced by changing times-of-observation—this adjustment alone changed the temperature trend by 0.3 degrees Fahrenheit (F) between 1960 and 1990.
3. Adjusting temperature to account for artificial errors caused when mercury thermometers were replaced by electronic temperature sensors.
4. Accounting for changes in the data resulting from station relocations and other station changes.
5. Generating data from appropriate nearby stations that fill in for days when observations where not made—data are only generated when records have too many missing values.
6. Correcting for the non-climatic warming caused by urban development.

Although HCN data are quality-controlled in various ways, most data adjustments are based on notes provided by the observer. These notes document, for example, when the observer moved the station, when he or she changed the observation time, and when the thermometer was updated. However, the notes are not always complete—observers may not report replacing a broken thermometer with one calibrated differently. Nevertheless, The HCN data are the best records available for estimating regional temperature trends. They have been used by the Intergovernmental Panel on Climate Change and the U.S. Climate Change Science Program.

Recently, the NCDC created an updated version of the HCN data, called HCN version 2. Version 2 makes a few modifications to quality control and effectively addresses bias introduced by poorly located stations, according to a journal article published this year in the Bulletin of the American Meteorological Society. This is important because proximity of Coop and HCN stations to brick houses, asphalt, and air-conditioning equipment can influence temperature data.

In the journal article, the HCN version 2 was analyzed, generating decadal trends for the period 1895–2007. Not surprisingly, many locations in both Arizona and New Mexico displayed strong warming trends over this period (Figure 1). Currently, this information is only available in monthly summaries. Next year, daily data will likely be available.

Coop and HCN provide long records that correspond to the climate at a particular location. But they also form the foundation of modeled climate data that enable a variety of users to obtain climate information at any location, circumventing the problem of relating a distant station's record to a site with a higher elevation and a different aspect. This gridded PRISM data, along with networks that capture extreme climate conditions and conditions in rural areas, will be addressed in the next issue.

For questions or comments, please contact Zack Guido, CLIMAS Associate Staff Scientist, at zguido@email.arizona.edu or (520) 882-0879.

Related Links

Cooperative Observer Program

1. Daily data:
http://cdo.ncdc.noaa.gov/dly/DLY

2. Monthly data for New Mexico:
http://www.wrcc.dri.edu/summary/Climsmnm.html

3. Monthly data for the Arizona:
http://www.wrcc.dri.edu/summary/Climsmaz.html

U.S. Historical Climate Network

1. Daily and monthly data:
http://cdiac.ornl.gov/epubs/ndp/ushcn/newushcn.html

2. HCN monthly values:
http://www.ncdc.noaa.gov/oa/climate/research/ushcn/

Temperature (through 3/18/09)

Source: High Plains Regional Climate Center

Temperatures since the water year began October 1 continue to average between 35 and 45 degrees Fahrenheit across the Colorado Plateau of northeastern Arizona and the northern half of New Mexico (Figure 1a). Only the highest elevations have seen average temperatures below 30 degrees F. Southern and eastern New Mexico and southeast Arizona have averaged between 45 and 55 degrees, while average temperatures across western and southwestern Arizona have ranged from 50 to 65 degrees. These temperatures generally have been 0–4 degrees above average for the water year across both states (Figure 1b). New Mexico has a few high elevation stations with temperatures 4–6 degrees above average. Warmer-than-average conditions for the water year have extended across most of the southwestern United States as the La Niña pattern forced storm tracks northward across the Pacific Northwest, leaving the Southwest warm and dry. Fortunately, a few storm systems have moved across Arizona and New Mexico, bringing cold and much-needed precipitation.

The past 30 days have brought warmer-than-average temperatures to both Arizona and New Mexico (Figures 1c–d). Western Arizona has been within 2 degrees F of average, but the eastern two-thirds of Arizona and all of New Mexico have been 2–8 degrees F warmer than average for this time of year. Only a few storms passed through the two states this past month to bring in some colder air, and they were felt primarily in New Mexico.

Notes:

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

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

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

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

On the Web:

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

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

Figure 1a. Water year '08–'09 (through March 18, 2009) average temperature.

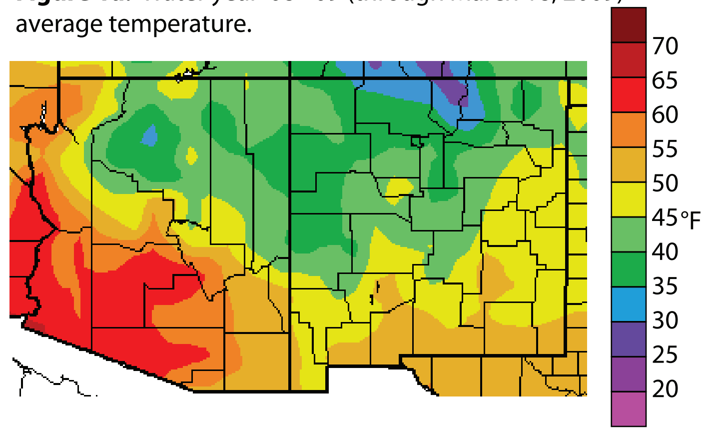


Figure 1b. Water year '08–'09 (through March 18, 2009) departure from average temperature.

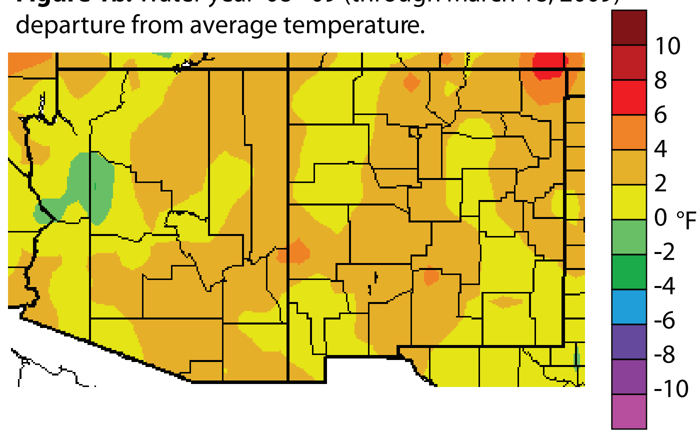


Figure 1c. Previous 30 days (February 17–March 18, 2009) departure from average temperature (interpolated).

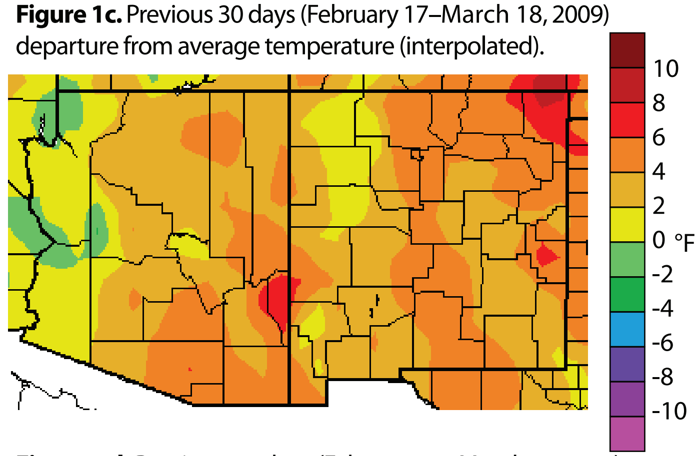
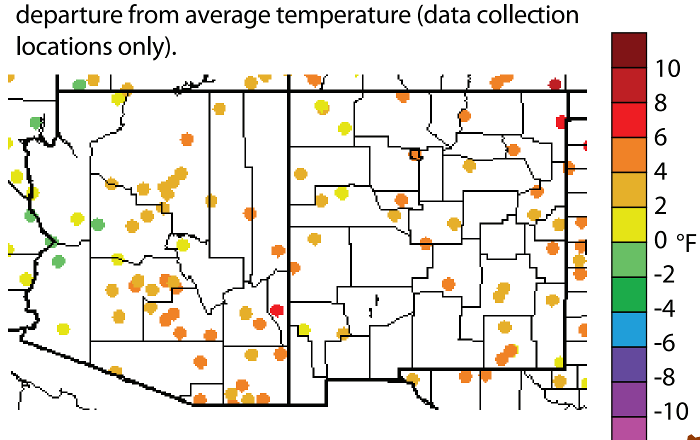


Figure 1d. Previous 30 days (February 17–March18, 2009) departure from average temperature (data collection locations only).



Precipitation (through 3/18/09)

Source: High Plains Regional Climate Center

The 2009 water year precipitation has been highly localized along the lower Colorado River in western Arizona, with pockets of 100 to 130 percent of average precipitation separated by areas of 50 to 100 percent of average (Figures 2a–b). The high elevations of northern and eastern New Mexico also have areas that have received 100 to 300 percent of average precipitation, but most of Arizona and northern New Mexico have received 5 to 90 percent of their average water year precipitation.

In the past 30 days, most of Arizona and New Mexico have had less than 50 percent of their average precipitation, with many areas in both states receiving less than 25 percent of average (Figures 2c–d). Only a strip of area in eastern New Mexico and an isolated area in western New Mexico have received more than 100 percent of their average precipitation. Until mid-February, many locations had a deeper-than-average snowpack; unfortunately, the recent warm and dry conditions have led to an early snowmelt, which will reduce the spring runoff. Since mid-February, only two significant winter storms have moved into the Southwest, and both of them brought much more precipitation to New Mexico than to Arizona. This is the reverse of the earlier winter storms that frequently missed New Mexico. Both states are now expecting more warm, dry weather.

Notes:

The water year begins on October 1 and ends on September 30 of the following year. As of October 1, 2008, we are in the 2009 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 '08–'09 (through March 18, 2009) percent of average precipitation (interpolated).

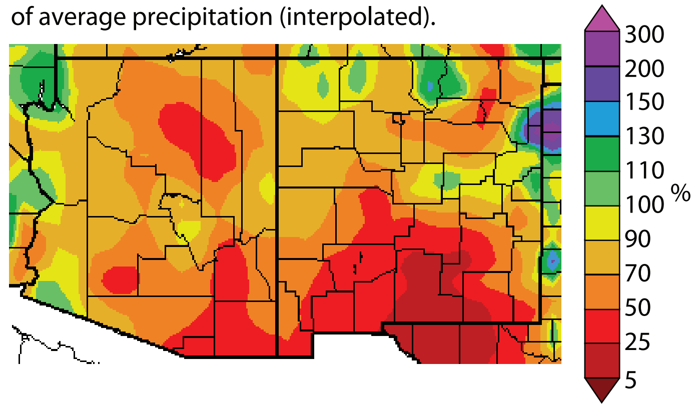


Figure 2b. Water year '08–'09 (through March 18, 2009) percent of average precipitation (data collection locations only).

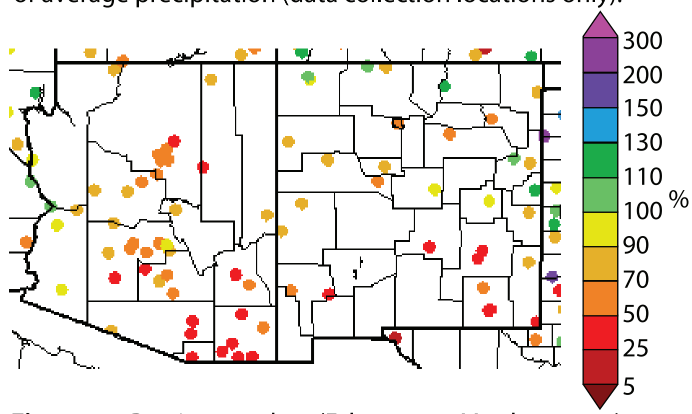


Figure 2c. Previous 30 days (February 17–March 18, 2009) percent of average precipitation (interpolated).

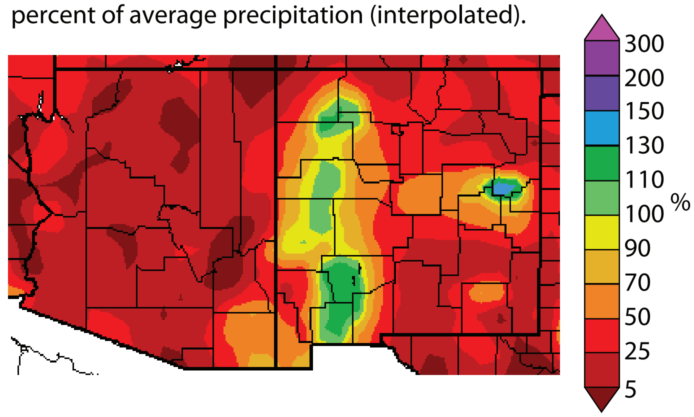
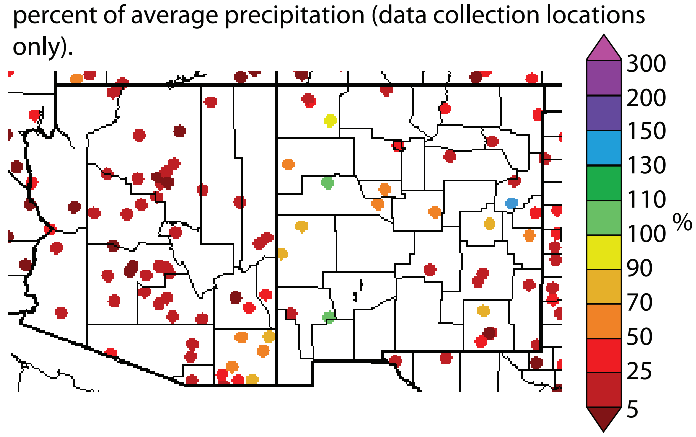


Figure 2d. Previous 30 days (February 17–March18, 2009) percent of average precipitation (data collection locations only).



U.S. Drought Monitor

(released 3/19/09)

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

The U.S. Drought Monitor reports worsening conditions for parts of southeastern Arizona and southwestern New Mexico (Figure 3). Some areas in these regions have drought intensities classified as abnormally dry and moderate. The drought status across both states has been influenced by a dry month in which most of Arizona and New Mexico have received less than 50 percent of the average precipitation (see Figures 2c–d). Elsewhere, large portions of Texas, which saw few changes from one month ago, remain in severe, extreme, and exceptional drought. In northern California, areas with extreme drought intensity one month ago now have severe drought.

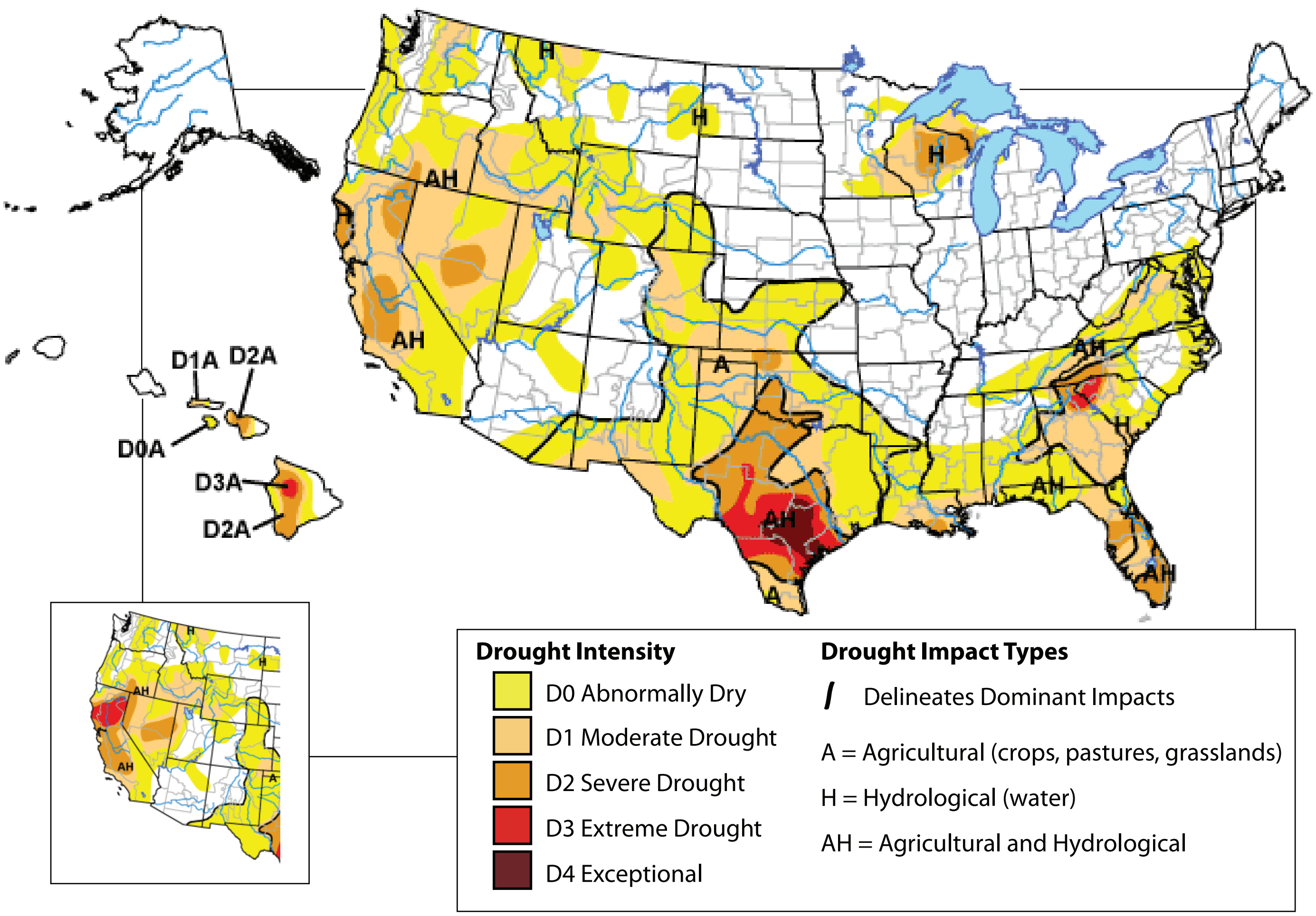
On March 17, approximately 61 percent of Arizona had no drought classification, while about 37 percent was abnormally dry. In the past month, the total area in Arizona with a drought intensity increased from about 21 to 39 percent. In New Mexico, about 45 percent of the state had no drought status on March 17. About 39 percent was abnormally dry and about 17 percent had moderate drought intensity. In the past month, the total area in New Mexico classified with a drought intensity decreased by about 5 percent.

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 the several agencies; the author of this monitor is Laura Edwards, Western Regional Climate Center.

Figure 3. Drought Monitor released March 19, 2009 (full size), and February 19, 2009 (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.unl.edu/dm/monitor.html

Arizona Drought Status

(data through 1/31/08)

Source: Arizona Department of Water Resources

Above-average precipitation in December through February helped improve short-term drought conditions across northwestern Arizona (Figure 4a). The Upper Colorado River watershed moved from abnormally dry drought status in January to normal conditions in February. Abnormally dry conditions remained across much of the rest of northern and central Arizona and also southeastern Arizona. Many of the winter storms since December have missed southeastern Arizona, leaving total precipitation amounts of less than 50 percent of average. Drought conditions worsened from abnormally dry to moderate in the Willcox Playa and Whitewater Draw watersheds due to this below-average precipitation pattern. Long-term drought status was not updated; it will be updated in April (Figure 4b).

So far, 2009 has brought relatively warm and dry weather to parts of Arizona, leaving much of the state with below-average precipitation and persisting or worsening short-term drought conditions. The Southwest isn't alone in this distinction. January and February 2009 were the driest start to any year since 1895, according to Richard Heim at the NOAA National Climatic Data Center (ABC15.com, March 12).

Figure 4a. Arizona short-term drought status for February 2009.

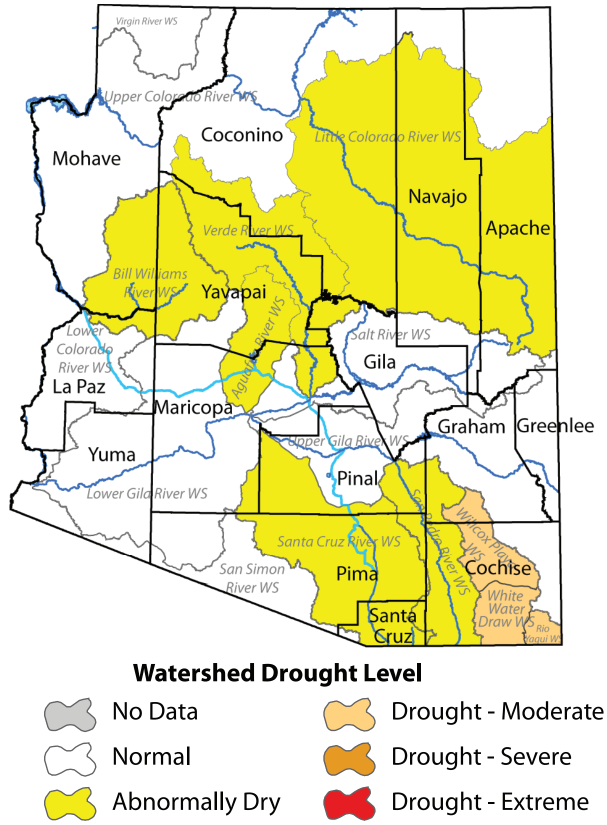
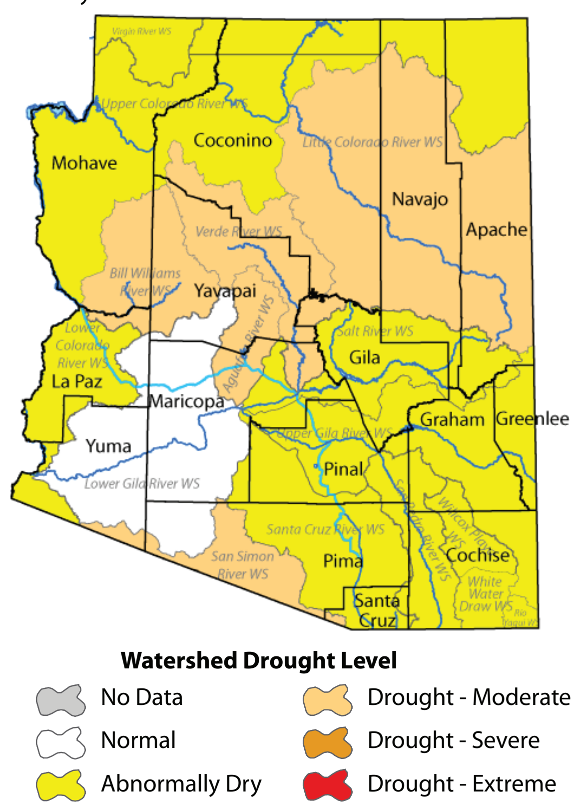


Figure 4b. Arizona long-term drought status for January 2009.



Notes:

The Arizona drought status maps are produced monthly by the Arizona Drought Preparedness Plan Monitoring Technical Committee. The maps are based on expert assessment of variables including, but not limited to, precipitation, drought indices, reservoir levels, and streamflow.

Figure 4a shows short-term or meteorological drought conditions. Meteorological drought is defined usually on the basis of the degree of dryness (in comparison to some "normal" or average amount) over a relatively short duration (e.g., months). Figure 4b refers to long-term drought, sometimes known as hydrological drought. Hydrological drought is associated with the effects of relatively long periods of precipitation shortfall (e.g., many months to years) on water supplies (i.e., streamflow, reservoir and lake levels, and groundwater). These maps are delineated by river basins (wavy gray lines) and counties (straight black lines).

On the Web:

For the most current Arizona drought status maps, visit:
http://www.azwater.gov/dwr/drought/DroughtStatus.html

New Mexico Drought Status

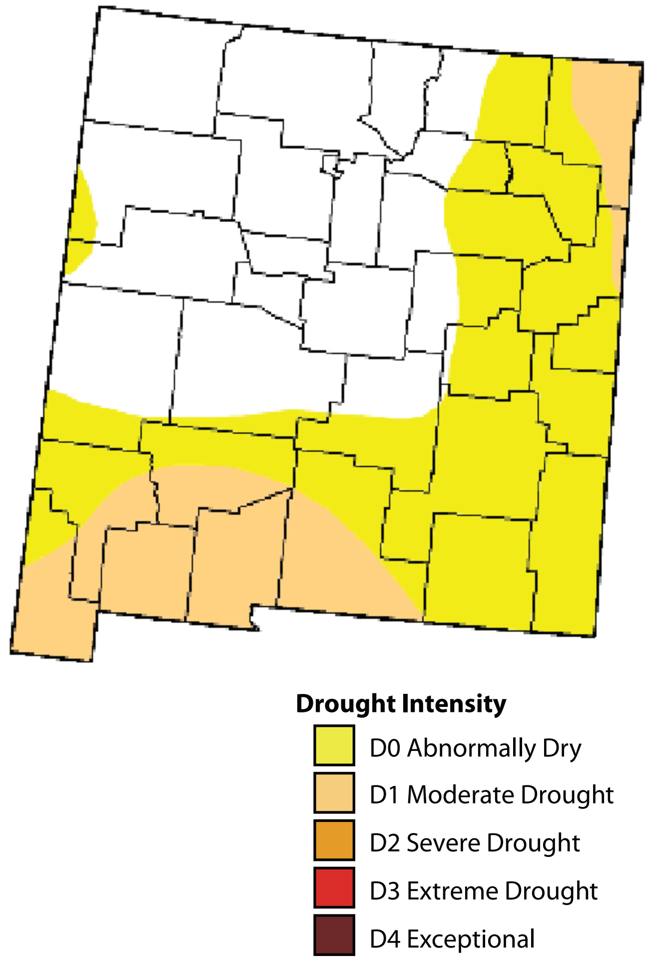
(released 3/19/09)

Source: New Mexico State Drought Monitoring Committee

Drought conditions worsened again this month across New Mexico, with 55 percent of the state experiencing some level of drought. The March 17 update of the National Drought Monitor indicated abnormally dry conditions have settled in across the eastern third and southern half of New Mexico (Figure 5). Moderate drought conditions exist across the southwestern quarter and extreme northeastern corner of the state. This pattern reflects an expansion of drought conditions since mid-February, when only abnormally dry conditions where present across the eastern and southern third of the state. The past 30 days have brought very dry and warm conditions to much of the region. Most of New Mexico has observed less than 50 percent of average precipitation and above-average temperatures between mid-February and mid-March which has helped push the expansion of short-term drought conditions.

A recent poll conducted by the Arizona State University Institute for Social Science Research indicates that drought is the top environmental concern for citizens across the Southwest. The ASU Southwest Poll released in early March 2009 surveyed people across Arizona, New Mexico, Texas, and Nevada on issues related to sustainability, the economy, and the environment. Drought scored the highest on a list of environmental concerns for the Southwest, while climate change and the extinction of plant and animal species scored the lowest.

Figure 5. New Mexico drought map based on data through March 17, 2009.



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

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 the several agencies.

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

Arizona Reservoir Levels

(through 2/28/09)

Source: National Water and Climate Center

Combined reservoir storage in Lakes Powell and Mead declined by 253,000 acre-feet during February (Figure 6). Nevertheless, the combined Powell and Mead storage is 3 percent (around 1.5 million acre-feet) greater than it was at the same time last year. During February, storage in the Salt River watershed was at 100 percent of capacity. The combined storage in the Salt-Verde reservoir system increased by more than 75,000 acre-feet.

In water-related news, inspectors at Lake Powell's Wahweap Marina saved the lake from contamination by quagga mussels when they prevented a mussel-encrusted boat from launching (*Deseret News*, March 13). The tiny mussels can damage water delivery systems.

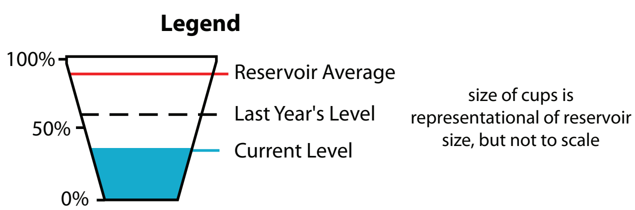
Notes:

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

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

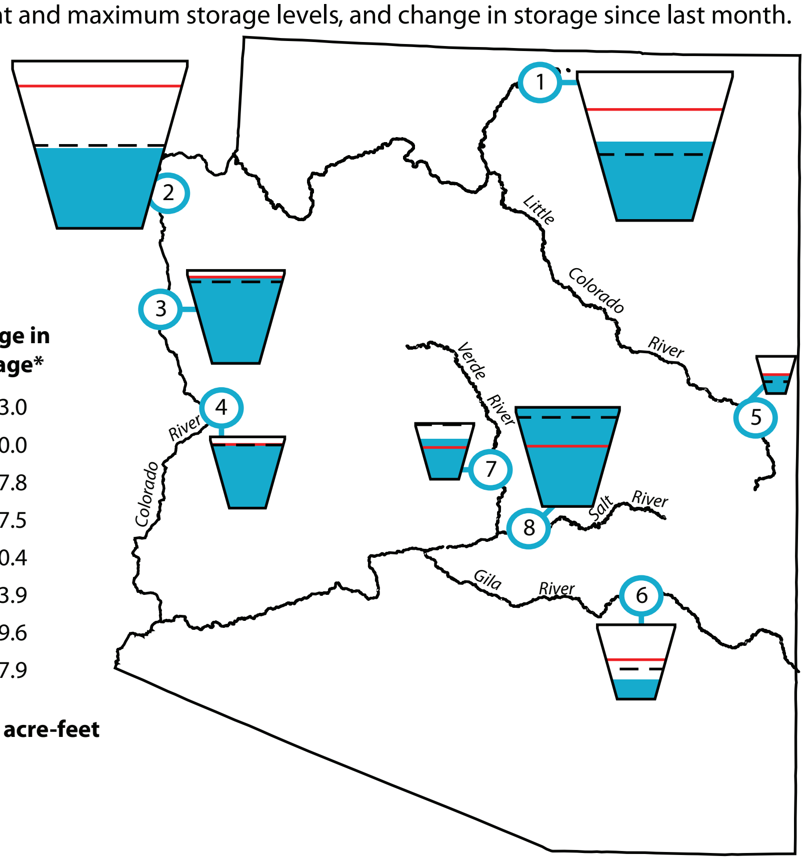
These data are based on reservoir reports updated monthly by the National Water and Climate Center of the U.S. Department of Agriculture's Natural Resource Conservation Service (NRCS). For additional information, contact Dino DeSimone, Dino.DeSimone@az.usda.gov.

Figure 6. Arizona reservoir levels for February 2009 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	53%	12,934.0	24,322.0	-213.0
2. Lake Mead	48%	12,533.0	26,159.0	-40.0
3. Lake Mohave	93%	1,675.2	1,810.0	27.8
4. Lake Havasu	88%	541.8	619.0	-17.5
5. Lyman Reservoir	49%	14.6	30.0	0.4
6. San Carlos	26%	231.4	875.0	3.9
7. Verde River System	72%	206.5	287.4	59.6
8. Salt River System	100%	2,017.3	2,025.8	17.9

*** 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 2/28/09)

Source: National Water and Climate Center

The total reservoir storage in New Mexico increased by 35,100 acre-feet during February (Figure 7). Elephant Butte Reservoir is now at 30 percent of capacity, compared with a mere 14 percent in March 2005. Pecos River reservoirs (reservoirs 9–12 on Figure 7) experienced slight storage increases.

In water-related news, a federal spending bill signed by President Obama will give $700,000 to the Navajo-Gallup water supply project, part of Navajo Nation's settlement for San Juan River water rights (*Farmington Daily Times*, March 18).

By proactively implementing a water conservation program to prepare for future droughts, Las Cruces, New Mexico, has reduced single family household water consumption by almost 10 percent during the last four years (*Las Cruces Sun-News*, March 17). Single family households are the largest water consumers in Las Cruces.

Notes:

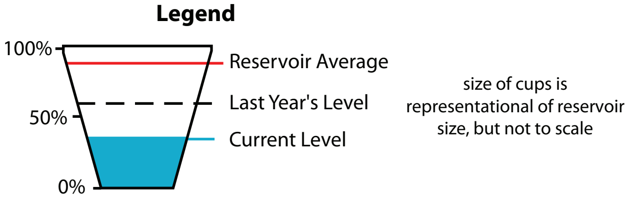
The map gives a representation of current storage levels for reservoirs in New Mexico. Reservoir locations are numbered within the blue circles on the map, corresponding to the reservoirs listed in the table. The cup next to each reservoir shows the current storage level (blue fill) as a percent of total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

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

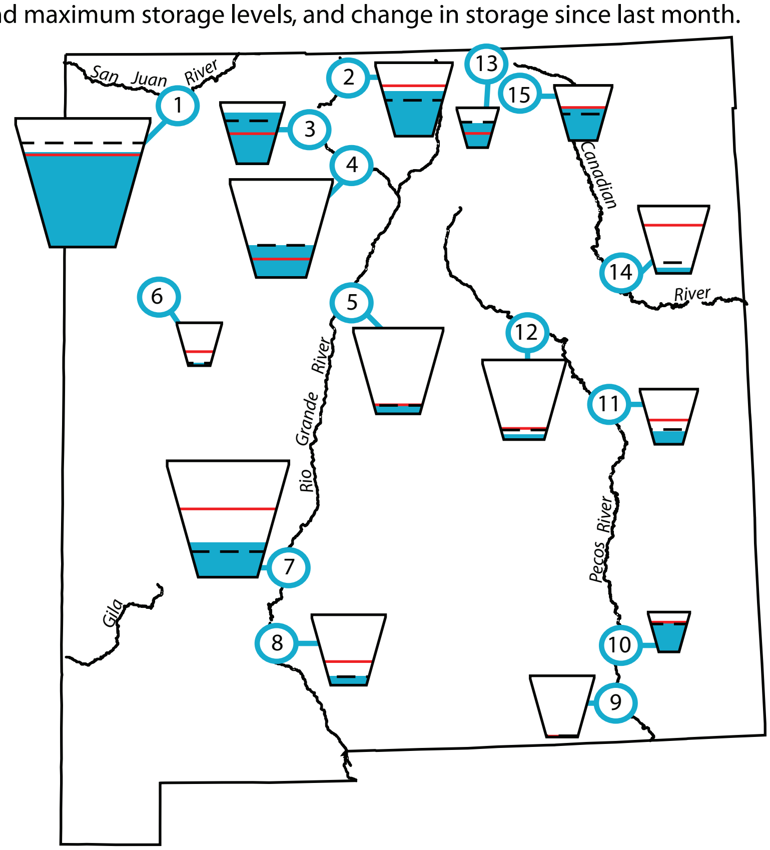
These data are based on reservoir reports updated monthly by the National Water and Climate Center of the U.S. Department of Agriculture's Natural Resource Conservation Service (NRCS). For additional information, contact Richard Armijo, Richard.Armijo@nm.usda.gov.

Figure 7. New Mexico reservoir levels for February 2009 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	74%	1,259.4	1,696.0	-5.3
2. Heron	61%	244.4	400.0	2.1
3. El Vado	83%	162.1	195.0	6.2
4. Abiquiu	33%	181.8	554.5	-2.2
5. Cochiti	10%	51.3	491.0	0.4
6. Bluewater	7%	2.6	38.5	0.2
7. Elephant Butte	30%	667.7	2,195.0	8.4
8. Caballo	13%	43.5	332.0	20.0
9. Brantley	2%	21.7	1008.2	1.1
10. Lake Avalon	73%	2.9	4.0	0.3
11. Sumner	24%	24.5	102.0	2.5
12. Santa Rosa	7%	31.7	438.3	0.3
13. Costilla	61%	9.8	16.0	0.4
14. Conchas	8%	21.6	254.2	-0.3
15. Eagle Nest	61%	47.8	79.0	1.0



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 3/19/09)

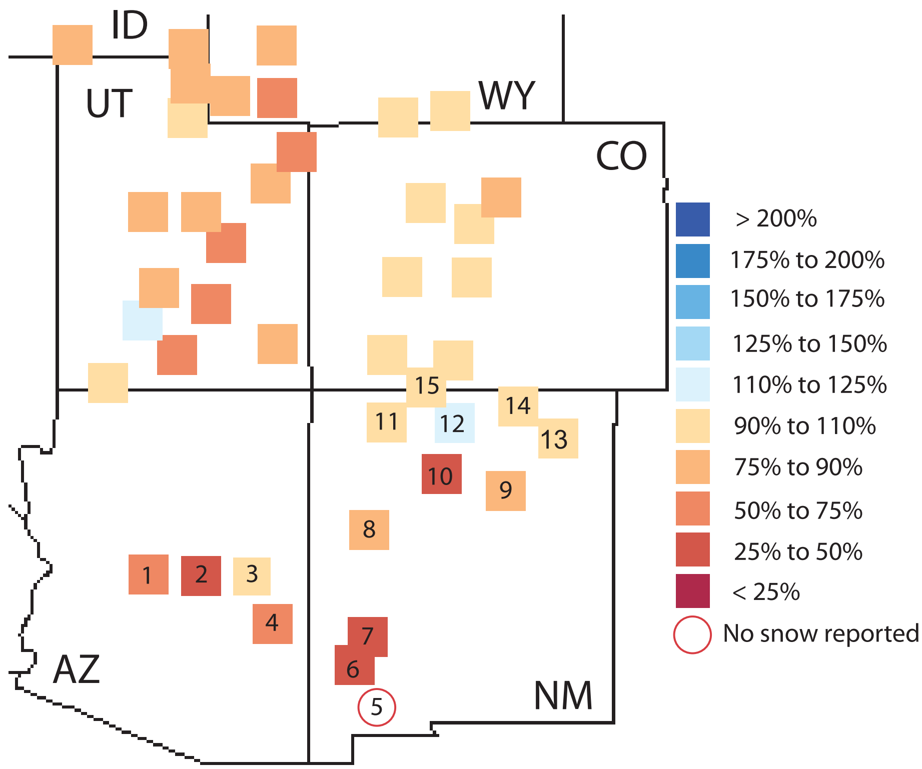
Sources: National Water and Climate Center, Western Regional Climate Center

Above-average temperatures and below-average precipitation over the past 30 days has led to a dramatic reduction in snowpack levels across much of Arizona and New Mexico. Snowpack levels were above average at many locations in eastern Arizona and northern New Mexico in February but have quickly retreated to below-average conditions at these same sites. Basin average snow water content (SWC) values are only at 50 percent of average for several major watersheds in Arizona (Figure 8). The Gila River Basin is reporting the lowest value—46 percent of average SWC—for this time of year, when snowpack is typically at peak levels.

Most New Mexico basins are also observing below-average SWC. The Mimbres Basin in the southwestern part of the state had no snowpack as of mid-March. Only the northernmost basins are reporting near-average levels. The Natural Resources Conservation Service in Arizona reports that the quick melting of snowpack has led to raging flows in many of Arizona's streams but will also lead to well below-average streamflow levels later in the spring season.

In the Upper Colorado River Basin, many snowpack telemetry (SNOTEL) monitoring stations in the Colorado Mountains measure near average or slightly below-average SWC.

Figure 8. Average snow water content (SWC) in percent of average for available monitoring sites as of March 19, 2009.



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 content (SWC) or snow water equivalent (SWE) is calculated from this information. SWC 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 SWC than light, powdery snow.

Figure 8 shows the SWC 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 SWC measurements made by the Natural Resource 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 2009)

Source: NOAA Climate Prediction Center (CPC)

The NOAA-Climate Prediction Center (NOAA–CPC) long-lead temperature forecasts for the continental U.S. show increasing chances for conditions to be similar to those during the warmest 10 years of 1971–2000 for much of the Southwest through the spring and into summer (Figures 9a–d). Nearly all of the forecast tools, which include long-term trends, El-Niño Southern Oscillation (ENSO) conditions, and various models, call for an increased likelihood for extra warmth across the Southwest.

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 1971–2000 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 2009.

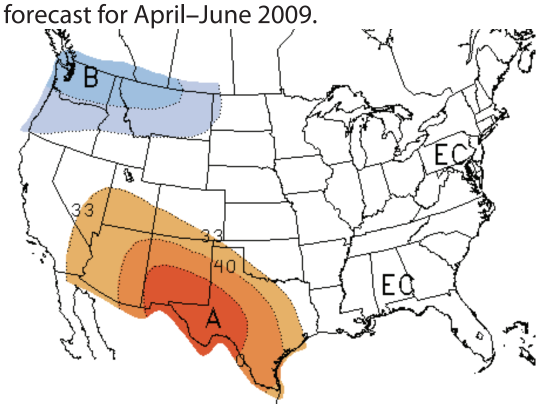
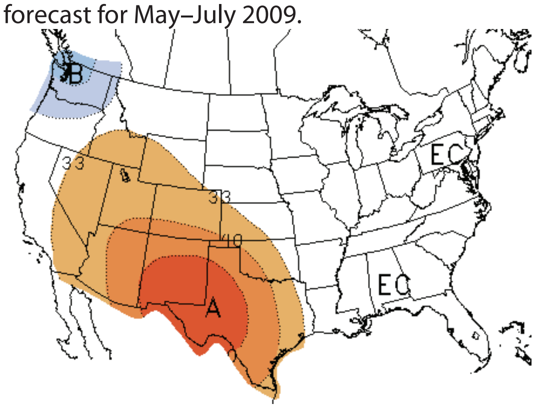


Figure 9b. Long-lead national temperature forecast for May–July 2009.



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

B=Below
40.0–49.9%
33.3–39.9%

Figure 9c. Long-lead national temperature forecast for June–August 2009.

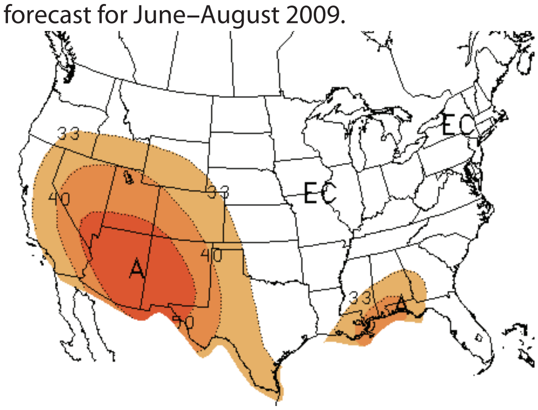
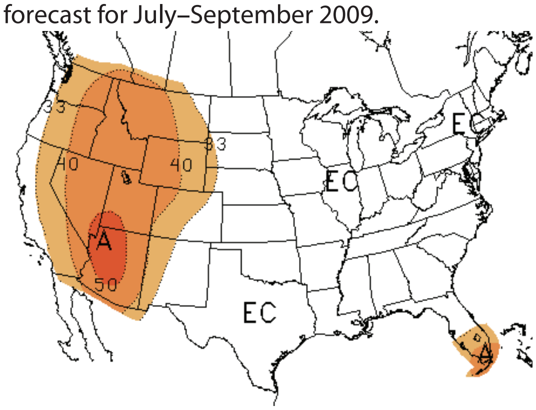


Figure 9d. Long-lead national temperature forecast for July–September 2009.



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 may load slowly on your computer)

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

Precipitation Outlook

(April–September 2009)

Source: NOAA Climate Prediction Center (CPC)

The NOAA-Climate Prediction Center (NOAA–CPC) long-lead precipitation forecasts for the Southwest show equal chances of below–average, above–average, and average conditions for Arizona and New Mexico through June (Figures 10a–10d). This indicates that for this period no forecast skill has been demonstrated or there is no clear climate signal. For the three-month periods May–July and April–August, the Southwest shows slightly increased chances for precipitation to be similar to the wettest 10 years of 1971–2000, rather than the baseline chance of 33 percent (Figures 10b–c). Contributing partly to these forecasts is support for enhanced monsoon conditions during the summer.

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 1971–2000 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 2009.

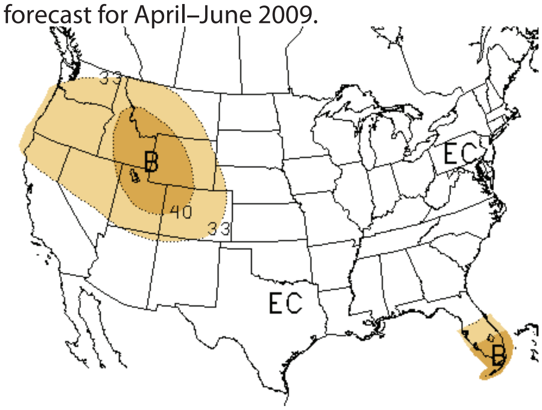


Figure 10b. Long-lead national precipitation forecast for May–July 2009.

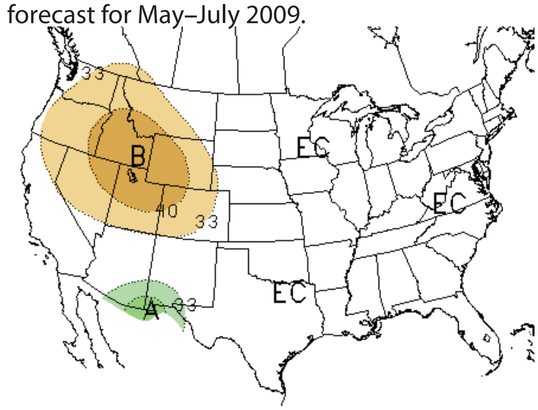


Figure 10c. Long-lead national precipitation forecast for June–August 2009.

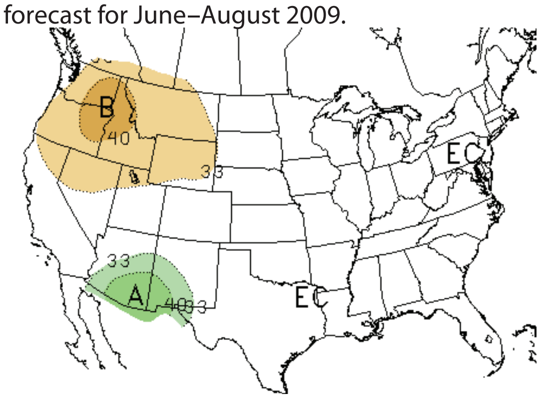
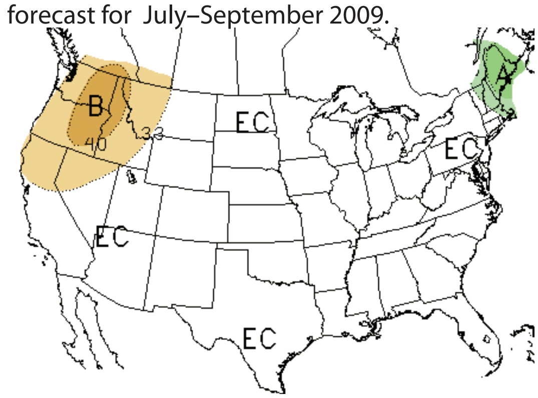


Figure 10d. Long-lead national precipitation forecast for July–September 2009.



B= Below: 33.3–39.9%, 40.0–49.9%

A=Above: 40.0–49.9%, 33.3–39.9%

EC= Equal chances. No forecasted anomalies.

On the Web:

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

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

Seasonal Drought Outlook
(through June 2009)

Source: NOAA Climate Prediction Center (CPC)

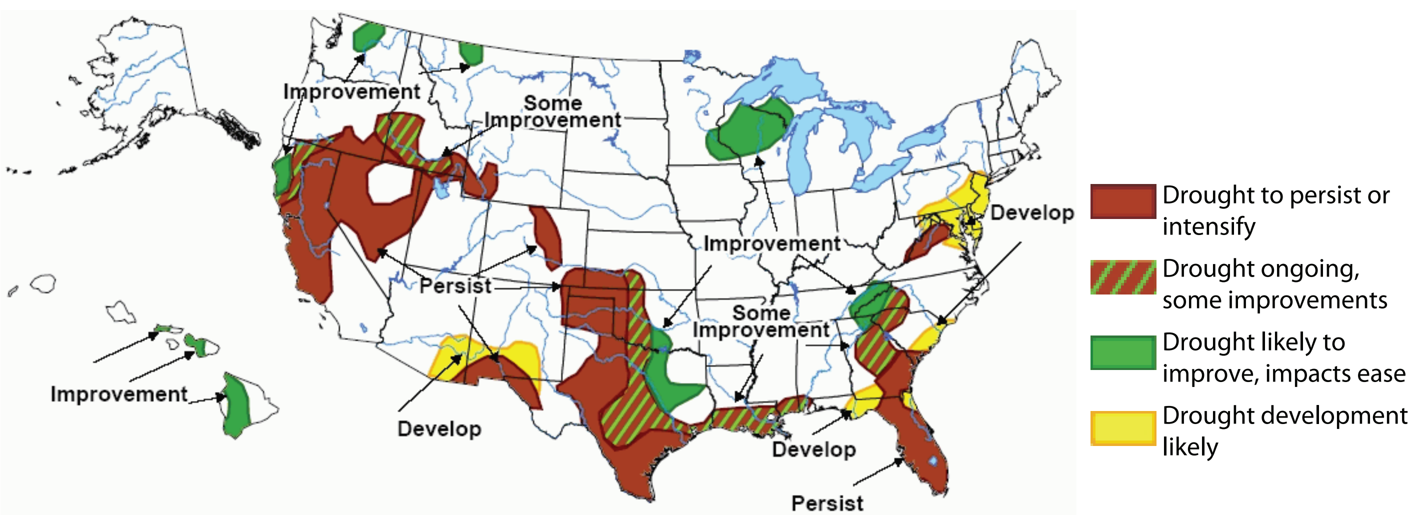
The National Oceanic and Atmospheric Administration's Climate Prediction Center (NOAA-CPC) reports that drought conditions for March 19 through June will generally intensify in the northern half of California and much of Nevada, Texas, and Florida (Figure 11). Drought also will persist and likely develop in southern New Mexico and southeastern Arizona. Parts of the U.S., including areas of northern California, Hawaii, Texas, and parts of the Great Lakes region, also will experience drought improvements.

The drought expansion in Arizona and New Mexico is based on several factors: currently dry areas, medium-range forecasts that indicated dry conditions, and a warm and dry monthly forecast for April, according to the NOAA-CPC. Historical trends aid the forecast for New Mexico. New Mexico has received below-normal rainfall for the April–June period which occured during a La Niña event, which appears to be winding down (Figure 14b). The forecast confidence for Arizona and New Mexico is moderate.

In California and the Great Basin, winter storms have continued into March, helping to improve drought conditions in some areas. The wet season is winding down, however, although at least one more beneficial storm is forecast, according to NOAA-CPC. This additional precipitation will keep California and adjacent parts of Nevada on pace for a near-normal water year. However, precipitation into April likely will be insufficient to make up for the deficits that have accumulated during the past three years. Also, spring-summer streamflow forecasts remain below normal, and the large reservoirs in the north will likely not fill up. As a result, the Drought Outlook indicates persisting drought for most of California and the Great Basin with a high degree of confidence.

Notes:
The delineated areas in the Seasonal Drought Outlook (Figure 11) 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 2009 (released March 19, 2009).



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

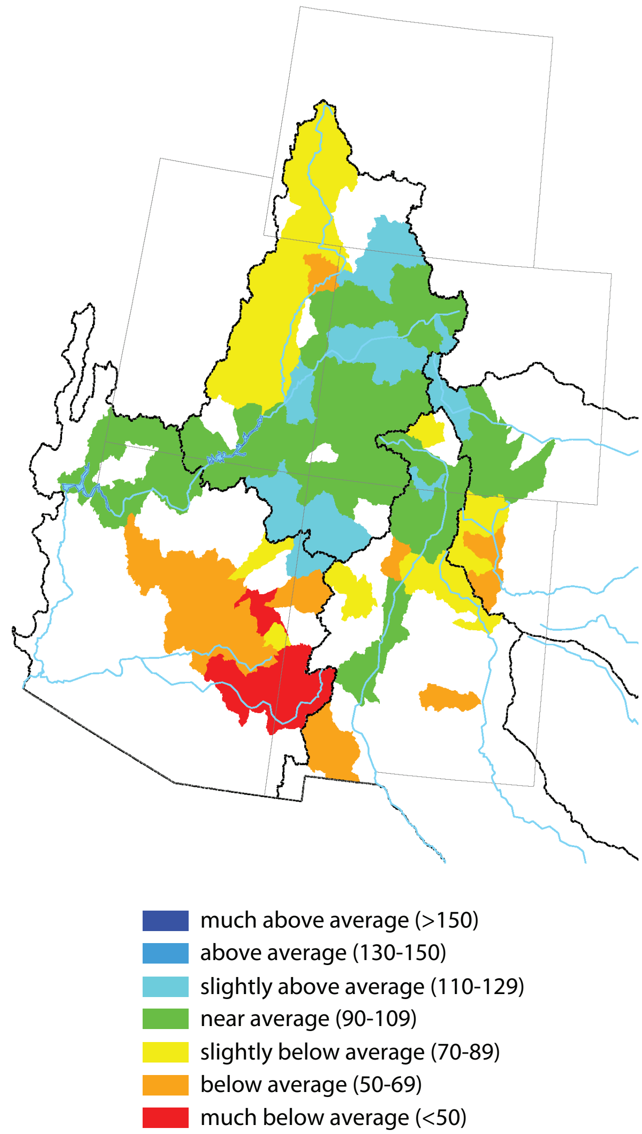
Streamflow Forecast
(for spring and summer)

Source: National Water and Climate Center

The March 1 streamflow forecast for the Southwest shows a wide range of projected flows for basins in Arizona and New Mexico (Figure 12). Most basins near the Four Corners (junction of Arizona, Utah, Colorado, and New Mexico) and in western Colorado are predicted to have average to above-average spring streamflow, and basins to the south and east of the Four Corners are predicted to have well below-average spring streamflow. There is at least a 50 percent chance that inflow to Lake Powell will be 88 percent of the 30-year average for April–July. Streams in the Upper Gila River Basin are all predicted to have less than 50 percent of average streamflow, and the inflow to San Carlos Reservoir for mid-March through May is predicted to be only 27 percent of average.

According to the USDA-Natural Resources Conservation Service (NRCS), streamflow forecasts for the Canadian River Basin in New Mexico range from 58 percent of average at the Conchas Reservoir Inflow to 82 percent of average for the Mora River near Golondrinas. Streamflow forecasts for the Pecos River Basin range from 76 percent of average for the Santa Rosa Lake Inflow to 86 percent of average for the Pecos River near Pecos. Streamflow forecasts for the Rio Grande Basin range from 115 percent of average for Costilla Creek near Costilla to 62 percent of average for the Jemez River below Jemez Canyon Dam. For the Rio Grande Basin at Otowi Bridge, a key measurement point north of Albuquerque, the USDA-NRCS forecasts a 50 percent chance of average streamflow.

Figure 12. Spring and summer streamflow forecast as of March 1, 2009 (percent of average).



Notes:
The forecast information provided in Figure 12 is updated monthly by the National Water and Climate Center, part of the U.S. Department of Agriculture's Natural Resources Conservation Service. Unless otherwise specified, all streamflow forecasts are for streamflow volumes that would occur naturally without any upstream influences, such as reservoirs and diversions. The USDA-NRCS only produces streamflow forecasts for Arizona between January and April, and for New Mexico between January and May.

The NWCC provides a range of forecasts expressed in terms of percent of average streamflow for various statistical exceedance levels. The streamflow 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.

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

El Niño Status and Forecast

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

The weak La Niña event that developed in December 2008 appears to be winding down. Sea surface temperatures (SSTs) were still below-average in the middle and eastern regions of the equatorial Pacific, but warmed slightly since last month. The NOAA-Climate Prediction Center (NOAA-CPC) reported that other sub-surface temperature measurements showed signs of warming and weakening La Niña conditions. The atmosphere is still reflecting La Niña conditions with another positive Southern Oscillation Index (SOI) value this past month and observations of above-average easterly winds continuing along the equator across the Pacific basin (Figure 13a). The NOAA-CPC notes that these observations are consistent with a weakening La Niña event.

The International Research Institute for Climate and Society (IRI) also supports the notion that the current La Niña event is waning. IRI forecasts a nearly 50 percent chance of neutral or La Niña conditions returning during the March–May period; there is virtually no chance of a El Niño conditions developing (Figure 13b). The odds tilt dramatically toward neutral conditions by the April–June forecast period, with the chance of a transition to neutral conditions at 64 percent, La Niña conditions persisting at 32 percent, and the chance of an El Niño event forming at 4 percent. This is above the historical probability (50 percent) of neutral conditions for this time year, indicating relatively high confidence in this forecast. Spring forecasts for below-average precipitation across the Southwest remain due to the expectation that the impact of La Niña on atmospheric circulation patterns will linger through the spring season.

Notes:

Figure 13a shows the standardized three month running average values of the Southern Oscillation Index (SOI) from January 1980 through February 2009. 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.

Figure 13b 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, the 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.

Figure 13a. The standardized values of the Southern Oscillation Index from January 1980–February 2009. 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).

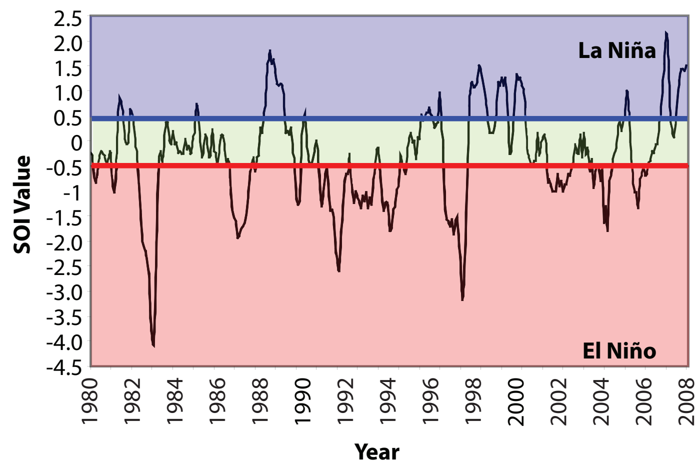
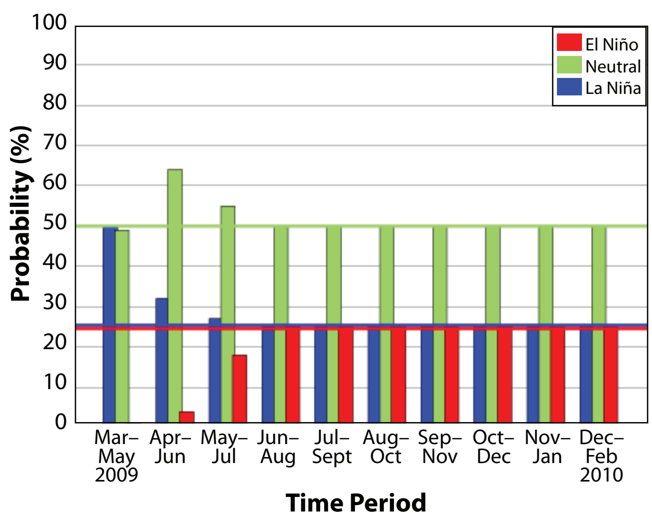


Figure 13b. IRI probabilistic ENSO forecast for El Niño 3.4 monitoring region (released March 19, 2009). Colored lines represent average historical probability of El Niño, La Niña, and neutral.



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/

Temperature Verification

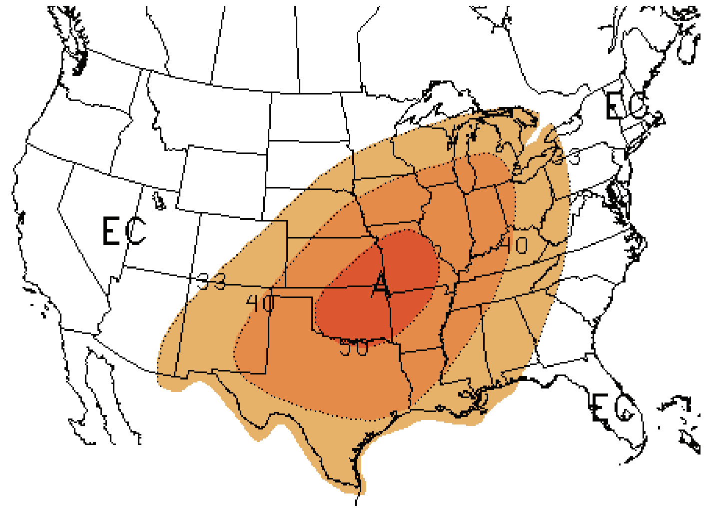
(December 2008–February 2009)

Source: NOAA Climate Prediction Center (CPC)

The NOAA-Climate Prediction Center (NOAA-CPC) seasonal temperature outlook for December 2008–February 2009 forecasted increased chances for temperature conditions to be similar to the warmest 10 years of the 1971-2000 period for most regions in the central U.S. (Figure 14a). The Southwest, New Mexico and eastern Colorado were forecasted to have slightly higher chances of above-average temperatures through February.

The overall temperatures observed for December–February were near-average at many locations in the central U.S. that were forecasted to have above-average temperatures (Figure 14b). While Arizona temperatures were slightly below average for this period, the southeastern half of New Mexico had slightly above-average temperatures. New Mexico's observed temperatures were similar to the above-average temperatures forecasted.

Figure 14a. Long-lead U.S. temperature forecast for December 2008–February 2009 (issued November 2008).



Notes:

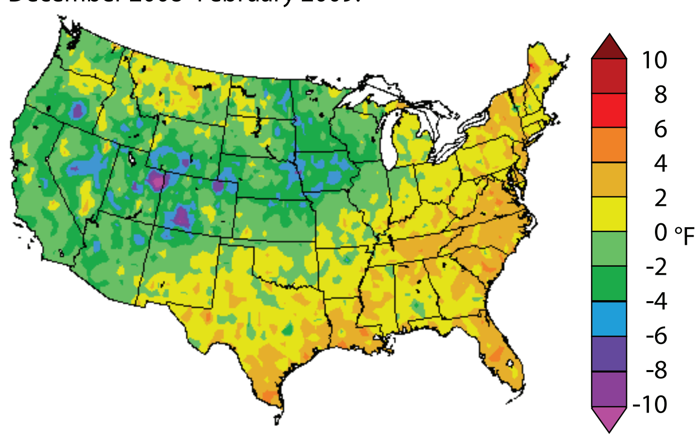
Figure 14a shows the NOAA Climate Prediction Center (CPC) temperature outlook for the months December 2008–Febrary 2009. This forecast was made in November 2008.

The outlook predicts 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.

Using past climate as a guide to average conditions and dividing the past record into 3 categories, there is a 33.3 percent chance of above-average, a 33.3 percent chance of average, and a 33.3 percent chance of below-average temperature. Thus, using the NOAA CPC likelihood forecast, in areas with light brown shading there is 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. Equal Chances (EC) indicates areas where reliability (i.e., the skill) of the forecast is poor and no prediction is offered.

Figure 14b shows the observed departure of temperature (degrees F) from the average for the December 2008–Febrary 2009 period. Care should be exercised when comparing the forecast (probability) map with the observed temperature maps. The temperature departures do not represent probability classes as in the forecast maps, so they are not strictly comparable. They do provide us with some idea of how well the forecast performed. In all of the figures on this page, the term average refers to the 1971–2000 average. This practice is standard in the field of climatology.

Figure 14b. Average temperature departure (in degrees F) for December 2008–February 2009.



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

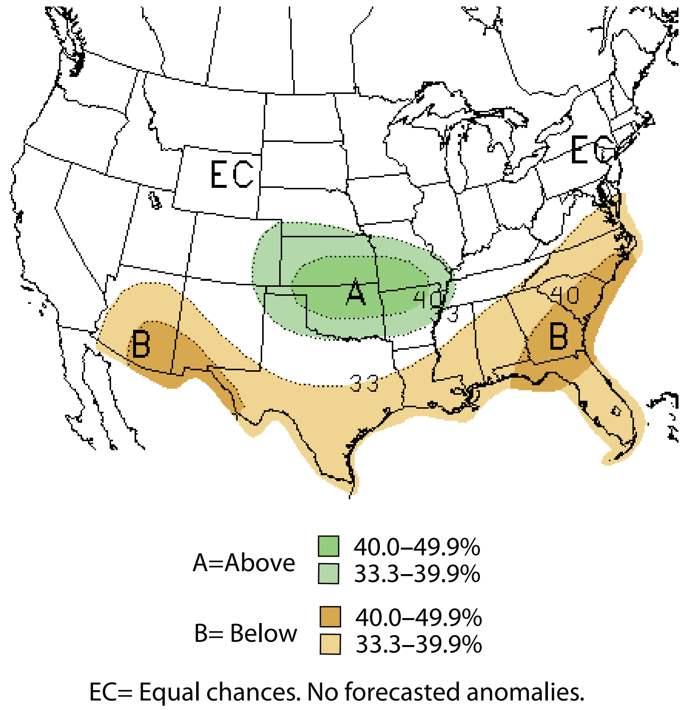
Precipitation Verification
(December 2008–February 2009)

Source: NOAA Climate Prediction Center (CPC)

The two-week lead time forecast issued by the NOAA-Climate Prediction Center (NOAA-CPC) seasonal precipitation outlook for December 2008–February 2009 predicted increased chances for precipitation to be similar to the driest 10 years of the 1971-2000 period for much of Arizona, New Mexico, and the Southeast (Figure 15a). In the Southwest, NOAA-CPC forecasted the highest probabilities—between 40 and 50 percent—for southeastern Arizona and southwestern New Mexico. NOAA-CPC also forecasted increased chances for precipitation to be similar to the wettest 10 years of the 1971-2000 period in the central U.S.

The average precipitation observed for December 2008–February 2009 were dry in the southeastern corner of Arizona and the southwestern half of New Mexico, with most areas receiving less than 70 percent of average precipitation (Figure 15b). Observed conditions and forecasts for the Southwest were similar. They were also similar in the central U.S., where many locations received precipitation well above their historical average. Precipitation was greater than the historical average in many parts of the southeastern U.S., where low rainfall was forecasted.

Figure 15a. Long-lead U.S. precipitation forecast for December 2008–February 2009 (issued November 2008).



Notes:

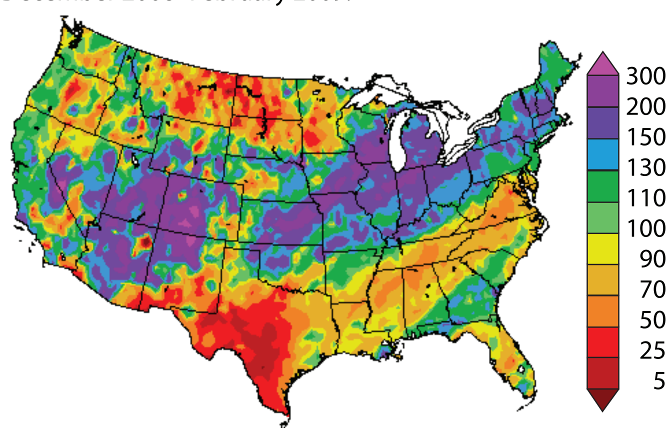
Figure 15a shows the NOAA Climate Prediction Center (CPC) precipitation outlook for the months December 2008–Febrary 2009. This forecast was made in November 2008.

The outlook predicts 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. Using past climate as a guide to average conditions and dividing the past record into 3 categories, there is a 33.3 percent chance of above-average, a 33.3 percent chance of average, and a 33.3 percent chance of below-average precipitation. Thus, using the NOAA CPC likelihood forecast, in areas with light brown shading there is 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. Equal Chances (EC) indicates areas where reliability (i.e., the skill) of the forecast is poor and no prediction is offered.

Figure 15b shows the observed percent of average precipitation for December 2008–Febrary 2009. Care should be exercised when comparing the forecast (probability) map with the observed precipitation maps. The observed precipitation amounts do not represent probability classes as in the forecast maps, so they are not strictly comparable, but they do provide us with some idea of how well the forecast performed.

In all of the figures on this page, the term average refers to the 1971–2000 average. This practice is standard in the field of climatology.

Figure 15b. Percent of average precipitation observed from December 2008–February 2009.



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